Protecting Alameda County Creeks, Wetlands & the Bay

cleanwater PROGRAM

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Union City
County of Alameda
Alameda County Flood Control and Water Conservation District
Zone 7 Water Agency

March 14, 2014

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

SUBJECT: **SUBMITTAL OF THE ALAMEDA COUNTYWIDE CLEAN WATER PROGRAM INTEGRATED MONITORING REPORT**

Dear Bruce:

As you know, various submission and reporting provisions of the Municipal Regional Stormwater Permit (MRP) authorize Permittee implementation and compliance though coordination of the countywide stormwater programs. The member agency Permittees of the Alameda Countywide Clean Water Program (ACCWP) through their Management Committee, and in conformance with the Memorandum of Agreement signed by their governing bodies, have authorized and directed me to prepare and submit certain reports as part of their compliance with submission of MRP-required reports.

Therefore, with this letter, I am submitting this ACCWP Integrated Monitoring Report on behalf of and for the benefit of the ACCWP member agency Permittees. By signing this letter on behalf of ACCWP, I certify under penalty of law that these documents and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gathered and evaluated the information submitted. Based on my inquiry of the person or persons who managed the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations. [40CFR 122.22(d)]

Sincerely,

James Scanlin
Program Manager

Attachments: Certification Statement (2 pages)
ACCWP Integrated Monitoring Report

Certification Statement

Report parts

This Integrated Monitoring Report submitted by the Alameda Countywide Clean Water Program includes the following parts:

Integrated Monitoring Report Part A: Water Quality Monitoring in Water Years 2012 and 2013 (prepared by ACCWP) including the following appendices:

- A.1 Creek Status Monitoring Report - Regional Parameters: Bioassessment and Physical Habitat
- A.2 Creek Status Monitoring Report - Regional Parameters: Water Quality, Sediment Chemistry and Toxicity, Water Column Toxicity
- A.3 Creek Status Monitoring Report -Targeted Parameters
- A.4A Stressor / Source Identification Project: Dublin Creek Site 204R00084 – Biological Community and Sediment Quality- Water Year 2013 Progress Report
- A.4B Stressor Source Identification Project: Castro Valley Creek Site 204R00047 –Sediment Quality - Water Year 2013 Progress Report
- A.4C Stressor Source Identification Project: Crow Creek - Low Dissolved Oxygen - Water Year 2013 Progress Report
- A.5 Pollutants of Concern (POC) Loads Monitoring Data Progress Report, Water Years (WYs) 2012 and 2013 and Regional Sediment Delivery Estimate/Budget: Preliminary Results (prepared for the Bay Area Stormwater Management Agencies Association)
- A.6 Review of Quality Assurance and Quality Control Results for Creek Status Monitoring - Water Years 2012 and 2013

Integrated Monitoring Report Part B: PCB and Mercury Loads Avoided and Reduced via Stormwater Control Measures (prepared for the Bay Area Stormwater Management Agencies Association)

Integrated Monitoring Report Part C: PCB and Mercury Load Reduction Planning (prepared for ACCWP) including the following appendices:

- A Land Use PCB Yield Maps by Municipality
- B Projected Mean Annual PCB Load Estimates by Municipality
- C Projected Mean Annual Total Mercury Load Estimates by Municipality
- D Potential Control Measures for Ettie Street Pump Station Watershed (ESPSW)
- E Preliminary Estimates of Costs and Effectiveness for Enhance Control
- F Caltrans Letter Dated March 7, 2014 - Mercury Allocation Sharing Scheme

Third party monitoring

Please note that consistent with provision C.8.a.iv of the MRP, two water quality monitoring requirements were fulfilled or partially fulfilled by third party monitoring in Water Years 2012 and 2013:

- As described in Part A of the attached Integrated Monitoring Report, the Regional Monitoring Program for Water Quality in San Francisco Bay (RMP) conducted a portion of the data collection in Water Years 2012 and 2013 on behalf of Permittees, pursuant to provision C.8.e – pollutants of concern loads monitoring (i.e., Table 8.4, Categories 1 and 2). The results of that monitoring are reported in Part A and appendices of the attached Integrated Monitoring Report. The Electronic Data submittal to the Water Board (and the California Environmental Data Exchange Network) of all data collected from all stations monitored by both permit fees and the RMP in water year 2013 pursuant to this provision is planned for April 2014 following completion of final quality assurance review.

- Additionally, as noted in section A.5.2 of the Integrated Monitoring Report Part A, data collected pursuant to provision C.8.e.iii (Long-term Monitoring – Table 8.4 – Category 3) was initiated by the State of California's Surface Water Ambient Monitoring Program (SWAMP) through its Stream Pollutant Trend Monitoring Program at two locations identified in Table 8.3 of the MRP. As stated in provision C.8.e.iii Permittees may use these data to comply with the monitoring requirements included in this provision. The schedule for SWAMP's review and reporting of data collected pursuant to this provision, however, differs from the schedule described in the MRP.

Per MRP provision C.8.a.iv the Permittees requested in March 2013 that the Executive Officer adjust the MRP due dates for these reporting deliverables to synchronize with the third party reporting schedules of SWAMP and the RMP, beginning with Water Years 2012 and continuing in Water Year 2013 and future years covered under the MRP.

ALAMEDA COUNTYWIDE CLEAN WATER PROGRAM

INTEGRATED MONITORING REPORT PART A:

WATER QUALITY MONITORING IN WATER YEARS 2012 AND 2013

MEMBER AGENCIES:

Alameda
Albany
Berkeley
Dublin
Emeryville
Fremont
Hayward
Livermore
Newark
Oakland
Piedmont
Pleasanton
San Leandro
Union City
County of Alameda
Alameda County FloodControl and WaterConservation District
Zone 7 Water Agency

Report prepared by
Alameda Countywide Clean Water Program
399 Elmhurst Street,
Hayward, California 94544

Submitted to:
California Regional Water Quality Control Board, San Francisco Bay Region

FINAL
March 14, 2014

ACKNOWLEDGEMENTS

ACCWP acknowledges the contributions of EOA, Inc. in assisting the preparation of various portions of the main body of the Integrated Monitoring Report Part A, particularly sections on POC Loads Monitoring Section and the Emerging Contaminants Work Plan. Additional acknowledgements for specific Appendices are included in those portions of the overall IMR.

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Table A - 11. ACCWP Cost Summary for MRP Provision C.8 - Water Quality Monitoring (Fiscal Years 2010/11through 2014/15). Only stormwater program and subcontractor costs are included (see text for details and explanation of allocations among sub-provisions).

LIST OF ATTACHMENTS

Attachment A. Electronic Data Submittal Transmittal Letter dated January 15, 2013 with attached file list and preliminary evaluation relative to applicable Water Quality Standards.

Attachment B. Electronic Data Submittal Transmittal Letter dated January 15, 2014 with attached file list and preliminary evaluation relative to applicable Water Quality Standards.

LIST OF APPENDICES

A.1 Creek Status Monitoring Report - Regional Parameters: Bioassessment and Physical Habitat

A.2 Creek Status Monitoring Report - Regional Parameters: Water Quality, Sediment Chemistry and Toxicity, Water Column Toxicity

A.3 Creek Status Monitoring Report -Targeted Parameters

Monitoring Project Reports:

A.4A Stressor / Source Identification Project: Dublin Creek Site 204R00084 – Biological Community and Sediment Quality- Water Year 2013 Progress Report

A.4B Stressor Source Identification Project: Castro Valley Creek Site 204R00047 – Sediment Quality - Water Year 2013Progress Report

A.4C Stressor Source Identification Project: Crow Creek - Low Dissolved Oxygen - Water Year 2013 Progress Report

A.5 Pollutants of Concern (POC) Loads Monitoring Data Progress Report, Water Years (WYs) 2012 and 2013andRegional Sediment Delivery Estimate/Budget: Preliminary Results

A.6 Review of Quality Assurance and Quality Control Results for Creek Status Monitoring - Water Years 2012 and 2013

LIST OF ACRONYMS

Acronym	Definition
AMS	Applied Marine Sciences
ACCWP	Alameda Countywide Clean Water Program
BASMAA	Bay Area Stormwater Management Agencies Association
B-IBI	Benthic Index of Biological Integrity
BMI	Benthic Macroinvertebrate
CEDEN	California Environmental Data Exchange Network
CSCI	California Stream Condition Index
DO	Dissolved oxygen
MRP	Municipal Regional Stormwater Permit
NPDES	National Pollutant Discharge Elimination System
QAPP	Quality Assurance Project Plan
RMC	Regional Monitoring Coalition
RMP	Regional Monitoring Program for Water Quality in San Francisco Bay
RWQCB	Regional Water Quality Control Board
SFBRWQCB	San Francisco Bay Regional Water Quality Control Board
SSID	Stressor/Source Identification
SOP	Standard Operating Procedure
SWAMP	Surface Water Ambient Monitoring Program
USA	Unified Stream Assessment

SECTION A.1 -INTRODUCTION

This Integrated Monitoring Report, Part A is submitted by the Alameda Countywide Clean Water Program (Program, ACCWP), on behalf of all towns, cities, counties and flood control agencies represented by the Program[1] (i.e., Permittees) subject to the Municipal Regional Stormwater NPDES Permit (MRP, Order R2009-0074) issued by the San Francisco Regional Water Quality Control Board (Water Board) on October 14, 2009. This report (including all appendices and attachments) fulfills the requirements of MRP Provision C.8.gfor interpreting and reporting monitoring data collected during Water Years 2012 (October 1, 2011 - September 30, 2012) and 2013 (October 1, 2012 – September 30, 2013).Monitoring data presented in this report were submitted electronically to the Water Board by RMC participants and may be obtained via the San Francisco Bay Area Regional Data Center of the California Environmental Data Exchange Network (CEDEN) at (http://water100.waterboards.ca.gov/ceden/sfei.shtml).

This report is organized into two main parts – the main body and appendices. The main body provides brief summaries of accomplishments made in Water Years 2012 and 2013 in compliance with MRP provision C.8. Summaries are organized by sub-provisions of the MRP and grouped into the following sections:

A.1 Introduction / Preface
A.2 San Francisco Estuary Receiving Water Monitoring
A.3 Creek Status Monitoring
A.4 Monitoring Projects
A.5 Pollutants of Concern and Long-Term Trends Monitoring
A.6 Sediment Delivery Estimate / Budget
A.7 Emerging Pollutants Work Plan
A.8 Citizen Monitoring and Participation
A.9 Summary of Results by Watershed
A.10 Monitoring Budget Summary and Recommendations
A.11 Reporting, Monitoring Protocols, and Data Quality

Appendices include data analyses for interpretive reports focused on specific types of water quality monitoring required by the MRP. Appendices are also grouped together by sub-provision and referenced within the applicable sections of the main body.

The main body of this report and associated appendices address the following reporting requirements for the annual Urban Creeks Monitoring Report (Provision C.8.g.iii) including as appropriate for each type of monitoring in Provision C.8:

- Descriptions of monitoring purpose and study design rationale

[1] The Cities of Alameda, Albany, Berkeley, Dublin, Emeryville, Fremont, Hayward, Livermore, Newark, Oakland, Piedmont, Pleasanton, San Leandro, and Union City; Alameda County; Alameda County Flood Control and Water Conservation District; and Zone 7 Water Agency.

- QA/QC summaries for sample collection and analytical methods, including a discussion of any limitations of the data;
- Descriptions of sampling protocols and analytical methods;
- Tables and Figures describing: Sample location descriptions (including waterbody names, and lat/longs); sample ID, collection date (and time where relevant), media (e.g., water, filtered water, bed sediment, tissue); concentrations detected, measurement units, and detection limits;
- Data assessment, analysis, and interpretation for Provision C.8.c.;
- Pollutant load and concentration at each mass emissions station;
- A listing of volunteer and other non-Permittee entities whose data are included in the report;
- Assessment of compliance with applicable water quality standards; and,
- A signed certification statement.

For the Integrated Monitoring Report (IMR) Part A also addresses the following additional reporting requirements in Provision C.8.g.v:

- A comprehensive analysis of all data collected pursuant to Provision C.8 during the permit term;
- A budget summary for each monitoring requirement;
- Recommendations for future monitoring;
- Methods, data, calculations, load estimates, and source estimates for each Pollutant of Concern Monitoring parameter.

A.1.1 REGIONAL COLLABORATIVE MONITORING (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[2]. The regional monitoring collaborative is referred to as the Bay Area Stormwater Management Agencies (BASMAA) Regional Monitoring Coalition (RMC). With notification of participation in the RMC, Permittees were required to commence water quality data collection by October 2011. In a November 2, 2010 letter to the Permittees, the Water Board's Assistant Executive Officer (Thomas Mumley) acknowledged that all MRP Permittees have opted to conduct monitoring required by the MRP through a regional monitoring collaborative, i.e. the BASMAA RMC.

In February 2011, the RMC developed a Multi-Year Work Plan (RMC Work Plan) to provide a framework for implementing regional monitoring and assessment activities required under MRP provision C.8. The RMC Work Plan summarizes RMC projects planned for implementation between Fiscal Years 2009-10 and 2014-15. Projects were collectively developed by RMC representatives to the BASMAA Monitoring and Pollutants of Concern Committee (MPC), and were conceptually agreed to by the

[2] See Appendix A.2 for a list of all participants in the RMC.

BASMAA Board of Directors (BOD). A total of 27 regional projects are identified in the RMC Work Plan, based on the requirements described in provision C.8 of the MRP.

Regionally-implemented activities in the RMC Work Plan are conducted under the auspices of the Bay Area Stormwater Management Agencies Association (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 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.

SECTION A.2 - SAN FRANCISCO ESTUARY RECEIVING WATER MONITORING(C.8.b)

As described in MRP provision C.8.b, Permittees are required to provide financial contributions towards implementing an Estuary receiving water monitoring program on an annual basis that at a minimum is equivalent to the Regional Monitoring Program for Water Quality in San Francisco Bay (RMP). Since the adoption of the MRP, Permittees have complied with this provision by making financial contributions to the RMP directly or through stormwater programs (Table A - 1). Additionally, Permittees actively participated in RMP committees and work groups through Permittee and/or stormwater program staff as described in the following sections, which also provide a brief description of the RMP and associated monitoring activities conducted during this reporting period.

The RMP is a long-term monitoring program that is discharger funded and shares direction and participation by regulatory agencies and the regulated community with the goal of assessing water quality in the San Francisco Bay.[3] The regulated community includes Permittees, publicly owned treatment works (POTWs), dredgers and industrial dischargers. The RMP is intended to answer the following core management questions:

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

[3] RMP Annual Work Plans can be found at www.sfei.org/rmp/what.

- What are the projected concentrations, masses, and associated impacts of contaminants in the Estuary?

Table A - 1.Stormwater Program annual contributions to the Regional Monitoring Program for Water Quality in the San Francisco Bay Estuary in 2013 by MRP-related Programs

RMC Participant	2013Contribution
Santa Clara Valley Urban Runoff Pollution Prevention Program	$177,950
Alameda Countywide Clean Water Program	$170,491
Contra Costa Clean Water Program	$139,457
San Mateo Countywide Water Pollution Prevention Program	$84,303
Vallejo Sanitation and Flood Control District	$12,826
Fairfield-Suisun Urban Runoff Management Program	$15,041
Total	**$600,068**

The RMP budget is generally broken into two major program elements: Status and Trends, and Pilot/Special Studies. The following paragraphs provide a brief overview of these programs.

RMP Status and Trends Monitoring Program

The Status and Trends Monitoring Program (S&T Program) is the long-term contaminant-monitoring component of the RMP. The S&T Program was initiated as a pilot study in 1989 and redesigned in 2007 based on a more rigorous statistical design that enables the detection of trends. In Water Year 2013the S&T Program was comprised of the following program elements that collect data to address RMP management questions described above:

- Water/Sediment/Biota Chemistry and Toxicity Monitoring
- Sediment Benthos Monitoring
- Small and Large Tributary Loading StudiesSmall Fish and Sport Fish Contamination Studies
- Studies to Determine the Causes of Sediment Toxicity
- Suspended Sediment, Hydrography and Phytoplankton Monitoring
- Bird Egg Monitoring

In fall 2011 the RMP Steering Committee, as part of a 5-year Master Planning process reviewed the S&T Program and agreed to reduce the frequency of some of data collection activities or elements in future years so that more funding will be available for pilot and special studies. Additional information on the S&T Program and associated monitoring data are available for downloading via the RMP website using the Status and Trends Monitoring Data Access Tool at www.sfei.org/rmp/data.htm.

RMP Pilot and Special Studies

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

In Water Years 2012 and 2013, a considerable amount of RMP and Stormwater Program staff time was spent in overseeing and implementing special studies associated with the RMP's Small Tributary Loading Strategy (STLS) and the STLS Multi-Year Monitoring Plan (MYP). Pilot and special studies associated with the STLS are intended to fill data gaps associated with loadings of Pollutants of Concern (POC) from relatively small tributaries to the San Francisco Bay. Additional information is provided on STLS-related studies under section C.8.e (POC and Long-Term Trends Monitoring) of this Report.

Participation in Committees, Workgroups and Strategy Teams

In Water Years 2012 and 2013, Permittees actively participated in the following RMP Committees and work groups:

- Steering Committee (SC)
- Technical Review Committee (TRC)
- Sources, Pathways and Loadings Workgroup (SPLWG)
- Contaminant Fate Workgroup (CFWG)
- Exposure and Effects Workgroup (EEWG)
- Emerging Contaminant Workgroup (ECWG)
- Sport Fish Monitoring Workgroup
- Toxicity Workgroup
- Strategy Teams (e.g., PCBs, Mercury, Dioxins, Small Tributaries, Nutrients)

Committee and workgroup representation was provided by Permittee, stormwater program staff and/or individuals designated by RMC participants and the BASMAA BOD. During Water Years 2012 and 2013 ACCWP Program staff actively participated in the SPLWG, CFWG, EEWG and the Small Tributaries Loading Strategy Work Group (see Section A.5 below). Representation included participating in meetings, reviewing technical reports and work products, reviewing articles included in the RMP's Pulse of the Estuary, and providing general program direction to RMP staff. RMC representatives to the RMP also provided timely summaries and updates to other stormwater program representatives (on behalf of Permittees) during MPC and/or BOD meetings and solicited timely input as needed to ensure Permittees' interests were adequately represented.

SECTIONA.3 - CREEK STATUS MONITORING(C.8.c)

Provision C.8.c requires Permittees to conduct creek status monitoring that is intended to answer the following management questions:

- Are water quality objectives, both numeric and narrative, being met in local receiving waters, including creeks, river and tributaries?
- Are conditions in local receiving waters supportive of or likely supportive of beneficial uses?

Creek status monitoring parameters, methods, occurrences, durations and minimum number of sampling sites for each stormwater program are described in Table 8.1 of the MRP. Based on the implementation schedule described in MRP Provision C.8.a.ii, creek status monitoring coordinated through the RMC began in October 2011.

Regional and Local Monitoring Designs

The RMC's regional monitoring strategy for complying with MRP provision C.8.c - Creek Status Monitoring is described in its *Creek Status and Long-Term Trends Monitoring Plan* (BASMAA 2011). The strategy includes a regional ambient/probabilistic monitoring component and a component based on local "targeted" monitoring. The combination of these monitoring designs allows each individual RMC participating program to assess the status of beneficial uses in local creeks within its Program (jurisdictional)area, while also contributing data to answer management questions at the regional scale (e.g., differences between aquatic life condition in urban and non-urban creeks)[4].

The Program submitted its Creek status monitoring data for Water Years 2012 and 2013 to the Water Board by January 15, 2013 and January 15, 2014, respectively. The analyses of results from Creek Status Monitoring conducted by the Program in Water Years2012 and 2013 are presented in Appendices A.1, A.2 and A.3 to this report, and key findings are summarized below in Section A.9. Table A - 2provides a list of which Creek Status monitoring parameters are included in the respective program-specific and jointly produced appendices.

[4]MRP provision C.8.a.i states in reference to all subsections of C.8 that "provided these datatypes, quantities, and quality are obtained, a regional monitoring collaborative may develop its own sampling design".

Table A - 2.Location of monitoring result analyses for each parameter in MRP Table 8.1.

Biological Response and Stressor Indicators	Detailed data Appendix to IMR		
	Appendix A.1	Appendix A.2*	Appendix A.3
Bioassessment (Benthic Macroinvertebrates and Algae) & Physical Habitat Assessments	X		
Chlorine		X	
Nutrients		X	
Water Toxicity		X	
Sediment Toxicity		X	
Sediment Chemistry		X	
General Water Quality (Continuous)			X
Temperature (Continuous)			X
Pathogen Indicators			X
Stream Survey (Unified Stream Assessment)			X

SECTIONA.4 - MONITORING PROJECTS(C.8.D)

Three types of monitoring projects are required by provision C.8.d of the MRP:

- Stressor/Source Identification Projects (C.8.d.i);
- BMP Effectiveness Investigations (C.8.d.ii); and,
- Geomorphic Projects (C.8.d.iii).

The overall scopes of these projects are generally described in the MRP and the RMC Work Plan. Based on MRP compliance schedules and program-specific requirements for these provisions, the following sections provide brief summaries of RMC participant progress made in Water Years 2012 and 2013 towards on monitoring projects required by the MRP.

Stressor/Source Identification Projects

As described in the MRP, Permittees who conduct Creek Status monitoring through a regional collaborative shall be required to initiate no more than ten Stressor/Source Identification projects when monitoring results trigger a follow-up action as indicated in MRP Table 8.1. To ensure consistency in interpretation of the Stressor/Source ID requirements (C.8.d.i) and a coordinated approach to compliance with that provision, RMC Permittee efforts in Water Year 2013includeda collaborative evaluation of Water Year 2012 Creek Status monitoring results and joint decision-making process for selecting sites for Stressor/Source Identification (SSID) follow-up by individual programs. RMC Program representatives reviewed the list of candidate SSID projects with Water Board staff in the April 2013 meeting of the RMC Work Group.

In consultation with Permittees, the Program developed plans to initiate the first follow-up action for each SSID projects in FY2013-14, but no later than the second fiscal year after the sampling event that triggered the project. As required by MRP Provision C.8.d.i,this first step is to conduct a site specific study (or non-site specific if the problem is widespread) in a stepwise process to identify and isolate the cause(s) of the trigger stressor/source. Initial study design, data collection and results for the following stressor/source identification projects are described in more detail in Section A.9 below and in Appendices A.4A, A.4B and A.4C:

- Dublin Creek: trigger results for biological community condition and sediment quality at probabilistic site 204R00084
- Castro Valley Creek: trigger results for sediment quality at probabilistic site 204R00047
- Crow Creek - trigger results for Low Dissolved Oxygen from General Water Quality measurements at targeted site 204CRW030

Subsequent follow-up steps involve identification, implementation, and evaluation of controls will be addressed after reviewing these results with relevant stakeholders.

BMP Effectiveness Investigation

The MRP requires Permittees to investigate the effectiveness of one Best Management Practice (BMP) for stormwater treatment or hydrograph modification control. ACCWP Permittees are addressing this project through monitoring of a BMP that is also being used to fulfill provisions C.11.e and C.12.e, as allowed by provision C.8.d.ii. A pair of media filters for stormwater treatment are being retrofitted at the Ettie Street Pump Station (ESPS) in Oakland with funding from a grant to BASMAA for the Clean Watersheds for a Clean Bay (CW4CB) project. As part of CW4CB Task 5, a consultant team prepared an effectiveness monitoring design for 8-10 pilot retrofit projects located throughout the jurisdictions of all MRP Permittees, which is limited to evaluating removal of mercury and PCBs. ACCWP initiated design of supplemental monitoring which includes additional analyses to address the full range of pollutants generally found in urban runoff.

Geomorphic Project

MRP provision C.8.d.iii requires Permittees to conduct one of three types of projects within Alameda County to answer the question: How and where can our creeks be restored or protected to cost-effectively reduce the impacts of pollutants, increased flow rates, and increased flow durations of urban runoff?

The Permittees addressed the project option in provision C.8.d.iii(2) to inventory locations for potential retrofit projects in which decentralized landscape-based stormwater retention units can be installed. Staff of the program and individual Permittees collaborated with Community Conservation Solutions on the Green Solution Project, funded by a U.S. EPA grant administered by the San Francisco Estuary Partnership. This project used input from Permittees, and other agencies to

develop a countywide inventory of publicly-owned parcels suitable for retrofit projects.(PSOMAS and GreenInfo Network. 2011). Project maps and reports are available at

http://www.conservationsolutions.org/html/projects/greensolution/greensolution_4Alameda.html

GIS datasets for the project are available from the San Francisco Estuary Partnership, which is developing additional Green Planning tools to assist Bay Area municipalities in identifying priority sites for Low Impact Development and in master planning for stormwater improvement through green infrastructure.

SECTIONA.5 - POC AND LONG-TERM TRENDS MONITORING (C.8.E)

A.5.1 POC LOADS MONITORING

Pollutants of Concern (POC) loads monitoring is required by provision C.8.e.i of the MRP. Loads monitoring is intended to assess inputs of POCs to the Bay from local tributaries and urban runoff, assess progress toward achieving wasteload allocations (WLAs) for TMDLs, and help resolve uncertainties associated with loading estimates for these pollutants. In particular, there are four priority management questions that need to be addressed though POC loads monitoring:

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? and,
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?

To assist participants in effectively and efficiently conducting POC loads monitoring required by the MRP and answer POC loads management questions listed above, an RMP Small Tributaries Loading Strategy (STLS) was developed in 2009 by the STLS Team, which included representatives from BASMAA, Water Board staff, RMP/SFEI and technical advisors. The objective of the STLS is to develop a comprehensive planning framework to coordinate POC loads monitoring/modeling between the RMP and RMC participants. This framework and a summary of activities and products to date are provided in the STLS Multi-Year Plan (STLS-MYP). With concurrence of participating Water Board Staff, the STLS-MYP presents an alternative approach to the POC loads monitoring requirements described in MRP Provision C.8.e.i, as allowed by Provision C.8.e. The most recent version of the STLS Multi-Year Plan was appended to the BASMAA RMC's Urban Creeks Monitoring Report in 2013, with various appendices provided along with previous semi-annual Monitoring Status

Reports. The main body of Version 2013 describes the major STLS elements, including recent activities summarized below.

RMC participant activities associated with POC loads monitoring during Water Years 2012and 2013 focused on bottom-of-watershed monitoring and the continued development of a watershed pollutant load estimation model, both of which were coordinated through the STLS Team and the associated RMP Sources Pathways Loadings Work Group (SPLWG).

STLS Multi-Year Plan Activities

Based on the consensus of the STLS Team, RMC representatives in coordination with SFEI staff created the STLS Multi-Year Plan to assist Permittees in complying with provision C.8.e (POC Monitoring). The Multi-Year Plan is an alternative POC monitoring program to the one described in the MRP that equally addresses the management information needs described in the MRP. The alternative approach addresses the four core POC loads monitoring management questions, while integrating activities funded by BASMAA via the RMC with those funded by the RMP. The Multi-Year Plan provides a more comprehensive description and work plan for STLS activities over the next 5 to10 years, including a detailed rationale for the methods and locations of proposed activities (e.g., POC loads monitoring in small tributaries).

The MYP includes four main elements that collectively address the four priority management questions for POC monitoring:

- Watershed modeling (Regional Watershed Spreadsheet Model);
- Bay Margins Modeling;
- Source Area Runoff Monitoring; and,
- Small Tributaries Monitoring

Previous MYP updates regarding STLS activities were provided in the Monitoring Status Report submitted to the Water Board in September 2012, and additional activities after July 2013 were summarized in the Urban Creeks Monitoring Report. The following paragraphs provide brief summaries of each of these elements and activities conducted during the period from October 2012 through September 2013:

Watershed Modeling –The STLS and RMP Sources, Pathways and Loading Work Group (SPLWG) continued to provide oversight in Water Years 2012 and 2013 to the construction and initial testing of the Regional Watershed Spreadsheet Model, which is the primary tool for estimation of overall POC loads to San Francisco Bay. Initial modeling efforts focused on developing load estimates for sediment, mercury and PCBs. For each POC a submodel architecture will be developed specific to its runoff characteristics and source areas in the Bay Area landscape. An initial test model was constructed for copper for which the submodel is similar to the basic hydrologic version and inputs from other efforts that were readily available. In the second half

of 2012, a graphic user interface was also developed that allows for customization and running of submodels by users who are not GIS software experts.

Bay Margins Modeling – in 2012 The RMP released a second draft Bay Margins Conceptual Model report incorporating extensive review comments by the RMP Contaminant Fate Work Group, which includes representatives from BASMAA. The RMP Steering Committee also authorized the development of a multi-year plan to develop a modeling framework with multiple objectives regarding nutrients and other contaminants of interest, which may be used to answer management questions regarding contaminant processes in the Bay Margins. The goals of the modeling strategy pertinent to the STLS include identification of high-leverage watersheds whose POC loadings contribute disproportionately to Bay impacts. Further development of the Bay Modeling Strategy planned in 2013 will include convening technical experts, stakeholders and RMP work groups to produce an initial draft workplan for Bay modeling-related activities.

Source Area Runoff Monitoring – This element of the STLS is intended as a placeholder for studies to develop Event Mean Concentrations (EMCs) of POCs to parameterize the Regional Watershed Model. On the advice of the SPLWG, initial RMP studies used alternative approaches to "back-calculate" EMCs from available data, as a cost-effective way to support the first iteration of the watershed model. The STLS Work Group received progress updates on initial modeling results in 2013 and will determine priorities for possible source area runoff field-data collection in Water Year 2015.

Small Tributaries Watershed Monitoring – For this STLS element, the approach outlined in the Multi-Year Plan consists of intensively monitoring a total of six "bottom-of-watershed" stations, over several years to accumulate samples needed to calibrate the watershed model and assist in developing loading estimates from small tributaries for priority POCs. Monitoring is also intended to provide a more limited characterization of additional lower priority analytes. Water Year 2013 was the second year of monitoring activities at four stations that were set up and mobilized beginning in October 2011. Two additional stations, North Richmond Pump Station and Pulgas Pump Station, were established in October 2012 to begin monitoring and complete the phasing in of watershed stations:

- Lower Marsh Creek(Contra Costa County)
- Guadalupe River (Santa Clara County)
- Lower San Leandro Creek (Alameda County)
- Sunnyvale East Channel (Santa Clara County)
- North Richmond Pump Station (Contra Costa County)
- Pulgas Pump Station (San Mateo County)

The stations in Lower Marsh Creek, Guadalupe River and Pulgas Pump Station are operated by the Contra Costa Clean Water Program, the Santa Clara Valley Urban Runoff Pollution Prevention Program and the San Mateo Countywide Water Pollution Prevention Program, respectively, on behalf of RMC participants. The stations in the Sunnyvale East Channel and North Richmond Pump Station are operated by SFEI on

behalf of the RMP, as was the Lower San Leandro Creek Station in its first year before operation was transferred to the Alameda Countywide Clean Water Program in summer 2012 for operation starting in WY2013.

Monitoring methods and laboratory analyses according to the descriptions in the STLS Multi-Year Plan are documented in a Field Manual and Quality Assurance Project Plan, currently under development as a BASMAA regional project. These documents are expected to be completed in Water Year 2014.Table A - 3 summarizes the analytes and analytical laboratories used for all samples.

For Water Year 2012, BASMAA 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. BASMAA again recently approved a contract with SFEI to continue to support these activities in Water Year 2014.

Water Year 2012-13 Results

Preliminary results of Water Year 2012 and 2013 POC Monitoring conducted by the STLS team are presented in Appendix A.5. A summary of ACCWP's POC monitoring activities conducted during this period are described below.

Table A - 3. Laboratory analysis methods used by the STLS team for POC (loads) monitoring in Water Years 2012 and 2013.

Analyte	Analytical Method[1]	Analytical Laboratory[1]
Carbaryl	EPA 632M	CA Dept. Fish & Wildlife WPCL
Fipronil	EPA 619M	CA Dept. Fish & Wildlife WPCL
Suspended Sediment Concentration	ASTM D3977	(EBMUD) Caltest Analytical Laboratory
Total Phosphorus	(EBMUD 488 Phosphorus) SM20 4500-P E	(EBMUD) Caltest Analytical Laboratory
Nitrate	(EPA 300.1) EPA 353.2	(EBMUD) Caltest Analytical Laboratory
Dissolved Orthophosphate	(EPA 300.1) SM20 4500-P E	(EBMUD) Caltest Analytical Laboratory
PAHs	AXYS MLA-021 Rev 10	AXYS Analytical Services Ltd.
PBDEs	AXYS MLA-033 Rev 06	AXYS Analytical Services Ltd.
PCBs	AXYS MLA-010 Rev 11	AXYS Analytical Services Ltd.
Pyrethroids	AXYS MLA-046 Rev 04	{AXYS Analytical Services Ltd.) Caltest Analytical Laboratory
Total Methylmercury	EPA 1630M	(Moss Landing Marine Laboratories) Caltest Analytical Laboratory
Total Mercury	EPA 1631EM	(Moss Landing Marine Laboratories) Caltest Analytical Laboratory
Copper	EPA 1638M	(Brooks Rand Labs LLC) Caltest Analytical Laboratory
Selenium	EPA 1638M	(Brooks Rand Labs LLC) Caltest Analytical Laboratory
Total Hardness	EPA 1638M	(Brooks Rand Labs LLC) Caltest Analytical Laboratory
Total Organic Carbon	{SM 5310 C) SM20 5310B	(Brooks Rand Labs LLC) Caltest Analytical Laboratory

1 – Methods and Laboratories shown in parentheses () were only used for data collected in WY2012

Comparisons to Numeric Water Quality Objectives/Criteria for Specific Analytes

Provision C.8.g.iii requires RMC participants to assess all data collected pursuant to provision C.8 for compliance with applicable water quality standards. In compliance with this requirement, an assessment of data collected at ACCWP's POC monitoring station at San Leandro Creek in Water Years2012 and 2013is provided in the following section.[5]

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

Freshwater vs. Saltwater- POC monitoring data were collected in freshwater receiving water bodies above tidal influence and therefore comparisons were made to freshwater water quality objectives/criteria.

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

Acute vs. Chronic Objectives/Criteria - For POC monitoring required by provision C.8.e, data were collected in an attempt to develop more robust loading estimates from small tributaries. Therefore, detecting the concentration of a constituent in any single sample was not the primary driver of POC monitoring. Monitoring was conducted during episodic storm events and results do not likely represent long-term (chronic) concentrations of monitored constituents. POC monitoring data collected in Water Year 2012 and 2013 were therefore compared to "acute" water quality objectives/criteria for aquatic life that represent the highest concentrations of an analyte to which an aquatic community can be exposed briefly (e.g., 1-hour) without resulting in an unacceptable effect. For analytes for which no water quality objectives/criteria have been adopted, comparisons were not made.

It is important to note that water quality objectives or criteria have only been promulgated for a small set of the analytes collected at POC monitoring stations. These include objectives for trace metals (i.e., copper, selenium and total mercury) and polychlorinated biphenyls (PCBs).
provides a comparison of data collected in Water Year 2012 and 2013 to applicable numeric water quality objectives/criteria for these analytes adopted by the San Francisco Bay Water Board or the State of California. Of these analytes, the MRP

[5] An assessment of data collected in compliance with provision C.8.c (Creek Status Monitoring) is provided in Appendices A.1 through A.3 of IMR Part A.

contains provisions addressing mercury (provision C.11), copper (provision C.13) and selenium (provision C.14).

All samples collected in Water Years 2012 and 2013 were below applicable numeric water quality objectives (i.e., freshwater acute objective for aquatic life) for mercury and selenium. With respect to copper, 100% of water samples collected from the San Leandro Creek stations in Water Years 2012 and 2013 were above the applicable water quality objective (i.e., freshwater acute objective for aquatic life). Management actions designed to reduce the impacts of copper on local receiving waters are currently underway as described in the Basin Plan Implementation Plan 7.2.1.2 and reflected in provision C.13 of the MRP.

For all other analytes measured via POC monitoring in Water Year 2012 and Water Year 2013 (e.g., pyrethroid pesticides and polycyclic aromatic hydrocarbons), the State of California has yet to adopt numeric water quality objectives applicable to beneficial uses of interest. For these analytes, an assessment of compliance of applicable water quality standards cannot be conducted at this time.

Table A - 4. Comparison of Water Year 2012 and 2013 POC (loads) monitoring data collected by ACCWP in San Leandro Creek to applicable numeric water quality objectives and criteria.

Analyte	Fraction	Numeric Water Quality Objective/Criteria	Unit	Type of Objective/Criteria	Source of Objective/ Criteria	# of Samples > Objective/Criteria /Total samples	
						WY2012	WY2013
Copper	Dissolved	13[6]	µg/L	Freshwater Acute Water Quality Objective for Aquatic Life (1-hr Average)	San Francisco Bay Water Quality Control Plan (SFBRWQCB 2011)	4/4	3/3
Selenium	Total	20	µg/L			0/4	0/3
Mercury	Total	2.1	µg/L			0/16	0/12

Summary of Toxicity Testing Results

In addition to comparisons of data for specific analytes, the results of toxicity testing conducted on water samples collected during storm events in Water Years 2012 and 2013 were evaluated in the context of adopted water quality objectives. Toxicity testing was conducted at each POC monitoring station using four different types of test organisms:

- *Pimephales promelas* (freshwater fish)

[6]The copper water quality objective is hardness dependent and therefore comparisons were made based on hardness values of samples collected synoptically with samples analyzed for copper. The objective presented in the table is based on a hardness of 100 mg/L.

- *Hyalella azteca* (amphipod)
- *Ceriodaphnia dubia* (crustacean)
- *Selenastrum capricornutum* (algae)

Both acute and chronic endpoints were recorded. A summary of toxicity results is presented in Table A - 5.

Table A - 5. Summary of Water Year 2012 and 2013 toxicity testing results for samples collected at the San Leandro Creek monitoring station.

Receiving Water	*Pimephales promelas*				*Hyalella azteca*		*Ceriodaphnia dubia*				*Selenastrum capricornutum*	
	Significant Reduction in Survival		Significant Reduction in Growth		Significant Reduction in Survival		Significant Reduction in Survival		Significant Reduction in Reproduction		Significant Reduction in Growth	
Water Year	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013
San Leandro Creek	**1/4**	**1/3**	0/4	0/3	**3/4**	0/3	0/4	0/3	0/4	0/3	0/4	0%
% of Samples with Significant Toxicity	25%	33%	0%	0%	75%	0%	0%	0%	0%	20%	0%	0%

Of the organisms exposed to water collected from POC monitoring stations, consistent toxicity was only observed for the amphipod *Hyalella azteca* in Water Year 2012 (9 of 11 samples). For all other organisms, a toxic endpoint was observed in only 1 of 55 endpoints (acute and chronic) calculated.

Of the organisms exposed to water collected from San Leandro Creek POC monitoring station in Water Years 2012 and 2013, toxicity was observed for the fathead minnow (*Pimephales promelas*) survival (25% in Water Year 2012 and 33% in Water Year 2013) and *Hyalella azteca* survival (75% in Water Year 2012). Observations of toxicity to *H. azteca* are similar to those from recent wet weather monitoring conducted in Southern California (Riverside County 2007, Weston Solutions 2006), the Imperial Valley (Phillips et al. 2007), the Central Valley (Weston and Lydy 2010), and the Sacramento-San Joaquin Delta (Werner et al., 2010), where follow up toxicity identification evaluations indicated that pyrethroid pesticides were almost certainly the cause of the toxicity observed. Based on recent studies conducted in California receiving waters, pyrethroid pesticides have also been identified as the likely current causes of sediment toxicity in urban creeks (Ruby 2013, Amweg et al. 2005, Weston and Holmes 2005, Anderson et al. 2010). These results are not unexpected given that *H. azteca* is considerably more sensitive to pyrethroids than other species tested as part of the POC monitoring studies (Palmquist 2008).

To further explore the potential causes of toxicity to in the seven samples from both years, pyrethroid concentrations in samples collected at the same time as those exhibiting toxicity were compiled and compared to thresholds (i.e., LC50s) known to

be lethal to *H. azteca*. LC50s for *H. azteca* were identified through a review of the scientific literature and are only available for a limited number of types of pyrethroids.[7] The results of these comparisons are provided in Table A - 6.

Results suggest that the concentration of one or more pyrethroid pesticides was above levels known to cause significant reduction in the survival to test organisms. Specifically, observed concentrations of bifenthrin were greater than LC50s in two of the three samples collected at the same time that significant toxicity was observed for *H. azteca* and of the two samples collected at the same time that significant toxicity was observed for *P. promelas*. The other sample where significant toxicity was observed for *P. promelas*, coincided with a concentration of cyfluthrin greater than the LC50 for *H. azteca*.

Given the results of previous toxicity studies conducted in receiving waters throughout California, it appears highly likely that pyrethroids could have caused toxicity to *H. azteca* and *P. promelas* observed in Water Year 2012 and possibly Water Year 2013. Management actions designed to reduce the impacts of pesticide-related toxicity are outlined in the TMDL and Water Quality Attainment Strategy for Diazinon and Pesticide-related Toxicity in Urban Creeks TMDL, and are currently underway via provision C.9 of the MRP.

Table A - 6. Water quality samples from San Leandro Creek with observed toxicity to Hyalella Azteca and Pimephales promelas and concentrations of pesticides detected.

Sample Date	Mean % Survival *H. azteca*	Mean % Survival *P. promelas*	Bifenthrin (ng/L)	Cyfluthrin (ng/L)	Cypermethrin (ng/L)	Delta/ Tralomethrin (ng/L)	Permethrin (ng/L)	Carbaryl (ng/L)
LC50 (ng/L)			7.7[a]	2.3[a]	2.3[a]	10[b]	48.9[c]	2100[d]
2/29/2012	**16%**	80%	-	-	-	1.41	13.1	J 10
3/14/2012	**36.0%**	**52.5%**	**17.4**	-	-	0.326	3.65	-
3/17/2012	**58%**	90%	**62.4**	-	-	1.74	7.49	-
4/13/2012	96%	80%	**10.2**	-	-	-	4.05	J 14
11/21/2012	98.0%	95%	5.5	**2.5**	J 0.8	J 0.6	-	-
11/30/2012	92%	**62.5%**	7.1	**5.4**	J 0.7	-	J 6	-
4/4/2013	96%	97.5%	2.8	-	-	-	-	-

[a] As reported by D. Weston, University of California, Berkeley.
[b] LC50 values for *Hyalella Azteca* unavailable. LC50 values listed are for Daphnia magna as reported by Xiu et al. (1989)
[c] Brander et al. (2009)
[d] USEPA (2012)
J: concentrations above the method detection limits but below the reporting limit

[7] Adverse effects concentrations for pyrethroids presented in Table 7 are not adopted water quality objectives and should not be used to draw conclusions about compliance with water quality standards. The comparison contained in this table is only intended to facilitate an evaluation of the potential need for further evaluation of the stressors causing the toxicity.

Dashes represent concentrations less than method detection limits.

A.5.2 LONG-TERM TRENDS MONITORING(C.8.E)

In addition to POC loads monitoring, Provision C.8.e requires Permittees to conduct long-term trends monitoring to evaluate if stormwater discharges are causing or contributing to toxic impacts on aquatic life. Required long-term monitoring parameters, methods, intervals and occurrences are included as Category 3 parameters in Table 8.4 of the MRP, and prescribed long-term monitoring locations are included in Table 8.3. Similar to creek status and POC loads monitoring, long-term trends monitoring was scheduled to begin in October 2011 for RMC participants.

As described in the *RMC Creek Status and Trends Monitoring Plan*(BASMAA 2011), the State of California's Surface Water Ambient Monitoring Program (SWAMP) through its Statewide Stream Pollutant Trend Monitoring (SPoT) Program currently monitors the seven long-term monitoring sites required by Provision C.8.e.ii. Sampling via the SPoT program is currently conducted at the sampling interval and for parameters as described in Provision C.8.e.iii in the MRP. The SPoT program is generally conducted to answer the management question:

- **What are the long-term trends in water quality in creeks?**

Based on discussions with Region 2 SWAMP staff, RMC participants intend to comply with MRP provision C.8.e that are associated with long-term trends via monitoring conducted by the SPoT program. This manner of compliance is consistent with the MRP language in provision C.8.e.ii. A SPoT program technical report on 2009-2010 data was released to the public in 2013 (Anderson et al., 2013). RMC representatives will continue to coordinate with the SPoT program on long-term monitoring to ensure MRP monitoring and reporting requirements are addressed[8]. Additional information on the SPoT program can be found at http://www.waterboards.ca.gov/water_issues/programs/swamp.

SECTION A.6 – SEDIMENT DELIVERY ESTIMATE / BUDGET (C.8.E.VI)

Provision C.8.e.vi of the MRP requires Permittees to develop a design for a robust sediment delivery estimate/sediment budget in local tributaries and urban drainages, and implement the study by July 1, 2012. The purpose of the sediment delivery estimate is to improve the Permittees' ability to estimate urban runoff contributions to loads of POCs, most of which are closely associated with sediment. To determine a strategy for a robust sediment estimate/budget, BASMAA representatives reviewed recent sediment delivery estimates developed by the RMP,

[8]MRP Provision C.8.a.iv "Third Party Monitoring" states that where an existing third-party organization has initiated plans to conduct monitoring that would fulfill one or more requirements of Provision C.8 but the monitoring would not meet MRP due date(s) by a year or less, the Permittees may request that the Executive Officer adjust the due date(s) to synchronize with such efforts.

and determined that these objectives would be met effectively through sediment-specific submodeling with the Regional Watershed Spreadsheet Model (RWSM), under the ongoing oversight of the RMP Sources Pathways Loadings Work Group and the Small Tributaries Loading Strategy (STLS) Work Group.

The implementation of the sediment delivery/budget study was designed to occur in coordination with the STLS Multi-Year Plan, with funding from both the RMP and BASMAA regional projects. Sediment-specific model developments included:

- Literature-based refinement of land-use based Event Mean Concentrations;
- Development of a sub-model incorporating bedrock type, hillslope and convergence processes, and level /age of urbanization;
- Incorporation and calibration of specific watershed sediment loads calculated from available USGS gauge data or previous monitoring stations; and
- Coordination of sediment submodeling with RWSM model development for PCBs and mercury
- Mapping of areas upstream of reservoirs and application of estimated delivery ratios to adjust modeled loads for storage of sediment within watersheds

BASMAA-funded activities included:

- Sensitivity analyses and evaluation of weaknesses in the initial set of sediment runoff coefficients for the RWSM;
- Implementation of high-priority improvements and convening a panel of local experts to provide input on the geological bases for model coefficients;
- Analysis of results of calibration on modeled sediment estimates and model loads; and
- Development of a RWSM geoprocessing tool to incorporate the sediment model structure and its parameterization from locally derived land use/geological sediment erosion coefficients and equations.

SFEI produced annual progress reports on overall RWSM development (e.g. Lent et al. 2012) and provided a June 2013 internal update to BASMAA on the sediment model. In December 2013 distributed for STLS review a draft report section with preliminary results of the RWSM models for PCBs and mercury, which apply coefficients based on particle concentrations to the estimates of suspended sediment loadings from the modeled watersheds. SFEI noted that the sediment model remains unverified and the parameterization calibration runs would potentially be improved by the addition of a climatic parameter as recommended by the expert panel.

SECTION A.7 – EMERGING POLLUTANTS WORK PLAN (C.8.E.V)

Provision C.8.e.vii of the MRP requires Permittees to develop a work plan and schedule for initial loading estimates and source analyses for contaminants of emerging concern (CECs). Contaminants that are mentioned in the MRP include: endocrine-disrupting compounds, PFOS/PFAS (PerfluorooctaneSulfonates (PFOS), Perfluoroalkylsulfonates (PFAS), and NP/NPEs (nonylphenols/nonylphenol esters - estrogen-like compounds). The work plan developed by Permittees is to be implemented in the next Permit term.

Consistent with these requirements, Permittees (via Countywide Stormwater Programs) have and will continue to coordinate the investigation and significance of CECs with the San Francisco Bay Regional Monitoring Program for Water Quality (RMP). As such, Permittees have participated in the development and funding of a CEC strategy entitled "Contaminants of Emerging Concern in San Francisco Bay: A Strategy for Future Investigations" (Sutton et.al. 2013). Consistent with the CEC strategy Permittees have also participated in the development and implementation of the following work plans, which are consistent with provision C.8.e.vii:

- Monitoring Alternative Flame Retardants in SF Bay Water, Sediment and Biota (Sutton et al. 2013);
- Monitoring Alternative Flame Retardants in SF Bay Water, Sediment, and Biota: Pathway Characterization – Wastewater and Stormwater (Sutton and Sedlak 2013); and
- Special two-year study of Bioanalytical tools entitled Linkage of in Vitro Assay Results with in Vivo End Points (Denslow et.al, 2012)[9].

In addition, Permittees have and continue to participate in the broader Statewide CEC investigation and monitoring efforts through RMP coordination with the State Water Board's contractor, the Southern California Coastal Water Research Project (SCCWRP).

Summary tables that illustrate the relationship between CECs of high priority to the broader statewide effort and the RMP strategy are included as Table A - 7 through Table A - 9. During the next Permit term, Permittees intend to continue to work with the RMP staff and update the current CEC strategy as needed based on the significance of the results of the various ongoing investigations. In addition, the need for the development of preliminary loading estimates as well as source analyses will be considered as part of the CEC strategy updates and investigatory results.

[9] Presentation to RMP Emerging Contaminants Work Group, May 15, 2012

Table A - 7. San Francisco Bay Regional Monitoring Program's CEC Pilot Monitoring Work Plan Approach - Receiving Waters, Sediment, and Tissue (Relative to SWRCB Panel Guidance).

Compound[1]	San Francisco Bay Risk level[2]	SWRCB Panel Guidance Embayment Water / Sediment/Tissue[3]	RMP Approach
Bis(2-ethylhexyl) phthalate (PPCP)	I	NA/NA/NA	Widely detected at low level in surface water, tissue, and sediment. Below available effects thresholds for sediment. Uncertainty regarding the applicability of thresholds to Bay data.
Bisphenol A (PPCP)	I	M/NA/NA	ND samples; DL high. Consider re-sampling using lower DLs. BPA is included in RMP Bioanalytical study[4].
Bifenthrin (pesticide)	II	M/M/NA	Hydrophobic; based on Bay sediment concentrations, expect ND in water
Butylbenzyl phthalate (PPCP)	I	NA/NA/NA	Exceed low apparent effects threshold values in sediment but high uncertainty regarding the application of these thresholds to the Bay. ND in mussel tissue.
Permethrin (pesticide)	II	M/M/NA	Hydrophobic; based on Bay sediment concentrations, expect ND in water
Estrone (hormone)		NA/NA/NA	No Bay data. Included in RMP Bioanalytical study[4]
Ibuprofen (PPCP)	II	NA/NA/NA	Mostly ND in pilot study. Low priority.
17-beta estradiol (hormone)		M/NA/NA	No Bay data. Include in bioanalytical tools.
Galaxolide –HHCB (PPCP)	II	M/NA/NA	Detected in Bay samples from 1999-2000 and in later Bay POCIS passive sampling study. Included in RMP Bioanalytical study[4]. Special study of PPCPs under consideration.
Diclofenac (PPCP)		NA/NA/NA	No data. RMP reviewing as part of PPCP paper.
p-Nonylphenol (PPCP)	III	NA/NA/NA	Detected in water, sediment and tissue. Included in RMP Bioanalytical study[4].
PBDE-47 and 99 (flame retardants)	III	NA/M/M	Analyzed extensively in water, sediment and tissue. Concentrations declining in multiple species. Prepared summary report on 10 years of RMP data[5].
Fipronil	III	M/M/NA	Monitored in sediment and water (pilot study).
PFOS (PFAS)	III	NA/M/M	Detected in elevated concentrations in seals and bird eggs. Continue monitoring in tissue (bird/seal). Consider evaluating effluent and sediments
Triclosan (PPCP)	II	NA/NA/NA	Low to ND in sediment. ND in water and mussels.
Non-PBDE Flame Retardants[6]	I	RMP	RMP special study; see note 6 below (RMP special study plan and addendum dated June 2013)

1 – Chlorpyrifos not included in monitoring – see SWRCB Panel September 2013 meeting notes and rationale
2 – Risk Levels (for San Francisco Bay Receiving Waters): Tier IV (High Concern), Tier III (Moderate Concern), Tier II (Low Concern), and Tier I (Possible Concern); see RMP report "Contaminants of Emerging Concern in San Francisco Bay: A Strategy for Future Investigations," Contribution 700, 2013.
3 - NA = Not Applicable, M = Monitoring suggested
4 – See RMP Detailed Workplan 2014, December 2013
5- PBDE Synthesis Report. Draft 2013.
6 – Additional SF Bay CEC special study; see discussion and rationale in "Contaminants of Emerging Concern in San Francisco Bay: A Strategy for Future Investigations," Contribution 700, 2013; RMP Study Plan "Monitoring Alternative Flame Retardants in SF bay Water, Sediment and Biota" Sutton and Sedlak, June 2013; and RMP addendum "Monitoring Alternative Flame Retardants in SF Bay Water, Sediment, and Biota: Pathway Characterization – Wastewater and Stormwater," Sutton and Sedlak, June 2013.

Table A - 8. San Francisco Bay Regional Monitoring Program's CEC Pilot Monitoring Work Plan Approach – Wastewater Treatment Plant Effluent (Relative to SWRCB Panel Guidance).

Compound[1]	San Francisco Bay Risk level[2]	SWRCB Panel Guidance Embayment Water / Sediment/Tissue[3]	RMP Approach
Bis(2-ethylhexyl) phthalate (PPCP)	I	NA	Consider monitoring in concert with butylbenxyl phthalate?
Bisphenol A (PPCP)	I	M	Included in RMP Bioanalytical study[4]
Bifenthrin (pesticide)	II	M	Effluent from 32 facilities have been monitored for pyrethroids. Report pending (Jan 2014).
Butylbenzyl phthalate (PPCP)	I	NA	Under consideration to analyze?
Permethrin (pesticide)	II	M	Effluent from 32 facilities have been monitored for pyrethroids. Report pending (Jan 2014).
Estrone (hormone)	I	M	Included in RMP Bioanalytical study[4]
Ibuprofen (PPCP)	II	NA	Mostly ND in pilot study in Bay.
17-beta estradiol (hormone)		NA	No data. Address using bioanalytical tools
Galaxolide –HHCB (PPCP)	II	M	Included in RMP Bioanalytical study[4]
Diclofenac (PPCP)		NA	No data. Conducting review of PPCPs.
p-Nonylphenol (PPCP)	III	NA	Included in RMP Bioanalytical study[4]
PBDE -47 and 99 (flame retardants)	III	M	Declining concentrations; Not a high priority to monitor in effluent due to use restrictions[5]
Fipronil	III	NA	Depending on water results, consider effluent?
PFOS (PFAS)	III	M	Consider monitoring PFOS and precursors in effluent?
Triclosan (PPCP)	II	NA	Not a high priority because low levels observed in Bay sediments.
Non-PBDE Flame Retardants[6]	I	RMP	RMP special study; see note 6 below (RMP special study plan and addendum dated June 2013)

1 – Chlorpyrifos not included in monitoring – see SWRCB Panel September 2013 meeting notes and rationale
2 – Risk Levels (for San Francisco bay Receiving Waters): Tier IV (High Concern), Tier III (Moderate Concern), Tier II (Low Concern), and Tier I (Possible Concern); see RMP report "Contaminants of Emerging Concern in San Francisco Bay: A Strategy for Future Investigations," Contribution 700, 2013.
3 - NA = Not Applicable, M = monitoring suggested
4 – See RMP Detailed Workplan 2014, December 2013
5- PBDE Synthesis Report. Draft 2013.
6 – Additional SF Bay CEC special study; see discussion and rationale in "Contaminants of Emerging Concern in San Francisco Bay: A Strategy for Future Investigations," Contribution 700, 2013; RMP Study Plan "Monitoring Alternative Flame Retardants in SF bay Water, Sediment and Biota" Sutton and Sedlak, June 2013; and RMP addendum "Monitoring Alternative Flame Retardants in SF Bay Water, Sediment, and Biota: Pathway Characterization – Wastewater and Stormwater," Sutton and Sedlak, June 2013

Table A - 9. San Francisco Bay Regional Monitoring Program's CEC Pilot Monitoring Work Plan Approach – Urban Creeks (Stormwater) (Relative to SWRCB Panel Guidance).

Compound[1]	San Francisco Bay Risk level[2]	SWRCB Panel Guidance Embayment Water / Sediment/Tissue[3]	RMP Approach
Bis(2-ethylhexyl) phthalate (PPCP)	II	NA	NA
Bisphenol A (PPCP)	II	M	NA
Bifenthrin (pesticide)	IV (UC)	M	Monitoring in urban creeks (UC)
Butylbenzyl phthalate (PPCP)	I	NA	NA
Permethrin (pesticide)	IV (UC)	M	Monitoring in urban creeks (UC)
Estrone (hormone)	I	M	NA
Ibuprofen (PPCP)	II	M	NA
17-beta estradiol (hormone)	I	M	NA
Galaxolide –HHCB (PPCP)	II	M	NA
Diclofenac (PPCP)		M	NA
p-Nonylphenol (PPCP)	III	NA	NA
PBDE -47 and 99 (flame retardants)	III	M	Monitoring in urban creeks (UC)
Fipronil	III	M	Monitoring in urban creeks (UC)
PFOS (PFAS)	III	M	Have monitored in the past (see Houtz and Sedlak 2012)
Triclosan (PPCP)	II	M	NA
Non-PBDE Flame Retardants[4]	I	RMP	RMP special study; see note 4 below (RMP special study plan and addendum dated June 2013)

1 – Chlorpyrifos not included in monitoring – see SWRCB Panel September 2013 meeting notes and rationale
2 – Risk Levels (FOR San Francisco Bay Receiving Waters): Tier IV (High Concern), Tier III (Moderate Concern), Tier II (Low Concern), and Tier I (Possible Concern); see RMP report "Contaminants of Emerging Concern in San Francisco Bay: A Strategy for Future Investigations," Contribution 700, 2013.
3 - NA = Not Applicable, M = monitoring suggested
4 – See RMP Detailed Workplan 2014, December 2013
5- PBDE Synthesis Report. Draft 2013.
6 – Additional SF Bay CEC special study; see discussion and rationale in "Contaminants of Emerging Concern in San Francisco Bay: A Strategy for Future Investigations," Contribution 700, 2013; RMP Study Plan "Monitoring Alternative Flame Retardants in SF bay Water, Sediment and Biota" Sutton and Sedlak, June 2013; and RMP addendum "Monitoring Alternative Flame Retardants in SF Bay Water, Sediment, and Biota: Pathway Characterization – Wastewater and Stormwater," Sutton and Sedlak, June 2013

SECTION A.8 - CITIZEN MONITORING AND PARTICIPATION (C.8.F)

In compliance with Provision C.8.f, Permittees are required to make reasonable efforts to seek out citizen and stakeholder input regarding waterbody function and quality, and to demonstrate within annual reports of their outreach efforts to these groups. During the reporting period in WYs 2012 and 2013, ACCWP staff communicated with local residents, creek groups and landowners with interests in creek conditions or water quality concerns as described below:

Friends of Sausal Creek

ACCWP coordinated its WY2012 deployment of six continuous temperature loggers in the Sausal Creek watershed with the Friends of Sausal Creek (FOSC) to encourage the group's pilot effort at redesigning their volunteer-based water quality monitoring program. A member of the FOSC Board of Directors accompanied ACCWP's consultant team to determine deployment locations and presented the temperature monitoring results to the FOSC's annual membership meeting on the "State of the Creek". Program staff will consult with FOSC staff and volunteers if they are interested in additional temperature monitoring at selected sites.

Along with sharing the Program's stream survey results with city of Oakland staff, Program staff discussed sharing the GIS data layers with the FOSC mapping project to assist in communications with creekside property owners. ACCWP will explore options for making the stream survey data available via its website.

The FOSC volunteer coordinator for Aquatic Insect Monitoring was invited as an observer to a training on SWAMP bioassessment protocols that was held at Sausal Creek in spring 2012 for RMC contractors. The FOSC volunteers use an educational Streamside Survey protocol as part of educational outreach to schoolchildren.

Friends of San Leandro Creek

ACCWP staff attended a meeting of Friends of San Leandro Creek in fall 2011 to make a presentation on the Pollutants of Concern Loads Monitoring station and discuss future presentation of station monitoring results. Staff also provided a preliminary summary of the turbidity results to the group's Watershed Awareness Coordinator in response to her interest in learning more about sources and impacts of suspended sediment in the creek. Data summaries and reports for the San Leandro Creek monitoring are shared with staff of the Friends group, the City of San Leandro and the ACFCWCD to inform their participation in joint watershed council discussions.

Other Citizen Observations

In Water Years 2012 and 2013 ACCWP mailed over 600 letters to creekside property owners and residents to inform them of planned monitoring activities and request permission to access the creek on or adjacent to their properties. Information from residents who contacted Program staff using the email or phone number provided in the letters, included:

- Reports of spills or concerns about maintenance issues that were referred to appropriate municipal stormwater representatives for follow-up.
- General comments or recollections about conditions in the creek and activities in the watershed

- Concerns or questions which were noted in instructions for field crews to check during the stream surveys.
- Observations on creek conditions and a series of fish kill events that began during the same time period as a Sonde deployment showing low dissolved oxygen in Crow Creek. These comments were incorporated in a reassessment of hypotheses to be tested for the SSID study (see Appendix A.4C).

SECTION A.9–SUMMARY OF RESULTS BY WATERSHED

The RMC monitoring design includes both regional and targeted components that are intended to address management questions in either a broader regional context or a more watershed-specific scale. This section reviews results described in the Appendices according to several spatial groupings:

- Countywide analysis of bioassessment data combined with sediment results (triad assessment) and water toxicity
- Specific watersheds for which multiple types of monitoring were conducted in WYs 2012 and 2013.

Alameda County occupies 739 square miles (1,914 sq km) of land area in the East Bay region of the San Francisco Bay Area, and discharges to portions of the Central Bay, South Bay and Lower South Bay. Its population of 1,510,271 (as of April 2010) is densest in the Bay Plain western portion of the County, where the largest cities include Oakland, Fremont, Berkeley and Hayward. Numerous small watersheds drain the western Bay Slope; the largest of these is the 48-square mile San Lorenzo Creek watershed which contains a mixture of urban and rural land uses, located mostly in unincorporated communities including Castro Valley and San Lorenzo.

The eastern portion of the county includes the cities of Dublin, Livermore and Pleasanton occupying the Livermore-Amador Valley, a portion of the very large and mostly undeveloped Alameda Creek Watershed. Alameda Creek crosses the East Bay hills through Niles Canyon and then passes between Fremont and Union City via a federally-funded flood control channel that replaced the waterbody formerly known as Coyote Hills Slough, cutting off the former lower channel now known as Old Alameda Creek.

A.9.1 ANALYSIS OF REGIONAL STRESSORS

Monitoring for regional parameters was conducted each year at 20 bioassessment sites in Alameda County (see Appendix A.1), with additional monitoring for water toxicity, sediment chemistry and toxicity at three of these sites located in urban areas as described in Appendix A.2. Stressor assessments in Appendices A.1 and A.2 address the question: **"What are major stressors to aquatic life in the RMC area?"** MRP Table 8.1 includes one or more "trigger criteria" for each monitoring parameter

which form the basis for the stressor assessments summarized below from detailed analyses in Appendices A.1 and A.2.

Bioassessment

The stressor analysis in Appendix A.1 calculated biological condition scores for Alameda County sites using two indicator approaches, the Southern California Benthic Index of Biological Integrity (SoCal B-IBI) and California Stream Condition Index (CSCI). The scores for nearly all sites show alteration of benthic macroinvertebrate (BMI) communities, and channel modification and other habitat changes associated with urbanization is the most prevalent stressor for benthic macroinvertebrate communities. Geomorphic changes to stream systems are commonly considered to begin as the effective impervious area of their catchment reaches approximately 10% (e.g. Schuler, 2004, SFBRWQCB 2012). Coleman et al. (2005) noted that ephemeral streams in arid climates may be even more sensitive to the hydrograph modifications arising from increased imperviousness. Management measures to minimize stream impacts from hydrograph modification are being implemented via controls on new and redevelopment projects under MRP Provision C.3.

The low scores and condition categories for most sites sampled in WYs 2012 and 2013 are consistent with results from previous years of monitoring in Alameda County and also are supported by studies elsewhere. SFRWQCB (2008) and (2012) noted that the instream or reach-based physical habitat measures used by bioassessment protocols are poor predictors of the quality of condition indices in urban streams, while SFRWQCB (2012). In contrast the CSCI considers landscape level attributes such as watershed size and slope in its procedure for determining the appropriate reference condition against which to evaluate each site.

While biological assessment condition scores and the categories (e.g., good, fair, poor) assigned to individual sites by the SoCal B-IBI differed somewhat from those calculated for the CSCI, the site rankings were generally similar. These can assist in the presentation of bioassessment data although no regulatory outcomes are presently associated with these categories. A limitation of the existing condition indices is that all have been designed for streams with perennial flow. SFRWQCB (2012) notes the importance and challenges of developing separate assessment tools for non-perennial streams.

Sediment Triad with Bioassessment

Table A - 10 summarizes stressor evaluation results for the "triad" sites where data were collected for sediment chemistry, sediment toxicity and bioassessment parameters. The combinations of relevant trigger criteria from MRP Table H-1 determine the required follow-up actions or "Next steps" as listed below for selected triad outcomes. The Program initiated site-specific studies at two of the six sites, 204R00084 and 204R00047, as the first step in the SSID process; as described in Appendices A.4A and A.4B respectively, initial follow-up suggests that the sources of chemicals with elevated Threshold Effect Concentration (TEC) quotients are

widespread and include runoff from nearby freeways as well as local roads and urban areas. However the sediment concentrations of the triggering analytes were generally similar to or lower than the levels found in other urban storm water conveyances. Assessment of sediment quality guidelines was affected somewhat by the large number of non-detect results, depending on whether those analytes were assigned values of one-half the Minimum Detection Limit as opposed to one-half of the Minimum Reporting Limit, as discussed in Appendix A.2. The trigger conditions were not associated with significant toxicity at these sites.

Table A - 10. Summary of sediment quality triad evaluation results for WY 2012 and WY 2013 data. Yellow highlighted cells indicate results above MRP trigger threshold.

Water Year	Waterbody	Site ID	B-IBI Condition Category	Sediment Toxicity	# TEC Quotients ≥ 1.0*	Mean PEC Quotient*	Sum of TU Equiv.*	Next Step per MRP Table H-1
2012	Castro Valley	204R00047	Poor	No	12	0.31	2.25	A
2012	Dublin Creek	204R00084	Very Poor	No	5	0.13	0.58	A
2012	Arroyo Mocho	204R00100	Very Poor	No	4	0.14	2.89	A
2013	Line 3A-A-3	204R00327	Very Poor	No	13	0.29	0.26	A
2013	Kottinger Creek	204R00447	Very Poor	No	6	0.22	1.37	A
2013	Canada del Aliso	205R00686	Very Poor	No	1	0.08	0.41	E

*as defined in MacDonald et al. (2000)

Key to Next Steps:

Action Code	Exceeds Bioassessment/ Toxicity/ Chemistry Threshold?	Next Step per MRP Table H-1
A	Yes/No/Yes	(1) Identify cause of impacts. (2) Where impacts are under Permittee's control, take management actions to minimize the impacts caused by urban runoff; initiate no later than the second fiscal year following the sampling event.
B	No/No/Yes	If PEC exceedance is Hg or PCBs, address under TMDLs.
C	Yes/Yes/Yes	(1) Identify cause(s) of impacts and spatial extent. (2) Where impacts are under Permittee's control, take management actions to address impacts.
D	No/Yes/Yes	(1) Take confirmatory sample for toxicity. (2) If toxicity repeated, attempt to identify cause and spatial extent. (3) Where impacts are under Permittee's control, take management actions to minimize upstream sources.
E	Yes/No/No	(1) Identify most probable cause of alterations in biological community. (2) Where impacts are under Permittee's control, take management actions to minimize impacts causing physical habitat disturbance.

Pesticide Toxicity Unit (TU) Equivalents also reached MRP trigger levels at three sites, although significant toxicity effects on *H. azteca* were not observed from these samples. As noted in Appendix A.2, Weston (2005) found that the ability of the TU

ratios to predict *H. Azteca* toxicity was more reliable with TU ratios below one (little or no mortality) and above four (high or full mortality), but less certain for TUs between 1 and 4, the upper end of the range within which the ACCWP results fell. Despite compositing of sediment samples, these can still be highly heterogeneous[10]. Results from a single, localized sampling event should not be used to draw conclusions about the sediment quality in a given waterbody or site.

Further sediment sampling was conducted in WY2013 for site-specific SSID studies to follow up at the WY2012 results from sites 204R00084 and 204R00047, (see Appendices A.4.B and A.4.). Management Actions designed to reduce the impacts of pesticide-related toxicity are outlined in the TMDL and Water Quality Attainment Strategy for Diazinon and Pesticide-related Toxicity in Urban Creeks TMDL, and are currently being implemented via provision C.9 of the MRP.

Water Column Toxicity

A total of 24 toxicity endpoints were derived through testing of 4 species at ACCWP's six triad sites. Of these endpoints, samples from two sites exhibited significant toxicity to at least one test species with survival and/or growth "< 50% of Control," indicating an initial re-testing should be done per MRP Table 8.1. Retesting inWY2013 at the Castro Valley Creek site 204R00047did not show repetition of the WY2012 toxic response.

As with the results from the San Leandro Creek POC loads monitoring station (see Section 5.1 above) the sediment chemistry analysis suggests that pyrethroid pesticides could have caused the observed toxicity. Management actions designed to reduce the impacts of pesticide-related toxicity are outlined in the TMDL and Water Quality Attainment Strategy for Diazinon and Pesticide-related Toxicity in Urban Creeks TMDL, and are currently underway via provision C.9 of the MRP.

A.9.2 DUBLIN CREEK WATERSHED

Dublin Creek is located on the west side of the Livermore-Amador Valley, running alongside Interstate Highway 580 and draining a watershed area of about 3.6 square miles (9.4 km^2).

ACCWP monitoring in this watershed during the MRP period included:

- RMC Bioassessment sampling at two sites, including one triad site, 204R00084
- Additional bioassessment and bedded sediment chemistry samples collected as part of the SSID project

As described in Appendix A.4A, macroinvertebrate condition categories sites were low for all sites: The SoCal B-IBI classified 204R00084 as "Very Poor" while 204DUB040

[10]As an example for which two detectable concentrations were available for a single sample, relative percent differences reported associated with blind field duplicate samples collected for ACCWP in WY2013 ranged from 4% to 42% for trace elements; 4% to 77% for PAHs, 9% to 40% for OC pesticides, and 8% to 11% for pyrethroids.

and 204R00724 were considered "Poor"; the CSCI condition category was "Fair" for all three sites. Sediment chemistry was generally similar to other urban areas although concentrations were generally lower than in previous storm drain sampling. Bifenthrin was the only pyrethroid detected, and organochlorine pesticides were generally low but highest at the base of a rural tributary. Chromium, mercury, nickel, copper and lead highest at the bottom of the watershed while PAHs, arsenic, cadmium, lead and zinc were highest at site 204DUB080 which received runoff from residential areas as well as a local road and the freeway.

ACCWP will review these initial results with affected Permittees and other watershed stakeholders to identify additional sources of data or information, and clarify needs, roles and responsibilities for further steps in the SSID project.

A.9.3 SAN LORENZO CREEK WATERSHED

The overall San Lorenzo Creek Watershed comprises a 48-square mile drainage basin with approximately 35-40 miles of perennial creeks. Major tributaries include…Stream habitat within the watershed ranges from highly modified flood control channels to steep gradient headwater streams that potentially could support salmonid populations.

Crow Creek Including Cull Creek

Crow Creek drains a 11.2 square mile (29.1 km^2) watershed that is mostly rural and privately owned, with suburban development around the lower reaches. The upper watershed is home to numerous equine boarding facilities and the Unincorporated Alameda County Clean Water Program and the District have worked with the Alameda Resource Conservation District on outreach and inspection for these facilities. The lowest portion of Crow Creek receives sporadic inputs from Cull Creek, a primarily non-urban watershed that is partially detained in Cull Canyon Reservoir just above the confluence with Crow Creek.

ACCWP monitoring in this watershed during the reporting period included:

- General Water Quality monitoring at one site in WY2012 which showed low Dissolved Oxygen during the September deployment. Additional follow up deployments at several sites in WY2013 were designed as part of an SSID project. In WY2013 DO concentrations generally decreased from July through to early October. All 7-day rolling daily averages met the COLD reference criteria (<7mg/L) during the sampling period. In July, all DO 7-day rolling averages met the WARM benchmark (<5mg/L), however, in August 40% of 7-day rolling averages were below 5mg/L and in September 80% of 7-day rolling averages were below the WARM benchmark of 5mg/L. There was no connectivity during the dry season with Cull Reservoir and the low DO in the spillway pool below Cull Dam remained localized to that site.
- Continuous temperature monitoring at three Crow Creek sites in WY2012 and three sites in WY2013(2 in Crow Creek below Cull, 1 in Cull Creek just above the confluence with Crow).No temperature triggers were observed during the

deployments from April to September, based on 7-day Mean Weekly Average Temperature (MWAT) calculations.
- Supplemental water quality sampling as part of the SSID project was not indicative of problems, with samples showing low nutrient concentrations, low BOD and low TOC.
- USA surveys were completed for accessible portions of Crow Creek in urban areas (see Appendix A.3).

From the results of WY2013 monitoring, few inferences can be made regarding sources of the low DO, and these are only broadly categorical. While illicit discharges to a storm drain may have been related to a specific low DO episode in WY2012, no similar discharge was reported or observed during the monitoring in WY2013. There is no evidence that ongoing storm drain discharges are causing the observed fluctuations in DO, although it is possible that some episodic illicit discharges have had short-term influences on creek conditions. ACCWP will review these initial results with affected Permittees and other watershed stakeholders to identify additional sources of data or information, and clarify needs, roles and responsibilities for further steps in the SSID project.

Castro Valley Creek Including Chabot Creek Tributary

The overall Castro Valley Creek watershed encompasses 5.5 square miles (14.2 km^2) of primarily residential land use with smaller amounts of open space and commercial and industrial areas. The longer Castro Valley Creek branch has been extensively channelized, and culverted but the main channel remains open for much of its length. The western 3 square mile Chabot Creek subwatershed is mostly underground storm drains and engineered channels, but a relatively natural channel section occurs in Carlos Bee Park just above its confluence with the Castro Valley branch. Interstate Highway 580 and the commercial strip along Castro Valley Boulevard cross the Chabot and Castro Valley creek branches in the lower part of the watershed.

ACCWP monitoring in this watershed during the reporting period included:

- RMC Bioassessment sampling at two sites, including one triad site(204R00047). Benthic macroinvertebrate community condition was Very Poor according to the SoCal B-IBI for sites on Chabot and Castro Valley Creeks, both of which were located in the older urban area south of I-580.
- Additional bedded sediment chemistry samples were collected at several sites in the main Castro Valley Creek branch as part of the SSID project. Higher concentrations of metals and legacy pesticides were found at an upstream site associated with a higher percentage of fine particles, but with lower pyrethroid concentrations than elsewhere. The site lowest in the watershed had relatively large particle sizes but also high concentrations of PAHs and pyrethroids compared to the other Castro Valley Creek sites.
- General Water Quality monitoring at one site in WY2012, just above the confluence with San Lorenzo Creek. No triggers were observed, based on rolling 7-day averages.

- Pathogen indicator monitoring at five sites in the main Castro Valley Creek branch in WY2012 showed *E. coli* and fecal coliform results above the REC-1 standard for moderately or infrequently used areas at all sites except for 204CVY150 just north of Heyer Avenue. Actual creek contact is sporadic and does not correspond to the assumptions for human health risk assessment that were used to develop the water quality standard being used for comparison[11]. Sample variability is high so results of a single sample are insufficient to determine average levels of pathogen indicators, and in dry weather urban runoff is likely to make little or no contribution to the observed bacterial levels.
- USA surveys completed for all accessible open channels (see Appendix A.3).

ACCWP will review these initial results with affected Permittees and other watershed stakeholders to identify additional sources of data or information, and clarify needs, roles and responsibilities for further steps in the SSID project.

San Lorenzo Creek Main Stem

Lower San Lorenzo Creek below Foothill Boulevard is in a concrete-lined federal flood control channel and receives relatively little drainage from the adjacent urban area. From Foothill Boulevard to its confluence with Crow Creek San Lorenzo Creek flows through mixed urban land use but retains its natural channel alignment despite localized areas of channeling or bank hardening. Much of this middle reach located downstream of Don Castro Dam is privately owned.

ACCWP monitoring in this watershed during the MRP period included:

- RMC Bioassessment sampling at two sites. Benthic macroinvertebrate community condition according to the SoCal B-IBI was Very Poor for site204R00639 in the flood control channel and Poor for site 204R00623 above Don Castro Reservoir.
- General Water Quality monitoring at one site in WY2012, just above the confluence with Castro Valley Creek. No triggers were observed, based on rolling 7-day averages.
- USA surveys completed for accessible portions of channels in urban areas (Appendix A.3).

A.9.4 OAKLAND WATERSHEDS

Oakland encompasses 15 main creeks with over 30 tributaries. Most creeks drain relatively small watersheds (< 10 square miles) with extensive amounts of culverting or channelization. Many of the creeks were monitored in 2004-2005 as part of a rotating watershed monitoring program by the regional SWAMP (SFBWRCB 2008). SFRWQCB (2008) also found that temperature and Dissolved Oxygen (DO) deployments went beyond their comparison benchmarks during summer in several

[11] Results of single samples collected for Creek Status Monitoring are evaluated in comparison to the water quality standards in Table 3.2 in the Basin Plan as follows, for colonies/100mL: moderately used area: 298; lightly used area: 406; infrequently used area: 576.

of the Oakland creeks monitored. However SFRWQCB (2012) noted that some water quality benchmarks were also exceeded at Bay Area sites specifically targeted for a reference site study because of the minimal human influence in their watersheds. The SWAMP program monitored fecal coliforms as the geometric mean of 5 samples but also noted that about 50% of the individual samples exceeded benchmarks set for individual samples.

Sausal Creek

The Sausal Creek watershed encompasses 4.2 square miles (11 km^2), flowing from the Oakland hills down through the city, and includes tributary subwatersheds for Shephard and Palo Seco Creeks. Approximately twenty percent of the watershed remains as open space, with the rest contains a mix of residential and commercial land uses. The headwaters and riparian corridor are relatively intact, while the sections below Dimond Park are mostly culverted or channelized. The watershed is home to an active watershed stewardship group, the Friends of Sausal Creek (FOSC), which developed a Watershed Action Plan (Stott Associates, 2000) focusing on six overall goals, including improvement of water quality as well as protection and restoration of natural resources and enhancing community awareness and stewardship.

ACCWP monitoring in this watershed during the reporting period included:

- RMC Bioassessment sampling at one site (204R00319) above MacArthur Blvd. where the benthic macroinvertebrate community condition was Fair according to the SoCal B-IBI.
- Continuous temperature monitoring at six sites in WY2012, at locations upstream of E. 27th Street in Oakland. No temperature triggers were observed during the deployments from April to September, based on 7-day MWAT calculations.
- Pathogen indicator monitoring at one site in WY2013 showed *E. coli* and fecal coliform results below the water quality standard. Actual sample variability is high, and other sampling by FOSC volunteers observed higher levels (Leidy, 2013). Patterns of creek contact by park users do not correspond to the assumptions for human health risk assessment that were used to develop the water quality standards available for comparison. In dry weather urban runoff is likely to make little or no contribution to the observed bacterial levels.
- USA surveys completed for all accessible open channels (Appendix A.3). Most of these were above I-580 where there is a high proportion of publicly accessible reaches. ACCWP will attempt to survey more privately-owned reaches in WY2015.

Lion Creek

The Lion Creek watershed encompasses 3.5 square miles (9.1 km^2). Tributary subwatersheds in the hills include Horseshoe Creek with relatively extensive open

space and Chimes Creek with the mostly residential land uses. Much of the former creek in the Oakland flatlands below Mills College has been culverted.

ACCWP monitoring in this watershed during the reporting period included:

- General Water Quality monitoring at two sites in WY2013. Site 204LIO050, Chimes Creek above the confluence with Lion, was only monitored during August-September as a substitute for the unsampleable 204AVJ130.No triggers were observed at 204LIO050, based on rolling 7-day averages. However DO was frequently low enough to meet trigger criteria at 204LIO080. Since this site is on the Mills College campus just below Lake Aliso, the data were forwarded to the college administration and also a faculty member interested in water quality monitoring for evaluation of lake management practices as potential contributors to the observed conditions.
- Continuous temperature monitoring at one site in WY2013. No temperature triggers were observed during the deployment from April to September, based on 7-day MWAT calculations.
- Pathogen indicator monitoring at two sites in WY2013showed *E. coli* and fecal coliform results above the REC-1 standard for moderately or infrequently used areas at the 204LIO050 site on Chimes Creek but not the 204LIO070 site near the Wetmore Avenue bridge. Actual creek contact is sporadic and does not correspond to the assumptions for human health risk assessment that were used to develop the water quality standard being used for comparison. Sample variability is high so results of a single sample are insufficient to determine average levels of pathogen indicators, and in dry weather urban runoff is likely to make little or no contribution to the observed bacterial levels.
- USA surveys completed for all accessible open channels (Appendix A.3). Most of these were in the flatter portions of the watershed below I-580. ACCWP will attempt to survey more privately-owned reaches in WY2015.

Arroyo Viejo

Arroyo Viejo flows to Damon Slough at San Leandro Bay from Knowland Park in the East Oakland Hills, with a total watershed area of about 6.3 square miles (16.3 km^2). Main tributaries above Interstate Highway 580, include the Rifle Range Branch, Melrose Highlands Branch, and Country Club Branch, with the 73rd Avenue Branch drainage below I-580. Arroyo Viejo Creek is a usually-perennial stream flowing through a mix of underground culverts and engineered channels in the Oakland flatlands.

ACCWP monitoring in this watershed during the reporting period included:

- General Water Quality monitoring at two sites (site 204AVJ130 was only monitored during spring due to unanticipated early drying out of the creek). No triggers were observed at site 204AVJ080 just below I-580 in spring, based on rolling 7-day averages. However frequency of low DO was enough to meet trigger criteria at both 204AVJ080 in fall and 204AVJ130 (near the Oakland Zoo) in spring. Despite normally being considered perennial at

204AVJ130, Arroyo Viejo was dry in this reach by August 2013, which necessitated an alternative Sonde deployment in Lion Creek.

- Pathogen indicator monitoring at one sites in WY2013 showed *E. coli* and fecal coliform results above the REC-1 standard for moderately or infrequently used areas at the204AVJ080 site. Actual creek contact is likely rare to sporadic and does not correspond to the assumptions for human health risk assessment that were used to develop the water quality standard being used for comparison. Sample variability is high so results of a single sample are insufficient to determine average levels of pathogen indicators, and in dry weather urban runoff is likely to make little or no contribution to the observed bacterial levels.
- USA surveys completed for all accessible open channels (Appendix A.3). Most of these were in the flatter portions of the watershed below I-580. ACCWP will attempt to survey more privately-owned reaches in WY2015.

SECTION A.10 MONITORING BUDGET SUMMARY AND RECOMMENDATIONS

Monitoring Budgets

Table A - 11summarizes the monitoring budget for each permit requirement during the five full Fiscal Years after MRP issuance. Costs for ACCWP meetings and general administration are not included. As noted above, per MRP provision C.8.a the monitoring was initiated in October 2011 to allow for planning, coordination and standardization of monitoring through the RMC. Since the annual monitoring is organized by Water Year rather than Fiscal Year, FY2012-13 is the first to reflect the cost of a full monitoring cycle. Other assumptions used for assigning costs according to sub-provisions of C.8 include:

C.8.b - San Francisco Estuary Receiving Water Monitoring	Financial contributions directly to the Regional Monitoring Program (RMP), staff costs to participate in RMP committees and workgroups, and tracking, commenting and reporting on RMP project and deliverables.
C.8.c -Status Monitoring/ Rotating Watersheds	Planning, managing and implementing ACCWP's portion (regional design and local parameters) of the Regional Monitoring Coalition (RMC) Creek Status Monitoring Program. Costs include staff and subcontractor (e.g., field and laboratory costs) time spent on program management, field work planning and implementation, field QA/QC, monitoring plan development, coordination with other programs, and expenses.
C.8.d - Monitoring Projects and C.8.f - Citizen Monitoring/Participati	Costs associated with planning, managing and implementing stressor/source identification projects, a BMP effectiveness evaluation, a geomorphic project, and coordination with volunteer monitoring or stewardship

on	groups in Alameda County.
C.8.e - Pollutants of Concern and Long-Term Trends Monitoring	Costs associated with planning, managing and implementing POC loads monitoring in compliance with C.8.e in coordination with the RMP Small Tributary Loading Strategy (STLS); and tracking the implementation of SWAMP's Stream Pollutant Trends (SPoT) program in compliance with provision C.8.e. Includes ACCWP's share of laboratory and data management costs implemented regionally through contracting with SFEI.
C.8.g - Reporting	Costs associated with planning and managing water quality data (except as noted above for C.8.e); identifying water quality standard exceedances; developing and submitting data in electronic formats to the Water Board; conducting data analysis and interpretation activities; and developing Urban Creeks Monitoring Reports, Integrated Monitoring Report (IMR) Part A, and specific reports associated with monitoring projects.
C.8.h - Monitoring Protocols and Data Quality	Costs associated with planning, development and implementation of quality assurance procedures and associated standard operating procedures to achieve SWAMP comparability, including ACCWP's contribution to regional project costs associated with development of SOPs, QAPP, field manuals, databases, database querying tools, etc.

Table A - 11. ACCWP Cost Summary for MRP Provision C.8 - Water Quality Monitoring (Fiscal Years 2010/11through 2014/15). Only stormwater program and subcontractor costs are included (see text for details and explanation of allocations among sub-provisions).

Requirement	MRP Provisions	2010-11	2011-12	2012-13	2013-14	2014-15*	Costs Per 5-year Permit Term	Average per Fiscal Year	% of Costs
San Francisco Estuary Receiving Water Monitoring	C.8.b	$184,662	$184,463	$187,244	$190,267	$193,745	$940,381	$188,076	21%
Creek Status Monitoring	C.8.c	$16,685	$261,910	$327,527	$337,869	$341,513	$1,285,505	$257,101	29%
Monitoring Projects and Citizen Monitoring & Participation	C.8.d & f	$2,000	$10,000	$14,710	$139,153	$71,000	$236,863	$47,373	5%
POC Loads and Long-Term Trends Monitoring	C.8.e	$5,000	$124,959	$253,563	$355,855	$260,147	$999,524	$199,905	22%
Data Management, QA/QC and Reporting	C.8.c,d,e, g & h	$174,286	$185,913	$241,942	$235,541	$154,500	$992,182	$198,436	22%
Totals		**$382,633**	**$767,245**	**$1,024,986**	**$1,258,686**	**$1,020,906**	**$4,454,455**	**$890,891**	100%

*Projected costs for FY14-15

Monitoring Recommendations

ACCWP recommendations for overall design and planning of future monitoring are shown below. Other, more detailed suggestions regarding specific implementation issues will continue to be documented and compiled through the RMC Work Group for discussion and potential incorporation in future versions of the RMC QAPP and SOPs.

Topic/MRP Provision	Recommendation
Overall C.8 Requirements: prioritization	Focus on 3 main activity areas: Creek Status, Monitoring Projects and POC Loads Monitoring and show how priorities correspond to actual benefit in answering specific management questions. Review existing Management Questions and eliminate those that have already have been answered or are not relevant to operation of an MS4 stormwater program
Overall C.8 Effort level	Total C.8. effort should not increase; also consider shifting data collection resources to give fuller support for information needs related to TMDL load reduction efforts.
C.8.b Estuary Monitoring.	Retain option to participate in "RMP or equivalent". Use the RMP Status & Trends component to address Trends questions rather than requiring stormwater programs to design plans which would extend across multiple permit terms.
C.8.c Creek Status Monitoring Parameters and Methods-general	Narrow the focus to getting good information tied to specific (and prioritized) management questions. Bioassessment for
C.8.c parameters - high priority	Optimize efforts on bioassessment and sediment chemistry: • consider a shorter list of analytes • link pesticide monitoring to statewide needs to inform regulatory decisions, as determined by DPR. If retained, pesticide monitoring should also link explicitly to goals in the separate C.9 provision. • Limit algae sampling to locations or special study situations where the information use will justify the effort.

Topic/MRP Provision	**Recommendation**
C.8.c parameters - low priority	Delete pathogen indicators or reduce frequency and limit to locations where exposure actually is significant. Consider limiting continuous temperature monitoring to locations or special study situations where the information use will justify the effort.
C.8.c parameters – streamline or improve usefulness of data	Delete the Stream Survey or allow this requirement to be fulfilled with the CRAM approach at bioassessment reaches—this information may be more useful and is likely to be more cost-effective for interpretation of bioassessments than increasing the physical habitat assessments done concurrent with bioassessment.
C.8.c triggers for follow-up steps	Revise "Triad" approach and Table H-1to • separate trigger for bioassessment, allowing flexibility for future biocriteria approaches. • streamline/revise sediment chemistry and sediment toxicity triggers to improve clarity and usefulness,
C.8.d Monitoring Projects	Limit scope to Stressor-Source ID projects, and for those clarify a) the process to be followed; b) endpoints for evaluation; and especially c) a SSID project should not be required to continue indefinitely if there problem has no significant causation from urban runoff.
C.8.e POC Monitoring	Include all technical/evaluation activities related to TMDL load reductions, rather than in C.11, C.12 etc. which should focus on implementation planning and management actions in priority watersheds.
C.8.e Technical activities toward TMDL implementation	Include screening and sorting of sites as well as studies to select enhanced control measures and follow-up evaluations of effectiveness.
C.8.e Existing POC Loads Monitoring stations	Fulfill as much as possible via the RMP, allow funds to be redirected to technical data gathering to support TMDL implementation
C.8.e Long Term Monitoring	Use the SWAMP SPoT program to address Trends questions rather than requiring stormwater programs to design monitoring plans which would extend across multiple permit terms.

SECTION A.11 –REPORTING, DATA QUALITY AND DATA MANAGEMENT (C.8.G&H)

Provision C.8.g requires Permittees to report annually on water quality data collected in compliance with the MRP. Annual reporting requirements include: 1) water quality standard exceedances; 2) creek status monitoring electronic reporting; and 3) urban creeks monitoring reporting. For RMC participants, creek status monitoring electronic data submittals to the Water Board were completed by January 15, 2013 for Water Year 2012 data and January 15, 2014 for Water Year 2013 data. Preliminary evaluations of data compared to water quality objectives were included in these submittals. Appendix A.6 presents and evaluates data quality procedures for ACCWP's Creek Status Monitoring in WYs 2012 and 2013. Additional evaluations of data quality for data collected pursuant to provision C.8 are also provided for specific parameters in individual Appendices.

Provision C.8.h requires that water quality data collected by Permittees in compliance with the MRP should be of a quality that is consistent with the State of California's Surface Water Ambient Monitoring Program (SWAMP) standards, set forth in the SWAMP Quality Assurance Project Plan (QAPP). To assist Permittees in meeting SWAMP data quality standards and developing data management systems that allow for easy access of water quality monitoring data by Permittees, the RMC coordinated guidance for SWAMP comparable data collection through several regional projects:

<u>Standard Operating and Quality Assurance Procedures</u>

For Creek Status Monitoring the RMC adapted existing creek status monitoring SOPs and QAPP developed by SWAMP to document the field procedures necessary to maintain comparable, high quality data among RMC participants. Version 1of these documents (BASMAA 2012a, 2012b) were completed in Water Year 2012 prior to field work. All interpretative issues or concerns raised during the initial two years of monitoring were resolved through the RMC Work Group and were documented in Version 2 (BASMAA 2014a, 2014b) along with minor revisions addressing lessons learned.

For POC Loads Monitoring, a draft Field Manual and QAPP were developed through the STLS Team and described in the Multi-Year Plan. BASMAA implemented a master contract with SFEI to contract for laboratory analyses for all sites operated by RMC programs as well as those operated by SFEI for the RMP.

<u>Information Management</u>

For Creek Status Monitoring, the RMC participants developed an Information Management Systems (IMS) to provide SWAMP-compatible storage and import/export of data for all RMC programs. A data management subgroup of the RMC Work Group met periodically for training and review of data management

issues, and suggested enhancements for data checking and to increase efficiency, which were implemented in 2013,

For POC Loads Monitoring BASMAA contracted with SFEI to design and maintain an IMS for management of data from stations operated by the RMC programs. SFEI also provided ongoing updates to the IMS and performed QA review of the data collected by RMC programs, consistent with the QA for data collected through the RMP.

The IMSs provide standardized data storage formats, thus providing a mechanism for sharing data among RMC participants and efficient submittal of data electronically to the Water Board per provision C.8.g.

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BASMAA. 2012b. Creek Status Monitoring Program Standard Operating Procedures. Prepared for BASMAA by EOA, Inc. on behalf of the Santa Clara Urban Runoff Pollution Prevention Program and the San Mateo Countywide Water Pollution Prevention Program, Applied Marine Sciences on behalf of the Alameda Countywide Clean Water Program, and Armand Ruby Consulting on behalf of the Contra Costa Clean Water Program. 196 pp.

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BASMAA. 2014b. Creek Status Monitoring Program Standard Operating Procedures, Final Version 2. Prepared for BASMAA by EOA, Inc. on behalf of the Santa Clara Urban Runoff Pollution Prevention Program and the San Mateo Countywide Water Pollution Prevention Program, Applied Marine Sciences on behalf of the Alameda Countywide Clean Water Program, and Armand Ruby Consulting on behalf of the Contra Costa Clean Water Program. 203 pp.

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ATTACHMENTS

Attachment A. Electronic Data Submittal Transmittal Letter dated January 15, 2013 with attached file list and preliminary evaluation relative to applicable Water Quality Standards.

Attachment B. Electronic Data Submittal Transmittal Letter dated January 15, 2014 with attached file list and preliminary evaluation relative to applicable Water Quality Standards.

cleanwater
PROGRAM

Protecting Alameda County Creeks, Wetlands & the Bay

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Union City
County of Alameda
Alameda County Flood Control and Water Conservation District
Zone 7 Water Agency

January 15, 2013

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

SUBJECT: Electronic Data Submittal - ACCWP Creek Status Monitoring from October 2011through September 2012 Pursuant to Provision C.8.g

Dear Mr. Wolfe:

The member agency Permittees of the Alameda Countywide Clean Water Program (Program) through their Management Committee, and in conformance with the Memorandum of Agreement signed by their governing bodies, have authorized and directed me to prepare and submit certain reports as part of their compliance with Monitoring requirements of the Municipal Regional Stormwater NPDES Permit (MRP, Order No. R2-2009-0074, CAS612008).

With this letter I am submitting a CD-ROM containing the Program's Creek Status Monitoring data collected between October 1, 2011 and September 30, 2012 pursuant to Provision C.8.c of the MRP. These data are provided in Microsoft Excel files listed in Attachment A, which are formatted according to templates compatible with data management requirements of the Surface Water Ambient Monitoring Program (SWAMP). The Program is submitting these data to the Regional Water Board by January 15, 2013 as specified in Provision C.8.g.ii of the MRP. Other data addressing the requirements of MRP Provision C.8.e, but not through the efforts of the Program, will be submitted through the entities responsible for Quality Assurance in a time schedule consistent with the Provisions of the MRP[1].

By signing this letter on behalf of the program, I certify under penalty of law that this document and all attachments are prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gathered and evaluated the information submitted. Based on my inquiry of the person or persons who managed the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations. [40CFR 122.22(d)].

[1] Data collection in Alameda County, and data management and Quality Assurance for all sites, of the alternative approach to Pollutants of Concern Loads Monitoring were performed by the San Francisco Estuary Institute through a collaboration between BASMAA and the RMP. Data collection and reporting for Long Term Trends Monitoring are the responsibility of the SWAMP Sediment Pollution Trends (SPoT) program.

The quality of all Creek Status Monitoring data was evaluated through data collection and evaluation methods consistent with the Standard Operating Procedures and Quality Assurance Project Plan developed through the BASMAA Regional Monitoring Coalition (RMC), a regional collaborative that includes all ACCWP member Permittees. These documents have been reviewed by Region 2 SWAMP staff for SWAMP-comparability where applicable, as provided in MRP C.8.h,

In conformance with MRP Provision C.8.g.ii, the Program has participated in the RMC's development of a regional information management system that supports electronic transfer of data to the Regional Data Center of the California Environmental Data Exchange Network (CEDEN). As requested by Water Board staff on August 5, 2011, concurrent with this submission the Program is transferring the subject monitoring data directly to CEDEN. As required in MRP Provision C.8.g.vii, the Program will notify stakeholders and members of the public of the availability of electronically submitted data and monitoring reports through its website and via other communications as appropriate.

We are in the process of identifying potential persistent water quality issues that would warrant a programmatic response as required by the MRP. Attachment A presents preliminary highlights of some of these issues. It should be emphasized that this water quality data review is preliminary and does not constitute a determination of whether water quality objectives were exceeded and/or if stormwater runoff or dry weather discharges are or may be causing or contributing to exceedances, if any. The Program is in the process of determining whether these data represent persistent exceedances in receiving waters; if it is determined that discharges under this permit are causing or contributing to persistent exceedances of the applicable water quality objectives, the Permittees will follow up as required by MRP Provision C.1. Where results meet trigger criteria for individual parameters as noted in Table 8.1 or Attachment H of the MRP, the Program will implement follow up Monitoring Project actions pursuant to MRP Provision C.8.d.

Please contact me if you have any questions or comments.

Sincerely,

James Scanlin
Program Manager

Attachment: CD ROM
Attachment A: list of datafiles on CD-ROM

Copy via email: Alameda Countywide Clean Water Program Management Committee Representatives

Attachment A

Data files for ACCWP Creek Status Monitoring
October 1, 2011-September 30, 2012

Sources of templates for data files (see file ACCWP-EDS_ToC_WY2012.xlsx for details):
SWAMP v2.5 Database references at http://swamp.mpsl.mlml.calstate.edu/
Kevin Lunde, SFRWQCB SWAMP Program (Continuous Monitoring)
EOA, Inc. (Stream Survey using Urban Streams Assessment)

Sample Purpose	Filename, including site ID	Evaluation of Water Quality[a]
WaterChem	SWAMP_WQ_ACCWP_205R00535_WET_chem.xls	No exceedance
WaterChem	SWAMP_WQ_ACCWP_205R00430_WET_chem.xls	No exceedance
WaterChem	SWAMP_WQ_ACCWP_205R00110_WET_chem.xls	No exceedance
WaterChem	SWAMP_WQ_ACCWP_204R00647_WET_chem.xls	6/18/12 Dissolved Oxygen was less than 5 mg/L for WARM Beneficial Use
WaterChem	SWAMP_WQ_ACCWP_204R00639_WET_chem.xls	6/19/12 pH exceeded 8.0 and electrical conductivity exceeded 900 us/cm for MUN Beneficial Use
WaterChem	SWAMP_WQ_ACCWP_204R00596_WET_chem.xls	No exceedance
WaterChem	SWAMP_WQ_ACCWP_204R00583_WET_chem.xls	No exceedance
WaterChem	SWAMP_WQ_ACCWP_204R00455_WET_chem.xls	6/13/12 Dissolved Oxygen was less than 5 mg/L for WARM Beneficial Use
WaterChem	SWAMP_WQ_ACCWP_204R00391_WET_chem.xls	6/6/12 Dissolved Oxygen was kess than 5 mg/L
WaterChem	SWAMP_WQ_ACCWP_204R00383_WET_chem.xls	No exceedance
WaterChem	SWAMP_WQ_ACCWP_204R00367_WET_chem.xls	No exceedance
WaterChem	SWAMP_WQ_ACCWP_204R00356_WET_chem.xls	No exceedance
WaterChem	SWAMP_WQ_ACCWP_204R00068_WET_chem.xls	6/4/12 total residual chloride exceeded 250 mg/L for MUN Beneficial Use
WaterChem	SWAMP_WQ_ACCWP_204R00340_WET_chem.xls	No exceedance
WaterChem	SWAMP_WQ_ACCWP_204R00319_WET_chem.xls	No exceedance
WaterChem	SWAMP_WQ_ACCWP_204R00303_WET_chem.xls	6/14/12 Dissolved Oxygen was less than 7 mg/L for COLD Beneficial Use
WaterChem	SWAMP_WQ_ACCWP_204R00191_WET_chem.xls	5/29/12 Dissolved Oxygen was less than 7 mg/L for COLD Beneficial Use
WaterChem	SWAMP_WQ_ACCWP_204R00100_WET_chem.xls	No exceedance
WaterChem	SWAMP_WQ_ACCWP_204R00084_WET_chem.xls	No exceedance
WaterChem	SWAMP_WQ_ACCWP_204R00047_WET_chem.xls	6/6/12 Dissolved Oxygen was less than 7 mg/L and pH exceeded 8.5 for COLD Beneficial Use

Sample Purpose	Filename, including site ID	Evaluation of Water Quality[a]
WaterTox	SWAMP_WQ_ACCWP_204R00100_WET_tox.xls	No significant toxicity
WaterTox	SWAMP_WQ_ACCWP_204R00084_WET_tox.xls	No significant toxicity
WaterTox	SWAMP_WQ_ACCWP_204R00047_WET_tox.xls	3/14/12 *Hyallela azteca* survival was less than 50% of Control (No re-sample/re-test was performed in spring)
SedChem	SWAMP_WQ_ACCWP_204R00100_DRY_chem.xls	No significant toxicity
SedChem	SWAMP_WQ_ACCWP_204R00084_DRY_chem.xls	No significant toxicity
SedChem	SWAMP_WQ_ACCWP_204R00047_DRY_chem.xls	No significant toxicity
WaterTox, SedTox	SWAMP_WQ_ACCWP_204R00047_DRY_tox.xls	No significant toxicity
WaterTox, SedTox	SWAMP_WQ_ACCWP_204R00100_DRY_tox.xls	No significant toxicity
WaterTox, SedTox	SWAMP_WQ_ACCWP_204R00084_DRY_tox.xls	No significant toxicity
WaterChem (Pathogens)	SWAMP_WQ_ACCWP_CVY150_DRY_pathogens.xls	No significant toxicity
WaterChem (Pathogens)	SWAMP_WQ_ACCWP_CVY140_DRY_pathogens.xls	7/11/12 *E. coli* exceeded Basin Plan Table 3.2 criterion for infrequently used area in REC-1 Beneficial Use
WaterChem (Pathogens)	SWAMP_WQ_ACCWP_CVY120_DRY_pathogens.xls	7/11/12 *E. coli* exceeded Basin Plan Table 3.2 criterion for moderately used area in REC-1 Beneficial Use.
WaterChem (Pathogens)	SWAMP_WQ_ACCWP_CVY080_DRY_pathogens.xls	7/11/12 *E. coli* exceeded Basin Plan Table 3.2 criterion for moderately used area in REC-1 Beneficial Use.
WaterChem (Pathogens)	SWAMP_WQ_ACCWP_CVY020_DRY_pathogens.xls	7/11/12 *E. coli* exceeded Basin Plan Table 3.2 criterion for moderately used area in REC-1 Beneficial Use.
Benthics, Algae, FieldMeasure, Habitat	SWAMP_BA_ACCWP_204R00391_merged_rev.xls	No exceedance
Benthics, Algae, FieldMeasure, Habitat	SWAMP_BA_ACCWP_204R00596_merged_rev.xls	No exceedance
Benthics, Algae, FieldMeasure, Habitat	SWAMP_BA_ACCWP_204R00191_merged_rev.xls	No exceedance
Benthics, Algae, FieldMeasure, Habitat	SWAMP_BA_ACCWP_204R00583_merged.xls	No exceedance
Benthics, Algae, FieldMeasure, Habitat	SWAMP_BA_ACCWP_204R00340_merged.xls	No exceedance
Benthics, Algae, FieldMeasure, Habitat	SWAMP_BA_ACCWP_204R00319_merged.xls	No exceedance
Benthics, Algae, FieldMeasure, Habitat	SWAMP_BA_ACCWP_204R00303_merged.xls	No exceedance
Benthics, Algae, FieldMeasure, Habitat	SWAMP_BA_ACCWP_204R00100_merged.xls	No exceedance
Benthics, Algae, FieldMeasure, Habitat	SWAMP_BA_ACCWP_204R00084_merged.xls	No exceedance
Benthics, Algae, FieldMeasure, Habitat	SWAMP_BA_ACCWP_204R00068_merged.xls	No exceedance

Data files for ACCWP Creek Status Monitoring October 1, 2011-September 30, 2012

Sample Purpose	Filename, including site ID	Evaluation of Water Quality[a]
Benthics, Algae, FieldMeasure, Habitat	SWAMP_BA_ACCWP_204R00047_merged.xls	No exceedance
Benthics, Algae, FieldMeasure, Habitat	SWAMP_BA_ACCWP_204R00356_merged.xls	No exceedance
Benthics, Algae, FieldMeasure, Habitat	SWAMP_BA_ACCWP_204R00367_merged.xls	No exceedance
Benthics, Algae, FieldMeasure, Habitat	SWAMP_BA_ACCWP_204R00383_merged.xls	No exceedance
Benthics, Algae, FieldMeasure, Habitat	SWAMP_BA_ACCWP_204R00455_merged.xls	No exceedance
Benthics, Algae, FieldMeasure, Habitat	SWAMP_BA_ACCWP_204R00639_merged.xls	No exceedance
Benthics, Algae, FieldMeasure, Habitat	SWAMP_BA_ACCWP_204R00647_merged.xls	No exceedance
Benthics, Algae, FieldMeasure, Habitat	SWAMP_BA_ACCWP_205R00110_merged.xls	No exceedance
Benthics, Algae, FieldMeasure, Habitat	SWAMP_BA_ACCWP_205R00430_merged.xls	No exceedance
Benthics, Algae, FieldMeasure, Habitat	SWAMP_BA_ACCWP_205R00535_merged.xls	No exceedance
ContinuousMonitoring (GenWQ)	CM_ACCWP_YSI_CRW030_2012_dry.xls	September 2012 Dissolved Oxygen concentrations were below the 7 mg/L level for COLD Beneficial Use for a majority of readings.
ContinuousMonitoring (GenWQ)	CM_ACCWP_YSI_CRW030_2012_wet.xls	No exceedance
ContinuousMonitoring (GenWQ)	CM_ACCWP_YSI_CVY005_2012_dry.xls	No exceedance
ContinuousMonitoring (GenWQ)	CM_ACCWP_YSI_CVY005_2012_wet.xls	No exceedance
ContinuousMonitoring (GenWQ)	CM_ACCWP_YSI_SLO065_2012_dry.xls	No exceedance
ContinuousMonitoring (GenWQ)	CM_ACCWP_YSI_SLO065_2012_wet.xls	No exceedance
ContinuousMonitoring (Temp)	CM_ACCWP_Hobo_CRW030_2012.xls	No exceedance
ContinuousMonitoring (Temp)	CM_ACCWP_Hobo_CRW050_2012.xls	No exceedance
ContinuousMonitoring (Temp)	CM_ACCWP_Hobo_SAU035_2012.xls	No exceedance
ContinuousMonitoring (Temp)	CM_ACCWP_Hobo_SAU070_2012.xls	No exceedance
ContinuousMonitoring (Temp)	CM_ACCWP_Hobo_SAU0090_2012.xls	No exceedance
ContinuousMonitoring (Temp)	CM_ACCWP_Hobo_SAU0100_2012.xls	No exceedance
ContinuousMonitoring (Temp)	CM_ACCWP_Hobo_SAU0110_2012.xls	No exceedance
ContinuousMonitoring (Temp)	CM_ACCWP_Hobo_SAU0200_2012.xls	No exceedance

Data files for ACCWP Creek Status Monitoring October 1, 2011-September 30, 2012

Sample Purpose	Filename, including site ID	Evaluation of Water Quality[a]
StreamSurvey	USA_ACCWP_Chabot_2012.xls	N/A
StreamSurvey	USA_ACCWP_CVC_2012.xls	N/A
StreamSurvey	USA_ACCWP_SLZ_2012.xls	N/A

[a] Based on preliminary review of water quality standards; these notes do not constitute a determination of whether water quality objectives were exceeded and/or if stormwater runoff or dry weather discharges are or may be causing or contributing to exceedances, Numeric water quality objectives for most data parameters have not been adopted to-date.

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cleanwater PROGRAM

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Alameda County Flood Control and Water Conservation District
Zone 7 Water Agency

January 15, 2014

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

SUBJECT: Electronic Data Submittal - ACCWP Creek Status Monitoring from October 2012 through September 2013 Pursuant to Provision C.8.g

Dear Mr. Wolfe:

The member agency Permittees of the Alameda Countywide Clean Water Program (Program) through their Management Committee, and in conformance with the Memorandum of Agreement signed by their governing bodies, have authorized and directed me to prepare and submit certain reports as part of their compliance with Monitoring requirements of the Municipal Regional Stormwater NPDES Permit (MRP, Order No. R2-2009-0074, CAS612008).

With this letter I am submitting a CD-ROM containing the Program's Creek Status Monitoring data collected between October 1, 2012 and September 30, 2013 pursuant to Provision C.8.c of the MRP. These data are provided in Microsoft Excel files listed in Attachment A, which are formatted according to templates compatible with data management requirements of the Surface Water Ambient Monitoring Program (SWAMP). The Program is submitting these data to the Regional Water Board by January 15, 2014 as specified in Provision C.8.g.ii of the MRP. Other data addressing the requirements of MRP Provision C.8.e, but not through the efforts of the Program, will be submitted through the entities responsible for Quality Assurance in a time schedule consistent with the Provisions of the MRP[1].

By signing this letter on behalf of the program, I certify under penalty of law that this document and all attachments are prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gathered and evaluated the information submitted. Based on my inquiry of the person or persons who managed the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations. [40CFR 122.22(d)].

[1] Data management and Quality Assurance of the alternative approach to Pollutants of Concern Loads Monitoring for all sites, including the San Leandro Creek site operated by ACCWP, were performed by the San Francisco Estuary Institute through a collaboration between BASMAA and the RMP. Data collection and reporting for Long Term Trends Monitoring are the responsibility of the SWAMP Sediment Pollution Trends (SPoT) program.

The quality of all Creek Status Monitoring data was evaluated through data collection and evaluation methods consistent with the Standard Operating Procedures and Quality Assurance Project Plan developed through the BASMAA Regional Monitoring Coalition (RMC), a regional collaborative that includes all ACCWP member Permittees. These documents have been reviewed by Region 2 SWAMP staff for SWAMP-comparability where applicable, as provided in MRP C.8.h,

In conformance with MRP Provision C.8.g.ii, the Program has participated in the RMC's development of a regional information management system that supports electronic transfer of data to the Regional Data Center of the California Environmental Data Exchange Network (CEDEN). As requested by Water Board staff on August 5, 2011, concurrent with this submission the Program is transferring the subject monitoring data directly to CEDEN. As required in MRP Provision C.8.g.vii, the Program will notify stakeholders and members of the public of the availability of electronically submitted data and monitoring reports through its website and via other communications as appropriate.

We are in the process of identifying potential persistent water quality issues that would warrant a programmatic response as required by the MRP. Attachment A presents preliminary highlights of some of these issues. It should be emphasized that this water quality data review is preliminary and does not constitute a determination of whether water quality objectives were exceeded and/or if stormwater runoff or dry weather discharges are or may be causing or contributing to exceedances, if any. The Program is in the process of determining whether these data represent persistent exceedances in receiving waters; if it is determined that discharges under this permit are causing or contributing to persistent exceedances of the applicable water quality objectives, the Permittees will follow up as required by MRP Provision C.1.

Please contact me if you have any questions or comments.

Sincerely,

James Scanlin
Program Manager

Attachment: CD ROM
Attachment A: list of datafiles on CD-ROM

Copy via email: Alameda Countywide Clean Water Program Management Committee Representatives

Attachment A

Data files for ACCWP Creek Status Monitoring
October 1, 2012-September 30, 2013

Sources of templates for data files (see file ACCWP-EDS_ToC_WY2013.xlsx for details):
SWAMP v2.5 Database references at http://swamp.mpsl.mlml.calstate.edu/
Kevin Lunde, SFRWQCB SWAMP Program (Continuous Monitoring)
EOA, Inc. (Stream Survey using Urban Streams Assessment)

Based on preliminary review of water quality standards; these notes do not constitute a determination of whether water quality objectives were exceeded and/or if stormwater runoff or dry weather discharges are or may be causing or contributing to exceedances, Numeric water quality objectives for most data parameters have not been adopted to-date.

Sample Purpose	Filename, including site ID	Evaluation of Water Quality[a]
WaterChem	AC_203R00983_WQ_Export_060613_14-01-07-14-53-30.xls	No exceedance
WaterChem	AC_204R00063_WQ_Export_060413_14-01-07-14-53-48.xls	No exceedance
WaterChem	AC_204R00327_WQ_Export_050713_14-01-07-14-53-57.xls	No exceedance
WaterChem	AC_204R00334_WQ_Export_050813_14-01-07-14-54-01.xls	No exceedance
WaterChem	AC_204R00447_WQ_Export_042213_14-01-07-14-54-10.xls	No exceedance
WaterChem	AC_204R00473_WQ_Export_050913_14-01-07-14-54-15.xls	No exceedance
WaterChem	AC_204R00590_WQ_Export_050813_14-01-07-14-54-20.xls	No exceedance
WaterChem	AC_204R00623_WQ_Export_060313_14-01-07-14-54-26.xls	No exceedance
WaterChem	AC_204R00724_WQ_Export_052113_14-01-07-14-54-31.xls	No exceedance
WaterChem	AC_204R00751_WQ_Export_060513_14-01-07-14-54-36.xls	No exceedance
WaterChem	AC_204R00852_WQ_Export_050613_14-01-07-14-54-43.xls	No exceedance
WaterChem	AC_204R00967_WQ_Export_042513_14-01-07-14-54-47.xls	No exceedance
WaterChem	AC_204R01316_WQ_Export_052213_14-01-07-14-54-50.xls	No exceedance
WaterChem	AC_204R01471_WQ_Export_052213_14-01-07-14-54-54.xls	No exceedance
WaterChem	AC_205R00174_WQ_Export_042313_14-01-07-14-55-05.xls	No exceedance
WaterChem	AC_205R00686_WQ_Export_042413_14-01-07-14-55-12.xls	4/24/13 Unionized ammonia greater than 25 ug/L criterion for annual average
WaterChem	AC_205R00878_WQ_Export_042413_14-01-07-14-55-17.xls	No exceedance

Sample Purpose	Filename, including site ID	Evaluation of Water Quality[a]
WaterChem	AC_205R01134_WQ_Export_052013_14-01-07-14-55-23.xls	No exceedance
WaterChem	AC_205R01198_WQ_Export_052013_14-01-07-14-55-28.xls	No exceedance
WaterChem	AC_205R01390_WQ_Export_052313_14-01-07-14-55-32.xls	No exceedance
WaterTox	AC_204R00047_WQ_Export_030513_14-01-07-14-59-53.xls (Retest from 2012 triad site)	No exceedance
WaterTox	AC_204R00327_WQ_Export_030613_14-01-07-15-00-02.xls	3/6/13 potential water toxicity effect for *Ceriodaphnia* reproduction
WaterTox	AC_204R00447_WQ_Export_030613_14-01-07-15-00-10.xls	3/6/13 potential water toxicity effect for *Hyalella* survival
WaterTox	AC_205R00686_WQ_Export_030613_14-01-07-15-00-21.xls	3/6/13 potential water toxicity effect for *Ceriodaphnia* reproduction
SedChem, SedTox	AC_204R00327_WQ_Export_070913_14-01-07-14-56-30.xls	No exceedance
SedChem, SedTox	AC_204R00447_WQ_Export_070913_14-01-07-14-56-39.xls	7/9/13 potential sediment toxicity effect for *Hyalella* growth
SedChem, SedTox	AC_205R00686_WQ_Export_070913_14-01-07-14-56-48.xls	7/9/13 potential sediment toxicity effect for *Hyalella* growth
WaterTox	AC_204R00327_WQ_Export_070913_14-01-08-00-00-00.xls	No exceedance
WaterTox	AC_204R00447_WQ_Export_070913_14-01-08-00-00-00.xls	7/9/13 potential water toxicity effects for *Hyalella* survival and *Pimephales* growth
WaterTox	AC_205R00686_WQ_Export_070913_14-01-08-00-00-00.xls	7/9/13 potential water toxicity effect for *Pimephales* growth
WaterChem (Pathogens)	AC_204AVJ080_WQ_Export_081413_14-01-08-09-06-01.xls	1/14/13 *E. coli* exceeded Basin Plan Table 3.2 criterion for moderately used area in REC-1 Beneficial Use.
WaterChem (Pathogens)	AC_204LIO050_WQ_Export_081413_14-01-08-09-06-08.xls	1/14/13 *E. coli* exceeded Basin Plan Table 3.2 criterion for moderately used area in REC-1 Beneficial Use.
WaterChem (Pathogens)	AC_204LIO070_WQ_Export_081413_14-01-08-09-06-14.xls	No exceedance
WaterChem (Pathogens)	AC_204SAU090_WQ_Export_081413_14-01-08-09-06-42.xls	No exceedance
WaterChem (Pathogens)	AC_204TEM100_WQ_Export_081413_14-01-08-09-08-32.xls	1/14/13 *E. coli* exceeded Basin Plan Table 3.2 criterion for infrequently used area in REC-1 Beneficial Use
Benthics, Algae, FieldMeasure, Habitat	AC_204R00751_BA_Export_060513_14-01-09-11-08-14.xls (sites 203R00983, 204R00063, 204R00327, 204R00334, 204R00447, 204R00473, 204R00590, 204R00623, 204R00724, 204R00751)	No exceedance

Sample Purpose	Filename, including site ID	Evaluation of Water Quality[a]
Benthics, Algae, FieldMeasure, Habitat	AC_205R01390_BA_Export_052313_14-01-09-11-08-37.xls (sites 204R00852, 204R00967, 204R01316, 204R01471, 205R00174, 205R00686, 205R00878, 205R01134, 205R01198, 205R01390)	No exceedance
ContinuousMonitoring (GenWQ)	CM_ACCWP_YSI_204AVJ080_2013_summer.xls	Dissolved Oxygen concentrations were below the 7 mg/L level for COLD Beneficial Use for all readings.
ContinuousMonitoring (GenWQ)	CM_ACCWP_YSI_204AVJ080_2013_spring.xls	No exceedance
ContinuousMonitoring (GenWQ)	CM_ACCWP_YSI_204LIO050_2013_summer.xls	No exceedance
ContinuousMonitoring (GenWQ)	CM_ACCWP_YSI_204AVJ130_2013_spring.xls	No exceedance
ContinuousMonitoring (GenWQ)	CM_ACCWP_YSI_204LIO080_2013_summer.xls	Dissolved Oxygen concentrations were below the 7 mg/L level for COLD Beneficial Use for all readings.
ContinuousMonitoring (GenWQ)	CM_ACCWP_YSI_204LIO080_2013_spring.xls	No exceedance
ContinuousMonitoring (Temp)	CM_Temp_ACCWP_204AVJ020_2013.xls	No exceedance
ContinuousMonitoring (Temp)	CM_Temp_ACCWP_204AVJ080_2013.xls	No exceedance
ContinuousMonitoring (Temp)	CM_Temp_ACCWP_204AVJ110_2013.xls	No exceedance
ContinuousMonitoring (Temp)	CM_Temp_ACCWP_204AVJ140_2013.xls	No exceedance
ContinuousMonitoring (Temp)	CM_Temp_ACCWP_204CRW020_2013.xls	No exceedance
ContinuousMonitoring (Temp)	CM_Temp_ACCWP_204CRW030_2013.xls	No exceedance
ContinuousMonitoring (Temp)	CM_Temp_ACCWP_204CUL010_2013.xls	No exceedance
ContinuousMonitoring (Temp)	CM_Temp_ACCWP_204LIO050_2013.xls	No exceedance
ContinuousMonitoring (Temp)	CM_Temp_ACCWP_204LIO130_2013.xls	No exceedance
StreamSurvey	USA_ACCWP_AVJ_2013	N/A
StreamSurvey	USA_ACCWP_CRW_2013	N/A
StreamSurvey	USA_ACCWP_GEC_2013	N/A
StreamSurvey	USA_ACCWP_SAU_2013	N/A
StreamSurvey	USA_ACCWP_SLZ_2013	N/A

[a] Based on preliminary review of water quality standards; these notes do not constitute a determination of whether water quality objectives were exceeded and/or if stormwater runoff or dry weather discharges are or may be causing or contributing to exceedances, Numeric water quality objectives for most data parameters have not been adopted to-date.

ALAMEDA COUNTYWIDE CLEAN WATER PROGRAM

CREEK STATUS MONITORING REPORT - REGIONAL PARAMETERS: BIOASSESSMENT AND PHYSICAL HABITAT

INTEGRATED MONITORING REPORT, PART A - APPENDIX A.1

WATER YEARS 2012 AND 2013

Report prepared by
Alameda Countywide Clean Water Program
399 Elmhurst Street,
Hayward, California 94544

Submitted to:
California Regional Water Quality Control Board, San Francisco Bay Region)

March 14, 2014

MEMBER AGENCIES:

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Protecting Alameda County Creeks, Wetlands & the Bay

Acknowledgements

EOA, Inc. contributed substantially to this report in preparation of the data analysis and discussion.

Preface

The Bay Area Stormwater Management Agencies Association(BASMAA) Regional Monitoring Coalition (RMC) collaboratively developed an outline for preparation of the Integrated Monitoring Report (IMR) to be submitted in compliance with the Municipal Regional Stormwater Permit (MRP) Reporting Provision C.8.g.v for all monitoring conducted during the MRP permit term.

The following participants make up the RMC and are responsible for preparing IMR documents on behalf of their respective member agencies:

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

This report was prepared by ACCWP to fulfill reporting requirements for a portion of the Creek Status monitoring data collected in Water Years 2012 (October 1, 2011 through September 30, 2012) and 2013 (October 1, 2012 through September 30, 2013) as part of the RMC's Monitoring Plan (BASMAA 2011)for certain parameters monitored according to Provision C.8.c of the MRP. This report is an Appendix to the full IMR Part A submitted by ACCWP on behalf of the following Permittees:

- The cities of Alameda, Albany, Berkeley, Dublin, Emeryville, Fremont, Hayward, Livermore, Newark, Oakland, Piedmont, Pleasanton, San Leandro, and Union City; Alameda County;
- Alameda County Flood Control and Water Conservation District and
- Zone 7 Water Agency

Data presented in this report were produced under the direction of the ACCWP using a probabilistic monitoring design. Other data collected in Alameda County during this period pursuant to MRP Provision C.8 are reported in the main body and other appendices of ACCWP's Integrated Monitoring Report, Part A.

In accordance with the RMC Creek Status and Long-Term Trends Monitoring Plan (BASMAA 2011),bioassessment monitoring data were collected in accordance with the BASMAA RMC

Quality Assurance Program Plan (QAPP; BASMAA, 2012a and 2014a) and BASMAA RMC Standard Operating Procedures (SOPs; BASMAA, 2012band 2014b). Where applicable, monitoring data were derived using methods comparable with methods specified by the California Surface Water Ambient Monitoring Program (SWAMP) QAPP[1]. ACCWP also submitted the data included in this report to the San Francisco Bay Regional Water Quality Control Board (SFBRWQCB) in electronic SWAMP-comparable format.

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

List of Acronyms

Acronym	Definition
ABL	Aquatic Bioassessment Laboratory
AFDM	Ash Free Dry Mass
AMS	Applied Marine Sciences, Inc.
ACCWP	Alameda Countywide Clean Water Program
BASMAA	Bay Area Stormwater Management Agencies Association
B-IBI	Benthic Index of Biological Integrity
BMI	Benthic Macroinvertebrate
CDFG	California Department of Fish and Game (now CDFW)
CDFW	California Department of Fish and Wildlife
CEDEN	California Environmental Data Exchange Network
CRAM	California Rapid Assessment Method
CSCI	California Stream Condition Index
DO	Dissolved oxygen
GIS	Geographic Information System
GRTS	Generalized Random Tessellated Stratified
IBI	Index of Biological Integrity
MRP	Municipal Regional Stormwater Permit
MQO	Measurement Quality Objective
MWAT	Maximum Weekly Average Temperature
NorCal B-IBI	Northern California Benthic Index of Biological Integrity
NPDES	National Pollutant Discharge Elimination System
NT	Non-Target
PHab	(Bioassessment) Physical Habitat Assessment
PSA	Perennial Streams Assessment
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QA/QC	Quality Assurance/Quality Control
QAO	Quality Assurance Officer
RMC	Regional Monitoring Coalition
RWQCB	Regional Water Quality Control Board
SCCWRP	Southern California Coastal Water Research Project
SFBRWQCB	San Francisco Bay Regional Water Quality Control Board
SMC	Southern California Stormwater Monitoring Coalition
SoCal B-IBI	Southern California Benthic Index of Biological Integrity
SOP	Standard Operating Procedure
SWAMP	Surface Water Ambient Monitoring Program
TNS	Target Not Sampled

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Executive Summary

In 2010, the seventeen member agencies of the Alameda Countywide Clean Water Program (ACCWP) joined other members of the Bay Area Stormwater Agencies Association (BASMAA) to form the BASMAA Regional Monitoring Coalition (RMC), as a collaborative effort to coordinate and oversee water quality monitoring required by Provision C.8 of the Municipal Regional National Pollutant Discharge Elimination System (NPDES) Stormwater Permit. This report presents the results of Creek Status Monitoring data collected by ACCWP during the two initial years of monitoring: Water Year (WY) 2012 extending from October 1, 2011 through September 30, 2012 and WY 2013 extending from October 1, 2012 through September 30, 2013[2].

Other parameters were addressed using a targeted design, with regional coordination and common methodologies. These parameters, along with the Bioassessment and physical habitat parameters addressed through the regional design, are reported in separate appendices or portions of the IMR Part A.

During WY 2012, ACCWP monitoring accounted for 20 out of 60 sites monitored by all RMC member agencies under the probabilistic design for bioassessment, physical habitat, and related water chemistry parameters. Three of the 20 sites were also monitored for water and sediment toxicity and sediment chemistry, as described in Appendix A.2 of the IMR Part A. During WY 2013, ACCWP monitored 20 new bioassessment sites.

The bioassessment data were used to evaluate potential stressors that may affect aquatic habitat quality and beneficial uses through a preliminary condition assessment for the monitored sites. The probabilistic design requires at least three years to produce sufficient data to develop a statistically-robust characterization of regional creek conditions, so the analysis and interpretation that can be completed with the first two years of data are necessarily limited.

The following MRP reporting requirements (per Provision C.8.g.iv) are addressed within this report or other portions of the IMR, as applicable:

- Descriptions of monitoring purpose and study design rationale

[2] Similar methods and QA/QC procedures are being implemented for Stressor-Source Identification (SSID) studies to investigate certain sites where WY2012 monitoring results indicated potential need for follow-up monitoring projects according to trigger criteria described in the MRP.

- QA/QC summaries for sample collection and analytical methods, including a discussion of any limitations of the data;
- Descriptions of sampling protocols and analytical methods;
- Tables and Figures describing: Sample location descriptions (including waterbody names, and lat/longs); sample ID, collection date (and time where relevant), media (e.g., water, filtered water, bed sediment, tissue); concentrations detected, measurement units, and detection limits;
- Data assessment, analysis, and interpretation for Provision C.8.c.;
- Pollutant load and concentration at each mass emissions station;
- A listing of volunteer and other non-Permittee entities whose data are included in the report;
- Assessment of compliance with applicable water quality standards; and
- A signed certification statement.

Stressor analyses were evaluated using three indicator approaches: Benthic Macroinvertebrate Index of Biotic Integrity (B-IBI) scores developed for streams in Northern California and Southern California regions, and the California Stream Condition Index (CSCI) which considers watershed attributes to identify comparable reference sites. The stressor analysis revealed that most sites show alteration of biological communities, and channel modification and other habitat changes associated with urbanization is a likely stressor for benthic macroinvertebrate communities.

In IMR Part A, the results of the above analyses are used in conjunction with related stressor assessments based on sediment chemistry and toxicity data[3] to determine potential follow-up actions. data and condition assessments to address the management questions underlying the RMC design (BASMAA 2011).

[3] in Appendix A.2 of IMR Part A

1. Introduction

This report fulfills a portion of the reporting requirements of Provision C.8.g.v of the Bay Area Municipal Regional Stormwater National Pollutant Discharge Elimination System Permit (MRP; SFBRWQCB 2009) for creek status monitoring data produced pursuant to MRP Provision C.8.c during Water Years(WYs) 2012 and 2013 (October 1, 2011 - September 30, 2013)under a regional probabilistic design. The regional probabilistic design was developed and implemented by the Bay Area Stormwater Management Agencies Association (BASMAA) Regional Monitoring Coalition (RMC). Additional ProvisionC.8.c data are reported in other appendices and portions of ACCWP's Integrated Monitoring Report Part A, of which this is Appendix A.2.

The RMC was formed in early 2010 as a collaboration among several BASMAA members and all MRP Permittees (Table 1-1) to focus on development and implementation of a regionally-coordinated water quality monitoring program. The intent of the regional monitoring effort is to improve stormwater management in the region and address water quality monitoring required by the MRP[4]. Through its implementation, the RMC allows Permittees and the San Francisco Regional Water Quality Control Board (SF Bay RWQCB) to effectively modify their previous creek monitoring programs and improve their collective ability to answer core management questions in a cost-effective and scientifically rigorous way. Participation in the RMC is coordinated by county stormwater programs and or Permittee representatives (or equivalent), and facilitated through the BASMAA Monitoring and Pollutants of Concern Committee (MPC). The RMC Work Group is a subgroup of the MPC that meets and communicates regularly to coordinate planning and implementation of monitoring-related activities. This workgroup includes staff from the SF Bay RWQCB at two levels – those generally engaged with the MRP as well as those working regionally with the State of California's Surface Water Ambient Monitoring Program (SWAMP).

[4]The San Francisco Bay Regional Water Quality Control Board (SFRWQCB) issued the five-year MRP to 76 cities, counties and flood control districts (i.e., Permittees) in the Bay Area on October 14, 2009 (SFRWQCB 2009). The BASMAA programs supporting MRP Regional Projects include all MRP Permittees as well as the cities of Antioch, Brentwood, and Oakley, which are not named as Permittees under the MRP but have voluntarily elected to participate in MRP-related regional activities. Note that the RMC regional monitoring design was expanded to include the portion of eastern Contra Costa County that drains to the San Francisco Bay in order to assist the CCCWP in fulfilling parallel provisions in their NPDES permit from the Region 5 SF Bay RWQCB.

Table 1-1. Regional Monitoring Coalition Participants.

Stormwater Programs	RMC Participants
Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP)	Cities of Campbell, Cupertino, Los Altos, Milpitas, Monte Sereno, Mountain View, Palo Alto, San Jose, Santa Clara, Saratoga, Sunnyvale, Los Altos Hills, and Los Gatos; Santa Clara Valley Water District; and, Santa Clara County
Alameda Countywide Clean Water Program (ACCWP)	Cities of Alameda, Albany, Berkeley, Dublin, Emeryville, Fremont, Hayward, Livermore, Newark, Oakland, Piedmont, Pleasanton, San Leandro, and Union City; Alameda County; Alameda County Flood Control and Water Conservation District; and, Zone 7
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 Countywide Water Pollution Prevention Program (SMCWPPP)	Cities and towns of Belmont, Brisbane, Burlingame, Daly City, East Palo Alto, Foster City, Half Moon Bay, Menlo Park, Millbrae, Pacifica, Redwood City, San Bruno, San Carlos, San Mateo, South San Francisco, Atherton, Colma, Hillsborough, Portola Valley, and Woodside; San Mateo County Flood Control District; and, San Mateo County
Fairfield-Suisun Urban Runoff Management Program (FSURMP)	Cities of Fairfield and Suisun City
Vallejo Permittees	City of Vallejo and Vallejo Sanitation and Flood Control District

The goals of the RMC are to:

1. Assist Permittees[5] in complying with requirements in MRP Provision C.8 (Water Quality Monitoring);
2. Develop and implement regionally consistent creek monitoring approaches and designs in the San Francisco Bay Area, through the improved coordination among RMC participants, SF Bay RWQCB[6] and other agencies with common goals; and
3. Stabilize the costs of creek monitoring by reducing duplication of effort and streamlining monitoring-related activities.

This report, together with Appendix A.2 to IMR Part A (a joint product developed by ACCWP and three other RMC programs) presents the results of the portions of Creek Status Monitoring that were conducted using a regional ambient (probabilistic) monitoring design to comply with Provision C.8.c (Table 1-2).The list of parameters in Table 1-2 derive from the MRP Table 8-1 (SFBRWQCB 2009; BASMAA 2012A, 2012B).

[5]For the CCCWP this includes addressing the eastern portion of Contra Costa County that drains to the San Francisco Bay that is within the jurisdiction of the Region 5 Regional Water Quality Control Board.

[6]The intent is to coordinate with SF Bay RWQCB staff working regionally with the State of California's Surface Water Ambient Monitoring Program (SWAMP).

Table 1-2. Creek Status Monitoring Parameters sampled in compliance with MRP Provision C.8.c. and the associated reporting format and Appendix to the ACCWP IMR Part A.

Biological Response and Stressor Indicators	Monitoring Design		Reporting	
	Regional Ambient (Probabilistic)	Local (Targeted)	Regional WY12 joint WY13	Local
Bioassessment & Physical Habitat Assessment	X		X	Appendix A.1
Chlorine	X		Appendix A.2	
Nutrients	X		Appendix A.2	
Water Toxicity	X		Appendix A.2	
Sediment Toxicity	X		Appendix A.2	
Sediment Chemistry	X		Appendix A.2	
General Water Quality		X		Appendix A.3
Temperature		X		Appendix A.3
Bacteria		X		Appendix A.3
Stream Survey		X		Appendix A.3

Data presented in this report were collected between October 1, 2011 and September 30, 2013, referred to hereafter as Water Years 2012 and 2013.

Prior to formation of the RMC, San Francisco Bay Area stormwater programs implemented monitoring designs that targeted creek reaches of interest to address site-specific management questions. Because the representativeness of such targeted data was unknown, the overall condition of all creek reaches in the Bay Area was also unknown. The RMC addressed this issue by augmenting targeted monitoring designs with an ambient (probabilistic) creek status design that integrates many elements of the individualized monitoring programs that currently exist in the region.

The probabilistic monitoring design described in subsequent sections of this report complies with MRP Provision C.8.c[7] by addressing the core monitoring questions listed below, which are further elaborated upon later in this report and in the main IMR. This monitoring design allow each individual RMC participating program to assess stream ecosystem conditions within its program area (e.g., county boundary) while contributing data to answer regional management questions about water quality and beneficial use condition in San Francisco Bay Area creeks.

1. What is the condition of aquatic life in creeks in the San Francisco Bay Area; are water quality objectives met and are beneficial uses supported?

[7] The MRP states that Provision C.8.c status monitoring is intended to answer the following questions: "Are water quality objectives, both numeric and narrative, being met in local receiving waters, including creeks, rivers and tributaries?"; "Are conditions in local receiving waters supportive of or likely to be supportive of beneficial uses?". The management questions described in this plan are intended to answer the questions posed in the MRP.

2. What are the major stressors[8] to aquatic life?
3. What are the long-term trends in water quality in creeks over time?

The remainder of this report addresses Study Area and Monitoring Design (Section 2), data collection and analysis methods (Section 3), results and discussion (Section 4), and Conclusions and Next Steps (Section 5). More specifically, this report includes the standard report content as required by MRP Provision C.8.g.v in the respective sections referenced in Table 1-3. Additional details or discussion may also be found in other Appendices or in the main IMR.

Table 1-3.Index to Standard Report Content per MRP Provision C.8.g.vi.

Report Section	Standard Report Content
2.0	Monitoring purpose and study design rationale
3.0	Sampling protocols and analytical methods
3.5	QA/QC summaries for sample collection and analytical methods
2.1	Sample location descriptions, sample dates, IDs
4.0	Sample concentrations detected, measurement units, detection limits
4.0	Data assessment, analysis and interpretation
See Main IMR[9]	List of volunteer and other non-Permittee entities whose data are included in the report.
5.0	Assessment of compliance with applicable water quality standards

2. Study Area & Monitoring Design

2.1 RMC Area

Status and trends monitoring was conducted in non-tidally influenced, flowing water bodies (i.e., creeks, streams and rivers) interspersed among 3,407 square miles of land in the RMC area. The water bodies monitored were drawn from a master list that included all perennial and non-perennial creeks and rivers that run through urban and non-urban areas within the portions of the five participating counties that fall within the SF Bay RWQCB boundary, and the eastern portion of Contra Costa County that drains to the Central Valley Regional Board (Figure 2-1).A total of 60 sites were sampled in 2012by RMC participants, with another 70sites sampled in 2013. Of these, data from 30 sites monitored in 2012 (Table 2-1) and 40 sites in 2013 (Table 2-2) by the four contributing Programs are included within the analysis for this report.

[8] Stressors are interpreted per MRP Table 8-1 (SFBRWQCB 2009) as results that "trigger" action based upon comparison with an identified threshold.

2.2 Regional Monitoring Design

In 2011, the RMC developed a regional probabilistic monitoring design to identify ambient conditions of creeks in the five main counties subject to the requirements of the MRP (SFBRWQCB 2009). The regional design was developed using the Generalized Random Tessellation Stratified (GRTS) approach developed by the United States Environmental Protection Agency (USEPA) and Oregon State University (Stevens and Olson 2004). GRTS offers multiple benefits for coordinating amongst monitoring entities including the ability to develop a spatially balanced design that produces statistically representative data with known confidence intervals. The GRTS approach has been implemented recently in California by several agencies including the statewide Perennial Streams Assessment (PSA) conducted by SWAMP (Ode et al. 2011) and the Southern California Stormwater Monitoring Coalition's(SMC) regional monitoring program conducted by municipal stormwater programs in Southern California (SMC 2007). For the purpose of developing the RMC's probabilistic design, the RMC area is considered to represent the "sample universe".

2.2.1 Site Selection

Sample sites were selected and attributed using the GRTS approach from a sample frame consisting of a creek network geographic information system (GIS) data set within the RMC boundary[10] (BASMAA 2011). This approach was agreed to by SF Bay RWQCB staff during RMC workgroup meetings although it differs from that specified in MRP Provision C.8.c.iv., e.g., sampling on the basis of individual watersheds in rotation and selecting sites to characterize segments of a waterbody(s).The sample frame includes non-tidally influenced perennial and non-perennial creeks within five management units representing areas managed by the storm water programs associated with the RMC. The sample frame was stratified by management unit to ensure that MRP Provision C.8.c sample size requirements (SFBRWQCB 2009) would be achieved.

The National Hydrography Plus Dataset (1:100,000) was selected as the creek network data layer to provide consistency with both the Statewide PSA and the SMC, and the opportunity for future data coordination with these programs. The RMC sample frame was classified by county and land use (i.e., urban and non-urban) to allow for comparisons between these strata. Urban areas were delineated by combining urban area boundaries and city boundaries defined by the U.S. Census (2000). Non-urban areas were defined as the remainder of the areas within the sample universe (i.e., RMC area).Based on discussion during RMC Workgroup meetings, with SF Bay

[10]Based on discussion during RMC Workgroup meetings, with SF Bay RWQCB staff present, the sample frame was extended to include the portion of Eastern Contra Costa County that drains to the San Francisco Bay in order to address parallel provisions in CCCWP's Region 5 Permit for Eastern Contra Costa County. Reporting on data collected for that permit, other than those collected via the RMC, however, is outside the scope of this report.

RWQCB staff present, RMC participants weighted their sampling efforts so that annual sampling efforts are approximately 80% in urban areas and 20% in non-urban areas for the purpose of comparison. RMC participants coordinated with the SF Bay RWQCB by identifying additional non-urban sites from their respective counties for SWAMP sampling.

Bioassessment sites sampled by ACCWP during the reporting period are shown in Figure 2-1 and Table 2-1.

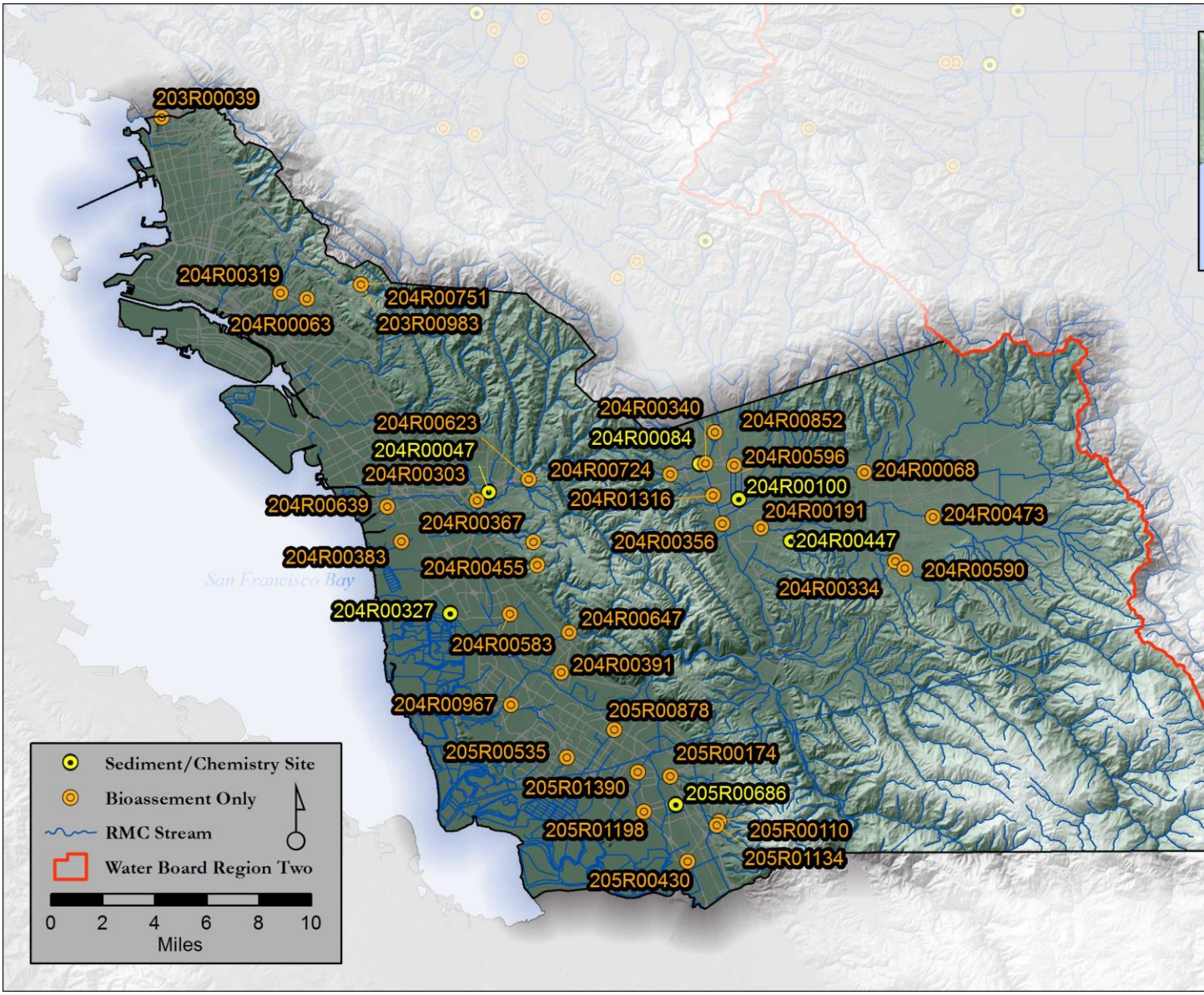

Figure 2-1. Alameda County sites sampled from the RMC probabilistic monitoring design in Water Years 2012 and 2013.

Table 2-1. Alameda County Bioassessment sites Sampled in Water Years 2012 and 2013 by ACCWP.

Site ID	Creek Name	Land Use	Latitude	Longitude	Sampling Date
204R00047	Castro Valley Creek	Urban	37.68826	-122.07257	
204R00068	Collier Creek Channel, Line 7-M	Urban	37.69908	-121.80891	
204R00084	Dublin Creek	Urban	37.70104	-121.92542	
204R00100	Arroyo Mocho	Urban	37.68280	-121.89625	
204R00191	Arroyo del Valle	Urban	37.66584	-121.87840	
204R00303	Chabot Creek	Urban	37.68421	-122.08200	
204R00319	Sausal Creek	Urban	37.79923	-122.21818	
204R00340	Big Canyon Creek, Line 7-J-1	Urban	37.70218	-121.92074	
204R00356	Arroyo de la Laguna	Urban	37.66873	-121.90920	
204R00367	Ward Creek	Urban	37.65957	-122.04172	
204R00383	Sulphur Creek	Urban	37.65909	-122.13676	
204R00391	Line5-M	Urban	37.58682	-122.02358	
204R00455	Zeile Creek	Urban	37.64676	-122.03931	
204R00583	Line 3A-D	Urban	37.61906	-122.05928	
204R00596	Line 7-G-2	Urban	37.70094	-121.90154	
204R00639	San Lorenzo Creek	Urban	37.68151	-122.14437	
204R00647	Dry Creek	Urban	37.60965	-122.01750	
205R00110	Agua Caliente	Urban	37.50273	-121.91225	
205R00430	Line 6-D	Urban	37.48229	-121.93782	
205R00535	Line 5-F-1	Urban	37.53942	-122.01980	
204R00447	Kottinger Creek	Urban	37.65844	-121.86108	4/22/13
205R00174	Line 6-K	Urban	37.52816	-121.94772	4/23/13
205R00686	Canada Del Aliso	Urban	37.51243	-121.94393	4/24/13
205R00878	Zone 5 Line B	Urban	37.5544	-121.98651	4/24/13
204R00967	Crandall Creek	Urban	37.56895	-122.05885	4/25/13
204R00852	Alamo Creek	Urban	37.71961	-121.91376	5/6/13
204R00327	Line 3A-A-3	Urban	37.62009	-122.10072	5/7/13
204R00334	Arroyo Valle	Urban	37.64659	-121.78812	5/8/13
204R00590	Arroyo Valle	Nonurban	37.64266	-121.78169	5/8/13
204R00473	Arroyo Mocho	Urban	37.67085	-121.76115	5/9/13
205R01134	Agua Caliente	Urban	37.50063	-121.91567	5/20/13
205R01198	Zone 6 Line G	Urban	37.50878	-121.9666	5/20/13
204R00724	Dublin Creek	Urban	37.69649	-121.94548	5/21/13
204R01316	Arroyo de la Laguna	Urban	37.68452	-121.91557	5/22/13
205R01390	Zone 6 Line G	Urban	37.53087	-121.97042	5/23/13
204R00623	San Lorenzo Creek	Urban	37.69461	-122.04478	6/3/13
204R00063	Peralta Creek	Urban	37.79651	-122.19966	6/4/13
204R00751	Redwood Canyon Creek	Nonurban	37.80408	-122.16134	6/5/13
203R00983	Strawberry Creek	Nonurban	37.80404	-122.16136	6/6/13
204R01471	Arroyo Mocho	Urban	37.96222	-121.86892	5/22/13

2.2.2 Management Questions

The RMC regional monitoring design was developed to address the management questions listed below. Those appearing in bolded font are addressed in this report in a preliminary manner. Those in normal font could not be addressed at this time due to the limited sample size available from the initial two years of monitoring, but can be answered in future years once sample sizes increase.

Table 2-2 illustrates the length of time that would be required to establish statistically representative sample sizes for each of the classified strata in the regional monitoring design, estimated for continuation of the present rate of annual bioassessment sampling.

1. **What is the condition of aquatic life in creeks in the RMC area; are water quality objectives met and are beneficial uses supported?**
    a. **What is the condition of aquatic life in the urbanized portion of the RMC area; are water quality objectives met and are beneficial uses supported?**
    b. **What is the condition of aquatic life in RMC participant counties; are water quality objectives met and are beneficial uses supported?**
    c. **To what extent does the condition of aquatic life in urban and non-urban creeks differ in the RMC area?**
    d. **To what extent does the condition of aquatic life in urban and non-urban creeks differ in each of the RMC participating counties?**
2. **What are major stressors to aquatic life in the RMC area?**
    a. **What are major stressors to aquatic life in the urbanized portion of the RMC area?**
3. **What are the long-term trends in water quality in creeks over time?**

Table 2-2. Cumulative numbers of bioassessment samples per monitoring year according to RMC design; shaded cells indicate when a minimum sample size may be available to develop a statistically representative data set to address management questions related to condition of aquatic life.

Monitoring Year	RMC Area (Region-wide)		Santa Clara County		Alameda County		Contra Costa County		San Mateo County		Fairfield, Suisun City and Vallejo[b]	
Land Use	*Urban*	*Non-Urban*	*Urban*	*Non-Urban*	*Urban*	*Non-Urban*	*Urban*	*Non-Urban*	*Urban*	*Non-Urban*	*Urban*	*Non-Urban*
Year 1 (WY 012)	**48**	22	16	6	16	6	8	4	8	4	0	2
Year 2 (WY2013)	**100**	**44**	**32**	12	**32**	12	16	8	16	8	8	0
Year 3[c] (WY2014)	**156**	**66**	**48**	18	**48**	18	24	12	24	12	12	6
Year 4 (WY2015)	**204**	**88**	**64**	24	**64**	24	**32**	16	**32**	16	12	8
Year 5 (WY2016)	**256**	**110**	**80**	**30**	**80**	**30**	**40**	20	**40**	20	16	10

[a] Assumes San Francisco Bay RWQCB will continue WY2012-13 sample effort of two non-urban sites annually in each RMC County

[b] Assumes: FSURMP and Vallejo only monitor urban sites; FSURMP monitors 4 sites in Year 2, 3 and 5; and Vallejo monitors 4 sites in Year 3.

[c]Final year of monitoring under the MRP 5-Year Permit.

3. Monitoring Methods

This section describes the methods used to evaluate monitoring sites identified in the regional sample draw, consistent with the Southern California Coastal Water Research Project (SCCWRP) Bioassessment Program (SCCWRP 2012), and to sample field data, consistent with the RMC workplan (BASMAA 2011), Field parameters sampled included benthic macroinvertebrate community, algal community and biomass, and physical habitat. Physico-chemical measurements (dissolved oxygen, temperature, conductivity, and pH), chlorine, and nutrients were sampled concurrently as required by the SWAMP protocol or MRP and are reported in Appendix A.2 if IMR Part A.

3.1 Site Evaluation

Sites identified in the regional sample draw were evaluated by each RMC participant in chronological order using a two-step process, consistent with that described by SCCWRP[11] (2012). Each site was evaluated to determine if it met the following RMC sampling location criteria:

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

1. The location (latitude/longitude) provided for a site is located on or is within 300meters of a non-impounded receiving water body;
2. Site is not tidally influenced;
3. Site is wadeable during the sampling index period;
4. Site has sufficient flow during the sampling index period to support standard operating procedures for biological and nutrient sampling.
5. Site is physically accessible and can be entered safely at the time of sampling;
6. Site may be physically accessed and sampled within a single day;
7. Landowner(s) grant permission to access the site[12].

In the first step, these criteria were evaluated to the extent possible using a "desktop analysis." Site evaluations were completed during the second step via field reconnaissance visits. Based on the outcome of site evaluations, sites were classified into one of three categories:

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

The Program evaluated 87 RMC sites during WY2012and 174 sites in WY2013. The outcome of these site evaluations is summarized in **Error! Reference source not found.**.

Table 3-1. Results of ACCWP bioassessment site evaluations in Water Years 2012 and 2013.

Monitoring Year	Target Sampleable	Target Non-sampleable	Non-Target	Unknown	Total
WY2012	20	4	13	50	87
WY2013	20	29	17	108	174

Notes:
1. Results are not additive due to changes in evaluation status for individual sites among WYs.
2. Table does not include additional sites evaluated by SWAMP during both WYs.

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

- Wet flowing (continuously wet or nearly so, flowing water);

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

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

Observations of flow status occurring during fall site reconnaissance events prior to occurrence of significant precipitation, and spring sampling occurring post- wet weather season were combined to classify sites as perennial or non-perennial as follows:

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

Many sites classified as Unknown in WY 2012 were reclassified in WY 2013 as Target or Non-Target. Due to low seasonal rainfall in the first part of WY2013, many Target sites were unsampleable due to low or no streamflow present during the index period.

3.2 Field Data Collection Methods

Field data were collected in accordance with existing SWAMP-comparable methods and procedures, as described in the RMC Quality Assurance Project Plan (QAPP) (BASMAA 2012a) and the associated Standard Operating Procedures (BASMAA 2012b).As of the writing of this report, initial versions of these documents are in process of being updated to maintain their currency and optimal applicability (BASMAA 2014a, 2014b[13]) The SOPs were developed using a standard format that describes health and safety cautions and considerations, relevant training, site selection, and sampling methods/procedures, including pre-fieldwork mobilization activities to prepare equipment, sample collection, and de-mobilization activities to preserve and transport samples. SOP FS-1 covers BMI and algae Bioassessments, and physical habitat measurements. Physico-chemical measurements (Dissolved oxygen, temperature, conductivity, and pH) were measured synoptically with algae and BMI sampling using a multi-parameter probe (see SOP FS-3, BASMAA 2012b, 2014b), and water quality samples were collected for nutrient analysis on or close to the date of bioassessment at each site. Results for these auxiliary measurements are discussed in Appendix A.2 of IMR Part A.

[13] Approval by BASMAA Board of Directors confirmed February 2014.

3.2.1 Bioassessments

In accordance with the RMC QAPP (BASMAA 2012a, 2014a), bioassessments were conducted during the spring index period (approximately April 15 – July 15) and at a minimum of 30 days after any significant storm (roughly defined as at least 0.5-inch[14] of rainfall within a 24-hour period). During WY2012, the last significant storm occurred on April 12-13, 2012. Due to scheduling constraints, AMS began bioassessment sampling for ACCWP during the week of May 14th, 2012.

In comparison, for WY2013 monitoring there was no region-wide, late season significant precipitation event that required delay of sampling. The last significant storm event of the season occurred on April 1st and precipitation exceeded the RMC criterion for only the northwestern section of Alameda County (i.e., Oakland and north). Monitoring stations were therefore prioritized so that non-affected portions of the county were monitored first, beginning on April 22, 2013.

Monitoring Design Implementation

Sampling was conducted in accordance with the RMC Multi-year Monitoring Plan (BASMAA 2011). The sampling plan (Table 2-2) illustrates the total number of sites that each RMC Permittee[15] plans to sample within the MRP term (SFBRWQCB 2009). It also illustrates the number of sampling years required to establish statistically representative samples for each strata (e.g., management unit and urban or non-urban land use) included in the regional monitoring design. A target of at least 80% of the sites sampled annually by RMC participants are in urban[16] areas with up to 20% in non-urban areas. Due to unforeseen field circumstances, however, this percentage may vary by year. For example, some sites may not be sampleable due to seasonal drying and/or access issues, thereby altering the relative proportion of urban-to-nonurban sites sampled in a given year (

[14] This number was erroneously reported as 0.25-inch over a 24-hour period in UCMR (BASMAA 2013).

[15]The scenario assumes continued SF Bay RWQCB sample effort averaging 2 sites per county as part of the total number of nonurban sites listed. Due to difficulties in finding sampleable sites, the actual number of sites sampled by the RWQCB varied among years.

[16]Some sites classified as urban, using the aforementioned data in a geographic information system, may be considered for reclassification as non-urban based on actual land uses of the drainage area despite location inside municipal jurisdictional boundaries.

). Such outcomes can be addressed in subsequent sampling years by adjusting the relative proportion of urban and non-urban sites, or while conducting regional statistical analyses by adjusting the number of sites considered from each stratum to the desired proportions.

Table 3-2. Number of Alameda County Bioassessment sites sampled in Water Years 2012 and 2013 by land use stratum.

Monitoring Year	Bioassessment Sites sampled by ACCWP		Bioassessment Sites sampled by SWAMP
Land Use	*Urban*	*Non-Urban*	*Non-Urban*
WY2012	20	0	0
WY2013	17	3	5
Total	**37**	**3**	**5**

Benthic Macroinvertebrates

Each bioassessment sampling site consisted of an approximately 150-meter stream reach that was divided into 11 equidistant transects placed perpendicular to the direction of flow. The sampling position within each transect alternated between 25%, 50% and 75% distance of the wetted width of the stream. Benthic macroinvertebrates (BMIs) were collected from a 1 ft2 area approximately 1 m downstream of each transect. The benthos were disturbed by manually rubbing coarse substrate followed by disturbing the upper layers of substrate to a depth of 4-6 inches to dislodge any remaining invertebrates into the net. Slack water habitat procedures were used at transects with deep and/or slow moving water (Ode 2007). Material collected from the eleven subsamples was composited in the field by transferring entire sample into one to two 1000 ml wide-mouth jar(s) and preserved with 95% ethanol.

Algae

Filamentous algae and diatoms were collected using the Reach-wide Benthos (RWB) method described in SOP FS-1 (BASMAA 2012b, 2014b). Algae samples were collected synoptically with BMI samples. The sampling position within each transect was the same as used for BMI sampling, however, samples were collected six inches upstream of the BMI sampling position and prior to BMI collection from that location. The algae were collected using a range of methods and equipment, depending on the particular substrate occurring at the site (i.e., erosional, depositional, large and/or immobile, etc) per SOP FS-1. Erosional substrates included any material (substrate or organics) that was small enough to be removed from the stream bed, but large enough in size to isolate an area equal in size to a rubber delimiter (12.6 cm2 in area). When a sample location along a transect was too deep to sample, a more suitable location was selected, either on the same transect or from one further upstream. Algae samples were collected at each transect prior to moving on to the next transect. Sample material (substrate and water) from all eleven transects was combined in a sample bucket, agitated, and a suspended algae sample was then poured into a 500 mL cylinder, creating a composite sample for the site. A 45 mL subsample was taken from the algae composite sample and combined with 5 mL

glutaraldehyde into a 50 mL sample tube for taxonomic identification of soft algae. Similarly, a 40 mL subsample was extracted from the algae composite sample and combined with 10 mL of 10% formalin into a 50 mL sample tube for taxonomic identification of diatoms. Laboratory processing included identification and enumeration of 300 natural units of soft algae and 600 diatom valves to the lowest practical taxonomic level.

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

3.2.2 Physical Habitat

Physical habitat assessments (PHab) were conducted at each BMI bioassessment sampling event using the PHab protocols described in Ode (2007) and augmented by Fetscher et al. (2009) (see SOP FS-1, BASMAA 2012b, 2014b). Physical habitat data were collected at each of the 11 transects and at 10 additional inter-transects (located between each main transect) by implementing the "Basic" level of effort, with the following additional measurements/assessments as defined in the "Full" level of effort (as prescribed in the MRP): water depth and pebble counts, cobble embeddedness, flow habitat delineation, and instream habitat complexity. At algae sampling locations, additional assessment of presence of micro- and macroalgae was conducted during the pebble counts. In addition, water velocities were measured at a single location in the sample reach (when possible) using protocols described in Ode (2007).

3.3 Laboratory Analysis Methods

ACCWP and other RMC participants agreed to use the same laboratories for individual parameters, developed standards for contracting with the labs, and coordinated quality assurance issues. All samples collected by RMC participants that were sent to laboratories for analysis were analyzed and reported per SWAMP-comparable methods as described in the RMC QAPP (BASMAA 2012a, 2014a). Analytical laboratory methods, are also reported in BASMAA (2012a).Analytical laboratory contractors used for benthic macroinvertebrate and algae analyses included:

- BioAssessment Services
- EcoAnalysts

3.4 Data Analysis

This section describes methods used to analyze Bioassessment data collected during Water Years 2012 and 2013..As the cumulative RMC sample sizes increase through monitoring conducted in future years (Table 2-3), it will be possible to develop a statistically representative data set to address management questions related to condition of aquatic life and report on these per MRP Provision C.8.g.iv. To provide a longer term perspective, BMI data from earlier monitoring by ACCWP and also SWAMP (SFBRWQCB 2008) were included in the analysis where previously compiled as part of a dataset for development of a Bay Area IBI.

3.4.1 Benthic Macroinvertebrate Data Analysis

EOA compiled BMI data from three sources: 1) Creek Status Monitoring conducted by ACCWP in 2012 and 2013, and a Stressor Source Identification (SSID) project conducted by ACCWP in 2013 (n=41); 2) historical bioassessment projects conducted by ACCWP and the San Francisco Bay Regional Water Quality Control Board (Water Board) between 2002 and 2007 (n=119); and 3) Water Board reference condition study conducted in 2012 (n=2). ACCWP provided the BMI data collected for the Creek Status and SSID projects. All the historical bioassessment data were obtained from the CalEDAS database, which was previously populated by Bay area stormwater programs and is currently managed by EOA, Inc. The Water Board provided bioassessment data collected during their reference study.

The combined data resulted in a total of 162 sampling events at 113 unique sites.[17]Historical data were collected using three different standardized field methods: California Stream Bioassessment Protocol (CSBP), Targeted Riffle, and Reachwide Benthos (RWB). Laboratory analytical methods remained consistent for all sampling events conduct under each project. All BMIs were identified at a Level 1 Standard Taxonomic Level of Effort, with the additional effort of identifying chironomids (midges) to subfamily/tribe instead of family (Chironomidae). The taxonomic resolution and life stage information for all BMI data was compared and revised when necessary to match the Surface Water Ambient Monitoring Program (SWAMP) master taxonomic list.

[17]Thirty sites from the historical ACCWP dataset were sampled more than once and fourteen of these sites were sampled more than twice.

Northern and Southern California Indices of Biological Integrity

All BMI data were compiled, formatted and forwarded to the Moss Landing Marine Laboratory[18] where Southern California (SoCal) B-IBI and the Northern California (NorCal) Benthic Macroinvertebrate Index of Biotic Integrity (B-IBI) scores were calculated using the new SWAMP reporting module.[19] The reporting module includes a routine that subsamples to a standardized number of 500 BMIs prior to the calculation of metrics used in B-IBIs. The metrics used to calculate each B-IBI are shown in Table 3-3. Upstream watershed area and ecoregion data were also used to meet the input requirements for the NorCal B-IBI.

Table 3-3. Component Metrics of Southern California and Northern California B-IBI.

SoCal B-IBI	NorCal B-IBI
• EPT Taxa • Number Coleoptera Taxa • Number Predator Taxa • Percent Intolerant • Percent Non-Insecta Taxa • Percent Collector-Filter + Collector-Gather Individuals • Percent Tolerant Taxa	• EPT Taxa • Number Coleoptera Taxa • Percent Predators • Percent Intolerant • Percent Non-Insecta Taxa • Percent Non-Gastropoda Scrapers • Number Diptera Taxa • Percent Shredder Taxa

California Stream Condition Index Score

California Stream Condition Index (CSCI) scores were calculated using the same BMI data used to calculate the B-IBIs described above. Delineations for the drainage area upstream of each BMI sampling location were compiled or created in ArcGIS. Watershed delineations for the historical bioassessment sampling locations and the Water Board reference study sampling locations (n=72) was obtained from Water Board staff. Watershed area delineations for each ACCWP site sampled via Creek Status Monitoring and the SSID project (n=41) were created using 30 meter Digital Elevation Model (DEM) data and the ArcHydro tool in ArcGIS. In most cases, the watershed/catchments polygons created in ArcGIS required editing to adjust the downstream edge of the drainage area to the sampling locations. When necessary, existing data

[18]Moss Landing Marine Laboratory supports SWAMP in the management of bioassessment data.

[19]The NoCal and SoCal B-IBI scores calculated for the 20 sites sampled by ACCWP in WY2012 and reported in the WY2012 Local Urban Creeks Status Monitoring Report (BASMAA 2013) are not identical to the B-IBI scores presented is this memorandum. One explanation is that slightly different methods were applied, with the tabulation and scoring of metrics completed manually in Urban Creeks Monitoring Report based on descriptions in Ode et al. (2005) and Rehn et al. (2005) while the tabulations in this report were prepared via the recently developed SWAMP Reporting Module. Another factor may relate to potential differences in the BMI taxa list (e.g., taxa level and the distinction of unique taxa) which could affect the scoring of each B-IBI metric. In an effort to remain consistent with statewide analyses of bioassessment data by SWAMP, the metrics and B-IBI scores generated by the SWAMP Reporting Module were used for the analyses presented in this report.

sources, including watershed/catchment data developed by SFEI and the Oakland Museum, were used to modify the DEM derived watershed boundaries. These were typically in the low gradient urban areas along the San Francisco Bay and Livermore Valley.

To develop the CSCI score, fourteen different GIS datasets were received from the California Department of Fish and Wildlife, and compiled and analyzed by EOA in ArcGIS to calculate a range of environmental attributes for each sampling location. Attributes calculated for each site included site elevation, average air temperature, and precipitation values. Elevation range was calculated from the difference in highest and lowest elevations in the watershed. The other eleven attributes were associated with soil properties that were averaged across the watershed using a zonal statistics tool in ArcGIS (http://www.arcgis.com/). The environmental variables data and BMI data were formatted and used as input files for "R" Studio statistical package and the necessary program scripts provided by staff from the Southern California Costal Water Research Project (SCCWRP), the organization that provided technical support to the State of California on the development of the CSCI. The program includes a subsampling routine that produces a standardized number of 500 BMIs for each site. The program output includes a summary table that averages CSCI scores over 20 iterations and calculates two indices that together form the CSCI Score – Observed over Expected (O/E) and a Multi-metric Index (pMMI). The output table also flags sites with inadequate numbers of unambiguous taxa (i.e., CSCI requires at least 360 unambiguous taxa).

3.4.2 Algae Data Analysis

The Diatom IBI (D18) developed by SCCWRP for the Draft Southern California Algae IBI, was used as a preliminary tool to explore its utility in assessing biological condition for each ACCWP site sampled via Creek Status Monitoring in 2012 and 2013. D18 is generated using five metrics (Table 3-4). Similar to BMI data, algae data for the 40 sites were compiled, formatted and forward to the Moss Landing Marine Laboratory for calculation of algae IBI scores. The SWAMP Reporting Module calculated diatom D18IBI scores for all 40 sites.

Table 3-4. Metrics used to calculate diatom D18" IBI.

Diatom "D18" IBI metrics
• Proportion halobiontic (preference for saline environment) • Proportion low total phosphorus indicators • Proportion nitrogen heterotrophs • Proportion requiring >50% dissolved oxygen saturation • Proportion sediment tolerant (highly motile)

The presentation of algae data is considered preliminary until taxonomic differences with the SWAMP master taxa list are reconciled. However, since diatom taxa are relatively well understood (as compared to soft algae), it was decided that diatom data could be used to generate a single assemblage diatom IBI.

3.4.3 Physical habitat condition

BASMAA (2013) prepared a data analysis of physical habitat scores from all RMC bioassessment sites monitored in WY2012, based on the combination of scores for three physical habitat sub-categories. While these scores can be useful in interpreting results from individual sites, their interpretation did not add substantially to the information from the IBI scores. The CSCI uses characteristics of the watershed draining to each site to develop the score for that site and thus integrates larger-scale physical habitat structure into the condition assessment.

4. Results & Discussion

The MRP places an emphasis on minimizing sources of pollutants that could impair water quality as a central purpose of urban runoff management programs. The MRP requires monitoring to address the management question, “What are the sources to urban runoff that contribute to receiving water problems?”The RMC accomplishes this through a multi-step process that involves conducting monitoring to provide data to inform an assessment of conditions and identification of stressors that may be impacting water quality and/or biological conditions. The information generated through the condition assessment and stressor assessment will then be used to help direct efforts to identify sources of problematic pollutants or other stressors in urban runoff discharges.

In this section, following a brief statement of data quality, the bioassessment data are evaluated against the trigger criteria shown in Table 8.1 and Table H-1 (for sediment triad data) of the MRP (SFBRWQCB 2009) to provide a preliminary identification of potential stressors. The results of the initial stressor assessment evaluation (BASMAA 2013) were used to initiate a stressor-source identification project following up on triad results in the Dublin Creek watershed (see Appendix A.4A of IMR Part A).

4.1 Statement of Data Quality

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

A comprehensive QA/QC program was implemented by each of the RMC Programs, which is solely responsible for the quality of the data submitted on its behalf, covering all aspects of the regional/probabilistic monitoring. In general, QA/QC procedures were implemented as specified in the RMC QAPP (BASMAA, 2012a, 2014a), and monitoring was performed according to protocols specified in the RMC SOPs (BASMAA, 2012b, 2014b), and in conformity with SWAMP protocols. Details of the results of evaluations of laboratory-generated QA/QC results are included in Appendix A.6 of IMR Part A, along with audits performed for field crews. Issues noted by the laboratories and/or RMC field crews are noted below where relevant.

4.2 Condition Assessment

Condition assessment addresses the RMC core management question ***"What is the condition of aquatic life in creeks in the RMC area; are aquatic life beneficial uses supported?"*** Appendix . A.2 of IMR Part A lists the beneficial uses of creeks sampled during WYs 2012 and 2013. By default creeks and other fresh water bodies are assigned the WARM and WILD presumptive uses in the Basin Plan (SFBRWQCB 2013).

Benthic Macroinvertebrates

Calculated NorCal B-IBI, SoCal B-IBI and CSCI scores were compared to explore and confirm the choice in indicator selection for analyzing BMI data as indicators of aquatic biological/ecological condition of freshwater streams in Alameda County. NorCal B-IBI, SoCal B-IBI and CSCI scores for the 162 sampling events conducted in Alameda County between 2002 and 2013 are presented in Attachment 1. Descriptive statistics are shown in Table 4-1.

Table 4-1. Descriptive statistics for NorCal B-IBI, SoCal B-IBI and CSCI scores for 162 sampling events conducted in Alameda County between 2002 and 2013.

Statistic	NoCal B-IBI Score (0-100)	SoCal B-IBI Score (0-100)	CSCI Score (>0)
Min	4	0	0.21
Median	24	23	0.66
Mean	31	32	0.70
Max	86	99	1.28

The NorCal and SoCal B-IBI scores were highly correlated, with an r^2statistic of 0.9 (Figure 4-1), suggesting that the B-IBIs are providing similar condition scores and are somewhat interchangeable for the sites assessed. As a result, only one B-IBI was used as condition index for further analyses. Because the ecoregions represented by the SoCal B-IBI are more similar to

those in Alameda County (i.e., Ecoregion 6), the SoCal B-IBI was selected and used in further evaluations presented below.

A comparison of SoCal B-IBI and CSCI scores for the 162 sampling events indicated a moderately strong correlation (r^2 =0.63), suggesting that the CSCI[20] may be a comparable tool to assess the condition of aquatic life in Alameda County creeks (Figure 4-2). The distribution of CSCI scores, however show much greater variability among the sites, especially at the low end of the scoring range (Figure 4-3).

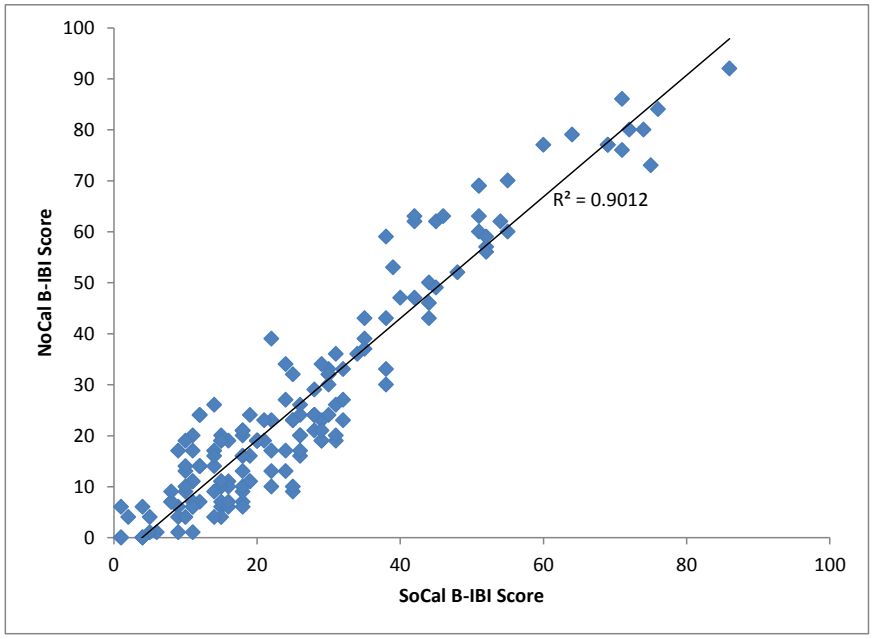

Figure 4-1. Comparison of NorCal and SoCal B-IBI scores calculated from BMI data collected at 162 sampling events in Alameda County between 2002 and 2013.

[20] The SoCal IBI score showed slightly less correlation with either of the two CSCI components: pMMI (r^2 = 0.59) and O/E (r^2 = 0.43).

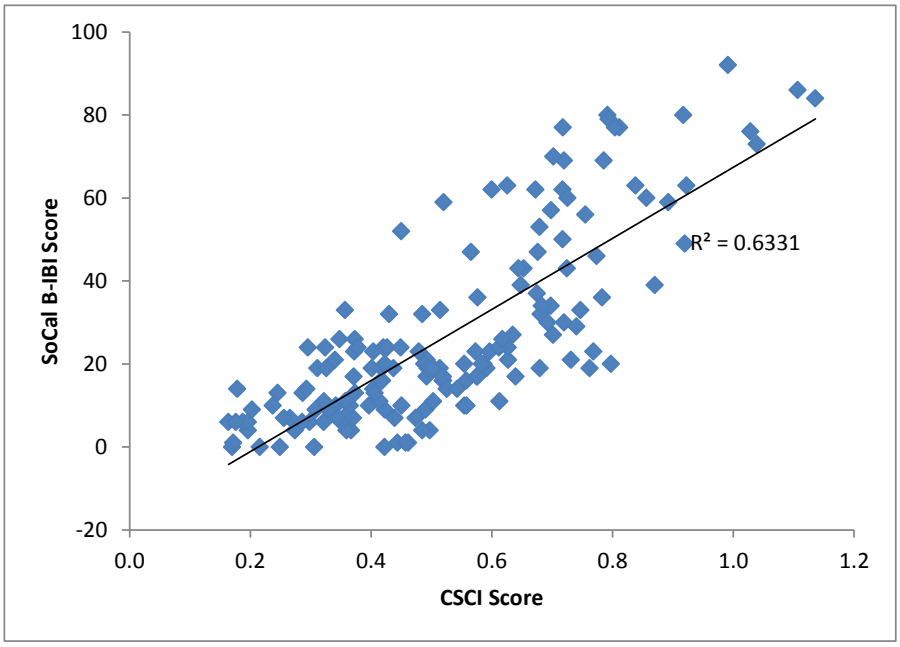

Figure 4-2. Linear regression between SoCal B-IBI and CSCI scores for the 162 sampling events conducted in Alameda County between 2002 and 2013.

These results suggest that the CSCI may be more responsive to the site specificity of BMI taxa due to the inclusion of a taxonomic completeness component (O/E) and/or the predictive ability of the pMMI as compared to the exclusively multi-metric approach of the SoCal IBI. Alternatively, the CSCI scores may not be accurately predicting the expected number of taxa resulting in an over- or under-estimated measure of taxonomic completeness. The O/E component was consistently higher than pMMI component, which may be driving the variability in the overall CSCI score (Figure 4-4).

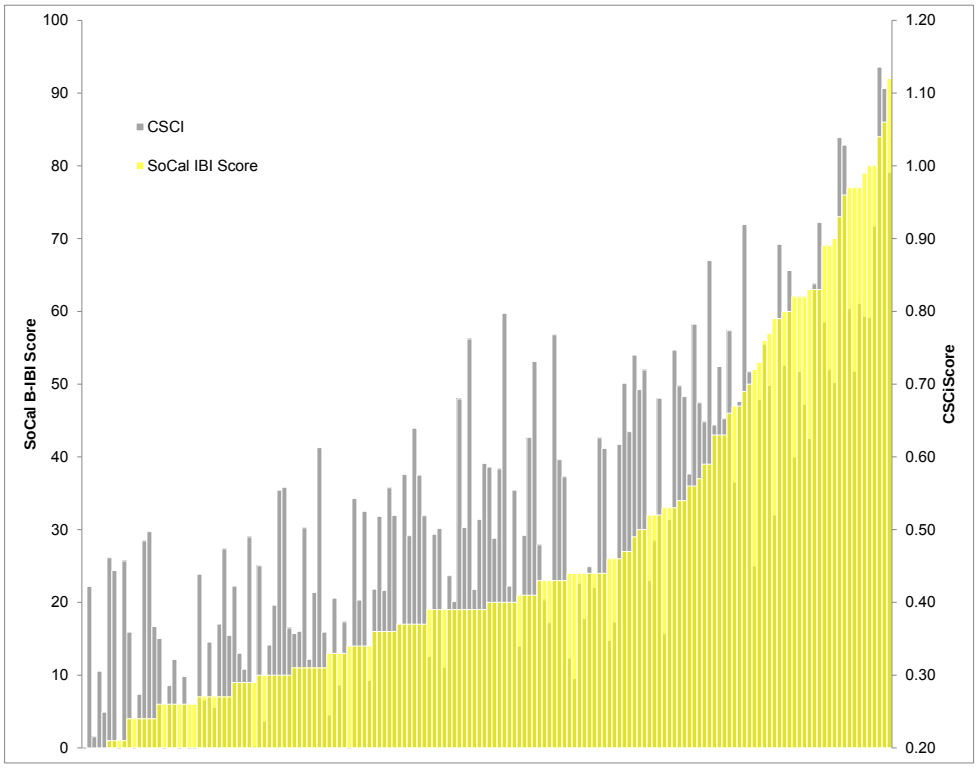

Figure 4-3. SoCal B-IBI and CSCI scores plotted for the 162 sampling events conducted in Alameda County between 2002 and 2013. Data is sorted by B-IBI scores increasing from left to right.

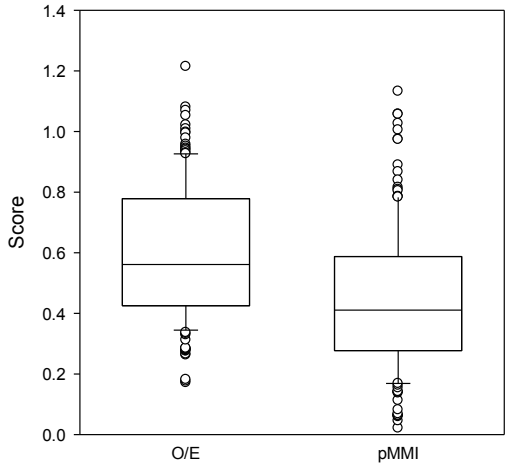

Figure 4-4. Comparison of O/E and pMMI scores for 162 sampling events in Alameda County conducted between 2002 and 2013.

Biological condition scores were further compared by stratifying sites (n = 113) by flow status and land use. For sites with multiple sampling events, average biological condition scores were calculated and used during the analyses. SoCal B-IBI and CSCI scores were compared for perennial (n=85) and non-perennial (n=28) sites sampled in Alameda County (Figure 4-5). Flow status was evaluated by ACCWP and Water Board staff during site observations made during the dry season. Sites with no flow status information or known to be dependent on managed flows were indicated as "unknown".

Biological condition scores were also stratified by land use (i.e., urban versus non-urban) classifications (Figure 4-6). Land use classifications were based on the BASMAA Regional Monitoring Coalition's Creek Status Monitoring Sample Frame, which was developed using a combination of urban areas (as defined by Association of Bay Area Governments) and city boundaries. For some areas, city boundaries include parks and undeveloped areas and thus sampling locations that are classified as urban may have a wide range of impacts associated with urban development.

Another measure associated with urbanization, imperviousness, was derived using the upstream watershed areas for each sampling location and overlaying with land use data in GIS database. Impervious coefficients were applied to land use classes described in the Alameda County Assessor Parcel data[21]. The percent watershed impervious area was calculated for all sites and used to compare biological condition scores at increasing levels of urbanization: >3%, 3-10% and >10% impervious (Figure 4-7). A linear regression between CSCI scores and percent watershed impervious is shown in Figure 4-8.

[21]Land use classes for the Assessor Parcel data were revised by EOA to more accurately depict current land use throughout Alameda County as part of trash generation mapping project.

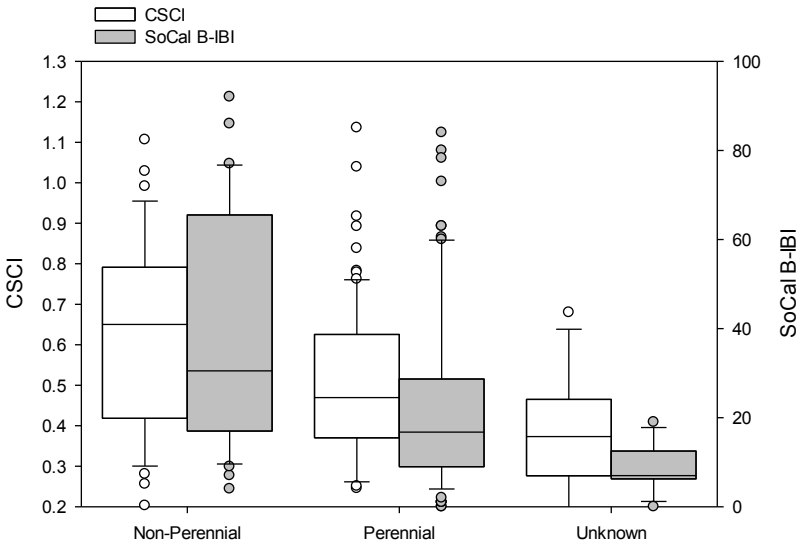

Figure 4-5. Comparison of SoCal B-IBI and CSCI scores for perennial (n=85) and non-perennial (n=28) sites sampled in Alameda County between 2002 and 2013. Average score were used for sites sampled more than once.

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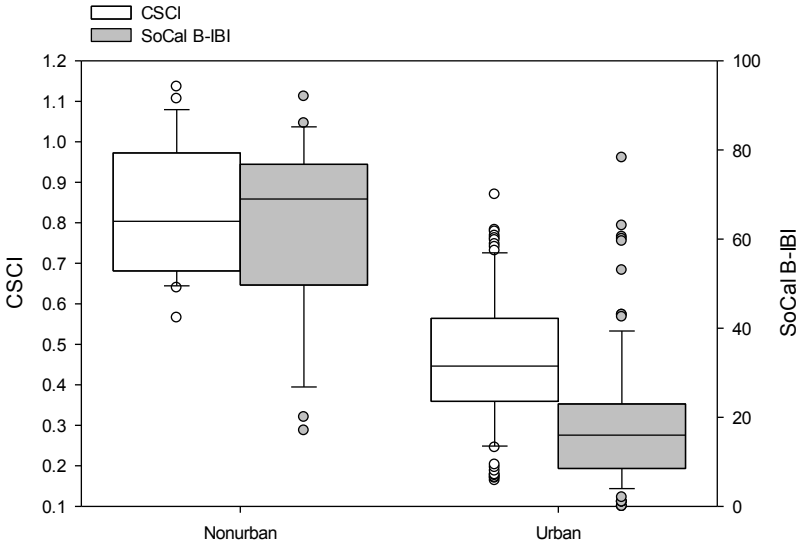

Figure 4-6. Comparisons of SoCal B-IBI and CSCI scores for urban (n=94) and non-urban (n=19) sites sampled in Alameda County between 2002 and 2013. Average score were used for sites sampled more than once.

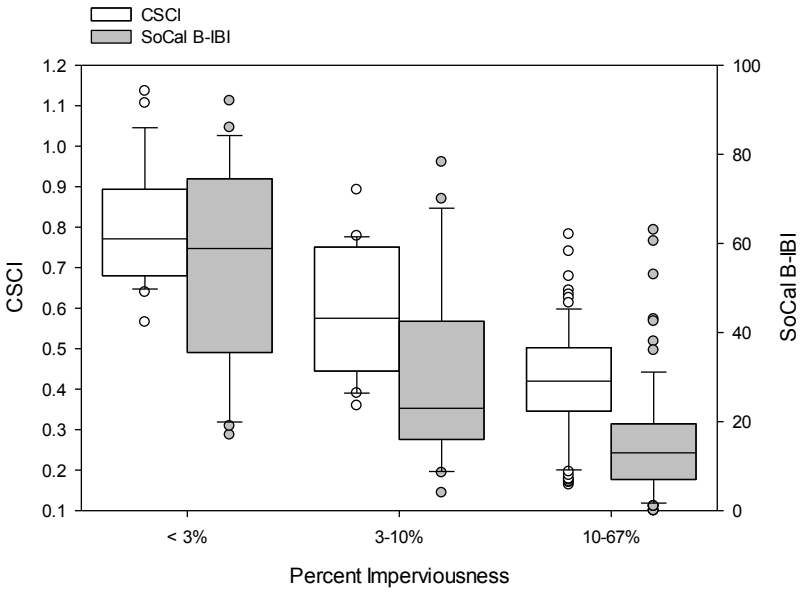

Figure 4-7. Comparisons of SoCal B-IBI and CSCI scores at sites sampled in Alameda County between 2002 and 2013 for three classifications of urbanization, defined as % watershed imperviousness. Average scores were used for sites sampled more than once.

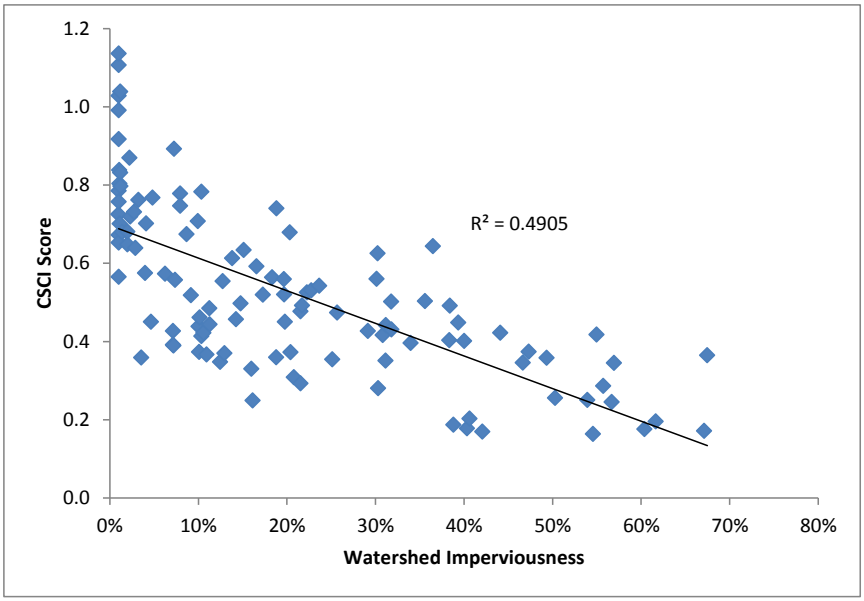

Figure 4-8. Linear regression of CSCI scores and percent watershed imperviousness for sites sampled in Alameda County between 2002 and 2013.

Benthic Algae

The diatom IBI scores for the 40 sites sampled by ACCWP between 2012 and 2013 were compared to CSCI scores (Figure 4-9) and SoCal B-IBI scores (Figure 4-10). The diatom IBI showed moderate to poor correlation to both BMI biological condition scores, suggesting that either diatom assemblages have different responses to stressors than BMI assemblages or the diatom IBI developed for Southern California may need further refinement for use in the Bay area.

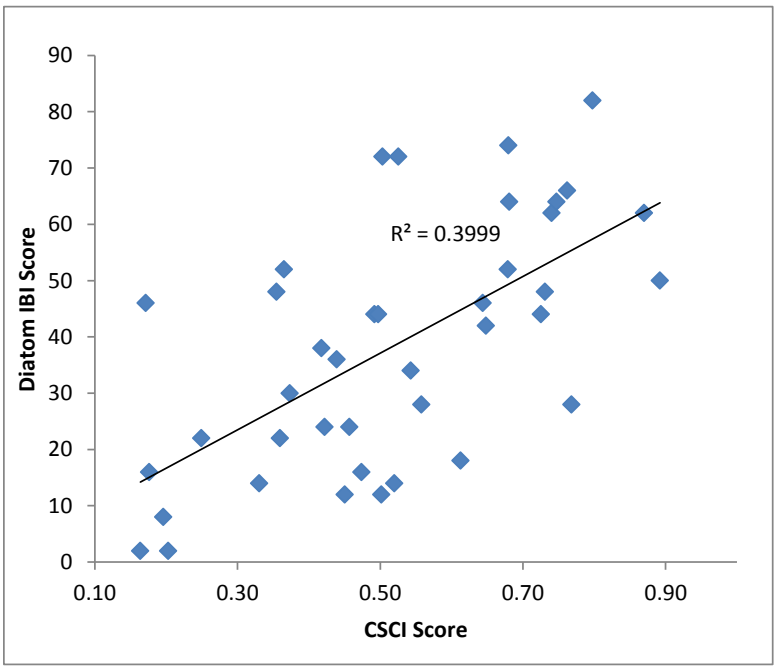

Figure 4-9. Linear regression of Diatom IBI and CSCI scores for 40 sites sampled during Water Years 2012 and 2013 in Alameda County.

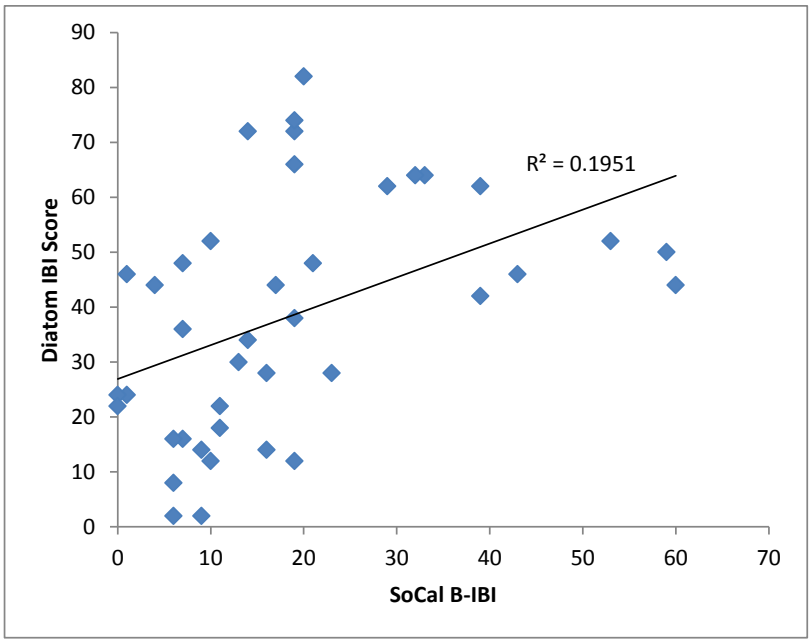

Figure 4-10. Linear regression of Diatom IBI and SoCal B-IBI scores for 40 sites sampled during Water Years 2012 and 2013 in Alameda County.

4.3 Stressor Assessment

This section addresses the question: ***"What are major stressors to aquatic life in the RMC area?"***Biological assessment condition categories (e.g., good, fair, poor) can assist in the presentation of bioassessment data and may or may not be tied to regulatory outcomes. For the purpose of this report, condition categories for Alameda County sites are presented using SoCal B-IBI and CSCI scores.

4.3.1 Stressor Analysis

The SoCal B-IBI condition categories are listed in Table 4-2 and provisional CSCI categories are presented in Table 4-3. To date, the State of California has not developed condition categories or thresholds to evaluate either B-IBI or CSCI scores and therefore scores at this point are not associated with regulatory outcomes. Condition categories for the diatom IBI were not developed at this time.

Table 4-2. Condition categories used to evaluate SoCal B-IBI scores

Condition Category	Southern California B-IBI
Very Good	80-100
Good	60-79
Fair	40-59
Poor	20-39
Very Poor	0-19

Table 4-3. Condition categories used to evaluate CSCI scores.

Category	CSCI Score
Good	> 0.83
Fair	0.55 – 0.83
Poor	< 0.55

Descriptive statistics for the biological condition scores for all sites sampled in Alameda County between 2002 and 2013 are shown in Table 4-4Table 4-4. SoCal B-IBI, CSCI and diatom IBI scores for the 40 sites sampled in Alameda County during 2012 and 2013 during the implementation of the MRP are listed in Table 4-5. Site characteristics related to land use classification, flow status, and channel modification status are also presented in Table 4-5 for reference.

Table 4-4. Descriptive statistics for CSCI, SoCal IBI and diatom IBI scores for the 162 sampling events conducted in Alameda County between 2002 and 2013.

Statistic	CSCI Score (>0)	SoCal B-IBI Score (0-100)	Diatom IBI (0-100)
Minimum	0.2	0	2
Median	0.5	16	40
Mean	0.5	19	38
Max	0.9	60	82

Using the CSCI condition categories for the 40 sites sampled during 2012 and 2013, 2 sites (5%) scored as "good", 15 sites (37%) as "fair", and 24 sites (58%) as "poor" (Table 4-5). Two of the three highest scoring sites exhibited entirely non-urban land uses in upstream watersheds. All poor sites using the CSCI were ranked very poor using the SoCal B-IBI. Highly modified channels represented 88% of the sites in the CSCI poor category.

Biological condition scores for sites sampled prior to 2012 were also calculated and presented in Attachment 2. Average scores at site sampled multiple times were used to calculate CSCI and SoCal B-IBI scores. Site locations and the provisional biological condition score (i.e., CSCI) for each sites sampled in Alameda County between 2002 and 2013 are illustrated in Figure 4-11. California Stream Condition Index (CSCI) scores for 135 sites sampled between 2002 and 2013 in Alameda County..

Table 4-5. CSCI, SoCal B-IBI and diatom IBI scores for the 40 sites sampled in Alameda County during 2012 and 2013. Site characteristics related to land use classification, flow status, and channel modification status are also presented.

Station Code	Creek	Land Use	Flow Status	Highly Modified Channel	CSCI	Condition Category	SoCal IBI Score	Condition Category	Diatom IBI

Station Code	Creek	Land Use	Flow Status	Highly Modified Channel	CSCI	Condition Category	SoCal IBI Score	Condition Category	Diatom IBI
204R00751	Redwood Canyon Creek	NU	P	N	0.89	Good	59	Fair	50
204R00647	Dry Creek	U	NP	N	0.87	Good	39	Poor	62
204R00590	Arroyo Valle	NU	NP	N	0.80	Fair	20	Poor	82
204DUB040	Dublin Creek	U	P	N	0.78	Fair	36	Poor	-
204R00623	San Lorenzo Creek	U	NP	N	0.77	Fair	23	Poor	28
204R00191	Arroyo Valle	U	P	N	0.76	Fair	19	Very Poor	66
204R00724	Dublin Creek	U	NP	N	0.75	Fair	33	Poor	64
204R00455	Zeile Creek	U	P	N	0.74	Fair	29	Poor	62
205R01134	Agua Caliente	U	P	N	0.73	Fair	21	Poor	48
203R00983	Strawberry Creek	U	U	N	0.73	Fair	60	Good	44
205R00110	Agua Caliente	U	P	N	0.68	Fair	32	Poor	64
204R00334	Arroyo Valle	U	U	N	0.68	Fair	19	Very Poor	74
204R00367	Ward Creek South Fork	U	P	N	0.68	Fair	53	Fair	52
204R00473	Arroyo Mocho	U	NP	N	0.65	Fair	39	Poor	42
204R00319	Sausal Creek	U	P	N	0.64	Fair	43	Fair	46
204R00084	Dublin Creek	U	P	Y	0.61	Fair	11	Very Poor	18
204R00068	Collier Creek Channel, Line 7-M	U	P	Y	0.56	Fair	16	Very Poor	28
205R00174	Zone 6 Line K	U	P	N	0.54	Poor	14	Very Poor	34
205R00430	Zone 6 Line D	U	P	Y	0.53	Poor	14	Very Poor	72
204R00852	Alamo Creek	U	NP	N	0.52	Poor	16	Very Poor	14
204R00063	Peralta Creek	U	P	N	0.50	Poor	19	Very Poor	72
204R00391	Zone 5 Line M	U	P	Y	0.50	Poor	19	Very Poor	12
204R00356	Arroyo de la Laguna	U	P	Y	0.50	Poor	4	Very Poor	44
204R00047	Castro Valley Cr	U	P	Y	0.49	Poor	17	Very Poor	44
204R01316	Arroyo de la Laguna	U	U	Y	0.47	Poor	7	Very Poor	16
204R00447	Kottinger Creek	U	P	N	0.46	Poor	1	Very Poor	24
204R00340	Big Canyon Cr, Line 7-J-1	U	P	Y	0.45	Poor	10	Very Poor	12
204R00100	Arroyo Mocho	U	U	Y	0.44	Poor	7	Very Poor	36
204R00596	Zone 7 Line G-2	U	P	Y	0.42	Poor	0	Very Poor	24
204R00303	Chabot Creek	U	P	N	0.42	Poor	19	Very Poor	38

Station Code	Creek	Land Use	Flow Status	Highly Modified Channel	CSCI	Condition Category	SoCal IBI Score	Condition Category	Diatom IBI
204R01471	Arroyo Mocho	U	U	Y	0.37	Poor	13	Very Poor	30
205R00535	Zone 5 Line F-1	U	P	Y	0.36	Poor	10	Very Poor	52
205R01198	Zone 6 Line G	U	U	Y	0.36	Poor	11	Very Poor	22
205R00686	Canada Del Aliso	U	P	Y	0.35	Poor	7	Very Poor	48
204R00639	San Lorenzo Creek	U	P	Y	0.33	Poor	9	Very Poor	14
205R01390	Zone 6 Line G	U	U	Y	0.25	Poor	0	Very Poor	22
204R00583	Zone 3A Line D	U	NP	Y	0.20	Poor	9	Very Poor	2
204R00327	Zone 3A Line A-3	U	P	Y	0.20	Poor	6	Very Poor	8
205R00878	Zone 5 Line B	U	U	Y	0.18	Poor	6	Very Poor	16
204R00383	Sulphur Creek	U	P	Y	0.17	Poor	1	Very Poor	46
204R00967	Crandall Creek	U	P	Y	0.16	Poor	6	Very Poor	2

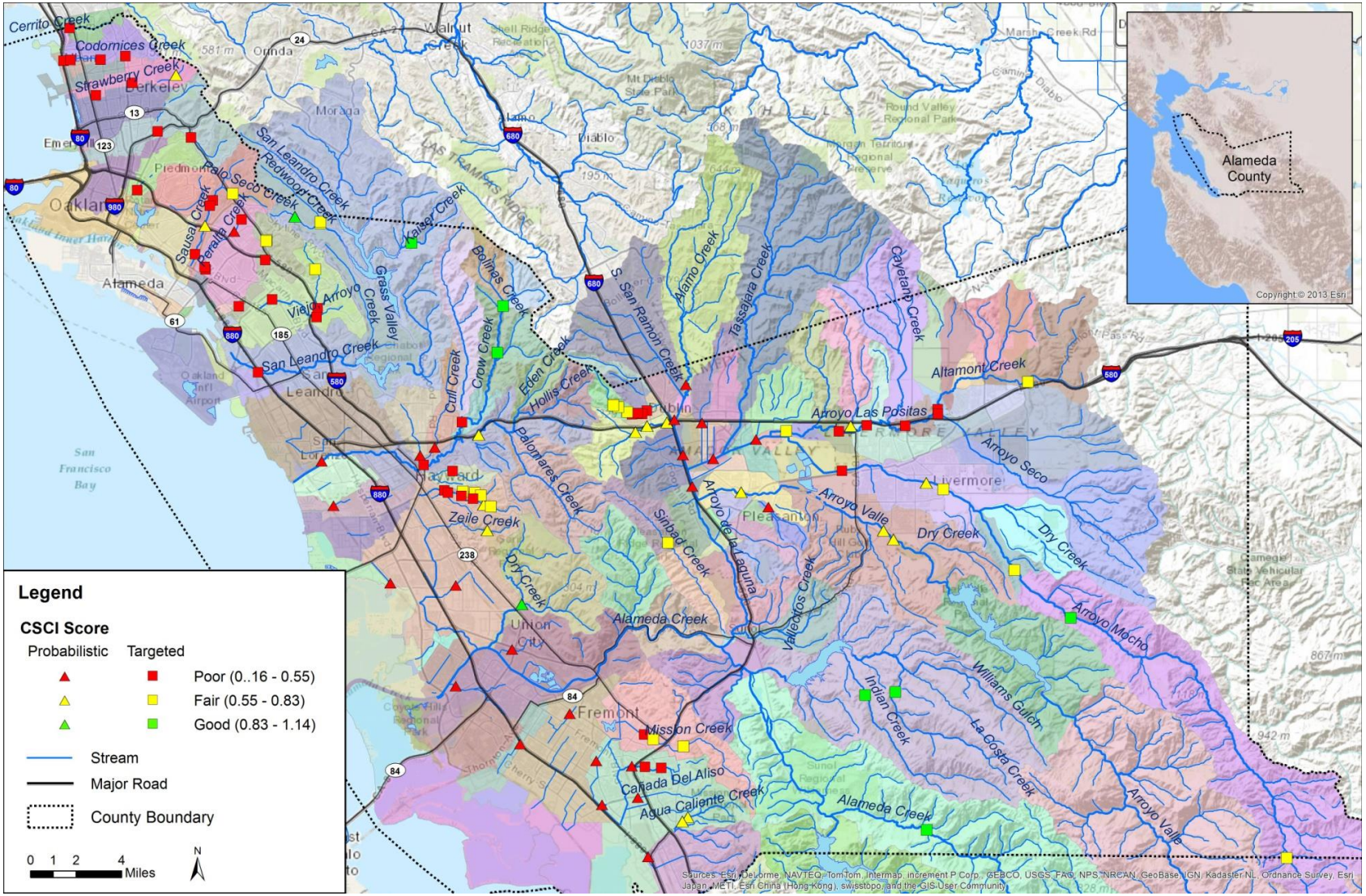

Figure 4-11. California Stream Condition Index (CSCI) scores for 135 sites sampled between 2002 and 2013 in Alameda County.

5. Conclusions and Next Steps

During water years 2012 and 2013, forty sites were monitored by ACCWP contributing to this report under the RMC regional probabilistic design for bioassessment, including benthic macroinvertebrates, algae taxonomy and physical habitat/algae observations.

The following MRP reporting requirements (Provision C.8.g.iv) were addressed within this report as applicable:

- Descriptions of monitoring purpose and study design rationale
- QA/QC summaries for sample collection and analytical methods, including a discussion of any limitations of the data;
- Descriptions of sampling protocols and analytical methods;
- Tables and Figures describing: Sample location descriptions (including waterbody names, and lat/longs); sample ID, collection date (and time where relevant), media (e.g., water, filtered water, bed sediment, tissue); concentrations detected, measurement units, and detection limits;
- Data assessment, analysis, and interpretation for Provision C.8.c.;
- Pollutant load and concentration at each mass emissions station;
- A listing of volunteer and other non-Permittee entities whose data are included in the report;
- Assessment of compliance with applicable water quality standards;

5.1 Summary of Stressor Analyses

The stressor analysis revealed that most sites show alteration of biological communities, and channel modification and other habitat changes associated with urbanization is a likely stressor for benthic macroinvertebrate communities. The low scores and condition categories for most sites sampled in WYs 2012 and 2013 are consistent with results from of previous years of monitoring in Alameda County and also supported by studies elsewhere.

Geomorphic changes to stream systems are commonly considered to begin as the effective impervious area of their catchment reaches approximately 10% (e.g. Schuler, 2004, SFBRWQCB 2012). However Coleman et al. (2005) found that much lower thresholds of imperviousness initiated channel enlargement in the Southern California streams they studied, suggesting that arid-climate ephemeral to intermittent streams are very sensitive to slight changes in impervious area within their watersheds.

5.2 Next Steps

MRP Table 8.1 requires bioassessment results to be evaluated for triggers as a triad along with results of sediment toxicity and chemistry according to the criteria in MRP Attachment H-1; this analysis is shown in the Section 9 of the main body of ACCWP's IMR Part A. During WY2013, the RMC collaboratively reviewed trigger results from WY2012 and selected a total of ten sites in four counties for implementation of stressor/source identification (SSID) projects based on prioritization of the type, extent and geographic spread of the triggers. Technical studies for SSID projects are to be initiated by the second Fiscal Year following the year in which the potential stressor was identified. ACCWP's progress reports on an SSID projects in Dublin Creek (Appendix A.4A to IMR Part A) reviews bioassessment scores for three sites along an urbanization gradient within that watershed.

ACCWP and other RMC participants will continue to implement the regional probabilistic monitoring design in WY2014. Site evaluation is underway for new bioassessment sites for Water Year 2014. Candidate sites classified with unknown sampling status as of WY2013 may continue to be evaluated for potential sampling in Water Year 2014.

6. References

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7. Attachment

Attachment A. NorCal B-IBI, SoCal B-IBI and CSCI Scores for BMI data collected during 162 sampling events at 135 sites in Alameda County between 2002 and 2013.

Attachment A. NorCal B-IBI, SoCal B-IBI and CSCI Scores for BMI data collected during 162 sampling events at 135 sites in Alameda County between 2002 and 2013.

Station Code	Creek	Sample Date	Project	NoCal IBI Score	SoCal IBI Score	CSCI Score
205R00110	Agua Caliente	6/18/2012	RMC_Creek Status	30	32	0.68
205R01134	Agua Caliente	5/20/2013	RMC_Creek Status	18	21	0.73
204ALA525	Alameda Creek	5/22/2012	SFRWQCB_Reference	71	86	1.11
204R00852	Alamo Creek	5/6/2013	RMC_Creek Status	18	16	0.52
204ALP100	Altamont Creek	4/26/2001	SFRWQCB	15	4	0.37
204ALP140	Altamont Creek	4/26/2001	SFRWQCB	14	17	0.64
204R00356	Arroyo de la Laguna	6/4/2012	RMC_Creek Status	14	4	0.50
204R01316	Arroyo de la Laguna	5/22/2013	RMC_Creek Status	11	7	0.47
204ALP010	Arroyo De Las Positas	4/20/2001	SFRWQCB	16	10	0.55
204ALP040	Arroyo De Las Positas	4/26/2001	SFRWQCB	12	7	0.37
204ALP070	Arroyo De Las Positas	4/26/2001	SFRWQCB	11	1	0.46
204ALP080	Arroyo De Las Positas	4/26/2001	SFRWQCB	10	4	0.48
204AHOACR	Arroyo Hondo	5/13/2004	SFRWQCB	75	73	1.04
204AMO180	Arroyo Mocho	4/11/2005	SFRWQCB	72	80	0.92
204AMO200	Arroyo Mocho	4/11/2005	SFRWQCB	40	47	0.57
204AMO070	Arroyo Mocho	4/12/2005	SFRWQCB	5	4	0.36
204AMO100	Arroyo Mocho	4/12/2005	SFRWQCB	24	27	0.70
204AMO160	Arroyo Mocho	4/12/2005	SFRWQCB	38	43	0.65
204R00100	Arroyo Mocho	5/30/2012	RMC_Creek Status	15	7	0.44
204R00473	Arroyo Mocho	5/9/2013	RMC_Creek Status	22	39	0.65
204R01471	Arroyo Mocho	5/22/2013	RMC_Creek Status	10	13	0.37
204ALP110	Arroyo Seco	4/26/2001	SFRWQCB	9	1	0.44
204R00191	Arroyo Valle	5/29/2012	RMC_Creek Status	20	19	0.76
204R00334	Arroyo Valle	5/8/2013	RMC_Creek Status	16	19	0.68
204R00590	Arroyo Valle	5/8/2013	RMC_Creek Status	18	20	0.80
204AVJ020	Arroyo Viejo	4/15/2004	ACCWP	18	7	0.27
204AVJ090	Arroyo Viejo	4/22/2004	ACCWP	32	33	0.51
204AVJ130	Arroyo Viejo	4/22/2004	ACCWP	25	23	0.40
204AVJ110	Arroyo Viejo	4/23/2004	ACCWP	54	62	0.72
204AVJ130	Arroyo Viejo	4/12/2005	SFRWQCB	22	10	0.34
204AVJ020	Arroyo Viejo	4/15/2005	SFRWQCB	29	19	0.44
204AVJ090	Arroyo Viejo	4/15/2005	SFRWQCB	28	21	0.34
204AVJ110	Arroyo Viejo	4/15/2005	SFRWQCB	52	57	0.70
204R00340	Big Canyon Cr, Line 7-J-1	6/11/2012	RMC_Creek Status	15	10	0.45
205R00686	Canada Del Aliso	4/24/2013	RMC_Creek Status	16	7	0.35

Station Code	Creek	Sample Date	Project	NoCal IBI Score	SoCal IBI Score	CSCI Score
204R00047	Castro Valley Cr	6/6/2012	RMC_Creek Status	9	17	0.49
203CER020	Cerrito Creek	4/11/2005	SFRWQCB	8	7	0.26
204R00303	Chabot Creek	6/14/2012	RMC_Creek Status	15	19	0.42
204R00068	Collier Creek, Line 7-M	5/31/2012	RMC_Creek Status	14	16	0.56
203COD030	Codornices Creek	4/13/2004	ACCWP	2	4	0.20
203COD080	Codornices Creek	4/13/2004	ACCWP	24	13	0.29
203COD120	Codornices Creek	4/13/2004	ACCWP	26	16	0.42
203COD020	Codornices Creek	4/14/2004	ACCWP	16	11	0.36
203COD020	Codornices Creek	4/11/2005	SFRWQCB	4	0	0.22
203COD080	Codornices Creek	4/12/2005	SFRWQCB	9	6	0.30
203COD120	Codornices Creek	4/13/2005	SFRWQCB	9	4	0.27
203COD030	Codornices Creek	5/1/2006	ACCWP	4	0	0.31
203COD080	Codornices Creek	5/1/2006	ACCWP	25	9	0.49
204R00967	Crandall Creek	4/25/2013	RMC_Creek Status	4	6	0.16
204SLO060	Crow Creek	4/25/2002	ACCWP	18	21	0.49
204SLO090	Crow Creek	4/25/2002	ACCWP	46	63	0.92
204SLO100	Crow Creek	4/25/2002	ACCWP	42	63	0.84
204SLO060	Crow Creek	4/22/2004	ACCWP	11	17	0.37
204SLO090	Crow Creek	4/22/2004	ACCWP	55	60	0.86
204SLO060	Crow Creek	4/27/2005	ACCWP	15	20	0.49
204SLO090	Crow Creek	4/27/2005	ACCWP	44	50	0.72
204R00647	Dry Creek	6/18/2012	RMC_Creek Status	35	39	0.87
204R00084	Dublin Creek	5/24/2012	RMC_Creek Status	11	11	0.61
204R00724	Dublin Creek	5/21/2013	RMC_Creek Status	30	33	0.75
204DUB040	Dublin Creek	5/30/2013	RMC_SSID	31	36	0.78
204LME100	Glen Echo Creek	4/13/2005	SFRWQCB	1	0	0.17
204LIO130	Horseshoe Creek	4/12/2004	ACCWP	45	62	0.60
204LIO129	Horseshoe Creek	4/15/2004	ACCWP	51	63	0.63
204LIO130	Horseshoe Creek	4/13/2005	SFRWQCB	38	59	0.52
204INDSAR	Indian Creek	5/6/2004	SFRWQCB	86	92	0.99
204SLE165	Kaiser Creek	5/3/2001	SFRWQCB	76	84	1.14
204R00447	Kottinger Creek	4/22/2013	RMC_Creek Status	5	1	0.46
204LACSAC	La Costa Creek	5/11/2004	SFRWQCB	71	76	1.03
204LIO030	Lion Creek	4/14/2004	ACCWP	14	14	0.18
204LIO080	Lion Creek	4/14/2004	ACCWP	48	52	0.45
204LIO080	Lion Creek	4/13/2005	SFRWQCB	38	33	0.36
204MRT080	Martin Canyon	4/24/2005	ACCWP	12	24	0.30

Station Code	Creek	Sample Date	Project	NoCal IBI Score	SoCal IBI Score	CSCI Score
204MRT060	Martin Canyon	5/1/2006	ACCWP	14	26	0.35
204MRT070	Martin Canyon	5/1/2006	ACCWP	11	20	0.42
204MRT080	Martin Canyon	5/1/2006	ACCWP	30	32	0.48
204MRT090	Martin Canyon	5/1/2006	ACCWP	19	16	0.52
204MRT100	Martin Canyon	5/1/2006	ACCWP	24	17	0.58
204MRT110	Martin Canyon	5/1/2006	ACCWP	51	69	0.72
204MRT120	Martin Canyon	5/1/2006	ACCWP	42	62	0.67
204MRT130	Martin Canyon	5/1/2006	ACCWP	55	70	0.70
205LGU130	Mission Creek	4/24/2002	ACCWP	21	23	0.57
205LGU140	Mission Creek	4/24/2002	ACCWP	45	49	0.92
205LGU140	Mission Creek	4/19/2004	ACCWP	44	43	0.72
205LGU120	Mission Creek	4/21/2004	ACCWP	15	11	0.36
205LGU140	Mission Creek	4/21/2004	ACCWP	42	47	0.68
205LGU120	Mission Creek	4/27/2005	ACCWP	10	9	0.42
205LGU140	Mission Creek	4/27/2005	ACCWP	30	30	0.69
205LGU140	Mission Creek	5/1/2006	ACCWP	44	46	0.77
204SAU130	Palo Seco Creek	4/12/2004	ACCWP	74	80	0.79
204SAU130	Palo Seco Creek	4/14/2005	SFRWQCB	69	77	0.72
204SAU130	Palo Seco Creek	5/2/2005	ACCWP	64	79	0.79
204SAU130	Palo Seco Creek	5/1/2006	ACCWP	60	77	0.81
204PRL020	Peralta Creek	4/13/2005	SFRWQCB	22	13	0.25
204PRL080	Peralta Creek	4/13/2005	SFRWQCB	15	10	0.40
204R00063	Peralta Creek	6/4/2013	RMC_Creek Status	20	19	0.50
204R00751	Redwood Canyon Creek	6/5/2013	RMC_Creek Status	52	59	0.89
205LGU070	Sabrecat Creek	4/24/2002	ACCWP	10	14	0.29
205LGU080	Sabrecat Creek	4/24/2002	ACCWP	8	9	0.31
204SLE030	San Leandro Creek	5/2/2001	SFRWQCB	19	11	0.41
204SLO030	San Lorenzo Creek	4/25/2002	ACCWP	15	11	0.50
204SLO030	San Lorenzo Creek	4/23/2004	ACCWP	11	6	0.35
204R00639	San Lorenzo Creek	6/19/2012	RMC_Creek Status	18	9	0.33
204R00623	San Lorenzo Creek	6/3/2013	RMC_Creek Status	29	23	0.77
204SAU080	Sausal Creek	4/25/2002	ACCWP	10	19	0.51
204SAU080	Sausal Creek	4/10/2004	ACCWP	26	24	0.42
204SAU080	Sausal Creek	4/12/2004	ACCWP	25	10	0.56
204SAU090	Sausal Creek	4/12/2004	ACCWP	34	36	0.58
204SAU030	Sausal Creek	4/13/2004	ACCWP	31	19	0.49
204SAU020	Sausal Creek	4/15/2004	ACCWP	8	7	0.35

Station Code	Creek	Sample Date	Project	NoCal IBI Score	SoCal IBI Score	CSCI Score
204SAU030	Sausal Creek	4/14/2005	SFRWQCB	12	14	0.40
204SAU080	Sausal Creek	4/14/2005	SFRWQCB	18	13	0.41
204SAU080	Sausal Creek	5/2/2005	ACCWP	20	19	0.31
204SAU090	Sausal Creek	5/2/2005	ACCWP	16	6	0.29
204R00319	Sausal Creek	6/7/2012	RMC_Creek Status	35	43	0.64
204SIN300	Sinbad Creek	5/15/2012	SFRWQCB_Reference	51	69	0.79
203STW010	Strawberry Creek	4/15/2004	ACCWP	28	24	0.43
203STW010	Strawberry Creek	4/12/2005	SFRWQCB	11	11	0.32
203STW030	Strawberry Creek	4/13/2005	SFRWQCB	18	16	0.42
203R00983	Strawberry Creek	6/6/2013	RMC_Creek Status	51	60	0.73
204SLO020	Sulphur Creek	4/21/2004	ACCWP	28	24	0.32
204SLO020	Sulphur Creek	5/2/2005	ACCWP	18	10	0.24
204R00383	Sulphur Creek	6/11/2012	RMC_Creek Status	6	1	0.17
203TEM090	Temescal Creek	4/12/2005	SFRWQCB	29	19	0.40
203TEM060	Temescal Creek	4/19/2005	SFRWQCB	15	6	0.19
204WRD020	Ward Creek	4/26/2005	ACCWP	15	19	0.33
204WRD030	Ward Creek	4/26/2005	ACCWP	18	6	0.32
204WRD020	Ward Creek	5/1/2006	ACCWP	31	20	0.55
204WRD030	Ward Creek	5/1/2006	ACCWP	22	17	0.52
204WRD020	Ward Creek	4/16/2007	ACCWP	25	23	0.60
204WRD030	Ward Creek	4/16/2007	ACCWP	20	19	0.59
204WRD040	Ward Creek North Fork	4/25/2005	ACCWP	22	23	0.48
204WRD050	Ward Creek North Fork	4/25/2005	ACCWP	25	32	0.43
204WRD060	Ward Creek North Fork	4/25/2005	ACCWP	12	24	0.45
204WRD040	Ward Creek North Fork	5/1/2006	ACCWP	29	21	0.63
204WRD050	Ward Creek North Fork	5/1/2006	ACCWP	30	24	0.63
204WRD060	Ward Creek North Fork	5/1/2006	ACCWP	29	34	0.70
204WRD040	Ward Creek North Fork	4/16/2007	ACCWP	26	20	0.59
204WRD050	Ward Creek North Fork	4/16/2007	ACCWP	38	30	0.72
204WRD060	Ward Creek North Fork	4/16/2007	ACCWP	52	56	0.75
204WRD070	Ward Creek South Fork	4/26/2005	ACCWP	31	26	0.37
204WRD080	Ward Creek South Fork	4/26/2005	ACCWP	32	23	0.37
204WRD090	Ward Creek South Fork	4/26/2005	ACCWP	19	24	0.38
204WRD070	Ward Creek South Fork	5/1/2006	ACCWP	26	20	0.58
204WRD080	Ward Creek South Fork	5/1/2006	ACCWP	26	17	0.58
204WRD090	Ward Creek South Fork	5/1/2006	ACCWP	24	34	0.68
204WRD070	Ward Creek South Fork	4/16/2007	ACCWP	32	27	0.63

Station Code	Creek	Sample Date	Project	NoCal IBI Score	SoCal IBI Score	CSCI Score
204WRD080	Ward Creek South Fork	4/16/2007	ACCWP	28	24	0.61
204WRD090	Ward Creek South Fork	4/16/2007	ACCWP	26	26	0.62
204R00367	Ward Creek South Fork	6/12/2012	RMC_Creek Status	39	53	0.68
204SLE170	WF Redwood Creek	5/2/2001	SFRWQCB	35	37	0.67
204SLE180	WF Redwood Creek	5/2/2001	SFRWQCB	69	77	0.80
204R00455	Zeile Creek	6/13/2012	RMC_Creek Status	28	29	0.74
204R00327	Zone 3A Line A-3	5/7/2013	RMC_Creek Status	1	6	0.20
204R00583	Zone 3A Line D	6/13/2012	RMC_Creek Status	14	9	0.20
205R00878	Zone 5 Line B	4/24/2013	RMC_Creek Status	11	6	0.18
205R00535	Zone 5 Line F-1	6/20/2012	RMC_Creek Status	10	10	0.36
204R00391	Zone 5 Line M	6/6/2012	RMC_Creek Status	21	19	0.50
205R00430	Zone 6 Line D	6/5/2012	RMC_Creek Status	12	14	0.53
205R01198	Zone 6 Line G	5/20/2013	RMC_Creek Status	19	11	0.36
205R01390	Zone 6 Line G	5/23/2013	RMC_Creek Status	4	0	0.25
205R00174	Zone 6 Line K	4/23/2013	RMC_Creek Status	12	14	0.54
204R00596	Zone 7 Line G-2	5/31/2012	RMC_Creek Status	1	0	0.42

CREEK STATUS MONITORING REPORT - REGIONAL PARAMETERS: Water Quality, Sediment Chemistry and Toxicity, Water Column Toxicity

Integrated Monitoring Report, Part A - Appendix A.2

Water Years 2012 and 2013 (October 1, 2011 – September 30, 2013)

Prepared for:

Alameda Countywide Clean Water Program

Contra Costa Clean Water Program

Fairfield Suisun Urban Runoff Management Program

City of Vallejo and Vallejo Sanitation and Flood Control District

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March 13, 2014

Acknowledgements

This report is derived from a portion of Appendix B to the Urban Creeks Monitoring Report (UCMR) for WY2012, prepared by EOA, Inc. and Armand Ruby Consulting (BASMAA 2013). Analyses contained herein derive in large part from the results and formats presented within the UCMR.

Preface

The Bay Area Stormwater Management Agencies Association (BASMAA) Regional Monitoring Coalition (RMC) collaboratively developed an outline for preparation of the Integrated Monitoring Report (IMR) to be submitted in compliance with the Municipal Regional Permit (MRP) Reporting Provision C.8.g.v for all monitoring conducted during the MRP permit term.

The following participants make up the RMC:

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

This report is a joint product funded by ACCWP, CCCWP, FSURMP, and Vallejo to fulfill reporting requirements for a portion of the Creek Status monitoring data collected in Water Years 2012 (October 1, 2011 through September 30, 2012) and 2013 (October 1, 2012 through September 30, 2013) through the RMC's probabilistic design for certain parameters monitored according to Provision C.8.c. This report is an Appendix to the full IMR submitted by each of the contributing Programs on behalf of their respective Permittees.

As described in the RMC Creek Status and Long-Term Trends Monitoring Plan (BASMAA 2011), RMC participants collected data by implementing Standard Operating Procedures (SOPs) in accordance with the Quality Assurance Program Plan (QAPP). Analytical laboratory analyses were also conducted under the direction of RMC participants. The quality of all data presented in this report, therefore, are assured by the RMC participants involved in their collection and management, and not the authors.

In addition to the RMC participants, San Francisco Bay Regional Water Quality Control Board staff, Kevin Lunde and Jan O'Hara, also participated in RMC workgroup meetings that contributed to design and implementation of the RMC Monitoring Plan. Additionally, these staff also provided input to the outline of the initial Urban Creeks Monitoring Report (BASMAA 2013) and threshold trigger analyses conducted herein.

List of Acronyms

ACCWP	Alameda Countywide Clean Water Program
AFDM	Ash Free Dry Mass
BASMAA	Bay Area Stormwater Management Agencies Association
B-IBI	Benthic Index of Biological Integrity
BMI	Benthic Macroinvertebrate
CCCWP	Contra Costa Clean Water Program
CDFW	California Department of Fish and Wildlife
CMC	Criteria Maximum Concentration
CTR	California Toxics Rule
DW	Dry Weight
DQO	Data Quality Objective
EDD	Electronic Data Deliverable
FSURMP	Fairfield Suisun Urban Runoff Management Program
GIS	Geographic Information System
GRTS	Generalized Random Tesselated Stratified
IBI	Index of Biological Integrity
LC50	Lethal Concentration to 50% of test organisms
LIMS	Laboratory Information Management System
MCL	Maximum Contaminant Level
MDL	Method Detection Limit
MPC	BASMAA Monitoring and Pollutants of Concern Committee
MQO	Measurement Quality Objective
MRP	Municipal Regional Permit
MS	Matrix Spike
MSD	Matrix Spike Duplicate
ND	Non-Detect
NorCal B-IBI	Northern California Benthic Index of Biological Integrity
NPDES	National Pollutant Discharge Elimination System
NT	Non-Target
PAH	Polycyclic aromatic hydrocarbon
PEC	Probable Effect Concentration
PHab	Physical Habitat Assessment
POC	Pollutant of Concern
PRM	Pathogen-Related Mortality
PSA	Perennial Streams Assessment
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
RL	Reporting Limit
RMC	Regional Monitoring Coalition
RMP	Regional Monitoring Program
RPD	Relative Percent Difference
RWB	Reach-Wide Benthos
RWQCB	Regional Water Quality Control Board
SCCWRP	Southern California Coastal Water Research Project

SFRWQCB	San Francisco Regional Water Quality Control Board
SMC	Southern California Stormwater Monitoring Coalition
SoCal B-IBI	Southern California Benthic Index of Biological Integrity
SOP	Standard Operating Procedure
STLS	Small Tributaries Loading Strategy
SWAMP	Surface Water Ambient Monitoring Program
TEC	Threshold Effect Concentration
TKN	Total Kjeldahl Nitrogen
TNS	Target Not Sampled
TOC	Total Organic Carbon
TS	Target Sampled
U	Unknown
USEPA	United States Environmental Protection Agency
TU	Toxicity Unit
WQ	Water Quality
WY	Water Year

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Executive Summary

The Integrated Monitoring Report (IMR) Part A reports monitoring data collected through implementation of the Regional Monitoring Coalition (RMC) during Water Years (WYs) 2012 (October 1, 2011 - September 30, 2012) and 2013 (October 1, 2012 – September 30, 2013). This Appendix A.2 presents the results for portions of creek status monitoring conducted by a subset of the RMC Programs for data collected using a probabilistic monitoring design used by all RMC participants. The RMC was formed by members of the Bay Area Stormwater Management Agencies Association (BASMAA) to assist member agencies in fulfilling requirements of Provision C.8 of the Municipal Regional Stormwater National Pollutant Discharge Elimination System Permit (MRP; SFBRWQCB 2009). Certain creek status monitoring parameters were addressed on a regional basis using the probabilistic design and are included in this report for the four Programs contributing to its development (ACCWP, CCCWP, FSURMP, and Vallejo).

Other parameters were addressed using a targeted design, with regional coordination and common methodologies. These parameters, along with the Bioassessment and physical habitat parameters addressed through the regional design, are reported in separate appendices or portions of the IMR Part A prepared individually by each RMC participating program.

During WY 2012, 60 sites were monitored by all RMC member agencies under the probabilistic design for bioassessment, physical habitat, and related water chemistry parameters, including 30 by two programs contributing to this joint report (ACCWP and CCCWP). Ten of the 60 sites were also monitored for water and sediment toxicity and sediment chemistry, including 5 sites monitored by ACCWP and CCCWP. During WY 2013, an additional 70 sites were monitored by all RMC member agencies, including 40 by the four contributing programs. Of these 40 sites, ten were monitored for water and sediment toxicity and sediment chemistry, with an additional two sites monitored for water and sediment toxicity and/or sediment chemistry, but not bioassessment.

The water and sediment chemistry and toxicity data were used to evaluate potential stressors that may affect aquatic habitat quality and beneficial uses. Each program also used bioassessment and related data to develop a preliminary condition assessment for the monitored sites, to be used in conjuction with the stressor assessment based on sediment chemistry and toxicity. The probabilistic design requires at least three years to produce sufficient data to develop a statistically-robust characterization of regional creek conditions, so the analysis and interpretation that can be completed with the first two years of data are necessarily limited.

The following MRP reporting requirements (per Provision C.8.g.iv) are addressed within this report or other portions of the IMR, as applicable:

- Descriptions of monitoring purpose and study design rationale
- QA/QC summaries for sample collection and analytical methods, including a discussion of any limitations of the data;
- Descriptions of sampling protocols and analytical methods;
- Tables and Figures describing: Sample location descriptions (including waterbody names, and lat/longs); sample ID, collection date (and time where relevant), media (e.g., water, filtered water, bed sediment, tissue); concentrations detected, measurement units, and detection limits;
- Data assessment, analysis, and interpretation for Provision C.8.c.;

- Pollutant load and concentration at each mass emissions station;
- A listing of volunteer and other non-Permittee entities whose data are included in the report;
- Assessment of compliance with applicable water quality standards; and
- A signed certification statement.

Findings associated with bioassessment biotic and habitat parameters are contained within Appendix A.1.

The stressor analysis revealed the following potential stressors, based on an analysis of the first two years of RMC data for ACCWP and CCCWP, and initial year of monitoring data for FSURMP and Vallejo.

- **Nutrients (and Conventional Constituents):** The MRP Table 8.1 trigger criterion for "Nutrients" (20% of results in one waterbody exceed one or more water quality standards or applicable thresholds) was considered to be met at only three of the 68 monitoring sites.
- **Water Toxicity:** Of the ten wet and dry season samples collected in 2012, not including retests, three water samples exhibited results "< 50% of Control" and therefore were resampled and retested in WY2013, per MRP Table 8.1. Following the retesting, two of the sites again exhibited significant toxicity at levels meeting MRP Table 8.1 trigger criteria.

  In 2013, two of fourteen samples collected in wet and dry season exhibited results meeting MRP Table 8.1 trigger criteria.
- **Sediment Toxicity:** Of the twelve samples collected cumulatively in WY2012 and WY2013, sediment toxicity results were more than 20% less than the control[1] in five samples, meeting the MRP Table 8.1 trigger criterion.
- **Sediment Chemistry:** Sediment chemistry results produced evidence of potential stressors in three ways, based on the criteria from MRP Table H-1:
  - At ten of twelve sites, three or more constituents had TEC quotients greater than or equal to 1.0.
  - At one of twelve sites, the mean PEC quotient was greater than 0.5.
  - At eight of twelve sites, the sum of TU equivalents for all measured pyrethroids was greater than 1.0.

The results of the above analyses are used in conjunction with related bioassessment data and condition assessments to address the management questions underlying the RMC design (BASMAA 2011). The trigger analysis identified a number of sites that may deserve further investigation to provide better understanding of the sources/stressors likely contributing to reduce ecological condition in Bay Area creeks.

[1]See body of report for RMC interpretation of MRP trigger criteria.

1.0 Introduction

This report fulfills a portion of the reporting requirements of Provision C.8.g.v of the Bay Area Municipal Regional Stormwater National Pollutant Discharge Elimination System Permit (MRP; SFBRWQCB 2009) for creek status monitoring data produced pursuant to MRP Provision C.8.c during Water Years (WYs) 2012 and 2013 (October 1, 2011 - September 30, 2013) under a regional probabilistic design. The regional probabilistic design was developed and implemented by the Bay Area Stormwater Management Agencies Association (BASMAA) Regional Monitoring Coalition (RMC). Provision C.8.c data collected at targeted sites (not included in the probabilistic design) are reported in separate "local" reports developed by RMC participants and submitted separately.

The RMC was formed in early 2010 as a collaboration among several BASMAA members and all MRP Permittees (Table 1-1) to focus on development and implementation of a regionally-coordinated water quality monitoring program. The intent of the regional monitoring effort is to improve stormwater management in the region and address water quality monitoring required by the MRP[2]. Through its implementation, the RMC allows Permittees and the San Francisco Regional Water Quality Control Board (SF Bay RWQCB) to effectively modify their previous creek monitoring programs and improve their collective ability to answer core management questions in a cost-effective and scientifically rigorous way. Participation in the RMC is coordinated by county stormwater programs and or Permittee representatives (or equivalent), and facilitated through the BASMAA Monitoring and Pollutants of Concern Committee (MPC). The RMC Work Group is a subgroup of the MPC that meets and communicates regularly to coordinate planning and implementation of monitoring-related activities. This workgroup includes staff from the SF Bay RWQCB at two levels – those generally engaged with the MRP as well as those working regionally with the State of California's Surface Water Ambient Monitoring Program (SWAMP).

[2]The San Francisco Bay Regional Water Quality Control Board (SFRWQCB) issued the five-year MRP to 76 cities, counties and flood control districts (i.e., Permittees) in the Bay Area on October 14, 2009 (SFRWQCB 2009). The BASMAA programs supporting MRP Regional Projects include all MRP Permittees as well as the cities of Antioch, Brentwood, and Oakley, which are not named as Permittees under the MRP but have voluntarily elected to participate in MRP-related regional activities. Note that the RMC regional monitoring design was expanded to include the portion of eastern Contra Costa County that drains to the San Francisco Bay in order to assist the CCCWP in fulfilling parallel provisions in their NPDES permit from the Region 5 SF Bay RWQCB.

Table 1-1. Regional Monitoring Coalition Participants.

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

The goals of the RMC are to:

1. Assist Permittees[3] in complying with requirements in MRP Provision C.8 (Water Quality Monitoring);
2. Develop and implement regionally consistent creek monitoring approaches and designs in the San Francisco Bay Area, through the improved coordination among RMC participants, SF Bay RWQCB[4] and other agencies with common goals; and
3. Stabilize the costs of creek monitoring by reducing duplication of effort and streamlining monitoring-related activities.

The RMC addresses the scope of subprovisions specified in MRP Provision C.8 (Table 1-2). This report is a joint product developed by four of the RMC programs (ACCWP, CCCWP, FSURMP, and Vallejo) to present and discuss some of the results of Creek Status Monitoring that were conducted using a regional ambient (probabilistic) monitoring design to comply with Provision C.8.c (Table 1-3). The list of parameters in Table 1-3 derive from the MRP Table 8-1 (SFBRWQCB 2009; BASMAA 2012a, 2012b).

[3]For the CCCWP this includes addressing the eastern portion of Contra Costa County that drains to the San Francisco Bay that is within the jurisdiction of the Region 5 Regional Water Quality Control Board.

[4]The intent is to coordinate with SF Bay RWQCB staff working regionally with the State of California's Surface Water Ambient Monitoring Program (SWAMP).

Table 1-2. Municipal Regional Permit Provisions addressed by the Integrated Monitoring Report.

Subprovision	Subprovision Title	Reporting Document
C.8.a	Compliance Options	• Regional Monitoring Coalition Creek Status & Long-Term Trends Monitoring Plan (BASMAA 2011)
C.8.b	San Francisco Bay Estuary Monitoring	• Regional Monitoring Program Annual Monitoring Results (www.sfei/rmp.org)
C.8.c	**Creek Status Monitoring**	• Integrated Monitoring Report, Part A (main body) • IMR Part A, Appendices (see index of Appendices in main body)
C.8.d	Monitoring Projects	See index of Appendices in main body of IMR Part A, if applicable
	• Stressor/Source Identification	• Stressor/Source Identification Reports (if applicable)
	• BMP Effectiveness Investigation	• BMP Effectiveness Reports (if applicable)
	• Geomorphic Project	• Geomorphic Project.Report (if applicable)
C.8.e	Pollutants of Concern (Loads) and Long-Term Trends Monitoring	• Pollutants of concern (POC) loads monitoring data progress report, Water Years 2012 and 2013 (see index of Appendices in main body)
C.8.f	Citizen Monitoring and Participation	• Integrated Monitoring Report, Part A (main body)
C.8.g	Data Analysis and Reporting	• Integrated Monitoring Report, Part A (main body) • IMR Part A, Appendices (see index of Appendices in main body)

Table 1-3. Creek Status Monitoring Parameters sampled in compliance with MRP Provision C.8.c. and the associated reporting format. A subset of Regfional parameters are reported jointly for both WYs in this report.

Biological Response and Stressor Indicators	Monitoring Design		Reporting	
	Regional Ambient (Probabilistic)	Local (Targeted)	Regional WY12 (joint WY13)	Local
Bioassessment & Physical Habitat Assessment	X		X	(WY2013)
Chlorine	X		X (X)	
Nutrients	X		X (X)	
Water Toxicity	X		X (X)	
Sediment Toxicity	X		X (X)	
Sediment Chemistry	X		X (X)	
General Water Quality		X		X
Temperature		X		X
Bacteria		X		X
Stream Survey		X		X

Data presented in this report were collected between October 1, 2011 and September 30, 2013, referred to hereafter as Water Years 2012 and 2013.

Prior to formation of the RMC, San Francisco Bay Area stormwater programs implemented monitoring designs that targeted creek reaches of interest to address site-specific management questions. Because the representativeness of such targeted data was unknown, the overall condition of all creek reaches in the Bay Area was also unknown. The RMC addressed this issue by augmenting targeted monitoring designs with an ambient (probabilistic) creek status design that integrates many elements of the individualized monitoring programs that currently exist in the region.

The probabilistic monitoring design described in subsequent sections of this report complies with MRP Provision C.8.c[5] by addressing the core monitoring questions listed below, which are further elaborated upon later in this report and in the main IMR. This monitoring design allow each individual RMC participating program to assess stream ecosystem conditions within its program area (e.g., county boundary) while contributing data to answer regional management questions about water quality and beneficial use condition in San Francisco Bay Area creeks.

1. What is the condition of aquatic life in creeks in the San Francisco Bay Area; are water quality objectives met and are beneficial uses supported?
2. What are the major stressors[6] to aquatic life?
3. What are the long-term trends in water quality in creeks over time?

The remainder of this report addresses Study Area and Monitoring Design (Section 2.0), data collection and analysis methods (Section 3.0), results and data interpretation (Section 4.0), and conclusions and Next Steps (Section 5.0). More specifically, this report includes the standard report content as required by MRP Provision C.8.g.v in the respective sections referenced in Table 1-4. Additional details or discussion may also be found in other Appendices or in the main IMR Part A.

Table 1-4. Index to Standard Report Content per MRP Provision C.8.g.vi.

Report Section	Standard Report Content
2.0	Monitoring purpose and study design rationale
3.0	Sampling protocols and analytical methods
3.5	QA/QC summaries for sample collection and analytical methods
2.1	Sample location descriptions, sample dates, IDs
4.0	Sample concentrations detected, measurement units, detection limits
4.0	Data assessment, analysis and interpretation
See Main IMR Part A[7]	List of volunteer and other non-Permittee entities whose data are included in the report.
5.0	Assessment of compliance with applicable water quality standards

[5]The MRP states that Provision C.8.c status monitoring is intended to answer the following questions: "Are water quality objectives, both numeric and narrative, being met in local receiving waters, including creeks, rivers and tributaries?"; "Are conditions in local receiving waters supportive of or likely to be supportive of beneficial uses?". The management questions described in this plan are intended to answer the questions posed in the MRP.

[6]Stressors are interpreted per MRP Table 8-1 (SFBRWQCB 2009) as results that "trigger" action based upon comparison with an identified threshold.

[7]Data collected by the San Francisco Regional Water Quality Control Board are not included in this report.

2.0 Study Area and Monitoring Design

2.1 RMC Area

Status and trends monitoring was conducted in non-tidally influenced, flowing water bodies (i.e., creeks, streams and rivers) interspersed among 3,407 square miles of land in the RMC area. The water bodies monitored were drawn from a master list that included all perennial and non-perennial creeks and rivers that run through urban and non-urban areas within the portions of the five participating counties that fall within the SF Bay RWQCB boundary, and the eastern portion of Contra Costa County that drains to the Central Valley Regional Board (Figure 2-1). A total of 60 sites were sampled in 2012 by RMC participants, with another 70 sites sampled in 2013. Of these, data from 30 sites monitored in 2012 (Table 2-1) and 40 sites in 2013 (Table 2-2) by the four contributing Programs are included within the analysis for this report.

2.2 Regional Monitoring Design

In 2011, the RMC developed a regional probabilistic monitoring design to identify ambient conditions of creeks in the five main counties subject to the requirements of the MRP (SFBRWQCB 2009). The regional design was developed using the Generalized Random Tessellation Stratified (GRTS) approach developed by the United States Environmental Protection Agency (USEPA) and Oregon State University (Stevens and Olson 2004). GRTS offers multiple benefits for coordinating amongst monitoring entities including the ability to develop a spatially balanced design that produces statistically representative data with known confidence intervals. The GRTS approach has been implemented recently in California by several agencies including the statewide Perennial Streams Assessment (PSA) conducted by SWAMP (Ode et al. 2011) and the Southern California Stormwater Monitoring Coalition's (SMC) regional monitoring program conducted by municipal stormwater programs in Southern California (SMC 2007). For the purpose of developing the RMC's probabilistic design, the RMC area is considered to represent the "sample universe".

2.2.1 Site Selection

Sample sites were selected and attributed using the GRTS approach from a sample frame consisting of a creek network geographic information system (GIS) data set within the RMC boundary[8] (BASMAA 2011). This approach was agreed to by SF Bay RWQCB staff during RMC workgroup meetings although it differs from that specified in MRP Provision C.8.c.iv., e.g., sampling on the basis of individual watersheds in rotation and selecting sites to characterize segments of a waterbody(s). The sample frame includes non-tidally influenced perennial and non-perennial creeks within five management units representing areas managed by the storm water programs associated with the RMC. The sample frame was stratified by management unit to ensure that MRP Provision C.8.c sample size requirements (SFBRWQCB 2009) would be achieved.

The National Hydrography Plus Dataset (1:100,000) was selected as the creek network data layer to provide consistency with both the Statewide PSA and the SMC, and the opportunity for future data coordination with these programs. The RMC sample frame was classified by county and land use (i.e., urban and non-urban) to allow for comparisons between these strata. Urban areas were delineated by

[8]Based on discussion during RMC Workgroup meetings, with SF Bay RWQCB staff present, the sample frame was extended to include the portion of Eastern Contra Costa County that drains to the San Francisco Bay in order to address parallel provisions in CCCWP's Region 5 Permit for Eastern Contra Costa County. Reporting on data collected for that permit, other than those collected via the RMC, however, is outside the scope of this report.

combining urban area boundaries and city boundaries defined by the U.S. Census (2000). Non-urban areas were defined as the remainder of the areas within the sample universe (i.e., RMC area). Based on discussion during RMC Workgroup meetings, with SF Bay RWQCB staff present, RMC participants weighted their sampling efforts so that annual sampling efforts are approximately 80% in urban areas and 20% in non-urban areas for the purpose of comparison (Figures 2-2 to 2-4). RMC participants coordinated with the SF Bay RWQCB by identifying additional non-urban sites from their respective counties for SWAMP sampling.

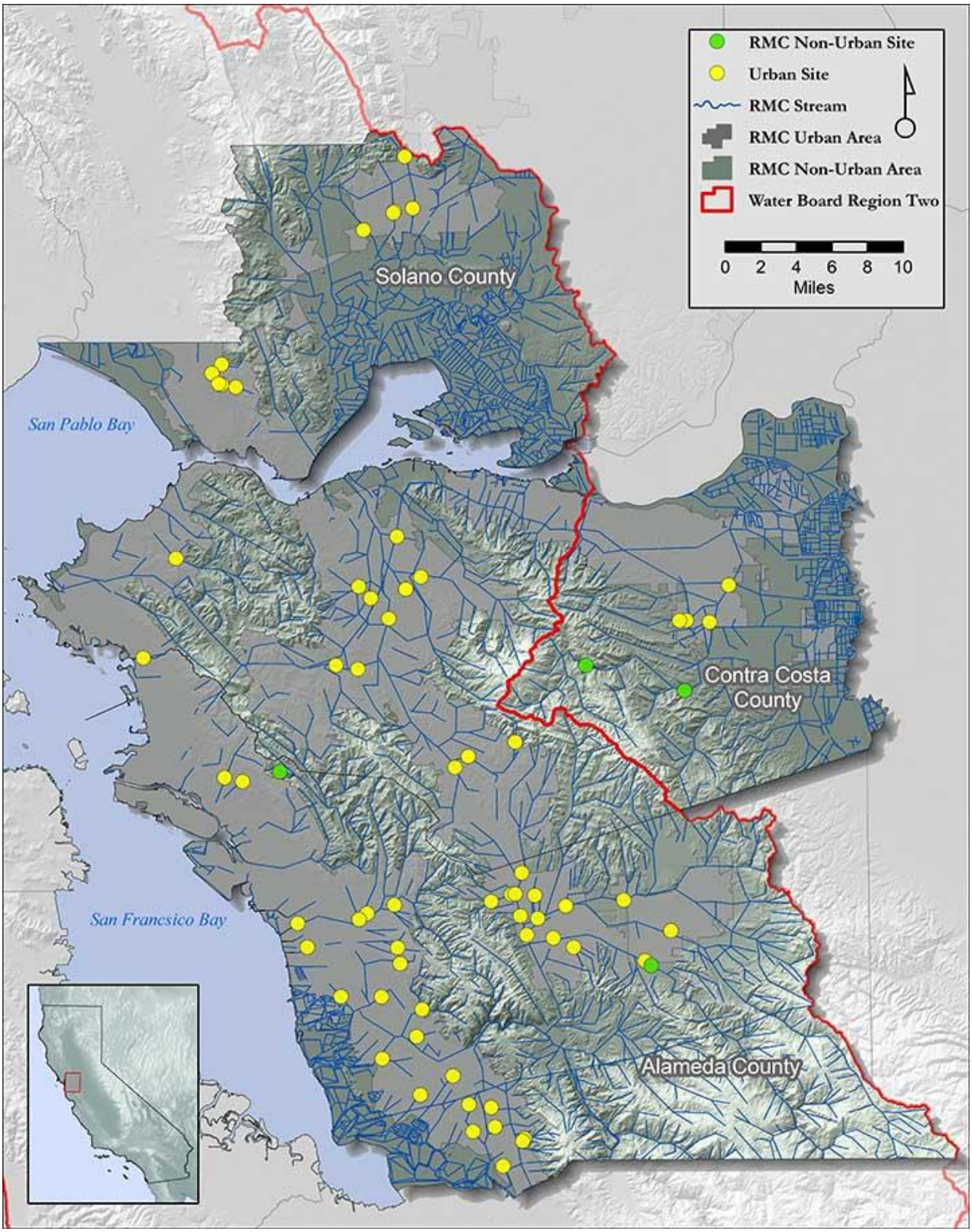

Figure 2-1. BASMAA RMC area, creeks included in the RMC probabilistic monitoring design, and the sites sampled in Water Years 2012 and 2013 by the Programs contributing to this report.

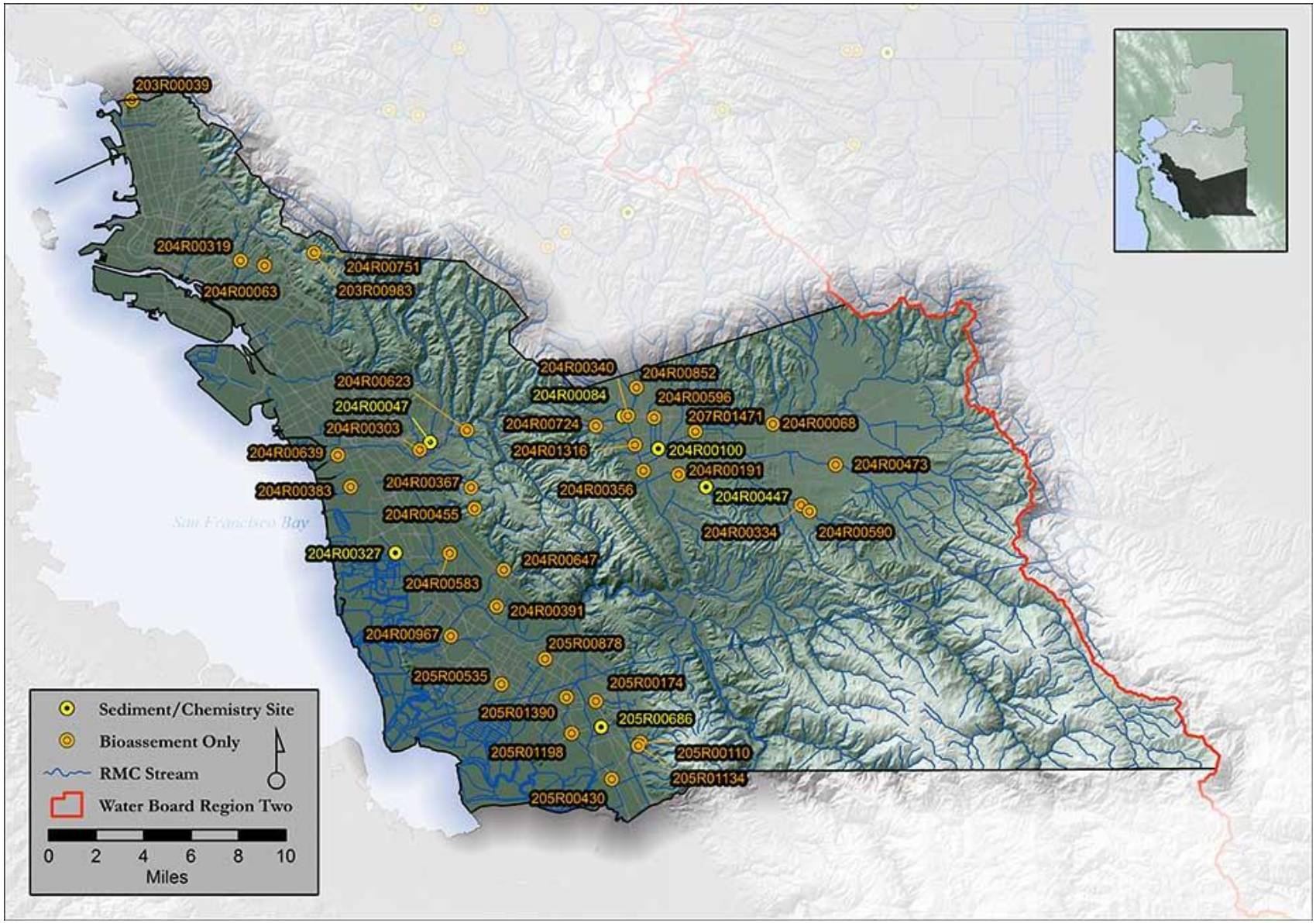

Figure 2-2. Alameda County sites sampled from the RMC probabilistic monitoring design in Water Years 2012 and 2013.

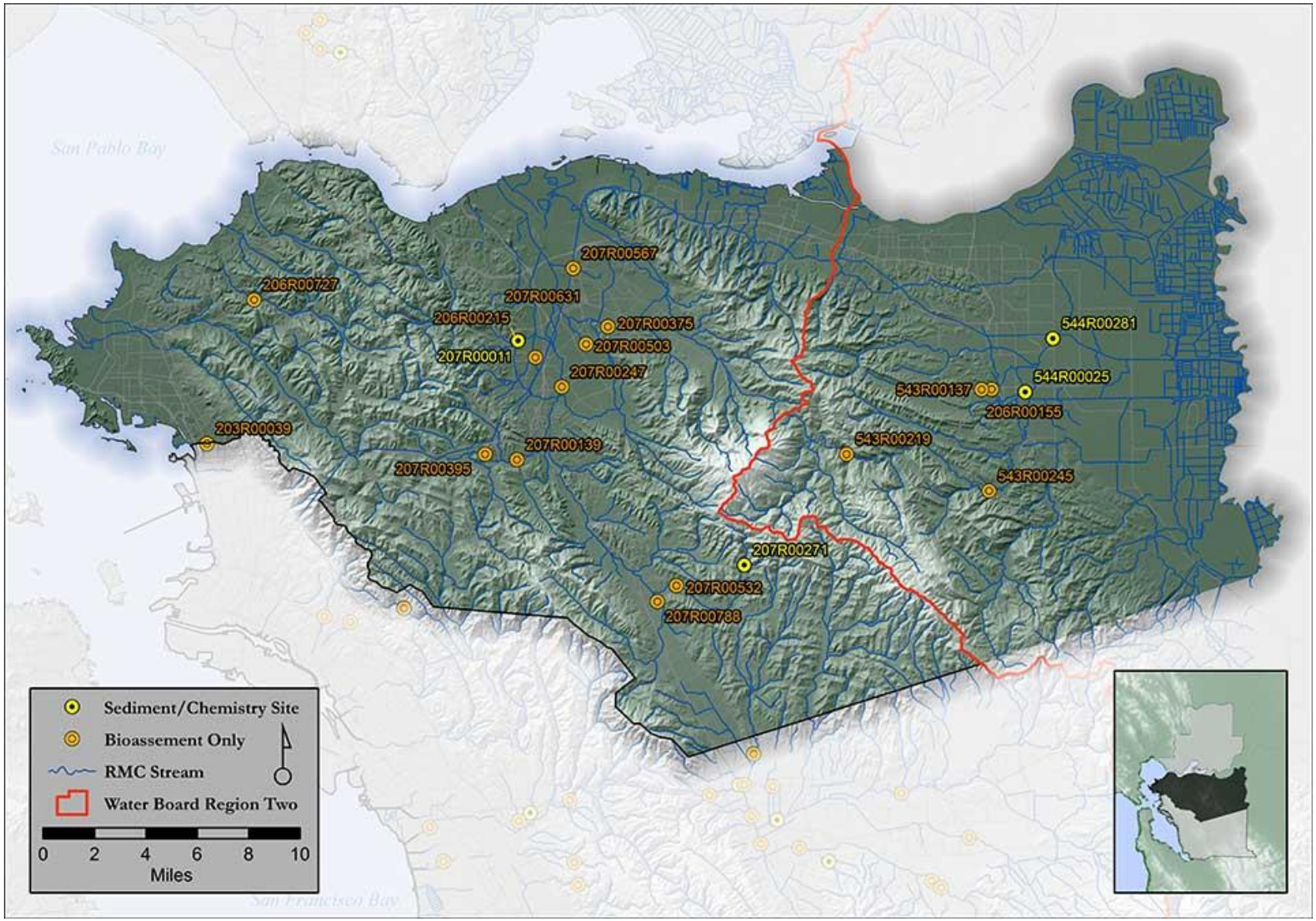

Figure 2-3. Contra Costa County sites sampled from the RMC probabilistic monitoring design in Water Years 2012 and 2013.

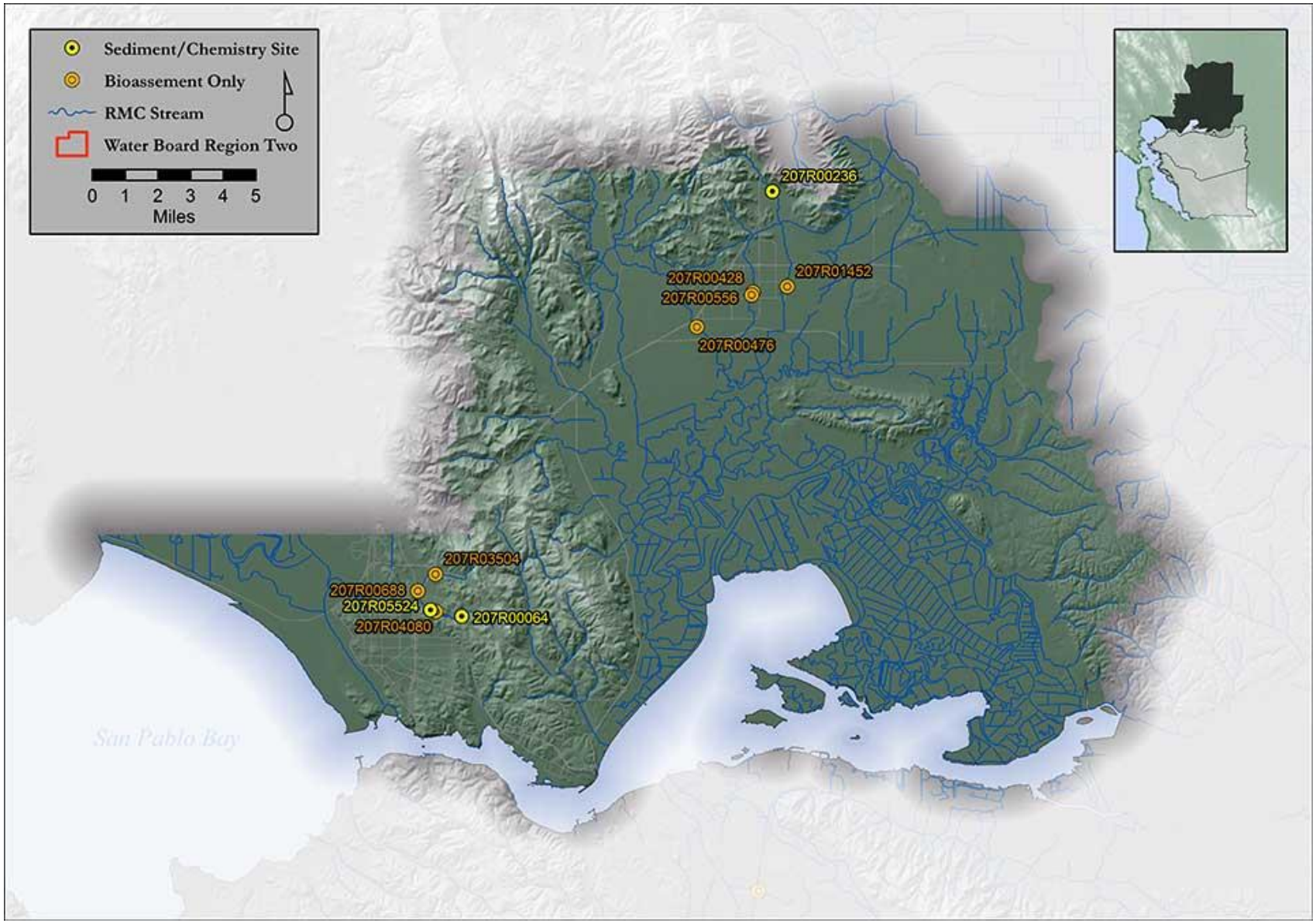

Figure 2-4. Solano County sites sampled from the RMC probabilistic monitoring design by FSURMP and Vallejo in WY 2013.

Table 2-1. Parameters sampled at sites from the RMC Probabilistic Monitoring Design in Water Year 2012 by sampling agency. Water toxicity sampled on 3/17/12 and 7/25/12; sediment toxicity and chemistry sampled on 7/25/12. FSURMP and Vallejo did not initiate RMC monitoring activities until WY2013.

Site ID	Creek Name	Land Use	Latitude	Longitude	Bioassessment, PHab, Chlorine, Nutrients	Water & Sediment Toxicity, Sediment Chemistry	Initial Sampling Date	Sampling Agency
204R00047	Castro Valley Creek	Urban	37.68826	-122.07257	x	x	6/6/2012	ACCWP
204R00068	Collier Channel, Line 7-M	Urban	37.69908	-121.80891	x		5/31/2012	ACCWP
204R00084	Dublin Creek	Urban	37.70104	-121.92542	x	x	5/24/2012	ACCWP
204R00100	Arroyo Mocho	Urban	37.68280	-121.89625	x	x	5/30/2012	ACCWP
204R00191	Arroyo del Valle	Urban	37.66584	-121.87840	x		5/29/2012	ACCWP
204R00303	Chabot Creek	Urban	37.68421	-122.08200	x		6/14/2012	ACCWP
204R00319	Sausal Creek	Urban	37.79923	-122.21818	x		6/7/2012	ACCWP
204R00340	Big Canyon Creek, Line 7-J-1	Urban	37.70218	-121.92074	x		6/11/2012	ACCWP
204R00356	Arroyo de la Laguna	Urban	37.66873	-121.90920	x		6/4/2012	ACCWP
204R00367	Ward Creek	Urban	37.65957	-122.04172	x		6/12/2012	ACCWP
204R00383	Sulphur Creek	Urban	37.65909	-122.13676	x		6/11/2012	ACCWP
204R00391	Line5-M	Urban	37.58682	-122.02358	x		6/6/2012	ACCWP
204R00455	Zeile Creek	Urban	37.64676	-122.03931	x		6/13/2012	ACCWP
204R00583	Line 3A-D	Urban	37.61906	-122.05928	x		6/13/2012	ACCWP
204R00596	Line 7-G-2	Urban	37.70094	-121.90154	x		5/31/2012	ACCWP
204R00639	San Lorenzo Creek	Urban	37.68151	-122.14437	x		6/19/2012	ACCWP
204R00647	Dry Creek	Urban	37.60965	-122.01750	x		6/18/2012	ACCWP
205R00110	Agua Caliente	Urban	37.50273	-121.91225	x		6/18/2012	ACCWP
205R00430	Line 6-D	Urban	37.48229	-121.93782	x		6/5/2012	ACCWP
205R00535	Line 5-F-1	Urban	37.53942	-122.01980	x		6/19/2012	ACCWP
203R00039	Cerrito Creek	Urban	37.89802	-122.30027	x		5/14/2012	CCCWP
206R00155	San Pablo Creek	Urban	37.92408	-121.74088	x		5/16/2012	CCCWP
206R00215	San Pablo Creek	Urban	37.95477	-122.07821	x		5/23/2012	CCCWP
207R00011	Grayson Creek	Urban	37.95485	-122.07829	x	x	5/22/2012	CCCWP
207R00139	Las Trampas Creek	Urban	37.88742	-122.07995	x		5/17/2012	CCCWP
207R00247	Walnut Creek	Urban	37.92833	-122.04745	x		5/22/2012	CCCWP
543R00137	Deer Creek	Urban	37.92408	-121.74807	x		5/15/2012	CCCWP
543R00219	Marsh Creek	Nonurban	37.88654	-121.84347	x		5/21/2012	CCCWP
543R00245	Marsh Creek	Nonurban	37.86732	-121.74947	x		5/21/2012	CCCWP
544R00025	Dry Creek	Urban	37.92611	-121.71722	x	x	5/15/2012	CCCWP

Table 2-2. Parameters sampled at sites from the RMC Probabilistic Monitoring Design in Water Year 2013 by sampling agency. Wet season water toxicity was sampled on 3/5/13 and 3/6/13 (ACCWP), 3/6/13 and 4/4/13 (CCCWP), and 3/20/13 (FSURMP and Vallejo). Dry season water toxicity was sampled on 7/9/13 (ACCWP and CCCWP), 7/11/13 (FSURMP and Vallejo). Sediment toxicity and chemistry and dry season chlorine were sampled 7/9/13 (ACCWP and CCCWP), 7/11/13 (FSURMP), and 7/18/13 (Vallejo).

Site ID	Creek Name	Land Use	Latitude	Longitude	Bioassessment, PHab, Chlorine, Nutrients	Water & Sediment Toxicity, Sediment Chemistry	Initial Sampling Date	Sampling Agency
204R00447	Kottinger Creek	Urban	37.65844	-121.86108	x	x	4/22/13	ACCWP
205R00174	Line 6-K	Urban	37.52816	-121.94772	x		4/23/13	ACCWP
205R00686	Canada Del Aliso	Urban	37.51243	-121.94393	x	x	4/24/13	ACCWP
205R00878	Zone 5 Line B	Urban	37.5544	-121.98651	x		4/24/13	ACCWP
204R00967	Crandall Creek	Urban	37.56895	-122.05885	x		4/25/13	ACCWP
204R00852	Alamo Creek	Urban	37.71961	-121.91376	x		5/6/13	ACCWP
204R00327	Line 3A-A-3	Urban	37.62009	-122.10072	x	x	5/7/13	ACCWP
204R00334	Arroyo Valle	Urban	37.64659	-121.78812	x		5/8/13	ACCWP
204R00590	Arroyo Valle	Nonurban	37.64266	-121.78169	x		5/8/13	ACCWP
204R00473	Arroyo Mocho	Urban	37.67085	-121.76115	x		5/9/13	ACCWP
205R01134	Agua Caliente	Urban	37.50063	-121.91567	x		5/20/13	ACCWP
205R01198	Zone 6 Line G	Urban	37.50878	-121.9666	x		5/20/13	ACCWP
204R00724	Dublin Creek	Urban	37.69649	-121.94548	x		5/21/13	ACCWP
204R01316	Arroyo de la Laguna	Urban	37.68452	-121.91557	x		5/22/13	ACCWP
205R01390	Zone 6 Line G	Urban	37.53087	-121.97042	x		5/23/13	ACCWP
204R00623	San Lorenzo Creek	Urban	37.69461	-122.04478	x		6/3/13	ACCWP
204R00063	Peralta Creek	Urban	37.79651	-122.19966	x		6/4/13	ACCWP
204R00751	Redwood Canyon Creek	Nonurban	37.80408	-122.16134	x		6/5/13	ACCWP
203R00983	Strawberry Creek	Nonurban	37.80404	-122.16136	x		6/6/13	ACCWP
204R01471	Arroyo Mocho	Urban	37.96222	-121.86892	x		5/22/13	ACCWP
206R00727	Pinole Creek	Urban	37.97913	-122.26646	x		5/13/13	CCCWP
207R00271	Sycamore Creek	Urban	37.82651	-121.91876	x	X	4/29/13	CCCWP
207R00375	Galindo Creek	Urban	37.96209	-122.01407	x		5/1/13	CCCWP
207R00395	Las Trampas Creek	Urban	37.89066	-122.10258	x		5/14/13	CCCWP
207R00503	Pine Creek	Urban	37.95234	-122.02984	x		5/2/13	CCCWP
207R00532	Tributary, Sycamore Creek	Urban	37.81527	-121.96726	x		4/29/13	CCCWP
207R00567	Walnut Creek	Urban	37.99528	-122.03836	x		4/30/13	CCCWP
207R00631	Grayson Creek	Urban	37.94515	-122.06595	x		5/16/13	CCCWP
207R00788	San Ramon Creek	Urban	37.80643	-121.98093	x		5/15/13	CCCWP
544R00281	Marsh Creek	Urban	37.95238	-121.69678	x	x	5/15/13	CCCWP
207R00236	Laurel Creek	Urban	38.30557	-122.02620		x	3/20/2013	FSURMP
207R00428	Union Ave. Creek	Urban	38.26096	-122.03772	x		5/21/2013	FSURMP

Site ID	Creek Name	Land Use	Latitude	Longitude	Bioassessment, PHab, Chlorine, Nutrients	Water & Sediment Toxicity, Sediment Chemistry	Initial Sampling Date	Sampling Agency
207R00476	Ledgewood Creek	Urban	38.24580	-122.06958	x		5/23/2013	FSURMP
207R00556	Union Ave. Creek	Urban	38.25963	-122.03854	x		5/15/2013	FSURMP
207R01452	Laurel Creek	Urban	38.26325	-122.01848	x		5/28/2013	FSURMP
207R00064	Blue Rock Springs Creek	Urban	38.11852	-122.20327	x	X*	5/28/2013	Vallejo
207R03504	Rindler Creek	Urban	38.13726	-122.21778	x		5/29/2013	Vallejo
207R00688	Blue Rock Springs Creek	Urban	38.12988	-122.22782	x		5/29/2013	Vallejo
207R04080	Blue Rock Springs Creek	Urban	38.12072	-122.21785	x		5/30/2013	Vallejo
207R05524	Blue Rock Springs Creek	Urban	38.12146	-122.22083		X*	7/18/2013	Vallejo

* Site 207R00064 had insufficient sediment to conduct sediment toxicity testing; sediment was thus collected from site 207R05524 the following week and analyzed for sediment chemistry and toxicity.

2.2.2 Management Questions

The RMC regional monitoring design was developed to address the management questions listed below. Those appearing in bolded font are addressed in this report in a preliminary manner. Those in normal font could not be addressed at this time due to the limited sample size available from the initial two years of monitoring, but can be answered in future years once sample sizes increase. Table 2-3 illustrates the length of time that would be required to establish statistically representative sample sizes for each of the classified strata in the regional monitoring design, estimated for continuation of the present rate of annual bioassessment sampling.

1. **What is the condition of aquatic life in creeks in the RMC area; are water quality objectives met and are beneficial uses supported?**
    a. **What is the condition of aquatic life in the urbanized portion of the RMC area; are water quality objectives met and are beneficial uses supported?**
    b. What is the condition of aquatic life in RMC participant counties; are water quality objectives met and are beneficial uses supported?
    c. **To what extent does the condition of aquatic life in urban and non-urban creeks differ in the RMC area?**
    d. To what extent does the condition of aquatic life in urban and non-urban creeks differ in each of the RMC participating counties?
2. **What are major stressors to aquatic life in the RMC area?**
    a. **What are major stressors to aquatic life in the urbanized portion of the RMC area?**
3. What are the long-term trends in water quality in creeks over time?

Table 2-3. Cumulative numbers of bioassessment samples per monitoring year according to RMC design; shaded cells indicate when a minimum sample size may be available to develop a statistically representative data set to address management questions related to condition of aquatic life.

Monitoring Year	**RMC Area** (Region-wide)		**Santa Clara County**		**Alameda County**		**Contra Costa County**		**San Mateo County**		**Fairfield, Suisun City and Vallejo** [b]	
Land Use	*Urban*	*Non-Urban*	*Urban*	*Non-Urban*	*Urban*	*Non-Urban*	*Urban*	*Non-Urban*	*Urban*	*Non-Urban*	*Urban*	*Non-Urban*
Year 1 (WY 012)	**48**	22	16	6	16	6	8	4	8	4	0	2
Year 2 (WY2013)	**100**	**44**	**32**	12	**32**	12	16	8	16	8	8	0
Year 3[c] (WY2014)	**156**	**66**	**48**	18	**48**	18	24	12	24	12	12	6
Year 4 (WY2015)	**204**	**88**	**64**	24	**64**	24	**32**	16	**32**	16	12	8
Year 5 (WY2016)	**256**	**110**	**80**	**30**	**80**	**30**	**40**	20	**40**	20	16	10

[a] Assumes San Francisco Bay RWQCB will continue WY2012-13 sample effort of two non-urban sites annually in each RMC County
[b] Assumes: FSURMP and Vallejo only monitor urban sites; FSURMP monitors 4 sites in Year 2, 3 and 5; and Vallejo monitors 4 sites in Year 3.
[c] Final year of monitoring under the MRP 5-Year Permit.

2.3 Monitoring Design Implementation

Sampling was conducted in accordance with the RMC Multi-year Monitoring Plan (BASMAA 2011). The sampling plan (Table 2-3) illustrates the total number of sites that each RMC Permittee[9] plans to sample within the MRP term (SFBRWQCB 2009). It also illustrates the number of sampling years required to establish statistically representative samples for each strata (e.g., management unit and urban or non-urban land use) included in the regional monitoring design. A target of at least 80% of the sites sampled annually by RMC participants are in urban[10] areas with up to 20% in non-urban areas. Due to unforeseen field circumstances, however, this percentage may vary by year. For example, some sites may not be sampleable due to seasonal drying and/or access issues, thereby altering the relative proportion of urban-to-nonurban sites sampled in a given year (Table 2-4). Such outcomes can be addressed in subsequent sampling years by adjusting the relative proportion of urban and non-urban sites, or while conducting regional statistical analyses by adjusting the number of sites considered from each stratum to the desired proportions.

Table 2-4. Number of Bioassessment sites sampled by contributing Programs in Water Years 2012 and 2013 by land use and county.

Monitoring Year	**Alameda County**		**Contra Costa County**		**FSURMP**		**Vallejo**	
Land Use	*Urban*	*Non-Urban*	*Urban*	*Non-Urban*	*Urban*	*Non-Urban*	*Urban*	*Non-Urban*
WY2012	20	0	8	2	0	0	0	0
WY2013	17	3	10	0	4	0	4	0
Total	**37**	**3**	**18**	**2**	**4**	**0**	**4**	**0**

[9]The scenario assumes continued SF Bay RWQCB sample effort averaging 2 sites per county as part of the total number of nonurban sites listed.

[10]Some sites classified as urban, using the aforementioned data in a geographic information system, may be considered for reclassification as non-urban based on actual land uses of the drainage area despite location inside municipal jurisdictional boundaries.

3.0 Monitoring Methods

This section describes the methods used to evaluate monitoring sites identified in the regional sample draw, consistent with the Southern California Coastal Water Research Project (SCCWRP) Bioassessment Program (SCCWRP 2012), and to sample field data, consistent with the RMC workplan (BASMAA 2011), Field parameters sampled included bioassessments (benthic macroinvertebrates, algae, and physical habitat), physico-chemical measurements (dissolved oxygen, temperature, conductivity, and pH), chlorine, nutrients, water samples for testing water toxicity, and sediment samples for testing sediment toxicity and chemistry.

3.1 Site Evaluation (*need revised numbers and text from Programs*)

Sites identified in the regional sample draw were evaluated by each RMC participant in chronological order using a two-step process, consistent with that described by SCCWRP[11] (2012). Each site was evaluated to determine if it met the following RMC sampling location criteria:

1. The location (latitude/longitude) provided for a site is located on or is within 300 meters of a non-impounded receiving water body;
2. Site is not tidally influenced;
3. Site is wadeable during the sampling index period;
4. Site has sufficient flow during the sampling index period to support standard operation procedures for biological and nutrient sampling.
5. Site is physically accessible and can be entered safely at the time of sampling;
6. Site may be physically accessed and sampled within a single day;
7. Landowner(s) grant permission to access the site[12].

In the first step, these criteria were evaluated to the extent possible using a "desktop analysis." Site evaluations were completed during the second step via field reconnaissance visits. Based on the outcome of site evaluations, sites were classified into one of three categories (see Attachment A):

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

During WY2012, 126 RMC sites were evaluated for sampling by ACCWP and CCCWP, with FSURMP and Vallejo initiating monitoring activities in WY2013. In WY2013, 271 sites were evaluated for sampling by the four Programs. The outcome of these site evaluations is summarized below for the two years and illustrated by Water Year in Figure 3-1 and Figure 3-2.

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

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

- **TS** –WY2012: 24% of sites (N=30); WY2013: 15% of sites (N=40) met all the site evaluation criteria for monitoring
- **TNS** – WY2012: 8% of sites (N= 10); WY2013: 18% of sites (N=50) met the sampleable "target" criteria but could not be sampled.
- **NT** – WY2012: 28% of sites (N = 35) ; WY2013: 26% of sites (N=71) did not meet the sampleable "target" criteria and could not be sampled.
- **U** – WY2012: 40% of sites (N = 51) ; WY2013: 41% of sites (N=110) had outstanding unknown characteristics and their sampling target status was unknown

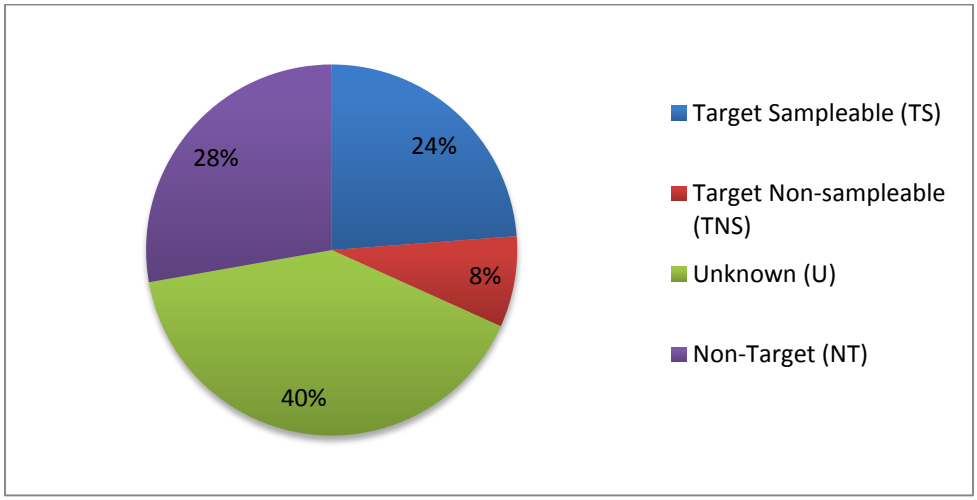

Figure 3-1. . Results of RMC Site Evaluations for Water Year 2012 for Four Collaborating Programs

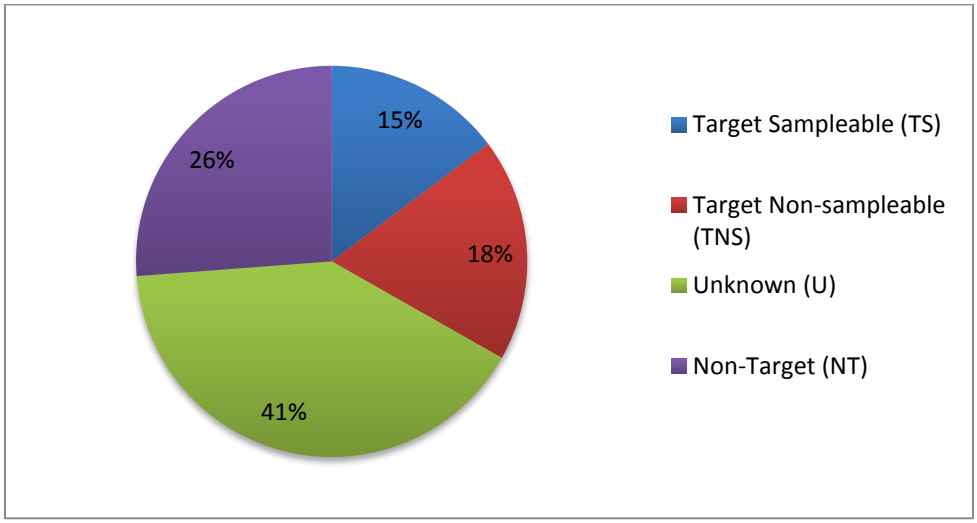

Figure 3-2. Results of RMC Site Evaluations for Water Year 2013 for Four Collaborating Programs

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

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

Observations of flow status occurring during fall site reconnaissance events prior to occurrence of significant precipitation, and spring sampling occurring post- wet weather season were combined to classify sites as perennial or non-perennial as follows:

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

3.2 Field Data Collection Methods

Field data were collected in accordance with existing SWAMP-comparable methods and procedures, as described in the RMC Quality Assurance Project Plan (QAPP) (BASMAA 2012a) and the associated Standard Operating Procedures (BASMAA 2012b). As of the writing of this report, initial versions of these documents are in process of being updated to maintain their currency and optimal applicability.[13] The SOPs were developed using a standard format that describes health and safety cautions and considerations, relevant training, site selection, and sampling methods/procedures, including pre-fieldwork mobilization activities to prepare equipment, sample collection, and de-mobilization activities to preserve and transport samples. The SOPs relevant to the monitoring discussed in this report are listed in Table 3-1.

Table 3-1. RMC Standard Operating Procedures (SOPs) pertaining to regional creek status monitoring.

SOP #	SOP
FS-2	Water Quality Sampling for Chemical Analysis, Pathogen Indicators, and Toxicity Testing
FS-3	Field Measurements, Manual
FS-6	Collection of Bedded Sediment Samples
FS-7	Field Equipment Cleaning Procedures
FS-8	Field Equipment Decontamination Procedures
FS-9	Sample Container, Handling, and Chain of Custody Procedures
FS-10	Completion and Processing of Field Datasheets
FS-11	Site and Sample Naming Convention
FS-12	Ambient Creek Status Monitoring Site Evaluation
FS-13	QA/QC Data Review

3.2.1 Bioassessments

In accordance with the RMC QAPP (BASMAA 2012a), bioassessments were conducted during the spring index period (approximately April 15 – July 15) and at a minimum of 30 days after any significant storm (roughly defined as at least 0.5-inch[14] of rainfall within a 24-hour period). During WY2012, the last significant storm occurred on April 12-13, 2012. As a result, bioassessments began during the week of May 14th, 2012.

In comparison, for WY2013 monitoring there was no region-wide, late season significant precipitation event that required delay of sampling. The last significant storm event of the season occurred on April 1st and, for the four Programs participating in this report, precipitation exceeded the RMC criterion for only the northwestern section of Alameda County (i.e., Oakland and north). Monitoring stations were therefore prioritized so that non-affected portions of the four collaborating Programs were monitored first.

Results for analysis of benthic macroinvertebrate, algae, and physical habitat parameters generated through conduct of bioassessment monitoring and analysis are reported in Program-specific IMR and its Appendix A.1.

[13] Approval anticipated February 2014.
[14] This number was erroneously reported as 0.25-inch over a 24-hour period in UCMR (BASMAA 2013).

3.2.2 Physico-chemical Measurements

Dissolved oxygen, temperature, conductivity, and pH were measured during bioassessment sampling using a multi-parameter probe (see SOP FS-3, BASMAA 2012b). Dissolved oxygen, specific conductivity, water temperature and pH measurements were made either by direct submersion of the instrument probe into the sample stream, or by collection and immediate analysis of grab sample in the field. Water quality measurements were taken approximately 0.1 m below the water surface at locations of the stream that appears to be completely mixed, ideally at the centroid of the stream. Measurements should occur upstream of sampling personnel and equipment and upstream of areas where bed sediments have been disturbed, or prior to such bed disturbance.

3.2.3 Chlorine

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

3.2.4 Nutrients and Conventional Analytes

Water samples were collected for nutrient analyses using the Standard Grab Sample Collection Method as described in SOP FS-2 (BASMAA 2012b), associated with bioassessment monitoring conducted. Sample containers were rinsed, as appropriate, using ambient water and completely filled and recapped below water surface whenever possible. An intermediate container was used to collect water for all sample containers with preservative already added in advance by laboratory. Sample container size and type, preservative type and associated holding times for each analyte are described in Table 1 of FS-9 (BASMAA 2012b). Syringe filtration method was used to collect samples for analyses of Dissolved Ortho-Phosphate and Dissolved Organic Carbon. All sample containers were labeled and stored on ice for transportation to laboratory, with exception of analysis of Ash Free Dry Mass and Chlorophyll-a samples, which were field-frozen on dry ice by some sampling teams where appropriate.

3.2.5 Water Toxicity

Samples were collected using the Standard Grab Sample Collection Method described above, filling the required number of 2.25-L labeled amber glass bottles with ambient water, putting them on ice to cool to 4 ±2 °C, and delivering to the laboratory within the required hold time. Bottle labels include station ID, sample code, matrix type, analysis type, project ID, and date and time of collection. The laboratory was notified of the impending sample delivery to meet the 24-hour sample delivery time requirement. Procedures used for sampling and transporting samples are described in SOP FS-2 (BASMAA 2012b).

3.2.6 Sediment Chemistry and Sediment Toxicity

In the case where sediment samples and water samples / measurements were collected at the same event, sediment samples were collected after any water samples were collected. Before conducting sampling, field personnel surveyed the proposed sampling area to identify appropriate fine-sediment depositional areas, to avoid disturbing possible sediment collection sub-sites. Personnel carefully entered the stream and started sampling at the closest appropriate reach, continuing upstream. Sediment samples were collected from the top 2 cm of sediment in a compositing container, thoroughly homogenized, and then aliquotted into separate jars for chemical and toxicological analysis using

standard clean sampling techniques (see SOP FS-6, BASMAA 2012b). Sample jars were submitted to respective laboratories per SOP FS-9 (BASMAA 2012b).

3.3 Laboratory Analysis Methods

RMC participants agreed to use the same laboratory for individual parameters, developed standards for contracting with the labs, and coordinated quality assurance issues. All samples collected by RMC participants that were sent to laboratories for analysis were analyzed and reported per SWAMP-comparable methods as described in the RMC QAPP (BASMAA 2012a). Analytical laboratory methods, reporting limits and holding times for chemical water quality parameters are also reported in BASMAA (2012a). Analytical laboratory contractors used for chemical and toxicological analysis included[15]:

- CalTest, Inc. – Sediment Chemistry, Nutrients, Chlorophyll a, Ash Free Dry Mass
- Pacific EcoRisk, Inc. - Water and Sediment Toxicity

3.4 Data Analysis

This section describes methods used to analyze portions of the data collected during implementation of bioassessments, as well as water and sediment toxicity, and sediment chemistry data. Discussion of bioassessment biology and condition is contained within Appendix A.1 The associated physical, chemical and toxicity testing data are then analyzed to identify potential stressors that may be impacting water quality and biological conditions. As the cumulative RMC sample sizes increase through monitoring conducted in future years (Table 2-3), it will be possible to develop a statistically representative data set to address management questions related to condition of aquatic life and report on these per MRP Provision C.8.g.iv.

3.4.1 Water and Sediment Chemistry and Toxicity

As part of the Stressor Assessment for this report, water and sediment chemistry and toxicity data generated during Water Years 2012 and 2013 were analyzed and evaluated to identify potential stressors that may be contributing to degraded or diminished biological conditions. Per Table 8.1 of the MRP (SFBRWQCB 2009), creek status monitoring data must be evaluated with respect to specified "Results that Trigger a Monitoring Project in Provision C.8.d.i." The trigger criteria listed in Table 8.1 were used as the principal means of evaluating the creek status monitoring data to identify sites where water quality impacts may have occurred. For water and sediment chemistry and toxicity data, the relevant trigger criteria are as follows:

- **Nutrients**: 20% of results in one waterbody exceed one or more water quality standard or established threshold. (Note: per MRP Table 8.1, this group of constituents includes variants of nitrogen and phosphorous, as well as other common, "conventional" constituents.)
- **Water Toxicity**: if toxicity results are less than 50% of Laboratory Control results, re-sample and re-test; if second sample yields less than 50% of Laboratory Control results, proceed to C.8.d.i. (Stressor/Source Identification).
- **Sediment Toxicity**: toxicity results are statistically different than and more than 20% less than results for Laboratory Control.

[15] BioVir Laboratories, Incorporated was similarly contracted for Pathogen Indicators. These data are reported elsewhere in each stormwater Program's IMR Part A and Program-specific Appendices.

- **Sediment Chemistry**: three or more chemicals exceed Threshold Effect Concentrations (TECs), mean Probable Effects Concentrations (PEC) Quotient greater than 0.5, or pyrethroids Toxicity Unit (TU) sum is greater than 1.0.

For sediment chemistry trigger criteria, threshold effect concentrations (TECs) and probable effects concentrations (PECs) are as defined in MacDonald et al., 2000. For all non-pyrethroid contaminants specified in MacDonald et al. (2000), the ratio of the measured concentration to the respective TEC value was computed as the TEC quotient. All results where a TEC quotient was equal to or greater than 1.0 were identified. PEC quotients were also computed for those same non-pyrethroid sediment chemistry constituents using PEC values from MacDonald et al. (2000). For each site the mean PEC quotient was then computed, and sites where mean PEC quotient was equal to or greater than 0.5 were identified. Pyrethroids toxic unit equivalents (TUs) were computed for individual pyrethroid results, based on available literature values for pyrethroids in sediment LC50 values.[16] Because organic carbon mitigates the toxicity of pyrethroid pesticides in sediments, the LC50 values were derived on the basis of TOC-normalized pyrethroid concentrations. Therefore, the pyrethroid concentrations as reported by the lab were divided by the measured total organic carbon (TOC) concentration at each site, and the TOC-normalized concentrations were then used to compute TU equivalents for each pyrethroid. Then for each site, the TU equivalents for the various individual pyrethroids were summed, and sites where the summed TU was equal to or greater than 1.0 were identified.

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

3.5 Quality Assurance and Control

Data quality assessment and quality control procedures are described in detail in the BASMAA RMC QAPP (BASMAA 2012a). They generally involved the following:

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

Data were collected according to the procedures described in the relevant SOPs (BASMAA 2012b), including appropriate documentation of data sheets and samples, and sample handling and custody. Laboratories providing analytical support to the RMC were selected based on demonstrated capability to adhere to specified protocols.

All data were thoroughly reviewed by the Programs responsible for collecting them, for conformance with QAPP requirements and field procedures were reviewed for compliance with the methods specified in the relevant SOPs. Data quality was assessed and qualifiers were assigned as necessary in accordance with SWAMP requirements. Evaluations of Program-specific data quality associated with monitoring conducted in Water Years 2012 and 2013 are contained elsewhere in the individual Program-specific portions of the IMR.

4.0 Results and Discussion

The MRP places an emphasis on minimizing sources of pollutants that could impair water quality as a central purpose of urban runoff management programs. The MRP requires monitoring to address the management question, "What are the sources to urban runoff that contribute to receiving water problems?" The RMC accomplishes this through a multi-step process that involves conducting monitoring to provide data to inform an assessment of conditions and identification of stressors that may be impacting water quality and/or biological conditions. The information generated through the condition assessment and stressor assessment will then be used to help direct efforts to identify sources of problematic pollutants or other stressors in urban runoff discharges.

In this section, following a brief statement of data quality, the physical, chemical and toxicity testing monitoring data are evaluated against the trigger criteria shown in Table 8.1 and Table H-1 (for sediment triad data) of the MRP (SFBRWQCB 2009) to provide a preliminary identification of potential stressors. The results of the initial stressor assessment evaluation (BASMAA 2013) are currently being used in follow-up efforts to plan and implement source identification projects.

4.1 Statement of Data Quality

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

A comprehensive QA/QC program was implemented by each of the RMC Programs, which is solely responsible for the quality of the data submitted on its behalf, covering all aspects of the regional/probabilistic monitoring. In general, QA/QC procedures were implemented as specified in the RMC QAPP (BASMAA, 2012a), and monitoring was performed according to protocols specified in the RMC SOPs (BASMAA, 2012b), and in conformity with SWAMP protocols. Details of the results of evaluations of laboratory-generated QA/QC results are included elsewhere in the Program-specific IMR and other appendices if applicable. Issues noted by the laboratories and/or RMC field crews are summarized below.

4.1.1 Sediment Chemistry

Several issues were reported by the analytical laboratory (Caltest), and the sediment chemistry data were qualified accordingly. These issues included:

- Low level contamination noted in Method Blanks
- Matrix Spike recoveries outside of control limits noted due to possible matrix interferences
- Many laboratory reporting limits (RLs) exceed RMC QAPP RLs due to the dry weight conversion, as well as target and non-target matrix interferences, which required the laboratories to concentrate less than normal.

4.1.2 Water Chemistry

Several issues were noted with respect to water chemistry analyses, including:

- In both 2012 and 2013, RMC field crews noted numerous instances where free chlorine was measured with the Hach field kits at concentrations higher than total chlorine.
- A limited number of Lab QA/QC sample results for nutrients and conventional parameters were reported by the laboratory as qualified data due to elevated minor issues not thought to affect the accuracy of sample results.
- Results of required field duplicates for several analytes exceeded QAPP MQOs. As the control limits for field duplicates are identical to those of lab duplicate analyses, this is not a surprising occurrence. Individual Programs' data were qualified as dictated by comparison with RMC MQOs (BASMAA 2012a).

4.1.3 Sediment Toxicity

In WY2012, for several sediment toxicity samples, during laboratory testing for chronic toxicity of ambient sediment to *Hyalella azteca*, the dissolved oxygen level dropped below 2.5 mg/L during testing; aeration was initiated following this observation per the EPA testing manual. It is possible that hypoxia could have had a role in the significantly reduced survival observation of *Hyalella azteca*. The low DO conditions were not experienced associated with WY2013 sampling.

4.1.4 Water Toxicity

In both WY2012 and WY2013, multiple aquatic toxicity samples were identified by the analytical laboratory as being affected during testing by pathogen-related mortality (PRM), a cause of interference in aquatic sample toxicity tests with ambient surface waters. In some cases in 2012, the affected samples were re-tested using a modified approach per Geis et al. (2003). In 2013, these re-tests used the standard EPA 20-replicate test (USEPA 2000) to assess impacts of PRM.[17]

4.2 Condition Assessment

Condition assessment addresses the RMC core management question ***"What is the condition of aquatic life in creeks in the RMC area; are aquatic life beneficial uses supported?"*** Statistical properties of the aquatic life use indicators used for this condition assessment -- benthic macroinvertebrates, and algae -- that were observed at the set of RMC sites sampled in WY 2012 and WY2013 are reported by individual Programs in the Program-specific Appendix A.1.

[17] As part of contracting for WY2014 creek status monitoring, RMC Programs have asked the laboratory to provide better documentation supporting PRM identification, when applicable.

Table 4-1. RMC creeks and associated designated beneficial uses listed in the San Francisco Bay Region Basin Plan (SFBRWQCB 2013). Creeks not listed in Chapter 2 of the Basin Plan do not appear in this table.

		← Human Consumptive Uses →							← Aquatic Life Uses →								Wildlife Use	Recreational Uses		
Site ID	Waterbody	AGR	MUN	FRSH	GWR	IND	PROC	COMM	SHELL	COLD	EST	MAR	MIGR	RARE	SPWN	WARM	WILD	REC-1	REC-2	NAV
ALAMEDA COUNTY																				
205R00110	Agua Caliente (Zone 6 Line F)															E	E	E	E	
204R00356	Arroyo de la Laguna				E					E			E		E	E	E	E	E	
204R00100	Arroyo Mocho				E					E			E		E	E	E	E	E	
204R00191	Arroyo del Valle		E		E					E			P	E	E	E	E	E	E	
204R00340	Big Canyon Creek, Line 7-J-1															E	E	E	E	
204R00047	Castro Valley Creek									E				E		E	E	E	E	
204R00303	Chabot Creek									E				E		E	E	E	E	
204R00068	Collier Canyon Creek													E		E	E	E	E	
204R00647	Dry Creek													E		E	E	E	E	
204R00084	Dublin Creek															E	E	E	E	
205R00430	Line 6D															E	E	E	E	
205R00535	Plummer Creek (Zone 5 Line F-1)										E			E			E	E	E	
204R00639	San Lorenzo Creek		E	E	E					E			E		E	E	E	E	E	
204R00319	Sausal Creek									E				E	E	E	E	E	E	
204R00383	Sulphur Creek															E	E	E	E	
204R00367	Ward Creek															E	E	E	E	
204R00455	Zeile Creek															E	E	E	E	
205R00686	Canada Del Aliso															E	E	E	E	
204R00967	Crandall Creek															E	E	E	E	
204R00852	Alamo Creek				E					P			E	E	E	E	E	E	E	
204R00334	Arroyo del Valle		E		E					E			P	E	E	E	E	E	E	

Site ID	Waterbody	AGR	MUN	FRSH	GWR	IND	PROC	COMM	SHELL	COLD	EST	MAR	MIGR	RARE	SPWN	WARM	WILD	REC-1	REC-2	NAV
204R00590	Arroyo del Valle		E		E					E			P	E	E	E	E	E	E	
204R00473	Arroyo Mocho				E					E			E		E	E	E	E	E	
205R01134	Agua Caliente															E	E	E	E	
204R00724	Dublin Creek															E	E	E	E	
204R01316	Arroyo de la Laguna				E					E			E		E	E	E	E	E	
205R00174	Line 6-K															E	E	E	E	
204R00623	San Lorenzo Creek		E	E	E					E			E		E	E	E	E	E	
204R00063	Peralta Creek															E	E	E	E	
204R00751	Redwood Canyon Creek			E						E					E	E	E	E	E	
203R00983	Strawberry Creek															E	E	E	E	
204R01471	Arroyo Mocho				E					E			E		E	E	E	E	E	
205R01198	Zone 6 Line G															E	E	E	E	
205R01390	Zone 6 Line G															E	E	E	E	
CONTRA COSTA COUNTY																				
203R00039	Cerrito Creek															E	E	E	E	
543R00137	Deer Creek	E	E							E			E		E	E	E	E	E	
207R00011	Grayson Creek									E			E	E		E	E	E	E	
207R00139	Las Trampas Creek									E				E		E	E	E	E	
543R00219	Marsh Creek							E						E		E	E	P	P	
543R00245	Marsh Creek							E						E		E	E	P	P	
206R00155	San Pablo Creek			E						E			E	E	E	E	E	E*	E	
206R00215	San Pablo Creek			E						E			E	E	E	E	E	E*	E	
207R00247	Walnut Creek									E			E	E	E	E	E	E	E	
206R00727	Pinole Creek									E			E	E	E	E	E	E	E	
207R00375	Galindo Creek									E						E	E	E	E	
207R00395	Las Trampas Creek									E				E		E	E	E	E	

Site ID	Waterbody	AGR	MUN	FRSH	GWR	IND	PROC	COMM	SHELL	COLD	EST	MAR	MIGR	RARE	SPWN	WARM	WILD	REC-1	REC-2	NAV
207R00503	Pine Creek									E			E	E	E	E	E	E	E	
207R00567	Walnut Creek									E			E	E	E	E	E	E	E	
207R00631	Grayson Creek									E			E	E		E	E	E	E	
207R00788	San Ramon Creek															E	E	E	E	
544R00281	Marsh Creek							E						E		E	E	P	P	
SOLANO - FSURMP																				
207R00236,	Laurel Creek			E						E			E		E	E	E	E	E	
207R01452	Laurel Creek			E						E			E		E	E	E	E	E	
207R00476	Ledgewood Creek			E						E			E		E	E	E	E	E	
SOLANO - Vallejo																				
207R00064	Blue Rock Springs Creek			E												E	E	E	E	
207R04080	Blue Rock Springs Creek			E												E	E	E	E	
207R05524	Blue Rock Springs Creek			E												E	E	E	E	
207R03504	Rindler Creek			E												E	E	E	E	

Notes:

COLD = Cold Fresh Water Habitat
FRSH = Freshwater Replenishment
GWR - Groundwater Recharge
MIGR = Fish Migration
MUN = Municipal and Domestic Water
NAV = Navigation
RARE= Preservation of Rare and Endangered Species
REC-1 = Water Contact Recreation
REC-2 = Non-contact Recreation
WARM = Warm Freshwater Habitat
WILD = Wildlife Habitat
P = Potential Use
E = Existing Use
L = Limited Use.
* = "Water quality objectives apply; water contact recreation is prohibited or limited to protect public health" (SFBRWQCB 2013).

4.3 Stressor Assessment

This section addresses the question: ***"What are major stressors to aquatic life in the RMC area?"*** Each monitoring category required by MRP Provision C.8.c, Table 8-1 is associated with a specification for "Results that Trigger a Monitoring Project in Provision C.8.d.i" (Stressor/Source Identification). The definitions of these "Results that Trigger…", as shown in Table 8.1, are considered to represent "trigger criteria", meaning that the relevant monitoring results should be forwarded for consideration as potential Stressor/Source Identification Projects per Provision C.8.d.i. The physical, chemical and toxicity testing data produced by RMC participants during WY2012 and WY2013 were compiled and evaluated, and analyzed against these trigger criteria. When the data analysis indicated that the associated trigger criteria were not met, those sites and results were identified as potentially warranting further investigation.

When interpreting analytical chemistry results, laboratory data often contain a relatively high proportion that is reported as either below method detection limits (MDLs) or between detection and reporting limits (RLs). Dealing with data in this range of the analytical spectrum introduces some level of uncertainty, especially when attempting to generate summary statistics for a dataset. In the compilation of statistics for analytical chemistry that follow, non-detect data (ND) were substituted with a concentration equal to one-half of the respective MDL as reported by the laboratory. This differs from UCMR (BASMAA 2013), which substituted a value of one-half of the RL for NDs.[18] The use of one-half of the MDL is the most common substitution in environmental science (e.g., Helsel 2010), and is thought to be more representative of laboratory results. Some of the results may therefore be slightly biased high or low with this associated analytical uncertainty, but this is not expected to affect the conclusions to any great extent.

4.3.1 Stressor Indicators

Water Chemistry Parameters

Table 4-2 provides a summary of descriptive statistics for the nutrients and related conventional constituents collected in association with the bioassessments in receiving waters. For the purposes of data analysis, Total Nitrogen was calculated as the sum of nitrate + nitrite + Total Kjeldahl Nitrogen (TKN).

[18] Substitution of one-half of the MRL in several cases brought about a situation where analytical data reported as ND was, for statistical purposes, estimated at higher concentrations than similar data reported between the MDL and RL. Specific instances are discussed in subsequent sections.

Table 4-2. Descriptive statistics for water chemistry results collected at RMC sites during Water Years 2012 and 2013. Results include two years of monitoring for ACCWP and CCCWP and one year (2013) for FSURMP and Vallejo.

"Nutrients"	N	N ≥ RL	Min	Max	Max Detected	Mean
Chloride	68	68	17	410	410	85
Chlorophyll a	68	55	<5.14	414.14	414.14	106.50
Dissolved Organic Carbon	68	66	<0.3	14	14	4.0
Ammonia as N	68	22	<0.04	0.79	0.79	0.09
Nitrate as N	68	47	<0.01	7.50	7.50	0.69
Nitrite as N	68	4	<0.002	0.19	0.19	0.012
Nitrogen, Total Kjeldahl	68	68	0.11	2.10	2.10	0.55
OrthoPhosphate as P	68	60	<0.006	0.85	0.85	0.10
Phosphorus as P	68	65	<0.007	3.5	3.5	0.16
Suspended Sediment Concentration	68	47	<2	171	171	14
Silica as SiO2	68	68	5.9	43	43	22

In comparing the effect of using one-half the MDL in place of one-half the MRL to estimate values of NDs, the differences are relatively minor (Table 4-3). The greatest difference is observed in calculation of chlorophyll a, while relatively minor differences are observed elsewhere.

Table 4-3. Calculation of mean concentration of water chemistry parameters using MDL- vs. MRL-based substitutions for non-detects.

"Nutrients"	MDL-based	MRL-based
Chloride	85	85
Chlorophyll a	106.50	114.61
Dissolved Organic Carbon	4.0	4.0
Ammonia as N	0.09	0.10
Nitrate as N	0.69	0.69
Nitrite as N	0.012	0.018
Nitrogen, Total Kjeldahl	0.55	0.55
OrthoPhosphate as P	0.10	0.10
Phosphorus as P	0.16	0.16
Suspended Sediment Concentration	14	14
Silica as SiO2	22	22

Water and Sediment Toxicity Testing

The laboratory determines whether a sample is "toxic" by statistical comparison of the results from multiple test replicates of selected aquatic species in the environmental sample to multiple test replicates of those species in laboratory control water. The threshold for determining statistical significance between environmental samples and control samples is fairly small, with statistically significant toxicity often occurring for environmental test results that are as high as 90% of the Control. Therefore, there is a wide range of possible toxic effects that can be observed – from 0% to approximately 90% of the Control values.

For water sample toxicity tests, MRP Table 8.1 identifies toxicity results of less than 50% of the Control as requiring follow-up action. For sediment sample tests, MRP Table H-1 identifies toxicity results more

than 20% less than the control as requiring follow-up action.[19] Therefore, in the tables that follow, samples that are identified by the lab as toxic (based on statistical comparison of samples vs. Control at $p < 0.05$) are further evaluated to determine whether the result was less than 50% of the associated Control (for water samples) or statistically different and more than 20% less than the Control (for sediment samples).

Samples for triad sites were targeted to be collected within creeks at sites where bioassessments were conducted in the same water year, where flow regime was assessed as perennial, and where sufficient fine-grained surficial sediments were likely to be present during dry season. The toxicity testing results are presented in context of the following three groups: 1) wet season water samples, 2) dry season water samples, and 3) dry season sediment samples. For each of these groups, the results are first presented in a table indicating which samples were found to be toxic by virtue of a statistically significant difference from the Control as determined by the laboratory. Detailed results are then presented in a subsequent table for the toxic samples, along with an assessment as to whether the toxic effect was less than 50% of the Control for water samples, or more than 20% less than the Control for sediment samples.

Wet Season Aquatic Toxicity

Per the MRP, ambient water samples were collected by the four collaborating Programs from five sites throughout the region during storm events in March 2012, and seven locations in March and April of 2013, and tested for toxic effects using four species: an aquatic plant (*Selenastrum capricornutum*), two aquatic invertebrates (*Ceriodaphnia dubia* and *Hyalella azteca*), and one fish species (*Pimephales promelas* or fathead minnow). 2013 testing also included re-tests at those locations sampled in 2012 where samples met MRP-defined thresholds triggering follow-up monitoring. The following sections discuss the results of 2012 and 2013 monitoring in the context of MRP triggers.

In 2012, no samples were found to be toxic to either *C. dubia* or *S. capricornutum*. Three of five samples were identified as toxic to *H. azteca* (Table 4-4). Two of five samples generated a toxic response within *P. promelas*. Of those two, one was identified with significant toxicity relative to the chronic endpoint (growth), and one relative to the acute endpoint criterion (survival). Both of these test results were identified by the toxicity-testing laboratory as having been affected by interference due to pathogen-related mortality (PRM), an acknowledged source of laboratory interference in receiving water samples. The lab reports for these samples include the following statement relative to the PRM-affected samples: "observations of PRM are not associated with or indicative of stormwater toxicity". In those three cases, the samples were re-tested using a method developed to minimize PRM interference (Geis et al., 2003). In both cases, no toxic response was observed.

In 2013, ambient water samples were collected from a total of ten sites during storm events in March and April 2013. Sampling was unable to be conducted synoptically due to the lack of storm events that met the mobilization criteria for sampling region-wide. Of the monitoring conducted, seven sites were tested with the four MRP test species identified previously. In addition, samples were collected from three sites sampled in 2012, as discussed previously, that required re-test per the MRP; these samples were analyzed only with the test species for which 2012 samples met MRP–defined triggers.

[19] Footnote #162 to Table H-1 of the MRP reads, "Toxicity is exhibited when Hyallela (sic) survival statistically different than and < 20 percent of control". Consistent with the UCMR (BASMAA 2013), for the purposes of this report, this is assumed to be intended to read "…statistically different than and more than 20 percent less than control".

As shown in Table 4-4, none of the 2013 samples analyzed against the full suite of test species were found to be toxic to *S. capricornutum*. Two samples were identified as toxic to *C. dubia*, both for the chronic endpoint (growth). Two samples were reported as toxic to *H. azteca*.

In 2013, one sample was identified as toxic to *P. promelas*, with significant toxicity relative to the acute endpoint criterion (survival). As in 2012, this toxic result was identified by the laboratory as having been caused by interference due to PRM. Following up on the initial identification of PRM, the laboratory was requested to re-test the sample media using the 20-replicate EPA (2000) protocol, which resulted in removal of the toxic response, supporting the initial identification of PRM as a contributor to mortality.

Table 4-4. Summary of WY2012 and WY2013 wet season water toxicity results for four-species tests. Shaded cells indicate monitoring conducted in WY2012.

Wet Season Water Samples			Date of Analysis	Toxicity relative to the Lab Control treatment?					
County/ Program	**Sample Station**	**Collection Date**		***S. capricornutum***	***C. dubia***		***H. azteca***	***P. Promelas***	
				Growth	Survival	Reproduction	Survival	Survival	Growth
ACCWP	204R00047	3/14/12	3/15/12	No	No	No	**Yes**	No	**Yes[1]**
ACCWP	204R00084	3/14/12	3/15/12	No	No	No	No	No	No
ACCWP	204R00100	3/14/12	3/15/12	No	No	No	No	**Yes[1]**	No
ACCWP	204R00327	3/6/13	3/6/13	No	No	**Yes**	No	No	No
ACCWP	204R00447	3/6/13	3/6/13	No	No	No	**Yes**	No	No
ACCWP	205R00686	3/6/13	3/6/13	No	No	**Yes**	No	No	No
CCCWP	207R00011	3/14/12	3/15/12	No	No	No	**Yes**	No	No
CCCWP	544R00025	3/14/12	3/17/12	No	No	No	**Yes**	No	No
CCCWP	207R00271	3/6/13	3/6/13	No	No	No	No	**Yes[2]**	No
CCCWP	544R00281	4/4/13	4/5/13	No	No	No	**Yes**	No	No
FSURMP	207R00236	3/20/13	3/21/13	No	No	No	No	No	No
Vallejo	207R00064	3/20/13	3/21/13	No	No	No	No	No	No

Notes:

[1] PRM was identified by laboratory in multiple replicates for this stormwater sample; toxicity was not observed in re-tests using Geis technique.

[2] PRM was identified by laboratory in multiple replicates for this stormwater sample; toxicity was not observed in re-tests using EPA 20-replicate method (USEPA 2000).

Table 4-5 provides detailed results for RMC WY2012 and WY2013 wet weather receiving water samples tested against the four target species and found to be toxic relative to the laboratory control. 2012 samples collected at sites 204R00047, 207R00011, and 544R00025, and 2013 sample collected at site 544R00281 each exhibited *H. azteca* survival that was signicantly different from and less than 50% of the control.

Table 4-5. Comparison between laboratory control and receiving water sample toxicity results (*H. azteca* and *C. dubia*) for RMC samples collected in WY 2012 and 2013 wet season, in the context of MRP trigger criteria.

County/ Program	Test Initiation Date	Species Tested	Treatment/ Sample ID	10-Day Mean % Survival	Mean Reproduction (# neonates/ female)	Comparison to MRP Table 8.1 Trigger Criteria
ACCWP	3/15/12	*Hyalella azteca*	Lab Control	100	NA	NA
	3/15/12		204R00047	**48***		**< 50% of Control**
CCCWP	3/15/12		Lab Control	100		NA
	3/15/12		207R00011	**32***		**< 50% of Control**
	3/15/12		Lab Control	94		NA
	3/15/12		544R00025	**0***		**< 50% of Control**
ACCWP	3/07/13	*H. azteca*	Lab Control	98	NA	NA
	3/07/13		204R00447	**60***		Not < 50% of control
	3/06/13	*C. dubia*	Lab Control	100	36.6	NA
	3/06/13		204R00327	100	**28.1***	Not < 50% of control
	3/06/13		Lab Control	100	36.6	NA
	3/06/13		205R00686	80	**24.6***	Not < 50% of control
CCCWP	4/4/13	*H. azteca*	Lab Control	100	NA	NA
	4/4/13		544R00281	**0***		**< 50% of control**

* The response at this test treatment was significantly less than the Lab Control at $p < 0.05$.

For the re-tests following up on 2012 triggers, three samples were re-tested with *H. azteca*, the species exhibiting toxic response, and two of these again showed an acute toxic response (Table 4-6). The two samples identified with significant toxicity, 207R00011 and 544R00025, both again met MRP triggers that would typically require follow-up retesting (Table 4-7). The single sample collected in 2013 that met triggers for re-testing (544R00281) will be similarly incorporated into 2014 monitoring.

Table 4-6. Summary of WY2013 wet season water toxicity testing conducted as re-tests of 2012 results.

Wet Season Water Samples			Date of Analysis	Toxicity Relative to the Lab Control Treatment?
County/ Program	Sample Station	Collection Date		*H. azteca*
				Survival
ACCWP	204R00047	3/5/2013	3/6/13	No
CCCWP	207R00011	3/6/2013	3/6/13	**Yes**
CCCWP	544R00025	4/4/2013	4/5/13	**Yes**

Table 4-7. Comparison between laboratory control and receiving water sample toxicity results (*H. azteca)* for RMC samples re-tested in WY2013 wet season, in the context of MRP trigger criteria.

County/ Program	Test Initiation Date (Time)	Species Tested	Treatment/ Sample ID	10-Day Mean % Survival	Mean Reproduction (# neonates/ female)	Comparison to MRP Table 8.1 Trigger Criteria
CCCWP	3/6/13	*H. azteca*	Lab Control	100		NA
	3/6/13		207R00011	**4***		**< 50% of control**
	4/4/13		Lab Control	100		NA
	4/4/13		544R00025	**20***		**< 50% of control**

* The response at this test treatment was significantly less than the Lab Control at $p < 0.05$.

Table 4-8 provides detailed results for the *P. promelas* tests that were noted to have statistically different results from laboratory controls, as well as the results of re-testing using a version of the Geis technique (for 2012 samples) or USEPA (2000) 20-replicate test (for 2013 samples). In three of the four cases, the original *P. promelas* tests were identified by the laboratory to be affected by PRM interference, based upon visual examination of test organisms. When re-tested using a technique designed to prevent PRM interference, toxicity was not observed in these samples, supporting the original determination of PRM interference in the initial tests.

As indicated in Table 4-8, while significantly less than the associated laboratory Control values in some cases, the affected results were in each case not less than the associated MRP threshold of less than 50% of the Control values for either survival or biomass growth.

Table 4-8. Comparison between laboratory control and receiving water sample toxicity results for *P. promelas* for RMC samples collected in the WY2012 and WY2013 wet seasons, in the context of MRP trigger criteria. Shaded cells indicate monitoring conducted in WY2012.

County/ Program	Test Initiation Date (Time)	Treatment/ Sample ID	Mean % Survival	Mean Biomass Value (mg)	Comparison to MRP Table 8.1 Trigger Criteria; Identification of PRM effects and PRM Method Re-tests
ACCWP	3/15/12	Lab Control	100	0.52	NA
	3/15/12	204R00047	95 (a)	**0.42*** (a)	Not < 50% of Control; PRM noted
	3/15/12	204R00100	**72.5* (**a)	0.46	Not < 50% of Control; PRM noted
	3/23/12	Lab Control	100	0.27	PRM method re-test (Geis et al., 2003)
	3/23/12	204R00047	90	0.29	PRM method re-test (Geis et al., 2003)
	3/23/12	204R00100	100	0.34	PRM method re-test (Geis et al., 2003)
CCCWP	3/6/13	Lab Control	97.5	0.73	NA
	3/6/13	207R00271	**50*** (a)	0.52	Not < 50% of Control; PRM noted and re-tested
	3/15/13	Lab Control	92.5	0.50	PRM method re-test (20-replicate test)
	3/15/13	207R00271	90	0.55	PRM method re-test (20-replicate test)

* The response at this test treatment was significantly less than the Lab Control at $p < 0.05$.
(a) PRM was observed in multiple replicates for this stormwater sample

Dry Season Aquatic Toxicity

Water samples were collected during the summer 2012 and 2013 periods from the same sites where wet season sampling occurred (five sites in 2012 and seven sites in 2013), and were again tested for aquatic toxicity using the same four test species. The results are summarized in Table 4-9. In

comparisons to the control samples, no samples collected in 2012 were found to be toxic to the test species.

There were multiple samples collected in 2013 where aquatic toxicity was observed by the laboratory. These included samples toxic to *C. dubia* (207R00064), *H. azteca* (204R00447 and 207R00271), and *P. promelas* (204R00327, 204R00447, 205R00686, 207R00271, and 544R00281).

Table 4-9. Summary of WY 2012 and WY2013 dry season aquatic toxicity results.

Dry Season Water Samples			Toxicity relative to the Lab Control treatment?					
County/ Program	**Sample Station**	**Collection Date**	***S. capricornutum***	***C. dubia***		***H. azteca***	***P. promelas***	
			Growth	Survival	Reproduction	Survival	Survival	Growth
ACCWP	204R00047	7/25/12	No	No	No	No	No	No
ACCWP	204R00084	7/25/12	No	No	No	No	No	No
ACCWP	204R00100	7/25/12	No	No	No	No	No	No
CCCWP	207R00011	7/25/12	No	No	No	No	No	No
CCCWP	544R00025	7/25/12	No	No	No	No	No	No
ACCWP	204R00327	7/9/13	No	No	No	No	No	**Yes**
ACCWP	204R00447	7/9/13	No	No	No	**Yes**	No	**Yes**
ACCWP	205R00686	7/9/13	No	No	No	No	No	**Yes**
CCCWP	207R00271	7/9/13	No	No	No	**Yes**	**Yes**	No
CCCWP	544R00281	7/9/13	No	No	No	No	No	**Yes**
FSURMP	207R00236	7/11/13	No	No	No	No	No	No
Vallejo	207R00064	7/11/13	No	No	**Yes**	No	No	No

For samples identified with significant toxicity, one of the two samples toxic to *H. azteca*, collected at site 207R00271, met the MRP criterion for triggering follow-on retesting (Table 4-10). The single sample identified as toxic to *C. dubia* did not meet the MRP trigger for follow-on testing.

Table 4-10. Comparison between laboratory control and receiving water sample toxicity results (*C. dubia* and *H. azteca)* for RMC samples collected WY2012 and WY2013 dry seasons and reported as toxic, in the context of MRP trigger criteria.

County/ Program	Test Initiation Date	Species Tested	Treatment/ Sample ID	10-Day Mean % Survival	Mean Reproduction (# neonates/ female)	Comparison to MRP Table 8.1 Trigger Criteria
ACCWP	7/10/13	*H. azteca*	Lab Control	100	NA	NA
	7/10/13		204R00447	**94***		Not < 50% of control
CCCWP	7/10/13	*H. azteca*	Lab Control	96		NA
	7/10/13		207R00271	**2***		**< 50% of control**
Vallejo	7/10/13	*C. dubia*	Lab Control	100	36.3	NA
	7/10/13		207R00064	100	**24.0***	Not < 50% of control

* The response at this test treatment was significantly less than the Lab Control at $p < 0.05$.

Multiple dry season *P. promelas* tests were noted to have statistically different results from laboratory control, each associated with WY2013 monitoring. As shown in Table 4-11, only one of the samples reported as significantly toxic to *P. promelas* fell below the MRP threshold of being < 50% of the control (207R00271). This sample was identified as affected by PRM, and re-tested using the standard EPA 20-

replicate method (USEPA 2000). Toxicity was not observed in the re-test, again supporting the original determination of PRM interference in the initial test.

Table 4-11. Comparison between laboratory control and receiving water sample toxicity results for *P. promelas* for RMC samples identified as toxic collected in the WY2012 and WY2013 dry seasons, in the context of MRP trigger criteria.

County/ Program	Test Initiation Date	Treatment/ Sample ID	Mean % Survival	Mean Biomass Value (mg)	Comparison to MRP Table 8.1 Trigger Criteria; Identification of PRM effects and PRM Method Re-tests
ACCWP	7/10/13	Lab Control	95	0.80	NA
	7/10/13	204R00327	92.5	**0.68***	Not < 50% of Control
	7/10/13	Lab Control	95	0.80	NA
	7/10/13	204R00447	97.5	**0.70* (a)**	Not < 50% of Control
	7/10/13	Lab Control	95	0.80	NA
	7/10/13	205R00686	77.5 (a)	**0.66***	Not < 50% of Control
CCCWP	7/10/13	Lab Control	95	0.80	NA
	7/10/13	207R00271	**27.5* (a)**	0.36	**< 50% of Control**
	7/18/13	Lab Control	97.5	0.56	PRM re-test using 20 replicate method
	7/18/13	207R00271	97.5	0.53	PRM re-test using 20 replicate method
	7/10/13	Lab Control	95	0.80	NA
	7/10/13	544R00281	97.5	**0.67***	Not < 50% of Control
Vallejo	7/11/13	Lab Control	98.8	0.21	NA
	7/11/13	207R00064	97.5	**0.16***	Not < 50% of Control

* The response at this test treatment was significantly less than the Lab Control at $p < 0.05$.
(a) PRM was observed in multiple replicates for this stormwater sample

Dry Season Sediment Toxicity

During the dry season, sediment samples were collected at the same sites where water toxicity samples were collected and tested for both sediment toxicity and an extensive list of sediment chemistry constituents. For sediment toxicity, testing was performed with just one species, *H. azteca*, a common benthic invertebrate. Both acute (survival) and chronic (growth) endpoints were reported.

The results of the WY2012 and WY2013 sediment toxicity testing are summarized in Table 4-12. Three of the five samples collected in WY2012 by the collaborating Programs were determined to be toxic to *H. azteca* for the acute endpoint (survival). There were no determinations of significant toxicity based upon the chronic endpoint (growth) in 2012. In 2013, three of seven samples collected were determined to be toxic to *H. azteca* for survival, and two of seven samples were identified as toxic for growth.

Table 4-12. Summary of WY2012 and WY2013 dry season sediment toxicity results. Shaded cells indicate monitoring conducted in WY2012.

Dry Season Sediment Samples			Date of Analysis	Toxicity relative to the Lab Control treatment?	
				H. azteca	
County/ Program	**Sample Station**	**Collection Date**		**Survival**	**Growth**
ACCWP	204R00047	7/25/12	7/28/12	**Yes**	N/A*
ACCWP	204R00084	7/25/12	7/28/12	No	No
ACCWP	204R00100	7/25/12	7/28/12	No	No
ACCWP	204R00327	7/9/13	7/14/13	No	No
ACCWP	204R00447	7/9/13	7/14/13	No	**Yes**
ACCWP	205R00686	7/9/13	7/14/13	No	**Yes**
CCCWP	207R00011	7/25/12	7/28/12	**Yes**	N/A*
CCCWP	544R00025	7/25/12	7/28/12	**Yes**	N/A*
CCCWP	207R00271	7/9/13	7/14/13	**Yes**	N/A*
CCCWP	544R00281	7/9/13	7/14/13	**Yes**	N/A*
FSURMP	207R00236	7/11/13	7/14/13	**Yes**	N/A*
Vallejo	207R05524	7/18/13	7/26/13	No	**Yes**

* Per EPA guidance, samples with a significant reduction in survival are not evaluated for chronic endpoints (i.e., growth).

Detailed results of sediment samples identified as having toxic effects from the WY2012 and WY2013 dry season samples are shown in Table 4-13, along with comparisons to the relevant trigger criteria from MRP Tables 8.1 and H-1. Over the first two years of monitoring, there was a single instance of a sample exhibiting significant toxicity that did not meet the MRP trigger of *H. azteca* survival reported as more than 20% less than the control (204R00047). For the remaining five samples for which significant toxicity was identified, the magnitude of the acute endpoint results met MRP thresholds potentially triggering follow-on activity.

Table 4-13. Detailed sediment toxicity results for dry season samples exhibiting significant toxicity to *H. azteca.* Shaded cells indicate sampling conducted in WY2012.

County/ Program	Test Initiation Date	Treatment/ Sample ID	Mean % Survival	Mean Dry Weight (mg)	Comparison to MRP Tables 8.1 and H-1 Trigger Criteria
ACCWP	7/28/12	Lab Control	96.3	0.23	NA
	7/28/12	204R00047	**88.8***	0.24	Not more than 20% < Control
ACCWP	7/14/13	Lab Control	91.3	0.28	NA
	7/14/13	204R00447	78.8	**0.15***	No MRP comparison for growth endpoint
	7/14/13	Lab Control	91.3	0.28	NA
	7/14/13	205R00686	87.5	**0.24***	No MRP comparison for growth endpoint
CCCWP	7/28/12	Lab Control	96.3	0.23	NA
	7/28/12	207R00011	**43.8***	0.09	**More than 20% < Control**
	7/28/12	Lab Control	96.3	0.23	NA
	7/28/12	544R00025	**60***	0.23	**More than 20% < Control**
CCCWP	7/14/13	Lab Control	91.3	0.281	NA
	7/14/13	207R00271	**0***	-	**More than 20% < Control**
	7/14/13	Lab Control	91.3	0.281	NA
	7/14/13	544R00281	**53.8***	0.109	**More than 20% < Control**
FSURMP	7/14/13	Lab Control	98.8	0.23	NA
	7/14/13	207R00236	**71.2***	0.09	**More than 20% < Control**
Vallejo	7/26/13	Lab Control	98.8	0.21	NA
	7/26/13	207R05524	97.5	**0.16***	No MRP comparison for growth endpoint

* The response at this test treatment was significantly less than the Lab Control treatment response at $p < 0.05$.

Sediment Chemistry Parameters

Descriptive statistics for sediment chemistry data for samples collected in Water Years 2012 and 2013 are provided in Table 4-14. Analytes are presented in alphabetical order.

It should be noted that a number of the sediment chemistry constituents assessed per the list in MacDonald et al. (2000) required some grouping of analytes. For example, the MacDonald "chlordane" constituent required the combination of "chlordane, cis" and "chlordane, trans" from the laboratory data, and the MacDonald "total DDTs" parameter required the aggregation of 6 isomers of DDD, DDE and DDT. The MacDonald list also includes 10 individual PAH compounds, as well as "Total PAHs". For this report, "Total PAHs" was computed as the sum of all 24 PAH compounds reported by the laboratory.

Table 4-14. Descriptive statistics for WY2012 and WY2013 sediment chemistry results[1]

Analyte	N	N ≥ MDL	Min	Max	Max Detected	Mean
Acenaphthene	12	2	<3.1	48	48	16
Acenaphthylene	12	1	<3.1	7.1	7.1	12
Anthracene	12	1	<3.1	220	220	30
Arsenic	12	12	2.1	26	26	7
Benz(a)anthracene	12	3	<3.1	700	700	72
Benzo(a)pyrene	12	2	<3.1	230	230	34
Benzo(b)fluoranthene	12	4	<3.1	430	430	61
Benzo(e)pyrene	12	2	<3.1	170	170	33
Benzo(g,h,i)perylene	12	3	<3.1	230	230	38
Benzo(k)fluoranthene	12	1	<3.1	170	170	26
Bifenthrin	12	12	<0.19	58	58	15
Biphenyl	12	1	<3.4	<610	11	66
Cadmium	12	12	<0.066	0.72	0.72	0.3
chlordane, cis-	12	0	<1.3	<21	NA	2
chlordane, trans-	12	0	<1.3	<21	NA	2
Chromium	12	12	<8.5	58	58	29
Chrysene	12	4	<3.1	870	870	92
Copper	12	12	8.6	92	92	33
Cyfluthrin, total	12	10	<0.31	15	15	5
Cyhalothrin, lambda, total	12	3	<0.076	4.2	4.2	1
Cypermethrin, total	12	5	<0.13	3.6	3.6	1
DDD(o,p')	12	0	<0.58	<43	NA	4
DDD(p,p')	12	3	<1.2	17	17	4
DDE(o,p')	12	0	<0.52	<43	NA	4
DDE(p,p')	12	4	<1.3	240	240	24
DDT(o,p')	12	1	<0.6	4.7	4.7	5
DDT(p,p')	12	1	<0.8	9.2	9.2	2
Deltamethrin/Tralomethrin	12	6	<0.15	23	23	3
Dibenz(a,h)anthracene	12	0	<3.1	<92	NA	12
Dibenzothiophene	12	1	<3.4	44	44	70
Dieldrin	12	0	<1.4	<92	NA	3
Dimethylnaphthalene, 2,6-	12	8	<3.1	360	360	84
Endrin	12	0	<0.78	<11	NA	2
Esfenvalerate/Fenvalerate, total	12	1	<0.16	1.2	1.2	0.4
Fluoranthene	12	8	<3.1	2100	2100	243
Fluorene	12	1	<3.1	67	67	17
HCH, gamma-	12	0	<0.66	<15	NA	2
Heptachlor epoxide	12	0	<0.63	<17	NA	2
Indeno(1,2,3-c,d)pyrene	12	1	<3.1	220	220	30
Lead	12	12	4.9	51	51	16
Mercury	12	12	<0.025	0.29	0.29	0.1
Methylnaphthalene, 1-	12	0	<3.1	<92	NA	12
Methylnaphthalene, 2-	12	0	<3.1	<92	NA	12
Methylphenanthrene, 1-	12	0	<3.1	<92	NA	12
Naphthalene	12	2	<3.1	14	14	13
Nickel	12	12	9.8	96	96	40
Permethrin, cis-	12	7	<0.14	9.3	9.3	3
Permethrin, trans-	12	3	<0.14	2.4	2.4	1
Perylene	12	1	<3.1	54	54	16
Phenanthrene	12	5	<3.1	1100	1100	117
Pyrene	12	9	<3.1	1900	1900	233
Total Organic Carbon	12	12	<0.38	9.2	9.2	3
Zinc	12	12	<9.8	740	740	187

[1] "N" = number of samples; "N>MDL" = number of samples detected above the laboratory method detection limit

4.3.2 Stressor Analysis

Stressor analysis provides an analysis of the water and sediment chemistry and toxicity testing results in comparison to various thresholds included in the MRP. This analysis is intended to provide a means of identifying potential stressors that may impact beneficial uses at the creek status monitoring locations.

Water Chemistry Parameters

According to MRP Table 8.1, the trigger criterion ("Results that Trigger a Monitoring Project in Provision C.8.d.i) for the "Nutrients" constituents analyzed in conjunction with the bioassessment monitoring is *"20% of results in one waterbody exceed one or more water quality standard or established threshold*." A search for relevant water quality standards or accepted thresholds was conducted using available sources, including the SF Basin Water Quality Control Plan (Basin Plan) (SFBRWQCB 2013), the California Toxics Rule (CTR) (USEPA 2000a), and various USEPA sources. Of the eleven water quality constituents monitored in association with the bioassessment monitoring (referred to collectively as "Nutrients" in MRP Table 8.1), water quality standards or established thresholds are available only for ammonia (unionized form), chloride, and nitrate plus nitrite, the latter two for waters with MUN beneficial use only, as indicated in Table 4-15.

For ammonia, the standard provided in the SF Bay Basin Plan (p. 3-7) applies to the un-ionized fraction, as the underlying criterion is based on un-ionized ammonia, which is the more toxic form. Conversion of RMC monitoring data from the measured total ammonia to un-ionized ammonia was therefore necessary. The conversion was based on a formula provided by the American Fisheries Society[20], and calculates un-ionized ammonia in freshwater systems from analytical results for total ammonia and field-measured pH, temperature, and electrical conductivity.

For chloride, a Secondary Maximum Contaminant Level (MCL) of 250 mg/L applies to those waters with MUN beneficial use, per the Basin Plan (Table 3-5), Title 22 of the California Code of Regulations (CDPH, internet source), and the USEPA Drinking Water Quality Standards (USEPA, internet source). This same threshold is additionally established in the Basin Plan (Table 3-7) for waters in the Alameda Creek watershed above Niles. For all other waters, the Criteria Maximum Concentration (CMC) water quality criterion of 860 mg/L (acute) and the Criterion Continuous Concentration (CCC) of 230 mg/L (USEPA Water Quality Criteria[21]) for the protection of aquatic life were used for comparison purposes.[22]

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

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[20]http://fisheries.org/hatchery

[21]National Recommended Water Quality Criteria**.** EPA's compilation of national recommended water quality criteria is presented as a summary table containing recommended water quality criteria for the protection of aquatic life and human health in surface water for approximately 150 pollutants. These criteria are published pursuant to Section 304(a) of the Clean Water Act (CWA) and provide guidance for states and tribes to use in adopting water quality standards. http://water.epa.gov/scitech/swguidance/standards/criteria/current/index.cfm

[22]Per UCMR (BASMAA 2012) the RMC participants used the 230 mg/L threshold as a conservative benchmark for comparison purposes for all locations not specifically identified within the Basin Plan, i.e. sites not within the Alameda Creek watershed above Niles nor identified as MUN; rather than the maximum concentration criterion of 830mg/L .

Table 4-15. Water quality thresholds available for comparison to Water Year 2012 and 2013 water chemistry constituents

Sample Parameter	Threshold	Units	Frequency/ Period	Application	Source
Ammonia	0.025	mg/L	Annual median	Unionized ammonia, as N. [Maxima also apply to Central Bay and u/s (0.16) and Lower Bay (0.4)]	SF Bay Basin Plan Ch. 3, p. 3-7
Chloride	230	mg/L	Criterion Continuous Concentration	Freshwater aquatic life	USEPA Nat'l. Rec. WQ Criteria, Aquatic Life Criteria
Chloride	860	mg/L	Criteria Maximum Concentration	Freshwater aquatic life	USEPA Nat'l. Rec. WQ Criteria, Aquatic Life Criteria Table
Chloride	250	mg/L	Secondary Maximum Contaminant Level	Alameda Creek Watershed above Niles and MUN waters, Title 22 Drinking Waters	SF Bay Basin Plan Ch. 3, Tables 3-5 and 3-7; CA Code Title 22; USEPA Drinking Water Stds. Secondary MCL
Nitrate + Nitrite (as N)	10	mg/L	Maximum Contaminant Level	Areas designated as Municipal Supply	SF Bay Basin Plan Ch. 3, Table 3-5

The comparisons of the measured nutrients data to the thresholds listed in Table 4-15 are shown in Table 4-16. The results for these three constituents are plotted against the prevailing thresholds in Figure 4-1 through Figure 4-3. Of the 68 sites monitored, the water quality standard was exceeded at one site for chloride (204R00068 in 2012).[23] Two results (sites 205R00686 and 207R03504, both sampled in 2013) exceeded the un-ionized ammonia standard.[24] No samples exceeded the nitrate + nitrite standard. The MRP Table 8.1 trigger criterion for "Nutrients" (20% of results in one waterbody exceed one or more water quality standards or applicable thresholds) was therefore considered to be exceeded at only three of the 68 sites.

Table 4-16. Comparison of water quality (nutrient) data to associated water quality thresholds for WY2012 and WY2013 water chemistry results. (NDs estimated as ½ MDL). Shaded cells indicates monitoring conducted in WY2012.

County/ Program	Site Code	Alameda Creek Above Niles	MUN	Parameter and Threshold			# of Parameters >Threshold/ Waterbody	% of Parameters >Threshold/ Waterbody
				Un-ionized Ammonia (as N)	Chloride	Nitrate + Nitrite (as N)		
				25 µg/L	230/250 mg/L [1]	10 mg/L [2]		
ACCWP	**204R00047**			25.0	97	NA	0	0%
ACCWP	**204R00068**	**X**		10.1	**410**	NA	1	**50%**

[23] This assessment is unaffected by usage of the CCC of 230 mg/L or CMC of 860 mg/L, as the single instance occurred at a site within Alameda Creek above Niles, and is therefore measured against the criterion of 250 mg/L.
[24] It should be noted that this standard is an annual median concentration, and comparison to an acute threshold may change this determination.

County/ Program	Site Code	Alameda Creek Above Niles	MUN	Parameter and Threshold			# of Parameters >Threshold/ Waterbody	% of Parameters >Threshold/ Waterbody
				Un-ionized Ammonia (as N)	Chloride	Nitrate + Nitrite (as N)		
				25 µg/L	230/250 mg/L [1]	10 mg/L [2]		
ACCWP	**204R00084**	**X**		0.14	64	NA	0	0%
ACCWP	**204R00100**	**X**		2.27	87	NA	0	0%
ACCWP	**204R00191**	**X**	**X**	1.26	57	0.26	0	0%
ACCWP	**204R00303**			2.48	46	NA	0	0%
ACCWP	**204R00319**			4.36	24	NA	0	0%
ACCWP	**204R00340**	**X**		1.47	160	NA	0	0%
ACCWP	**204R00356**	**X**		3.10	110	NA	0	0%
ACCWP	**204R00367**			1.59	54	NA	0	0%
ACCWP	**204R00383**			1.46	54	NA	0	0%
ACCWP	**204R00391**			1.47	93	NA	0	0%
ACCWP	**204R00455**			1.20	36	NA	0	0%
ACCWP	**204R00583**			5.67	51	NA	0	0%
ACCWP	**204R00596**	**X**		0.67	240	NA	0	0%
ACCWP	**204R00639**		**X**	8.99	64	0.06	0	0%
ACCWP	**204R00647**			0.67	39	NA	0	0%
ACCWP	**205R00110**			1.16	32	NA	0	0%
ACCWP	**205R00430**			4.61	80	NA	0	0%
ACCWP	**205R00535**			0.87	110	NA	0	0%
ACCWP	**203R00983**			0.47	17	NA	0	0%
ACCWP	**204R00063**			2.53	29	NA	0	0%
ACCWP	**204R00327**			0.72	39	NA	0	0%
ACCWP	**204R00334**	**x**	**x**	0.32	63	0.07	0	0%
ACCWP	**204R00447**	**x**		6.04	230	NA	0	0%
ACCWP	**204R00473**	**x**		1.45	42	NA	0	0%
ACCWP	**204R00590**	**x**	**x**	2.63	50	0.01	0	0%
ACCWP	**204R00623**			2.34	47	NA	0	0%
ACCWP	**204R00724**	**x**		0.49	79	NA	0	0%
ACCWP	**204R00751**			0.28	29	NA	0	0%
ACCWP	**204R00852**	**x**		0.79	130	NA	0	0%
ACCWP	**204R00967**			2.81	110	NA	0	0%
ACCWP	**204R01316**	**x**		2.16	120	NA	0	0%
ACCWP	**204R01471**	**x**		1.92	190	NA	0	0%
ACCWP	**205R00174**			3.98	150	NA	0	0%
ACCWP	**205R00686**			**46.55**	140	NA	1	**50%**
ACCWP	**205R00878**			6.75	68	NA	0	0%
ACCWP	**205R01134**			0.00	30	NA	0	0%
ACCWP	**205R01198**			0.00	94	NA	0	0%
ACCWP	**205R01390**			0.49	90	NA	0	0%
CCCWP	**203R00039**			1.41	38	NA	0	0%
CCCWP	**206R00155**			2.57	23	NA	0	0%
CCCWP	**206R00215**			0.51	97	NA	0	0%
CCCWP	**207R00011**			5.23	80	NA	0	0%
CCCWP	**207R00139**			1.40	40	NA	0	0%

County/ Program	Site Code	Alameda Creek Above Niles	MUN	Parameter and Threshold			# of Parameters >Threshold/ Waterbody	% of Parameters >Threshold/ Waterbody
				Un-ionized Ammonia (as N)	Chloride	Nitrate + Nitrite (as N)		
				25 µg/L	230/250 mg/L [1]	10 mg/L [2]		
CCCWP	**207R00247**			4.05	46	NA	0	0%
CCCWP	**543R00137**			9.49	210	NA	0	0%
CCCWP	**543R00219**			3.57	140	NA	0	0%
CCCWP	**543R00245**			0.19	180	NA	0	0%
CCCWP	**544R00025**			2.30	160	NA	0	0%
CCCWP	**206R00727**			3.19	39	NA	0	0%
CCCWP	**207R00271**			0.00	23	NA	0	0%
CCCWP	**207R00375**			1.05	160	NA	0	0%
CCCWP	**207R00395**			3.15	43	NA	0	0%
CCCWP	**207R00503**			6.11	110	NA	0	0%
CCCWP	**207R00532**			13.74	62	NA	0	0%
CCCWP	**207R00567**			0.69	110	NA	0	0%
CCCWP	**207R00631**			3.42	83	NA	0	0%
CCCWP	**207R00788**			2.84	35	NA	0	0%
CCCWP	**544R00281**			7.75	130	NA	0	0%
FSURMP	**207R00428**			1.13	48	NA	0	0%
FSURMP	**207R00476**			0.04	17	NA	0	0%
FSURMP	**207R00556**			0.90	61	NA	0	0%
FSURMP	**207R01452**			1.69	46	NA	0	0%
Vallejo	**207R03504**			**112.69**	34	NA	1	**50%**
Vallejo	**207R04080**			10.28	44	NA	0	0%
Vallejo	**207R00688**			13.50	35	NA	0	0%
Vallejo	**207R00064**			3.61	38	NA	0	0%
# Values >Threshold:				2	1	0		
% Values >Threshold:				3%	1%	0%		
Overall Number and % of Sites Meeting Trigger Criterion [3]:							**3**	**4%**

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

[2] Nitrate + nitrite threshold applies only to sites with MUN beneficial use

[3] Sites where >20% of results exceed one or more water quality standard or established threshold

NA = threshold does not apply

Bolded value exceeds threshold

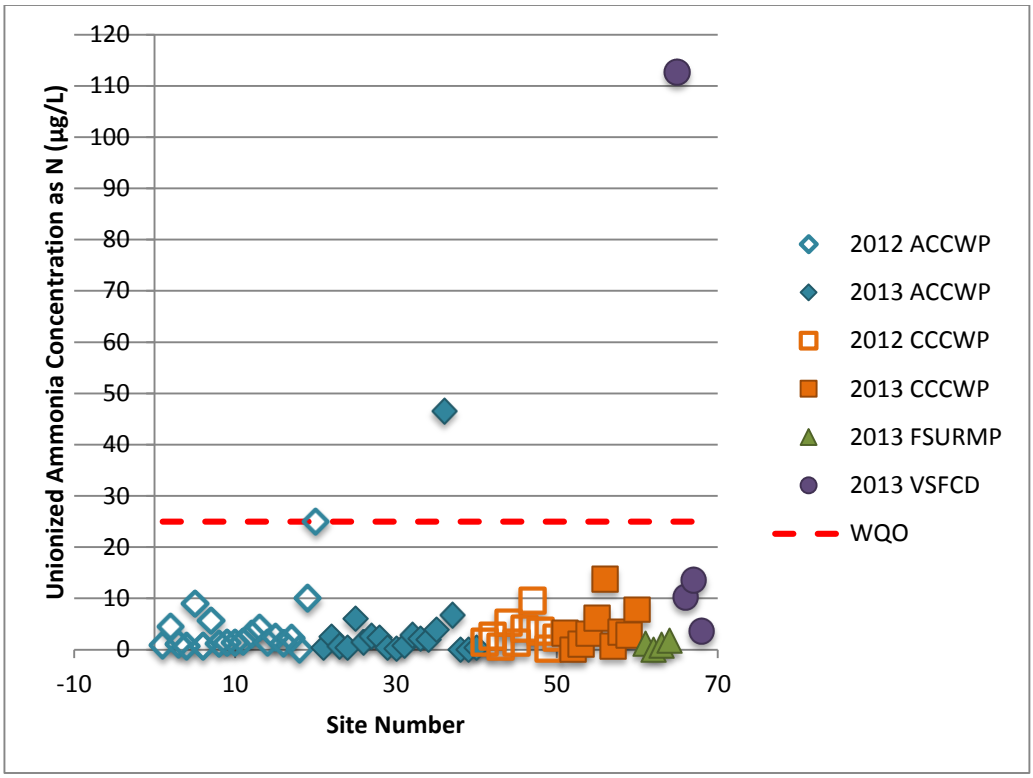

Figure 4-1. Plot of unionized ammonia (calculated from total ammonia, pH, temperature, and electrical conductivity) with threshold indicated, WY2012 and WY2013 data.

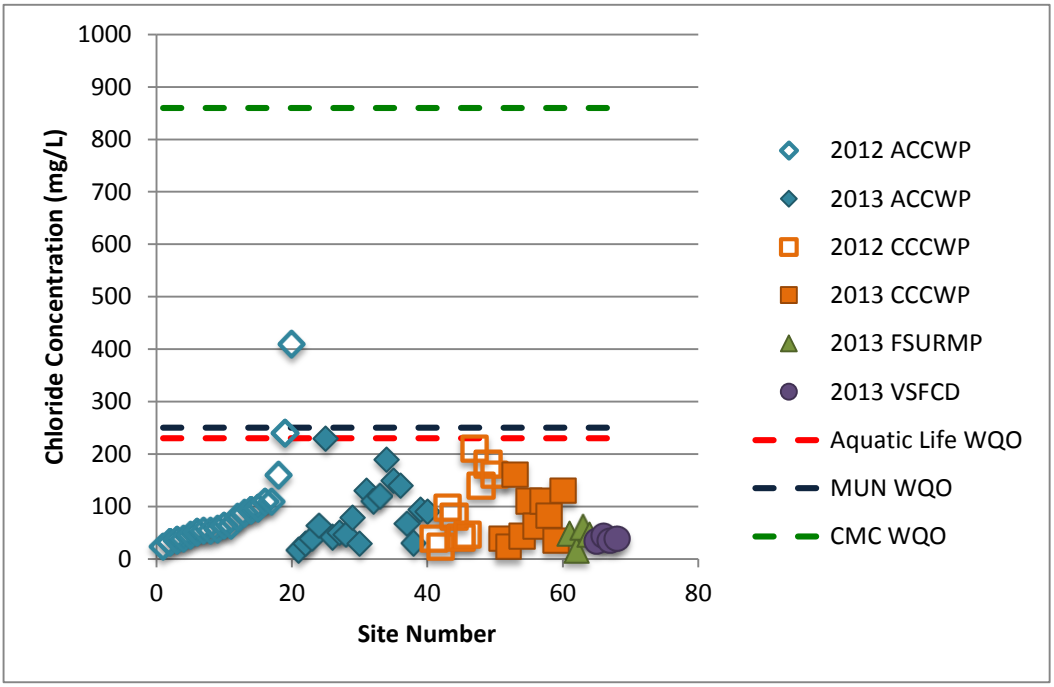

Figure 4-2. Plot of chloride with Aquatic Life and MUN thresholds indicated, WY2012 and WY2013 data

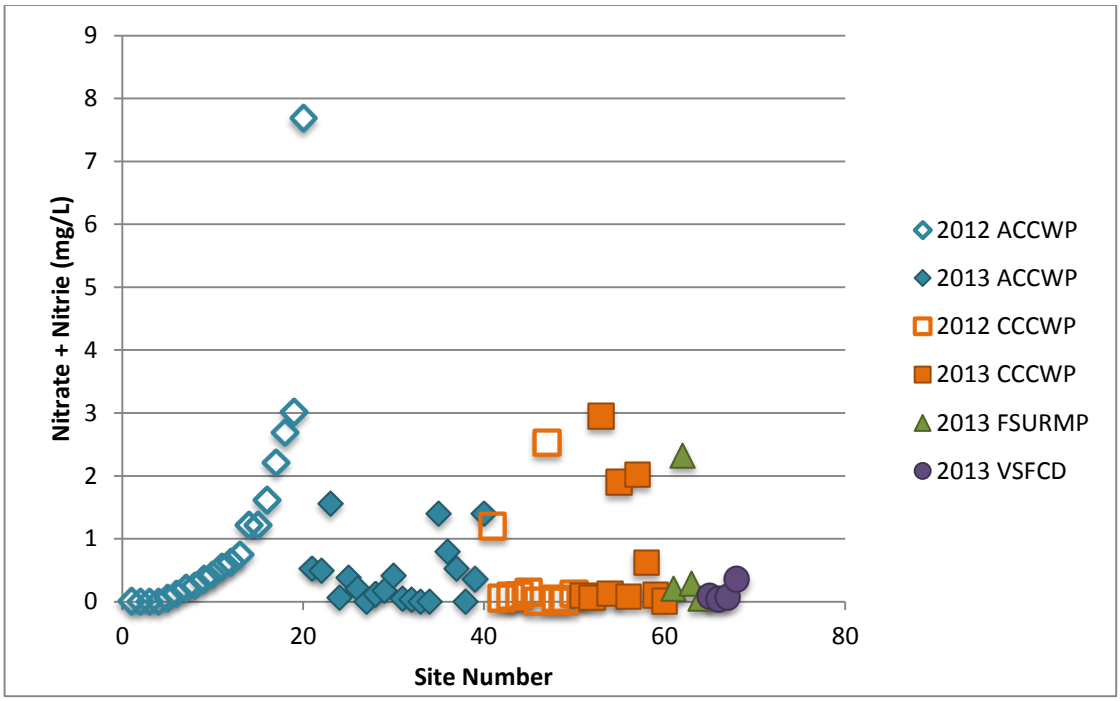

Figure 4-3. Plot of nitrate and nitrite as N, WY2012 and WY2013 data (threshold not shown = 10 mg/L for MUN only).

Free and Total Chlorine Testing

The results of field testing for free and total chlorine and comparisons to the MRP Table 8.1 trigger threshold are summarized in Table 4-17. The MRP trigger criterion for chlorine states, "After immediate resampling, concentrations remain >0.08 mg/L".

There were 35 site measurements for free and total chlorine in 2012 collected by ACCWP and CCCWP, as the toxicity sites were each tested twice (spring and summer). In 2013, there were 45 measurements collected, with the added participation of FSURMP and Vallejo. Of the 74 measurements collected overall, 15% exceeded the threshold for free chlorine, and 12% exceeded the threshold for total chlorine; as noted previously, there appears to be an issue with the field kits and free chlorine measurements sometimes exceeded those for total chlorine. Overall, the percentage of samples meeting the trigger threshold for free and/or total chlorine was 19%.

Table 4-17. Summary of chlorine testing results for samples collected in WY2012 and WY2013 in comparison to Municipal Regional Permit trigger criteria. Shaded cells represent data collected in WY2012.

County/ Program	Site Code	Sample Date	Chlorine, Free	Chlorine, Total	Meets Trigger Threshold?
ACCWP	204R00047	6/6/12	**0.12**	0.08	**Yes**
ACCWP	204R00047	7/25/12	<0.04	0.04	No
ACCWP	204R00068	5/31/12	<0.04	0.04	No
ACCWP	204R00084	5/24/12	<0.04	**0.10**	**Yes**
ACCWP	204R00084	7/25/12	<0.04	<0.04	No
ACCWP	204R00100	5/30/12	**0.12**	0.04	**Yes**
ACCWP	204R00100	7/25/12	**0.12**	0.08	**Yes**

County/ Program	Site Code	Sample Date	Chlorine, Free	Chlorine, Total	Meets Trigger Threshold?
ACCWP	204R00191	5/29/12	**0.10**	<0.04	**Yes**
ACCWP	204R00303	6/14/12	<0.04	<0.04	No
ACCWP	204R00319	6/7/12	<0.04	<0.04	No
ACCWP	204R00340	6/11/12	0.08	0.08	No
ACCWP	204R00356	6/4/12	0.04	0.04	No
ACCWP	204R00367	6/12/12	<0.04	<0.04	No
ACCWP	204R00383	6/11/12	**0.12**	**0.12**	**Yes**
ACCWP	204R00391	6/6/12	<0.04	<0.04	No
ACCWP	204R00455	6/13/12	**0.10**	<0.04	**Yes**
ACCWP	204R00583	6/13/12	**0.12**	**0.16**	**Yes**
ACCWP	204R00596	5/31/12	**0.12**	**0.12**	**Yes**
ACCWP	204R00639	6/19/12	0.04	0.04	No
ACCWP	204R00647	6/18/12	<0.04	<0.04	No
ACCWP	205R00110	6/18/12	<0.04	<0.04	No
ACCWP	205R00430	6/5/12	0.04	<0.04	No
ACCWP	205R00535	6/20/12	<0.04	<0.04	No
ACCWP	203R00983	6/6/13	<0.04	<0.04	No
ACCWP	204R00063	6/4/13	<0.04	<0.04	No
ACCWP	204R00327	5/7/13	<0.04	<0.04	No
ACCWP	204R00334	5/8/13	<0.04	<0.04	No
ACCWP	204R00447	4/22/13	0.06	<0.04	No
ACCWP	204R00473	5/9/13	<0.04	<0.04	No
ACCWP	204R00590	5/8/13	<0.04	<0.04	No
ACCWP	204R00623	6/3/13	<0.04	<0.04	No
ACCWP	204R00724	5/21/13	0.04	**0.2**	**Yes**
ACCWP	204R00751	6/5/13	<0.04	<0.04	No
ACCWP	204R00852	5/6/13	<0.04	<0.04	No
ACCWP	204R00967	4/25/13	<0.04	<0.04	No
ACCWP	204R01316	5/22/13	0.04	<0.04	No
ACCWP	204R01471	5/22/13	**0.12**	**0.16**	**Yes**
ACCWP	205R00174	4/23/13	<0.04	<0.04	No
ACCWP	205R00686	4/24/13	<0.04	<0.04	No
ACCWP	205R00878	4/24/13	<0.04	<0.04	No
ACCWP	205R01134	5/20/13	<0.04	<0.04	No
ACCWP	205R01198	5/20/13	<0.04	<0.04	No
ACCWP	205R01390	5/23/13	<0.04	<0.04	No
ACCWP	204R00327	7/9/13	<0.04	<0.04	No
ACCWP	204R00447	7/9/13	<0.04	<0.04	No
ACCWP	205R00686	7/9/13	<0.04	<0.04	No
CCCWP	203R00039	5/14/12	<0.04	<0.04	No
CCCWP	206R00155	5/16/12	<0.04	<0.04	No
CCCWP	206R00215	5/23/12	<0.04	<0.04	No
CCCWP	207R00011	5/22/12	<0.04	<0.04	No
CCCWP	207R00011	7/25/12	0.04	<0.04	No
CCCWP	207R00139	5/17/12	**0.12**	0.04	**Yes**
CCCWP	207R00247	5/22/12	0.03	0.04	No

County/ Program	Site Code	Sample Date	Chlorine, Free	Chlorine, Total	Meets Trigger Threshold?
CCCWP	543R00137	5/15/12	<0.04	<0.04	No
CCCWP	543R00219	5/21/12	0.04	0.06	No
CCCWP	543R00245	5/21/12	0.04	<0.04	No
CCCWP	544R00025	5/15/12	<0.04	<0.04	No
CCCWP	544R00025	7/25/12	<0.04	**0.12**	**Yes**
CCCWP	206R00727	5/13/13	0.04	0.05	No
CCCWP	207R00271	4/29/13	<0.04	<0.04	No
CCCWP	207R00375	5/1/13	<0.04	<0.04	No
CCCWP	207R00395	5/14/13	0.04	0.04	No
CCCWP	207R00503	5/2/13	<0.04	<0.04	No
CCCWP	207R00532	4/29/13	<0.04	<0.04	No
CCCWP	207R00567	4/30/13	<0.04	<0.04	No
CCCWP	207R00631	5/16/13	<0.04	<0.04	No
CCCWP	207R00788	5/15/13	<0.04	<0.04	No
CCCWP	544R00281	5/15/13	<0.04	<0.04	No
CCCWP	207R00271	7/9/13	<0.04	<0.04	No
CCCWP	544R00281	7/9/13	<0.04	<0.04	No
FSURMP	207R00428	5/21/13	0.06	0.04	No
FSURMP	207R00476	5/23/13	**0.2**	**0.12**	**Yes**
FSURMP	207R00556	5/15/13	NR	**0.2**	**Yes**
FSURMP	207R01452	5/28/13	**0.16**	**0.1**	**Yes**
FSURMP	207R00236	8/14/13	0.07	0.05	No
Vallejo	207R03504	5/29/13	<0.04	<0.04	No
Vallejo	207R04080	5/30/13	<0.04	<0.04	No
Vallejo	207R00688	5/29/13	<0.04	<0.04	No
Vallejo	207R00064	5/28/13	<0.04	<0.04	No
Number of samples exceeding 0.08 mg/L:			12	10	16
Percentage of samples exceeding 0.08 mg/L:			16%	14%	22%

Water and Sediment Toxicity Testing

The analysis of toxicity testing results and comparisons to MRP trigger thresholds, as presented in detail earlier in this section, are summarized in Table 4-18 for those WY2012 samples that initially exceeded thresholds.

The MRP Table 8.1 trigger criterion for water column toxicity stipulates "If toxicity results less than 50% of control results, repeat sample. If 2nd sample yields less than 50% of control results, proceed to C.8.d.i.". Therefore the three 2012 water samples indicated in Table 4-18 as having results "< 50% of Control" were re-tested in 2013.

Three sites were re-tested in wet season 2013 for the test species that triggered the re-test. While the ACCWP re-test (site 204R00047) did not exhibit toxicity in the re-test, the two CCCWP sites again exhibited significant toxicity to *H. azteca*, with survival less than the MRP trigger of 50% of the Control. Results of these re-tests are summarized in Table 4-19.

Table 4-18. Overall summary of 2012 aquatic and sediment toxicity samples with toxic response in comparison to Municipal Regional Permit trigger criteria.

County/ Program	Test Initiation Date	Species Tested	Test Regimen	Treatment/ Sample ID	Comparison to Table 8.1 (Water) and Table H-1 (Sediment) Trigger Criteria
Water					
ACCWP	3/15/12	*H. azteca*	Acute (survival)	204R00047	**< 50% of Control**
CCCWP	3/15/12	*H. azteca*	Acute (survival)	207R00011	**< 50% of Control**
CCCWP	3/15/12	*H. azteca*	Acute (survival)	544R00025	**< 50% of Control**
Sediment					
CCCWP	7/28/12	*H. azteca*	Acute (survival)	207R00011	**More than 20% < Control**
CCCWP	7/28/12	*H. azteca*	Acute (survival)	544R00025	**More than 20% < Control**

Table 4-19. Overall summary of WY2013 aquatic toxicity re-tests triggered by WY2012 MRP toxicity trigger criteria.

County/ Program	Test Initiation Date	Species Tested	Treatment/ Sample ID	10-Day Mean % Survival	Comparison to MRP Table 8.1 Trigger Criteria
ACCWP	3/7/13	*H. azteca*	Lab Control	98	NA
	3/7/13		204R00047	98	No signficant difference
CCCWP	3/7/13	*H. azteca*	Lab Control	98	NA
	3/7/13		204R00047	**4***	**< 50% of control**
CCCWP	4/5/13	*H. azteca*	Lab Control	100	NA
	4/5/13		204R00047	**20***	**< 50% of control**

* The response at this test treatment was significantly less than the Lab Control treatment response at $p < 0.05$.

The analysis of toxicity testing results and comparisons to MRP trigger thresholds, also as detailed earlier, are summarized in Table 4-20 for those WY2013 samples that initially exceeded thresholds. In addition to the results identified, there was one additional toxicity test, *P. promelas* collected at site 207R00271 in July 2013, for which signficiant toxicity was identified in the initial analysis, but the 20-replicate re-analysis (USEPA 2000) to address PRM identified by the laboratory removed the toxic response.[25]

[25] See discussion in Section 4.3.1, Dry Season Aquatic Toxicity, and Table 4-11.

Table 4-20. Overall summary of 2013 toxicity results in comparison to Municipal Regional Permit trigger criteria.

County/ Program	Test Initiation Date	Species Tested	Test Regimen	Treatment/ Sample ID	Comparison to Table 8.1 (Water) and Table H-1 (Sediment) Trigger Criteria
Water					
CCCWP	4/5/13	*H. azteca*	Acute (survival)	544R00281	**< 50% of Control**
CCCWP	7/10/13	*H. azteca*	Acute (survival)	207R00271	**< 50% of Control**
Sediment					
CCCWP	7/14/13	*H. azteca*	Acute (survival)	544R00281	**More than 20% < Control**
CCCWP	7/14/13	*H. azteca*	Acute (survival)	207R00271	**More than 20% < Control**
FSURMP	7/14/13	*H. azteca*	Acute (survival)	207R00236	**More than 20% < Control**

Sediment Chemistry Parameters

Sediment chemistry results are evaluated as potential stressors in three ways, based upon the following criteria from MRP Table H-1:

- Calculation of threshold effect concentration (TEC) quotients by analyte; determine whether site has three or more TEC quotients greater than or equal to 1.0;[26]
- Calculation of probable effect concentration (PEC) quotients for all analytes at a given site; determine whether site has mean PEC quotient greater than or equal to 0.5; and,
- Calculation of pyrethroid toxic unit (TU) equivalents as sum of TU equivalents for all measured pyrethroids; determine whether site has sum of TU equivalents greater than or equal to 1.0.

More detail is provided below on each of these three factors.

For sediment chemistry results, Table 4-21 provides threshold effect concentration (TEC) quotients for all non-pyrethroid sediment chemistry constituents, calculated as the measured concentration divided by the TEC value, per MacDonald et al. (2000). This table also provides a count of the number of constituents that exceed TEC values for each site, as evidenced by a TEC quotient greater than or equal to 1.0.

The number of TEC quotients greater than or equal to 1.0 for each site ranges from a low of 0 to a high of 13, out of 27 constituents included in MacDonald et al. (2000). Ten of twelve sites sampled met the relevant trigger criterion from MRP Table H-1, which is interpreted to stipulate three or more constituents with TEC quotients greater than or equal to 1.0.

Table 4-22 provides PEC quotients for all non-pyrethroid sediment chemistry constituents, and calculated mean values of the PEC quotients for each site, with the mean PEC quotient highlighted for sites where mean PEC quotient greater than or equal to 0.5. One site (544R00025) met the MRP Table

[26] Consistent with 2012 Regional UCMR (BASMAA 2013) interpretation, this analysis assumes that there is a typographical error in Table H-1 and that the criterion is meant to read, “3 or more chemicals exceed TECs”.

H-1 action criteria with a mean PEC greater than 0.5. The mean PEC quotients are shown graphically by site in Figure 4-4.

Table 4-23 provides a summary of the calculated toxic unit equivalents for the pyrethroids for which there are published LC50 values in the literature, as well as a sum of calculated toxic unit (TU) equivalents for each site. Because organic carbon mitigates the toxicity of pyrethroid pesticides in sediments, the LC50 values were derived on the basis of TOC-normalized pyrethroid concentrations. Therefore, the pyrethroid concentrations as reported by the lab were divided by the measured TOC concentration at each site, and the TOC-normalized concentrations were then used to compute TU equivalents for each pyrethroid. The individual TU equivalents were then summed to produce a total pyrethroid TU equivalent value for each site. Eight of the twelve sites meet the MRP Table H-1 action criterion with at least one TU quotient greater than or equal to 1.0. These results are shown graphically in Figure 4-5. In most cases, the greatest contributor to the TU sum is bifenthrin (greater than 1.0 TU in six of the twelve samples). Both deltamethrin and cyfluthrin exceeded 1.0 TUs in one of the twelve samples.

Some of the calculated numbers for TEC quotients, PEC quotients, and pyrethroid TU equivalents may be artificially elevated due to the method used to account for filling in non-detect data (as discussed previously, concentrations equal to one-half of the respective laboratory MDLs were substituted for non-detect data so these statistics could be computed). This, however, is not expected to greatly influence assessments.

In assessing the effect of using one-half of the MDL in place of one-half of the MRL to estimate ND results for statistical purposes, relatively large differences were observed in some cases for the 2012 assessments reported in the UCMR (BASMAA 2013), which have been recalculated for this report. For example, assessments for trace metals remain unchanged, as there were no NDs reported for any of the metals analyzed. In comparison, calculated TEC quotients for individual and total PAHs are lower across-the-board using the MDL due to the relatively large proportion of NDs and the difference between MDLs and MRLs reported. For example, for site 204R00047, the number of TEC quotients above the 1.0 threshold dropped from six to one. Similar to the case for PAHs, the TEC quotients for OC pesticides showed decreases associated with the change in estimation technique. However, there remain multiple cases where the TEC quotient is greater than 1.0; it should be noted that 2012 analyses are predominantly non-detects, and therefore that the TEC quotients calculated are driven by the MDL rather than quantified laboratory results. TEC quotients for OC pesticides calculated for this report are approximately one-half of UCMR reported calculations.

Table 4-21. Threshold Effect Concentration (TEC) quotients for 2012 and 2013 sediment chemistry constituents. Bolded values indicate TEC quotient ≥ 1.0

Stormwater Program, Site ID	ACCWP 204R00047 (2012)	ACCWP 204R00084 (2012)	ACCWP 204R00100 (2012)	ACCWP 204R00327 (2013)	ACCWP 204R00447 (2013)	ACCWP 205R00686 (2013)	CCCWP 207R00011 (2012)	CCCWP 544R00025 (2012)
Metals (mg/kg DW)								
Arsenic	0.32	0.55	0.51	0.26	0.84	0.25	0.21	0.46
Cadmium	0.23	0.63	0.08	0.55	0.73	0.17	0.07	0.16
Chromium	0.20	0.76	**1.34**	0.55	**1.24**	0.21	0.20	0.65
Copper	0.70	0.70	0.85	0.76	**2.91**	0.92	0.27	0.89
Lead	0.36	0.59	0.25	**1.42**	0.59	0.17	0.18	0.36
Mercury	0.28	0.21	**1.61**	0.67	0.83	0.22	0.83	0.14
Nickel	0.57	**1.32**	**4.23**	**1.15**	**3.30**	0.57	0.43	**1.15**
Zinc	**1.40**	0.79	0.44	**1.32**	**6.12**	**3.14**	0.38	0.74
PAHs (µg/kg DW)								
Anthracene	0.45	0.19	0.04	**3.85**	0.09	0.07	0.53	0.80
Fluorene	0.33	0.14	0.03	0.87	0.06	0.05	0.39	0.59
Naphthalene	0.14	0.06	0.01	0.08	0.07	0.02	0.17	0.26
Phenanthrene	0.69	0.05	0.01	**5.39**	0.14	0.12	0.15	0.23
Benz(a)anthracene	0.24	0.10	0.02	**6.48**	0.12	0.20	0.28	0.43
Benzo(a)pyrene	0.41	0.07	0.02	**1.53**	0.03	0.03	0.20	0.31
Chrysene	0.15	0.07	0.01	**5.24**	0.31	0.29	0.18	0.28
Fluoranthene	0.90	0.15	0.01	**4.96**	0.10	0.12	0.50	0.11
Pyrene	**2.15**	0.36	0.01	**9.74**	0.23	0.38	**1.03**	0.24
Total PAHs	**1.31**	0.34	0.05	**5.38**	0.20	0.40	**1.04**	**1.01**
Pesticides (µg/kg DW)								
Chlordane	**6.48**	0.90	0.49	0.40	0.65	0.52	**2.59**	**4.01**
Dieldrin	**6.84**	0.92	0.50	0.37	0.61	0.50	**2.63**	**3.95**
Endrin	**2.48**	0.34	0.18	0.34	0.54	0.45	0.95	**1.44**
Heptachlor Epoxide	**3.44**	0.47	0.24	0.13	0.40	0.17	**1.36**	**2.02**
Lindane (gamma-BHC)	**3.16**	0.42	0.23	0.14	0.44	0.18	**1.24**	**1.88**
Sum DDD	**6.15**	**4.08**	0.44	0.76	0.35	0.28	**2.43**	**5.43**
Sum DDE	**10.92**	**1.47**	0.79	0.94	**2.12**	0.38	**4.27**	**79.91**
Sum DDT	**6.73**	**2.91**	0.48	**1.23**	0.27	0.23	**2.64**	**3.92**
Total DDTs	**17.52**	**6.94**	**1.26**	**2.23**	**1.81**	0.66	**6.88**	**55.93**
Number of constituents with TEC quotient ≥ 1.0	**12**	**5**	**4**	**13**	**6**	**1**	**10**	**11**

Stormwater Program, Site ID	**CCCWP 207R00271 (2013)**	**CCCWP 544R00281 (2013)**	**FSURMP 207R00236 (2013)**	**Vallejo 207R05524 (2013)**
Metals (mg/kg DW)				
Arsenic	0.25	0.72	**1.12**	**2.66**
Cadmium	0.08	0.20	0.15	0.23
Chromium	0.28	0.92	0.99	0.81
Copper	0.31	**1.08**	**1.68**	**1.55**
Lead	0.14	0.27	0.53	0.39
Mercury	0.23	0.46	0.23	**1.00**
Nickel	0.57	**3.22**	**2.42**	**2.03**
Zinc	0.46	0.99	**1.32**	**1.40**
PAHs (µg/kg DW)				
Anthracene	0.03	0.06	0.10	0.09
Fluorene	0.02	0.04	0.07	0.06
Naphthalene	0.01	0.02	0.03	0.03
Phenanthrene	0.01	0.02	0.03	0.05
Benz(a)anthracene	0.01	0.03	0.05	0.05
Benzo(a)pyrene	0.01	0.02	0.04	0.03
Chrysene	0.01	0.04	0.03	0.03
Fluoranthene	0.00	0.02	0.01	0.03
Pyrene	0.01	0.04	0.08	0.10
Total PAHs	0.02	0.10	0.10	0.13
Pesticides (µg/kg DW)				
Chlordane	0.40	0.43	0.69	0.65
Dieldrin	0.37	0.39	0.63	0.61
Endrin	0.34	0.36	0.59	0.54
Heptachlor Epoxide	0.13	0.14	0.22	0.20
Lindane (gamma-BHC)	0.14	0.15	0.23	0.23
Sum DDD	0.21	0.23	0.37	0.35
Sum DDE	0.29	**4.20**	0.47	0.45
Sum DDT	0.17	0.18	0.29	0.27
Total DDTs	0.50	**2.86**	0.85	0.80
Number of constituents with TEC quotient ≥ 1.0	**0**	**4**	**4**	**5**

Table 4-22. Probable Effect Concentration (PEC) quotients for WY2012 and WY2013 sediment chemistry constituents. Yellow highlighted cells indicate sites where mean PEC quotient ≥ 0.5 (trigger threshold per MRP Table H-1); bolded values indicate individual PEC quotients > 1.0.

Stormwater Program, Site ID	ACCWP 204R00047 (2012)	ACCWP 204R00084 (2012)	ACCWP 204R00100 (2012)	ACCWP 204R00327 (2013)	ACCWP 204R00447 (2013)	ACCWP 205R00686 (2013)	CCCWP 207R00011 (2012)	CCCWP 544R00025 (2012)
Metals (mg/kg DW)								
Arsenic	0.09	0.16	0.15	0.08	0.25	0.07	0.06	0.14
Cadmium	0.05	0.12	0.02	0.11	0.14	0.03	0.01	0.03
Chromium	0.08	0.30	0.52	0.22	0.49	0.08	0.08	0.25
Copper	0.15	0.15	0.18	0.16	0.62	0.19	0.06	0.19
Lead	0.10	0.16	0.07	0.40	0.16	0.05	0.05	0.10
Mercury	0.05	0.03	0.27	0.11	0.14	0.04	0.14	0.02
Nickel	0.27	0.62	**1.98**	0.53	**1.54**	0.27	0.20	0.53
Zinc	0.37	0.21	0.12	0.35	**1.61**	0.83	0.10	0.19
PAHs (µg/kg DW)								
Anthracene	0.03	0.01	0.00	0.26	0.01	0.00	0.04	0.05
Fluorene	0.05	0.02	0.00	0.13	0.01	0.01	0.06	0.09
Naphthalene	0.05	0.02	0.00	0.02	0.02	0.01	0.05	0.08
Phenanthrene	0.12	0.01	0.00	0.94	0.02	0.02	0.03	0.04
Benz(a)anthracene	0.02	0.01	0.00	0.67	0.01	0.02	0.03	0.04
Benzo(a)pyrene	0.04	0.01	0.00	0.16	0.00	0.00	0.02	0.03
Chrysene	0.02	0.01	0.00	0.67	0.04	0.04	0.02	0.04
Fluoranthene	0.17	0.03	0.00	0.94	0.02	0.02	0.09	0.02
Pyrene	0.28	0.05	0.00	**1.25**	0.03	0.05	0.13	0.03
Total PAHs	0.09	0.02	0.00	0.38	0.01	0.03	0.07	0.07
Pesticides (µg/kg DW)								
Chlordane	**1.19**	0.16	0.09	0.07	0.12	0.10	0.48	0.74
Dieldrin	0.21	0.03	0.02	0.01	0.02	0.02	0.08	0.12
Endrin	0.03	0.00	0.00	0.00	0.01	0.00	0.01	0.02
Heptachlor Epoxide	0.53	0.07	0.04	0.02	0.06	0.03	0.21	0.31
Lindane (gamma-BHC)	**1.50**	0.20	0.11	0.07	0.21	0.09	0.59	0.89
Sum DDD	**1.07**	0.71	0.08	0.13	0.06	0.05	0.42	0.95
Sum DDE	**1.10**	0.15	0.08	0.09	0.21	0.04	0.43	**8.07**
Sum DDT	0.45	0.19	0.03	0.08	0.02	0.01	0.17	0.26
Total DDTs	0.16	0.06	0.01	0.02	0.02	0.01	0.06	0.52
Mean PEC Quotient	0.31	0.13	0.14	0.29	0.22	0.08	0.14	**0.51**

Stormwater Program, Site ID	CCCWP 207R00271 (2013)	CCCWP 544R00281 (2013)	FSURMP 207R00236 (2013)	Vallejo 207R05524 (2013)
Metals (mg/kg DW)				
Arsenic	0.07	0.21	0.33	0.79
Cadmium	0.02	0.04	0.03	0.05
Chromium	0.11	0.36	0.39	0.32
Copper	0.07	0.23	0.36	0.33
Lead	0.04	0.08	0.15	0.11
Mercury	0.04	0.08	0.04	0.17
Nickel	0.27	**1.50**	**1.13**	0.95
Zinc	0.12	0.26	0.35	0.37
PAHs (µg/kg DW)				
Anthracene	0.00	0.00	0.01	0.01
Fluorene	0.00	0.01	0.01	0.01
Naphthalene	0.00	0.01	0.01	0.01
Phenanthrene	0.00	0.00	0.00	0.01
Benz(a)anthracene	0.00	0.00	0.01	0.00
Benzo(a)pyrene	0.00	0.00	0.00	0.00
Chrysene	0.00	0.01	0.00	0.00
Fluoranthene	0.00	0.00	0.00	0.01
Pyrene	0.00	0.00	0.01	0.01
Total PAHs	0.00	0.01	0.01	0.01
Chlordane	0.07	0.08	0.13	0.12
Dieldrin	0.01	0.01	0.02	0.02
Endrin	0.00	0.00	0.01	0.01
Heptachlor Epoxide	0.02	0.02	0.03	0.03
Lindane (gamma-BHC)	0.07	0.07	0.11	0.11
Sum DDD	0.04	0.04	0.06	0.06
Sum DDE	0.03	0.42	0.05	0.05
Sum DDT	0.01	0.01	0.02	0.02
Total DDTs	0.00	0.03	0.01	0.01
Mean PEC Quotient	0.04	0.13	0.12	0.13

Table 4-23. Calculated pyrethroid toxic unit equivalents, 2012 and 2013 sediment chemistry data. Yellow highlighted cells indicate sites where the sum of the pyrethroid TU equivalents is ≥ 1.0; bolded values indicate individual pyrethroid TUs > 1.0.

Pyrethroid	LC50 (ng/g dw)	ACCWP 204R00047 (2012)	ACCWP 204R00084 (2012)	ACCWP 204R00100 (2012)	ACCWP 204R00327 (2013)	ACCWP 204R00447 (2013)	ACCWP 205R00686 (2013)	CCCWP 207R00011 (2012)	CCCWP 544R00025 (2012)
Bifenthrin	0.52	**1.756**	0.370	0.096	0.14	**1.21**	0.14	**1.469**	**3.302**
Cyfluthrin	1.08	0.201	0.028	**2.680**	0.02	0.05	0.19	0.302	0.043
Cypermethrin	0.38	0.137	0.072	0.045	0.04	0.02	0.01	0.163	0.112
Deltamethrin	0.79	0.083	0.041	0.025	0.01	0.06	0.05	0.092	0.064
Esfenvalerate	1.54	0.016	0.023	0.014	0.00	0.00	0.00	0.051	0.036
Lambda-Cyhalothrin	0.45	0.025	0.036	0.022	0.02	0.01	0.01	0.081	0.056
Permethrin	10.83	0.028	0.006	0.003	0.02	0.01	0.00	0.012	0.009
Sum of Toxic Unit Equivalents per Site		**2.245**	0.575	**2.886**	0.26	**1.37**	0.41	**2.17**	**3.62**

Pyrethroid	LC50 (ng/g dw)	CCCWP 207R00271 (2013)	CCCWP 544R00281 (2013)	FSURMP 207R00236 (2013)	Vallejo 207R05524 (2013)
Bifenthrin	0.52	**4.58**	0.96	**3.17**	0.12
Cyfluthrin	1.08	0.96	0.04	0.76	0.04
Cypermethrin	0.38	0.10	0.01	0.56	0.01
Deltamethrin	0.79	**4.62**	0.01	0.11	0.00
Esfenvalerate	1.54	0.01	0.00	0.05	0.00
Lambda-Cyhalothrin	0.45	0.13	0.01	0.55	0.01
Permethrin	10.83	0.08	0.00	0.06	0.00
Sum of Toxic Unit Equivalents per Site		**10.48**	**1.03**	**5.26**	0.19

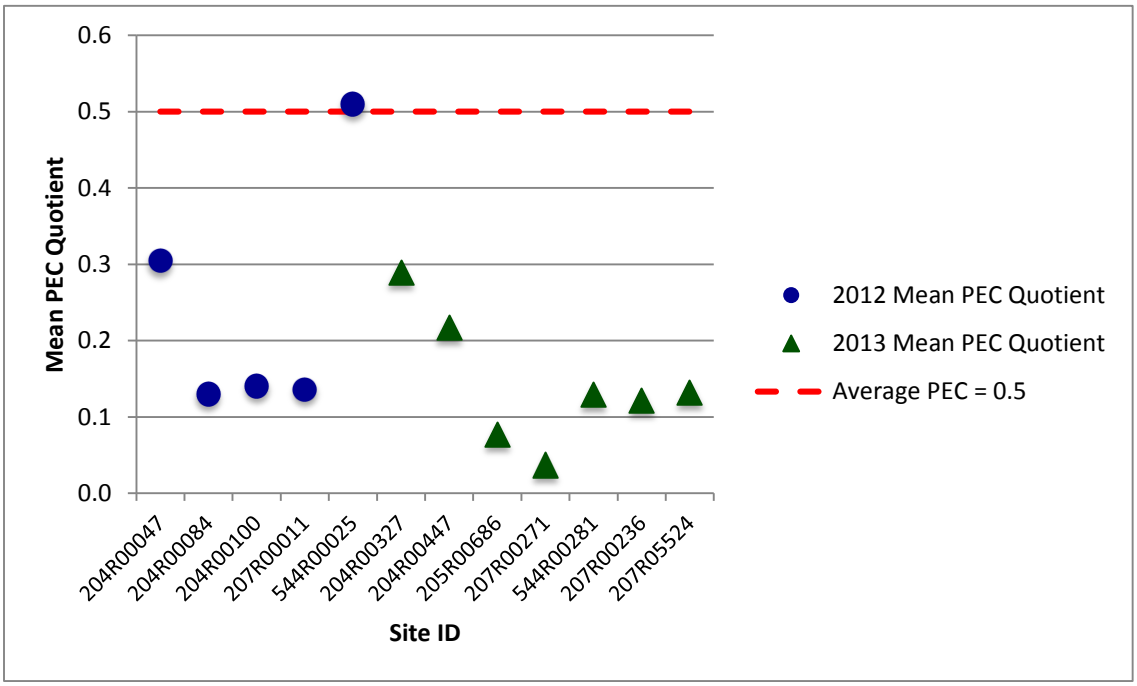

Figure 4-4. Plot of mean PEC quotient per site, WY2012 and WY2013 data

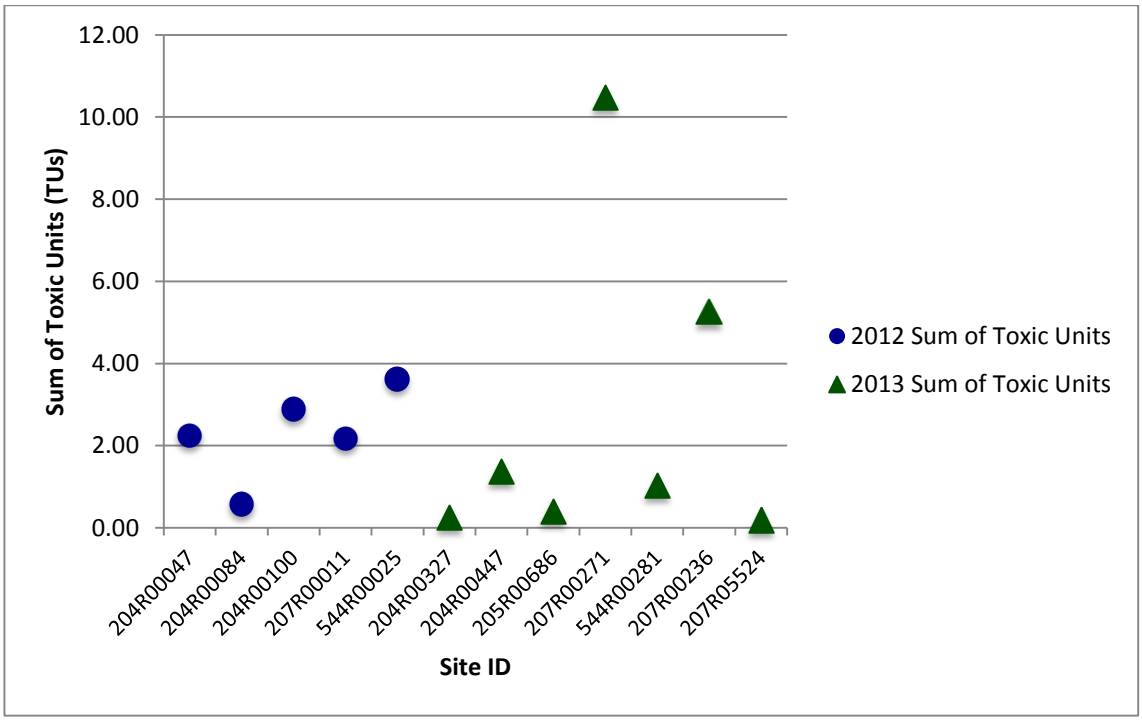

Figure 4-5. Plot of the sum of pyrethroid toxic unit equivalents per site, WY2012 and WY2013 data

Sediment Triad Analysis

Table 4-24 summarizes stressor evaluation results for those sites with data collected for sediment chemistry, sediment toxicity and bioassessment parameters; due to site conditions only five of the seven 2013 sites planned for triad sampling were monitored for the full suite of bioassessment, sediment chemistry, and water and sediment toxicity. Biological condition assessments are also shown for WY2012 using a provisional regional consensus approach based on the Southern California benthic macroinvertebrate Index of Biological Integrity (B-IBI); condition assessments for WY2013 are discussed elsewhere in the program-specific IMRs.

Table 4-24. Summary of sediment quality triad evaluation results, WY 2012 (shaded cells) and sediment chemistry/toxicity evaluation results, WY 2013 data (shaded cells - see program-specific portions of IMR for bioassessment and Table H-1 analyses. Yellow highlighted cells indicate results above MRP trigger threshold.

Agency/ Program	Waterbody	Site ID	B-IBI Condition Category	Sediment Toxicity	# TEC Quotients ≥ 1.0:	Mean PEC Quotient	Sum of TU Equiv.	Next Step per MRP Table H-1
ACCWP	Castro Valley	204R00047	Poor	No	12	0.31	2.25	A
ACCWP	Dublin Creek	204R00084	Very Poor	No	5	0.13	0.58	A
ACCWP	Arroyo Mocho	204R00100	Very Poor	No	4	0.14	2.89	A
CCCWP	Grayson Creek	207R00011	Very Poor	Yes	10	0.14	2.17	C
CCCWP	Dry Creek	544R00025	Very Poor	Yes	11	0.51	3.62	C
ACCWP	Line 3A-A-3	204R00327		No	13	0.29	0.26	
ACCWP	Kottinger Creek	204R00447		No	6	0.22	1.37	
ACCWP	Canada del Aliso	205R00686		No	1	0.08	0.41	
CCCWP	Sycamore Creek	207R00271		Yes	0	0.04	10.48	
CCCWP	Marsh Creek	544R00281		Yes	4	0.13	1.03	
FSURMP	Laurel Creek	207R00236	NA	Yes	4	0.12	5.26	
Vallejo	Blue Rock Springs Cr	207R05524	NA	No	5	0.13	0.19	

Key to Next Steps:

Action Code	Exceeds Bioassessment/ Toxicity/ Chemistry Threshold	Next Step per MRP Table H-1 (selected)
A	Yes/No/Yes	(1) Identify cause of impacts. (2) Where impacts are under Permittee's control, take management actions to minimize the impacts caused by urban runoff; initiate no later than the second fiscal year following the sampling event.
B	No/No/Yes	If PEC exceedance is Hg or PCBs, address under TMDLs.
C	Yes/Yes/Yes	(1) Identify cause(s) of impacts and spatial extent. (2) Where impacts are under Permittee's control, take management actions to address impacts.
D	No/Yes/Yes	(1) Take confirmatory sample for toxicity. (2) If toxicity repeated, attempt to dentify cause and spatial extent. (3) Where impacts are under Permittee's control, take management actions to minimize upstream sources.

While MacDonald et al. (2000) generated PECs for multiple trace element, PAH, OC pesticide, and pyrethroid pesticide parameters, there was insufficient data at time of its publication to evaluate the consensus PECs generated as to their predictive ability for associated sediment toxicity for each of the analytes reported. Analytes for which predictive ability is particularly uncertain include various PAH (anthracene, fluorine, and fluoranthene) and OC pesticide (dieldrin, DDDs, DDTs, endrin, heptachlor epoxide, and lindane) parameters (MacDonald et al. 2000).

Additionally, MacDonald et al. (2000) TECs and PECs were generated with the assumption that the predictive ability of the thresholds would be acceptable if the prediction was correct 75% of the time. For the twelve samples collected by the four contributing Programs, a single sample exceeded the mean PEC criterion of 0.5; significant toxicity was reported associated with this sample (Table 4-24). For the one sample that had more than three analytes exceed associated PECs, statistically significant toxicity was not reported.

When examining pyrethroids concentrations, a similar degree of uncertainty exists. Weston (2005) reported that predictions of sediment toxicity to H. azteca were supported by observed results for sites with TU ratios below one (little or no mortality) and above four (high or full mortality). For TUs between one and four, however, the predictive ability of the TU is less certain (Weston 2005). Half of the twelve samples analyzed by the four collaborating Programs in WY2012 and WY2013 fell within this range (Table 4-23). This uncertainty can potentially be seen in the RMC results where a sample with a pyrethroid TU of 1.0 was associated with a toxic sample, and one with a TU of 2.9 was not (Table 4-23).

5.0 Conclusions and Next Steps

During water years 2012 and 2013, sixty-eight sites were monitored by the four Programs contributing to this report under the RMC regional probabilistic design for bioassessment, physical habitat, and related water chemistry parameters. Twelve sites were also monitored for water and sediment toxicity and sediment chemistry. The water and sediment chemistry and toxicity data were used to evaluate potential stressors that may affect aquatic habitat quality and beneficial uses. Each program also used bioassessment and related data to develop a preliminary condition assessment for the monitored sites, to be used in conjunction with the stressor assessment based on sediment chemistry and toxicity.

The following MRP reporting requirements (Provision C.8.g.iv) were addressed within this report as applicable:

- Descriptions of monitoring purpose and study design rationale
- QA/QC summaries for sample collection and analytical methods, including a discussion of any limitations of the data;
- Descriptions of sampling protocols and analytical methods;
- Tables and Figures describing: Sample location descriptions (including waterbody names, and lat/longs); sample ID, collection date (and time where relevant), media (e.g., water, filtered water, bed sediment, tissue); concentrations detected, measurement units, and detection limits;
- Data assessment, analysis, and interpretation for Provision C.8.c.;
- Pollutant load and concentration at each mass emissions station;
- A listing of volunteer and other non-Permittee entities whose data are included in the report;
- Assessment of compliance with applicable water quality standards;

Candidate sites classified with unknown sampling status as of WY2013 may continue to be evaluated by the individual stormwater programs for potential sampling in Water Year 2014.

5.1 Summary of Stressor Analyses

The stressor analysis revealed the following potential stressors, based on an analysis of the first two years of data collection activities collected by the four Programs under the RMC umbrella:

- **Water Quality –** Of 11 parameters[27] sampled in association with bioassessment monitoring, applicable water quality standards were only identified for ammonia, chloride, and nitrate + nitrite (sites with MUN beneficial use only). Of the results generated at the 68 sites monitored by the four collaborating Programs reporting herein for those three parameters, only two un-ionized ammonia concentrations and one chloride concentration exceeded the applicable water quality standard or threshold; each of these occurred at different sites. The MRP Table 8.1 trigger thresholds for "Nutrients" (i.e., 20% of results in one waterbody exceed one or more water quality standards or applicable thresholds) was therefore exceeded at only three of the 68 sites.

[27] Algal mass (ash-free dry weight), Chlorophyll a, Dissolved Organic Carbon, Ammonia, Nitrate, Total Nitrogen, Dissolved OrthoPhosphate, Phosphorus, Suspended Sediment Concentration, Silica and Chloride

- **Water Toxicity –** 96 toxicity endpoints were derived through testing of 4 species at 24 sites regionwide during two wet season and two dry season events. Of these endpoints, samples from five sites exhibited significant toxicity to at least one test species with survival and/or growth "< 50% of Control," indicating re-testing per MRP Table 8.1. Three of these were the result of WY2012 monitoring and were re-tested in WY2013. Of these three re-tests, two exhibited a toxic response at levels meeting MRP thresholds.
- **Sediment Toxicity –** Of the bedded sediment collected from 12 sites, a toxic response in test species *H. azteca* was observed at 9 sites. Results were more than 20% less than the control at 5 of these sites, meeting the Table H-1 sediment toxicity criterion.
- **Sediment Chemistry -** Results produced evidence of potential stressors in 3 ways, based on the criteria from MRP Table H-1: **(**1) at 10 of 12 sites, 3 or more constituents exhibited TEC quotients greater than 1.0[28], (2) at 1 of 12 sites, the mean PEC quotient was > 0.5, and (3) at 8 of 12 sites, the sum of TU equivalents for all measured pyrethroids was greater than or equal to 1.0.
- **Sediment Triad Analyses (partial) –** sediment chemistry and toxicity results were evaluated as two of the three lines of evidence used in the triad approach for assessing overall stream condition, along with biological community data discussed in Appendix A.1.

5.2 Next Steps

The preceding analysis has identified a number of potential sites that may deserve further evaluation and/or investigation to provide better understanding of the sources/stressors that may be contributing to reduced water quality and lower biological condition at these sites. During WY2013, the RMC collaboratively reviewed trigger results from WY2012 and selected a total of ten sites in four counties for implementation of stressor/source identification (SSID) projects based on prioritization of the type, extent and geographic spread of the triggers. Individual RMC Programs are reporting elsewhere in the IMR on technical studies for SSID projects in their respective jurisdictions, which are to be initiated by the second Fiscal Year following the year in which the potential stressor was identified.

RMC participants will continue to implement the regional probabilistic monitoring design in WY2014. Site evaluation and sampling are planned at new sites for this Water Year, as well as resampling and retesting as required to complete the evaluaton of trigger thresholds per MRP Table 8.1.

[28] For nearly all sites, chromium and nickel concentrations in sediment exceeded TEC values. Considering that both metals are naturally occurring at relatively high levels in Bay Area soils, and concentrations generally exceed TEC values in reference or non-urban sites, TEC values presented in MacDonald et al. (2000) may not be applicable to the Bay Area. These observations should be considered in future evaluations of sediment chemistry data collected by RMC participants in Bay Area creeks.

6.0 References

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ALAMEDA COUNTYWIDE CLEAN WATER PROGRAM

CREEK STATUS MONITORING REPORT - TARGETED PARAMETERS

WATER YEARS 2012 AND 2013 INTEGRATED MONITORING REPORT, PART A - APPENDIX A.3

Report prepared by

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Submitted to:

California Regional Water Quality Control Board, San Francisco Bay Region

FINAL

March 14, 2014

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Alameda County Flood Control and Water Conservation District

Zone 7 Water Agency

Protecting Alameda County Creeks, Wetlands & the Bay

Preface

The Bay Area Stormwater Management Agencies Association (BASMAA) Regional Monitoring Coalition (RMC) collaboratively developed an outline for preparation of the Integrated Monitoring Report (IMR) to be submitted in compliance with the Municipal Regional Stormwater Permit (MRP) Reporting Provision C.8.g.v for all monitoring conducted during the MRP permit term.

The following participants make up the RMC and are responsible for preparing IMR documents on behalf of their respective member agencies:

- 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); and
- City of Vallejo and Vallejo Sanitation and Flood Control District (Vallejo).

This report was prepared by ACCWP to fulfill reporting requirements for a portion of the Creek Status monitoring data collected in Water Years 2012 (October 1, 2011 through September 30, 2012) and 2013 (October 1, 2012 through September 30, 2013) as part of the RMC's Monitoring Plan (BASMAA, 2011) for certain parameters monitored according to Provision C.8.c of the MRP. This report is an Appendix to the full IMR Part A submitted by ACCWP on behalf of the following Permittees:

- The cities of Alameda, Albany, Berkeley, Dublin, Emeryville, Fremont, Hayward, Livermore, Newark, Oakland, Piedmont, Pleasanton, San Leandro, and Union City;
- Alameda County;
- Alameda County Flood Control and Water Conservation District and
- Zone 7 Water Agency

Data presented in this report were produced under the direction of the ACCWP using a targeted (non-probabilistic) monitoring design. Other data collected in Alameda County during this period pursuant to MRP Provision C.8 are reported in the main body and other appendices of ACCWP's Integrated Monitoring Report, Part A.

In accordance with the RMC Creek Status and Long-Term Trends Monitoring Plan (BASMAA, 2011), targeted monitoring data were collected in accordance with the BASMAA RMC Quality

Assurance Program Plan (QAPP; BASMAA, 2012a and 2014a) and BASMAA RMC Standard Operating Procedures (SOPs; BASMAA, 2012b and 2014b). Where applicable, monitoring data were derived using methods comparable with methods specified by the California Surface Water Ambient Monitoring Program (SWAMP) QAPP[1]. ACCWP also submitted the data included in this report to the San Francisco Bay Regional Water Quality Control Board (SFBRWQCB) in electronic SWAMP-comparable format.

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

List of Acronyms

Acronym	Definition
AMS	Applied Marine Sciences
ACCWP	Alameda Countywide Clean Water Program
ACFCWCD	Alameda County Flood Control Water Conservation District
BASMAA	Bay Area Stormwater Management Agency Association
CCCWP	Contra Costa Clean Water Program
CEDEN	California Environmental Data Exchange Network
CRAM	California Rapid Assessment Method
DO	Dissolved oxygen
DQO	Data Quality Objective
EBMUD	East Bay Municipal Utility District
E. coli	*Escherichia coli*
FOSC	Friends of Sausal Creek
FSURMP	Fairfield Suisun Urban Runoff Management Program
I-	Interstate Highway
IMR	Integrated Monitoring Report
MPC	Monitoring and Pollutants of Concern Committee
MPN	Most Probable Number
MRP	Municipal Regional Permit
MQO	Measurable Quality Objective
MWAT	Maximum Weekly Average Temperature
NPDES	National Pollution Discharge Elimination System
QAPP	Quality Assurance Project Plan
RMC	Regional Monitoring Coalition
RMP	Regional Monitoring Program
RWQCB	Regional Water Quality Control Board
SCVURPPP	Santa Clara Valley Urban Runoff Pollution Prevention Program
SFBRWQCB	San Francisco Bay Regional Water Quality Control Board
SFEI	San Francisco Estuary Institute
SMCWPPP	San Mateo County Water Pollution Prevention Program
SOP	Standard Operating Protocol
SSID	Stressor/Source Identification
SWAMP	Surface Water Ambient Monitoring Program
UCMP	Urban Creek Monitoring Report
USA	Unified Stream Assessment
USEPA	United States Environmental Protection Agency
WQO	Water Quality Objective
WY	Water Year

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Executive Summary

In 2010, the seventeen members of the Alameda Countywide Clean Water Program (ACCWP) joined other members of the Bay Area Stormwater Agencies Association (BASMAA) to form the Regional Monitoring Coalition (RMC), to coordinate and oversee water quality monitoring required by Provision C.8 of the Municipal Regional National Pollutant Discharge Elimination System (NPDES) Stormwater Permit (MRP). This report presents the details of the Creek Status Monitoring for parameters that use a targeted (non-probabilistic) monitoring design, and is one of several documents prepared to comply with the MRP Reporting Provision C.8.g.

The ACCWP Targeted Creek Status Monitoring in Water Year 2012 (WY2012) was conducted in two urban watersheds (Sausal Creek and portions of the San Lorenzo Creek system) while monitoring in WY2013 was conducted in San Lorenzo Creek (including Castro Valley/Chabot and Crow Creeks), as well as a number of Oakland creeks (Arroyo Viejo, Lion and Glen Echo).

Monitoring in both years included:

- Continuous temperature monitoring at eight locations each year[2]at hourly intervals over five months;
- General water quality monitoring at three locations each year with assessment of temperature, dissolved oxygen (DO), pH and specific conductivity at 15-minute intervals during two one week periods in Spring and late Summer/Fall;
- Pathogen indicator (*E. coli* and fecal coliform) quantification once at five sites each year; and
- Nine miles of stream surveys using the Center for Watershed Protection's protocol for Unified Stream Assessment.

The results of the targeted Urban Creek Monitoring indicated:

Continuous Temperature

Continuous temperature monitoring results in WY2012 and WY2013 did not show any Mean Weekly Average Temperatures that reached trigger criteria at any sites.

General Water Quality

Results of the General Water Quality assessment are presented in Table E-1 for all parameters where at least some of the rolling 7-day averages reached the applicable water quality standard

[2] In WY2013 continuous temperature monitors were deployed at a total of nine locations, one more than the MRP requirement of eight locations, to account for potential loss or failure. At time of retrieval, one unit deployed at site 204AVJ080 was unable to be located after multiple attempts at retrieval.

or threshold used for comparison. Dissolved oxygen was the only parameter for which at least 20% of the rolling 7-day averages reached or were below the threshold and so met the trigger criterion in the MRP.

Table E-1. Percentage of Weekly 7-Day Rolling Averages Meeting MRP Trigger Thresholds for General Water Quality Monitoring sites in WY2012 and WY2013

		Applicable threshold or water quality standard				
Site ID	**Monitoring Season**	**Temperature > 19°C**	**pH < 6.5**	**pH > 8.5**	**DO < 5mg/L (WARM)**	**DO < 7mg/L (COLD)**
204CRW030	September 2012	0.0%	0.0%	0.0%	0.0%	**67.7%**
204AVJ080	September 2013	0.0%	0.0%	0.0%	**100.0%**	**100.0%**
204AVJ130	April 2013	0.0%	0.0%	0.0%	0.0%	**20.0%**
204LIO080	May 2013	0.0%	0.0%	0.0%	0.0%	16.7%
204LIO080	September 2013	0.0%	0.0%	0.0%	**100.0%**	**100.0%**

BOLD: percentage of rolling averages reaching trigger criteria, if above zero.

Pathogen Indicator Bacteria

Eight of ten water samples collected for pathogen indicators recorded elevated fecal coliform and *E. coli* concentrations of between 500 and >16,000 most probable number (MPN) per 100mL. The results are presented in Table E-2. Actual creek contact at most of these sites is sporadic and does not correspond to the assumptions for human health risk assessment that were used to develop the water quality standard being used for comparison. Due to high sample variability the results of a single sample are insufficient to determine average levels of pathogen indicators, and in dry weather urban runoff is likely to make little or no contribution to the observed bacterial levels.

Table E-2: Comparison of WY2012 and WY2013 Pathogen Indicator Concentrations to Water Quality Objectives and Triggers.

Creek Name	Site ID	Site Name	Fecal Coliform (MPN/100mL*)	*E. coli* (MPN/100mL*)
Castro Valley	204CVY020	Chabot Creek at Carlos Bee Park	**900**	**900**
Castro Valley	204CVY080	Castro Valley Creek above confluence with Chabot Creek	**900**	**900**
Castro Valley	204CVY120	CV Creek Park at Castro Valley Library	**1,700**	**1,700**
Castro Valley	204CVY140	Castro Valley Creek North side of Berdina Rd	**>/= 16,000**	**>/= 16,000**
Castro Valley	204CVY150	Castro Valley Creek North side of Heyer Ave	**500**	500
Arroyo Viejo	204AVJ080	Along Golf Links Dr. just west of I-580	**500**	**500**
Lion Creek	204LIO050	Chimes Creek at Mills	**700**	**700**
Lion Creek	204LIO070	Lion Creek near Wetmore Ave bridge	230	230
Sausal Creek	204SAU090	Below Leimert Ave. bridge	8	8
Temescal Creek	204TEM100	Near Broadway Terrace and Duncan	**3,000**	**3,000**

*Most Probable Number per 100mL
BOLD font indicates result meets trigger conditions.

Stream Survey

The overall reach assessment scores (including both WY2012 and WY2013) ranged from 20 to 110. Sausal Creek had the highest average score of 85, with a more complex instream habitat and vegetated banks. Crow Creek had the second highest average score of 70, with natural creek mileage and more optimal instream habitat. In San Lorenzo Creek the highly channelized lower reaches had a low average score (31) while the upper reaches had higher scores (average of 65). The extensively altered Chabot Creek also had a low average score of 46 with poor instream habitat complexity, sparse vegetation and deeply entrenched channels in the natural stream reaches. The majority of outfalls were stormdrains. Erosion and trash were found in localized areas.

Stressor Evaluation

Where applicable, targeted monitoring data were evaluated against numeric Water Quality Objectives or other applicable thresholds described for each parameter in Table 8.1 of the MRP, to determine whether results "trigger" a potential stressor/source identification monitoring project as described in MRP Provision C.8.d.i). The following trigger conditions were identified:

- No temperature triggers were observed during ACCWP monitoring in WY2012 or WY2013.

- Dissolved oxygen concentrations were lower than 7mg/L in at least 20% of results for at least one deployment at Site 204CRW030 in WY2012 and at 204AVJ080, 204AVJ130 and 204LIO080 in WY2013 based on analysis of the 7-day rolling averages for continuous monitoring observations.

- Seven of the ten water samples analyzed for pathogen indicators were above trigger levels for lightly and moderately used REC1 beneficial use, although limited public accessibility at many sites make human usage much less likely to produce the exposure risks assumed in developing the water quality criteria used for reference.

Where triggers or potential trigger conditions have been identified in WY2012 and WY2013 results, ACCWP has initiated three Stressor/Source Identification (SSID) projects and will also work with local stormwater managers to identify appropriate follow-up activities.

1 Introduction

This Creek Status Monitoring Report complies with Municipal Regional Permit (MRP) Reporting Provision C.8.gfor a portion of Creek Status Monitoring data collected on behalf of Alameda County Permittees during Water Years 2012 and 2013 (October 1, 2011 through September 30) in compliance with MRP Provision C.8.c. Data presented in this report were developed using a targeted (non-probabilistic) monitoring design. This report is Appendix A.3 to the overall to the Integrated Monitoring Report (IMR) prepared by the BASMAA Regional Monitoring Coalition (RMC).

The RMC was formed in early 2010 as a collaboration among a number of BASMAA members and MRP Permittees, listed in Table 1-1. The RMC's focus is developing and implementing a regionally coordinated water quality monitoring program to address water quality monitoring required by the MRP. Implementation of the RMC's Creek Status and Long-Term Trends Monitoring Plan allows Permittees and the Water Board to effectively modify their existing creek monitoring programs, and improve their ability to collectively answer core management questions in a cost-effective and scientifically rigorous way. Participation in the RMC is facilitated through the BASMAA Monitoring and Pollutants of Concern Committee (MPC) and its associated RMC Work Group.

The goals of the RMC are to:

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

Table 1-1. Regional Monitoring Coalition Participants.

Stormwater Programs	RMC Participants
Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP)	Cities of Campbell, Cupertino, Los Altos, Milpitas, Monte Sereno, Mountain View, Palo Alto, San Jose, Santa Clara, Saratoga, Sunnyvale, Los Altos Hills, and Los Gatos; Santa Clara Valley Water District; and, Santa Clara County.
Alameda Countywide Clean Water Program (ACCWP)	Cities of Alameda, Albany, Berkeley, Dublin, Emeryville, Fremont, Hayward, Livermore, Newark, Oakland, Piedmont, Pleasanton, San Leandro, and Union City; Alameda County; Alameda County Flood Control and Water Conservation District; and, Zone 7 of the Alameda County Flood Control and Water Conservation District (Zone 7 Water Agency).
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 Countywide 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 RMC addresses the scope of sub-provisions specified in MRP Provision C.8.c (Table 1-2).This report includes the standard report content as required by MRP Provision C.8.g.v in the respective sections referenced in Table 1-2 and presents the results of the portions of Creek Status Monitoring that were conducted to comply with Provision C.8.c using a targeted (non-probabilistic) monitoring design (Table 1-3) as described in the RMC's Status and Long-Term Trends Monitoring Plan (BASMAA, 2011).

Table 1-2. Municipal Regional Permit Provisions Addressed by the Regional Monitoring Coalition.

MRP C.8 Subprovision Number	MRP C.8 Sub-provision Title	Reporting Documents
C.8.a	Compliance Options	Regional Monitoring Coalition Creek Status & Long-Term Trends Monitoring Plan.
C.8.b	San Francisco Bay Estuary Monitoring	Regional Monitoring Plan Annual Monitoring Results.
C.8.c	Creek Status and Long-Term Trends Monitoring	Regional Urban Creeks Monitoring Report; Local Urban Creeks Monitoring Report.
C.8.d	Monitoring Projects: Stressor/Source Identification; BMP Effectiveness Investigation; Geomorphic Project.	Stressor/Source Identification Report; BMP Effectiveness Report; Integrated Monitoring Report.
C.8.e	Pollutants of Concern (Loads) Monitoring	Integrated Monitoring Report.
C.8.f	Citizen Monitoring and Participation	Annual Urban Creeks Monitoring Report.
C.8.g	Data Analysis and Reporting	As described above.

Table 1-3. Creek Status Monitoring Parameters Monitored in Compliance with MRP Provision C.8.c.and the Associated Reporting Format.

Monitoring Elements of MRP Provision C.8.c	Monitoring Design		Reporting	
	Regional Ambient (Probabilistic)	Local (Targeted)	Regional	Local
Bioassessment & Physical Habitat Assessment	X		X	
Chlorine	X		X	
Nutrients	X		X	
Water Toxicity	X		X	
Sediment Toxicity	X		X	
Sediment Chemistry	X		X	
General Water Quality		X		X
Temperature		X		X
Bacteria		X		X
Stream Survey		X		X

The remainder of this report describes the Study Area and Monitoring Design (Section 2), the Monitoring Methods (Section 3), the Results (Section 4), the preliminary Stressor Assessment (Section 5), and the Conclusions & Next Steps (Section 6).

2 Study Area & Design

2.1 Regional Monitoring Coalition Area

The RMC area encompasses 3,407 square miles of land in the San Francisco Bay Area. This includes the portions of the five participating counties that fall within the San Francisco Bay RWQCB boundary, as well as the eastern portion of Contra Costa County that drains to the Central Valley region (Figure 2-1). Creek Status monitoring is being conducted in flowing water bodies (i.e., creeks, streams and rivers) interspersed among the RMC area, including perennial and non-perennial creeks and rivers that run through both urban and non-urban areas.

2.2 Alameda County Targeted Monitoring Areas

Alameda County occupies 739 square miles (1,914 sq. km) of land area in the East Bay region of the San Francisco Bay Area, and discharges to portions of the Central Bay, South Bay and Lower South Bay. Its population of 1,510,271 (as of April 2010) is densest in the Bay Plain western portion of the County, where the largest cities include Oakland, Fremont, Berkeley and Hayward. The eastern portion of the county includes the cities of Dublin, Livermore and Pleasanton occupying the Livermore-Amador Valley, a portion of the very large and mostly undeveloped Alameda Creek Watershed.

In WY2012, ACCWP's targeted monitoring focused on two watersheds: San Lorenzo Creek and Sausal Creek. In WY2013, additional creeks were investigated in the Oakland City including Lion, Glen Echo and Arroyo Viejo. The monitoring is summarized in Table 2-1.

Table 2-1. Summary of Targeted Monitoring in Alameda County Watersheds During Water Years 2012 and 2013.

Watershed	WY2012	WY2013
San Lorenzo Creek	GWQ, SS (partial)	SS (remaining urban portions)
Crow Creek	Temp, GWQ, SS (partial)	
Castro Valley Creek	GWQ, PI, SS	N/A
Chabot Creek	SS	N/A
Sausal Creek	Temp	PI, SS (partial)
Arroyo Viejo	N/A	PI, SS (partial)
Lion Creek	N/A	PI
Glen Echo Creek	N/A	SS (partial)
Temescal Creek	N/A	PI

Legend: Temp = temperature; GWQ = General Water Quality, PI = Pathogen Indicators, SS = Stream Survey

During each year of monitoring, watersheds were chosen each with distinct management issues and stakeholder concerns as described below.

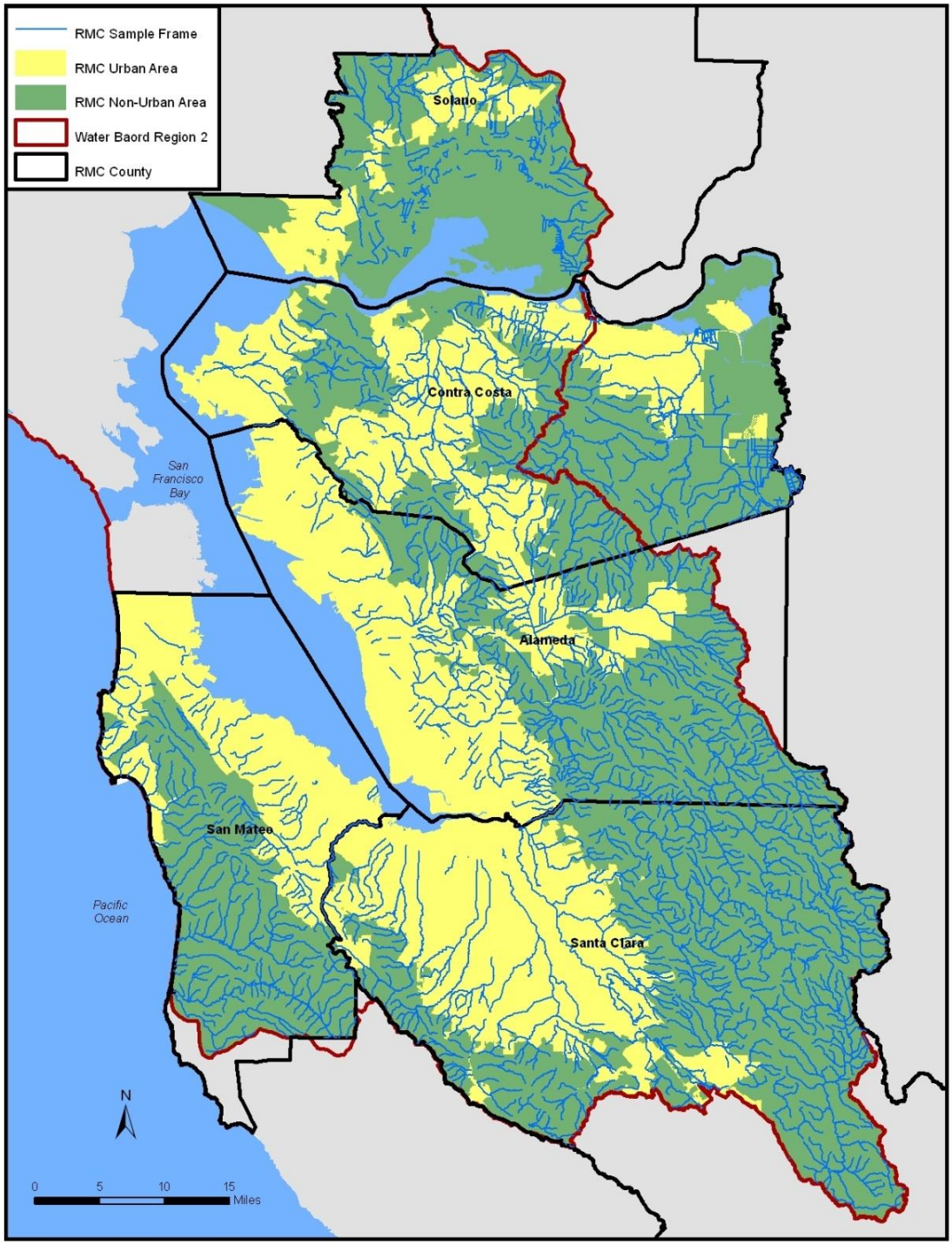

Figure 2-1. Map of BASMAA RMC Area, Major Creeks, Transportation Features.

2.2.1 San Lorenzo Creek Watershed

The overall San Lorenzo Creek Watershed drains approximately 48 square miles (30,000 acres) of land and extends from the San Francisco Bay to the ridge-tops of the East Bay hills (Figure 2-2). The watershed encompasses both urban and non-urban areas, mostly in unincorporated portions of Alameda County. Within the watershed are over 81 miles of natural creeks including some segments of Castro Valley and Chabot Creeks within the urbanized area, and Crow Creek spanning both rural and suburban development. Upper Sulphur Creek (formerly a separate drainage) also discharges part of its runoff into San Lorenzo Creek near Second Street in Hayward.

The San Lorenzo Creek watershed has undergone extensive hydromodification in the 20th century, including construction of the flood control channel in the lower portions of the watershed by the US Army Corps of Engineers, and Cull Canyon and Don Castro Reservoirs by the Alameda County Flood Control and Water Conservation District (SFEI, 2001). The San Lorenzo Creek Watershed is also coterminous with Zone 2 of the District, which has in recent years sponsored several restoration projects along Castro Valley Creek and other tributaries and sponsored geomorphic and fisheries surveys in non-urban portions of several creeks.

Beneficial uses (SFRWQCB, 2011) assigned to San Lorenzo Creek and its tributaries include the following abbreviated list:

- Cold Freshwater Habitat (COLD) is assigned to San Lorenzo Creek and all of its tributaries;
- Fish Migration (MIGR) is assigned to the main stem of San Lorenzo Creek and to Crow Creek, along with the non-urban tributary Palomares Creek;
- Water Contact and Non-contact Recreation (REC-1 and REC-2). Public parks or other facilities allow access or approaches to sections of Castro Valley, Chabot and Crow Creeks. Swimming recreational areas at Cull and Don Castro Reservoirs are managed by the East Bay Regional Park District;
- Municipal and Domestic Supply (MUN), Freshwater Replenishment (FRESH) and Groundwater Recharge (GWR) are assigned to San Lorenzo Creek but none of its tributaries. The aquifer beneath the downstream portion of San Lorenzo Creek is a site of an East Bay Municipal Utility District (EBMUD) project for groundwater storage to provide drought protection.

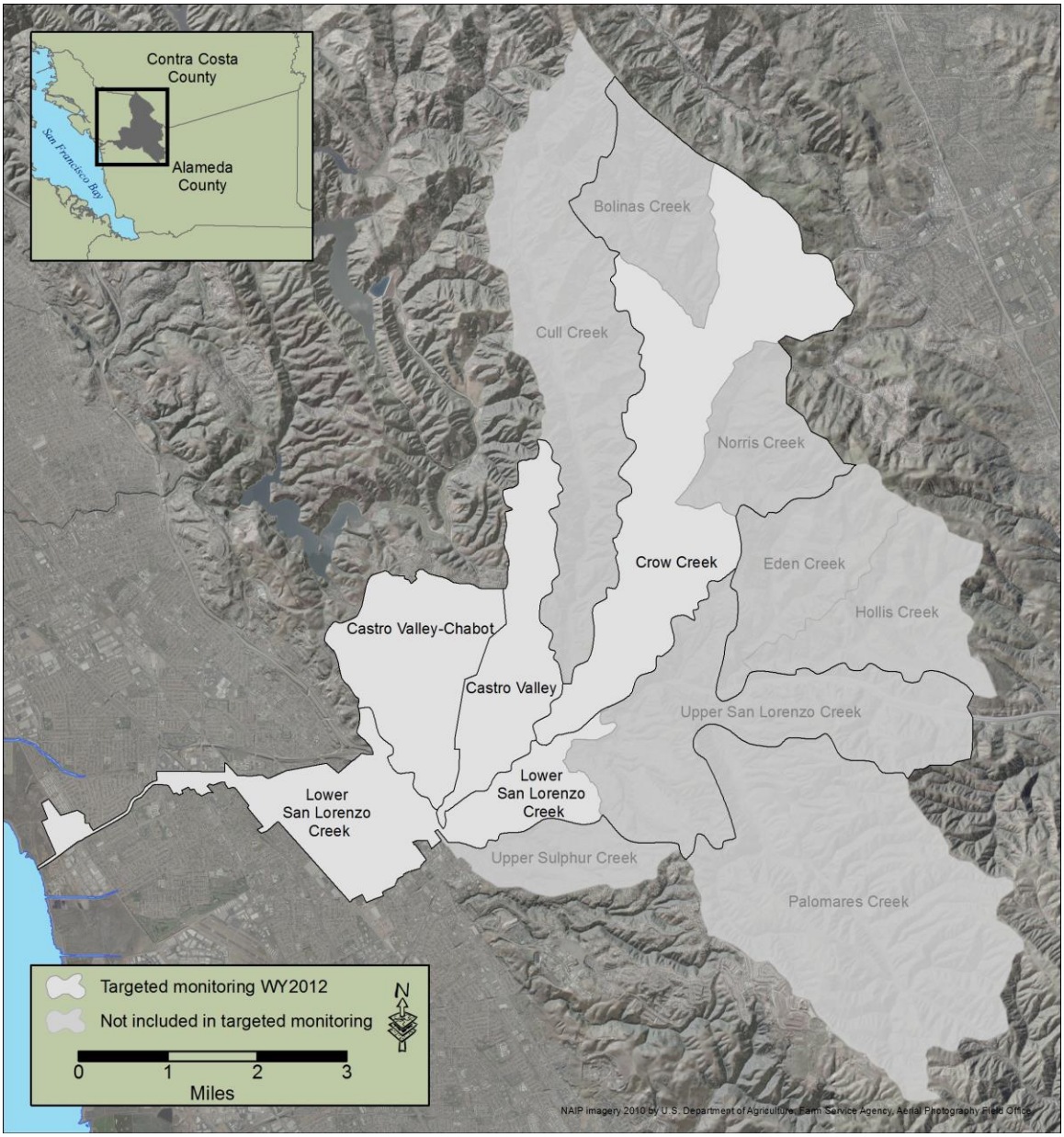

Figure 2-2. Map of the San Lorenzo Creek Watershed and Major Subwatersheds.

2.2.1.1 Crow Creek Subwatershed

The upper tributaries of Crow Creek lie in grasslands and oak woodlands. Much of this estimated 11.2 square mile (29.1 km^2) square mile watershed is heavily grazed, and also has the most equine facilities of any of the subwatersheds of San Lorenzo Creek. The Unincorporated Alameda County Clean Water Program and the District have worked with the Alameda Resource Conservation District on outreach and inspection for these facilities. Most ownership of creeks is private. In the lower, suburban reaches of Crow Creek it receives sporadic inputs from Cull

Creek, a primarily non-urban watershed that is partially detained in Cull Reservoir just above the confluence.

2.2.1.2 Castro Valley and Chabot Creek Subwatersheds

The total Castro Valley Creek watershed encompasses about 5.5 square miles of primarily residential land use with smaller amounts of open space and commercial and industrial areas. The creek's two main branches have undergone different degrees of alteration:

- Castro Valley Creek is the longer, eastern branch that flows from undeveloped open space through urbanized Castro Valley to its confluence with the main stem of San Lorenzo Creek. While most of the reaches have been extensively channelized, and culverted sections are extensive in side tributaries and under major roads or freeways, the main channel remains open for much of its length;

- Chabot Creek, the western branch, is located almost entirely in storm drains and engineered channels. A relatively natural channel section occurs in Carlos Bee Park just above its confluence with the Castro Valley branch.

2.2.1.3 Lower and Middle Reaches of San Lorenzo Creek

The Federal flood control channel of San Lorenzo Creek extends from Foothill Boulevard to San Francisco Bay and receives relatively little drainage from the adjacent urban area. Most of this channel is concrete-lined and presents a barrier to upstream fish passage due to the uniform gradient and lack of resting pools. From Foothill Boulevard to its confluence with Crow Creek, San Lorenzo Creek flows through mixed urban land use but retains its natural channel alignment and has localized areas of channeling or bank hardening. Upper San Lorenzo Creek is above Don Castro Dam in a non-urban setting, although affected by the reservoir and by construction of Interstate 580 above or over much of its length.

2.2.2 Oakland Creeks

Targeted monitoring was conducted in several creeks within the City of Oakland during WY2012 and/or WY2013.

Table 2-2 shows the Beneficial Uses assigned to these creeks (SFRWQCB 2011).

Table 2-2. Beneficial Uses Assigned to Oakland Creeks Monitored in Water Years 2012 and 2013.

Creek	COLD	RARE, SPWN	WARM, WILD	REC-1, REC2
Sausal Creek.	X	X	X	X
Lion Creek	X	--	X	X
Arroyo Viejo	X	--	X	X
Glen Echo Creek	--	--	X	X
Temescal Creek	X	--	X	X

2.2.2.1 Sausal Creek Watershed

The Sausal Creek Watershed encompasses approximately 2,700 acres or 4.2 square miles (11 km^2) within the city of Oakland (Figure 2-3). Although approximately twenty percent of the watershed remains as open space, most of the watershed is a mix of residential and commercial land uses. The headwaters and riparian corridor are relatively intact and preserved public parks, while the sections below Dimond Park are mostly culverted or channelized. The watershed is home to an active watershed stewardship group, the Friends of Sausal Creek (FOSC), which developed a Watershed Action Plan (Stott Associates, 2000) focusing on six overall goals, including improvement of water quality as well as protection and restoration of natural resources and enhancing community awareness and stewardship. FOSC has monitored and advocated for a resident population of rainbow trout in the upper watershed.

2.2.2.2 Lion Creek

The Lion Creek watershed encompasses 3.5 square miles (9.1 km^2) in East Oakland. Tributary subwatersheds in the hills include Horseshoe Creek, with relatively extensive open space, and Chimes Creek with mostly residential land uses. Much of the former creek in the Oakland flatlands below Mills College has been culverted.

2.2.2.3 Arroyo Viejo

Arroyo Viejo flows to Damon Slough at San Leandro Bay from Knowland Park in the East Oakland Hills, with a total watershed area of about 4,000 acres or 6.3 square miles (16.3 km^2). Main tributaries above Interstate Highway (I) 580, include the Rifle Range Branch, Melrose Highlands Branch, and Country Club Branch, with the 73rd Avenue Branch drainage below I-580. Arroyo Viejo is a perennial stream flowing through a mix of underground culverts and engineered channels in the Oakland flatlands.

2.2.2.4 Glen Echo Creek

The Glen Echo Creek Watershed of approximately 1,650 acres or 2.6 square miles (6.6 km^2) encompasses portions of Piedmont and Oakland which feed into the western arm of Lake

Merritt. Named subwatersheds include the Broadway Branch, Rockridge Branch, and Cemetery Creek (a historical name for the main stem of Glen Echo Creek).

2.2.2.5 Temescal Creek

The Temescal Creek watershed encompasses 6.8 square miles (17.6 km^2) in North Oakland and Emeryville. Reaches below Lake Temescal are culverted while the upper portion has culverted sections under the Warren Freeway and in the Montclair commercial district. The watershed contains a mix of residential and commercial landuses.

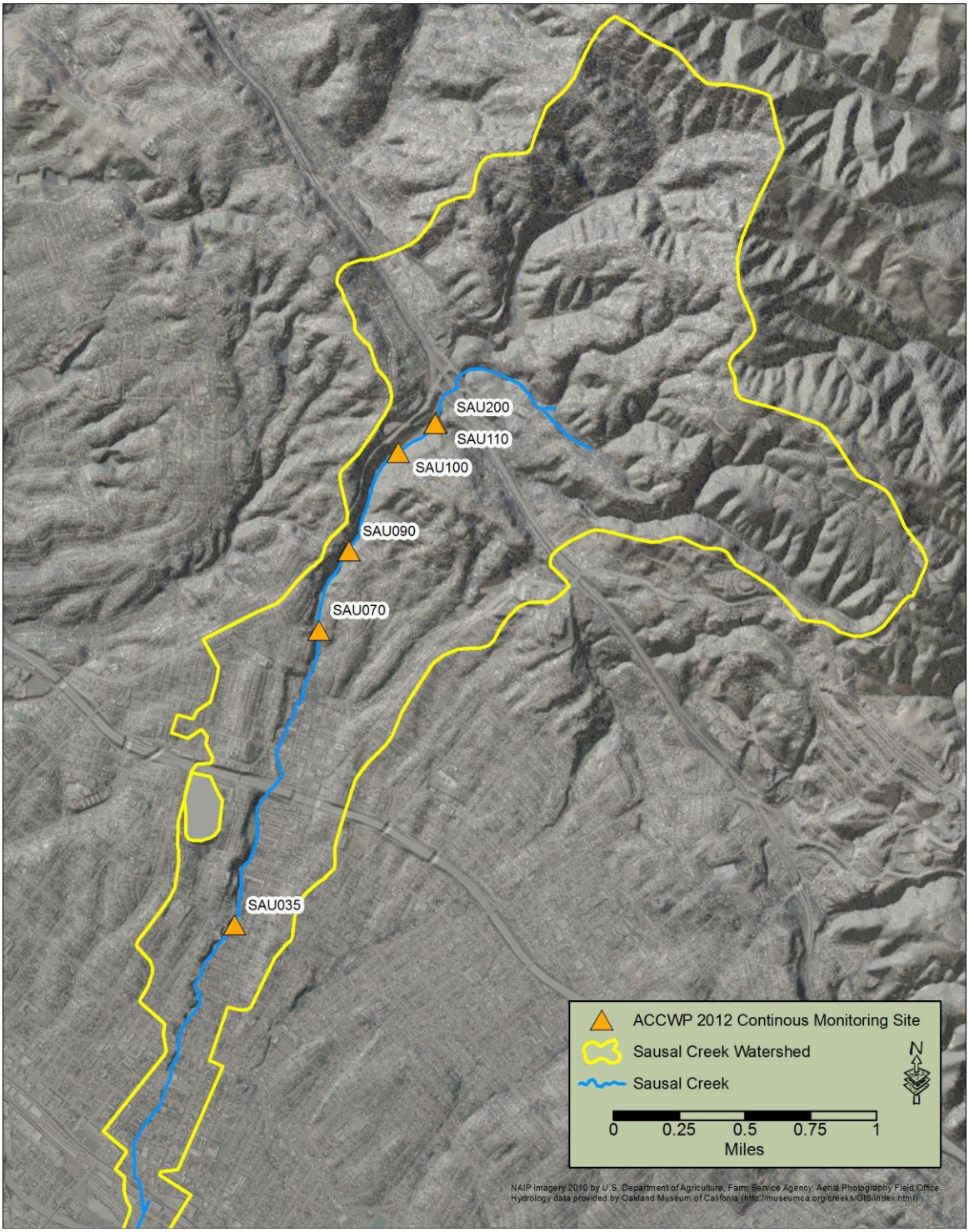

Figure 2-3. Sausal Creek Watershed- Temperature Monitoring Locations in Water Year 2012.

2.3 Targeted Monitoring Design

In the targeted monitoring program design, site locations were identified based on the directed principle[3]to address the following management questions:

1) *What is the range of general water quality measurements at targeted sites of interest?*
2) *Do general water quality measurements indicate potential impacts to aquatic life?*
3) *What are the pathogen indicator concentrations at creek sites where water contact recreation may occur?*
4) *What are the overall physical and/or ecological conditions of creek reaches and specific point impacts within each reach?*

2.3.1 Water Year 2012

Table 2-3 and Table 2-4 summarize ACCWP targeted monitoring conducted during WY2012 (October 1, 2011 - September 30, 2012) including:

- Eight Continuous Water Temperature monitoring locations;
- Three General Water Quality monitoring locations;
- Five Pathogen Indicator monitoring locations; and
- Twenty-seven Stream Survey Reaches monitored encompassing approximately nine creek miles (Table 2-4).

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

Table 2-3. Summary of Targeted Monitoring Locations and Parameters for Water Year 2012 in Alameda County

Site Characteristics						Parameters		
Creek/Sub-watershed	**Site Code (RMC No)**	**Site Description**		**Latitude**	**Longitude**	**Pathogen Indicators**	**Water Temperature (continuous)[4]**	**General Water Quality**
Crow Creek	204CRW030	Crow Creek below confluence with Cull Creek		37.70056	-122.05500		X	
Crow Creek	204CRW050	Crow Creek below Norris Creek		37.71750	-122.03750		X	
Sausal Creek	204SAU035	Sausal Creek at the corner of E. 27th Street and Barry Place		37.79126	-122.22140		X	
Sausal Creek	204SAU070	Sausal Creek at El Centro pool off El Centro Ave		37.80745	-122.21589		X	
Sausal Creek	204SAU090	Sausal Creek at Leimert Avenue, upstream of SAU070		37.81197	-122.21391		X	
Sausal Creek	204SAU100	Sausal Creek at Dimond Canyon at golf course upstream of SAU090		37.81735	-122.21061		X	
Sausal Creek	204SAU110	Palo Seco Creek above confluence with Sausal, upstream of SAU100		37.81894	-122.20756		X	
Sausal Creek	204SAU200	Sausal Creek above confluence with Palo Seco Creek		37.81903	-122.20748		X	
Crow Creek	204CRW030	Crow Creek below confluence with Cull Creek	Spring	37.70056	-122.05500			X
			Fall	37.70120	-122.05511			X
Castro Valley Creek	204CVY005	Castro Valley Creek above confluence with San Lorenzo (Alternate code: CVC)		37.67846	-122.08011			X

[4]Sampling site locations were adjusted by field staff to optimize locations where (1) water level was expected to be of sufficient depth to cover probes over the course of the entire dry season, and (2) avoid highly trafficked areas.

Site Characteristics						Parameters		
Creek/Sub-watershed	**Site Code (RMC No)**	**Site Description**		**Latitude**	**Longitude**	**Pathogen Indicators**	**Water Temperature (continuous)[4]**	**General Water Quality**
San Lorenzo Creek	204SLO065	San Lorenzo Creek above confluence with Castro Valley (Alternate code: SLZ)	Spring	37.67795	-122.08014			X
			Fall	37.67801	-122.08066			X
Chabot Creek	204CVY020	Chabot Creek within Carlos Bee Park above confluence with Castro Valley Creek		37.68205	-122.08073	X		
Castro Valley Creek	204CVY080	Castro Valley Creek within Carlos Bee Park above confluence with Chabot Creek		37.68180	-122.08061	X		
Castro Valley Creek	204CVY120	Castro Valley Creek adjacent to Norbridge Avenue and Redwood Road		37.69285	-122.07163	X		
Castro Valley Creek	204CVY140	Castro Valley Creek between Berdina Road and Forest Avenue		37.70136	-122.07028	X		
Castro Valley Creek	204CVY150	Castro Valley Creek adjacent to Heyer Ave.		37.70446	-122.06913	X		

Table 2-4. Summary of Stream Survey Reaches targeted for Water Year 2012 Monitoring in Alameda County.

Watershed Reach ID	Latitude	Longitude	Survey Date	Channel Type
San Lorenzo Creek-A	37.675957	-122.153074	9/26/12	Concrete, trapezoidal
San Lorenzo Creek-B	37.682041	-122.143105	9/26/12	Concrete, vertical
San Lorenzo Creek-C	37.684763	-122.138659	9/26/12	Concrete, vertical
San Lorenzo Creek-D	37.684476	-122.130122	9/27/12	Concrete, vertical
San Lorenzo Creek-E	37.684858	-122.128679	9/27/12	Concrete, vertical
San Lorenzo Creek-F	37.685616	-122.116805	9/27/12	Concrete, vertical
San Lorenzo Creek-G	37.684371	-122.108477	9/27/12	Concrete, vertical
San Lorenzo Creek-H	37.685765	-122.098482	9/28/12	Concrete, vertical
San Lorenzo Creek-I	37.680619	-122.093675	9/28/12	Concrete, vertical
Castro Valley Creek-A	37.677973	-122.080438	10/3/12	Natural channel
Castro Valley Creek-C	37.684044	-122.075577	10/4/12	Concrete, trapezoidal
Castro Valley Creek-E	37.687069	-122.073371	10/4/12	Concrete, trapezoidal
Castro Valley Creek-H	37.691227	-122.070817	10/4/12	Concrete, trapezoidal
Castro Valley Creek-I	37.692792	-122.071414	10/4/12	Natural channel
Castro Valley Creek-K	37.695533	-122.071989	10/5/12	Concrete channel
Castro Valley Creek-M	37.69744	-122.071341	10/5/12	Concrete and natural
Castro Valley Creek-N	37.704465	-122.069049	10/5/12	Concrete channel
Castro Valley Creek-O	37.708626	-122.064453	10/11/12	Concrete channel
Castro Valley Creek-P	37.711428	-122.063624	10/11/12	Concrete channel
Castro Valley Creek-Q	37.713676	-122.063455	10/11/12	Natural channel
Castro Valley Creek-R	37.713676	-122.063455	10/11/12	Natural channel
Chabot Creek-A	37.681829	-122.080683	10/11/12	Natural channel
Chabot Creek-B	37.684281	-122.082039	10/12/12	Concrete and natural
Chabot Creek-C	37.688189	-122.082333	10/12/12	Concrete and natural
Chabot Creek-E	37.691186	-122.083263	10/3/12	Concrete, trapezoidal
Chabot Creek-G	37.694777	-122.087368	10/3/12	Concrete, trapezoidal
Chabot Creek-H	37.695766	-122.086374	10/11/12	Concrete, trapezoidal

Notes: 1. Coordinates represent the downstream starting point for each stream survey reach.
2. San Lorenzo Creek Reach K and Castro Valley Creek Reach B were not surveyed due to access or safety issues.
Castro Valley Creek Reaches P, Q and R channels were not fully accessible throughout their length.

2.3.2 Water Year 2013

Table 2-5 and Table 2-6 summarize ACCWP targeted monitoring conducted during WY2013 (October 1, 2012 - September 30, 2013) including:

- Nine Continuous Water Temperature monitoring locations;
- Four General Water Quality monitoring locations Table 2-3;
- Five Pathogen Indicator monitoring locations; and
- Thirty-six Stream Survey Reaches monitored encompassing approximately 10.96 creek miles (Table 2-6).

Table 2-5. Summary of Targeted Monitoring Locations and Parameters for Water Year 2013 in Alameda County

Site characteristics					Parameters		
Watershed	**Site ID**	**Description**	**Lat**	**Long**	**Pathogen**	**Temp**	**Gen WQ**
Arroyo Viejo	204AVJ020	Arroyo Viejo Rec. Center	37.76261	-122.17526		X	
Arroyo Viejo	204AVJ080	Along Golf Links Dr. just west of I-580	37.75489	-122.15235		X	X
Arroyo Viejo	204AVJ110	Rifle Range branch	37.77724	-122.14774		X	
Arroyo Viejo	204AVJ130	Above Zoo at Golf Links Drive	37.75318	-122.14936			X (Spring only)
Arroyo Viejo	204AVJ140	Knowland Park Zoo	37.75589	-122.14088		X	
Lion Creek	204LIO050	Chimes Creek at Mills	37.78022	-122.17876		X	X (Fall only)
Lion Creek	204LIO080	Mills College at Alumni House	37.7824	-122.1803			X
Lion Creek	204LIO130	Horseshoe Creek	37.79201	-122.17945		X	
Cull Creek	204CUL010	Cull Creek below dam above "overpass" bridge	37.7027	-122.05539		X	
Crow Creek	204CRW020	Crow Creek near Earl Warren Park	37.70012	-122.05506		X	
Crow Creek	204CRW030	Crow Creek below Cull Creek	37.70017	-122.05523		X	
Arroyo Viejo	204AVJ080	Along Golf Links Dr. just west of I-580	37.75489	-122.15235	X		
Lion Creek	204LIO050	Chimes Creek at Mills	37.78022	-122.17876	X		
Lion Creek	204LIO070	Lion Creek near Wetmore Ave bridge	37.77761	-122.18331	X		
Sausal Creek	204SAU090	Below Leimert Ave. bridge	37.811906	-122.21370	X		
Temescal Creek	204TEM100	Near Broadway Terrace and Duncan	37.84061	-122.22251	X		

Table 2-6. Summary of Stream Survey Reaches targeted for Water Year 2013 Monitoring in Alameda County.

Watershed Reach ID	Latitude	Longitude	Survey	Channel Type
San Lorenzo- Reach L	37.67786	-122.08065	10/2/2013	Natural
San Lorenzo- Reach M	37.67881	-122.07685	10/2/2013	Primarily Natural
San Lorenzo- Reach N	37.68111	-122.07103	10/2/2013	Natural
San Lorenzo- Reach O	37.68414	-122.06672	10/2/2013	Primarily Natural
San Lorenzo- Reach P	37.68593	-122.06316	10/1/2013	Natural
San Lorenzo- Reach Q	37.68842	-122.06087	10/1/2013	Natural
Crow Creek – Reach A	37.69237	-122.05907	9/17/2013	Natural
Crow Creek – Reach B	37.69442	-122.05922	9/17/2013	Natural
Crow Creek – Reach C	37.69767	-122.05678	9/17/2013	Mostly natural
Crow Creek – Reach D	37.701471	-122.05453	9/17/2013	Concrete/ partially open
Crow Creek – Reach E	37.70262	-122.05021	9/17/2013	Concrete and natural
Crow Creek – Reach F	37.70475	-122.04408	9/19/2013	Natural / partially open
Sausal Creek – Reach	37.0836	-122.21669	9/23/2013	Natural
Sausal Creek – Reach	37.80579	-122.21587	9/23/2013	Natural
Sausal Creek – Reach	37.80748	-122.21572	9/23/2013	Natural
Sausal Creek – Reach	37.81211	-122.21333	9/23/2013	Natural
Sausal Creek – Reach	37.81885	-122.20761	9/23/2013	Natural
Sausal Creek – Reach	37.82629	-122.20245	9/25/2013	Natural
Sausal Creek – Reach	37.81902	-122.20773	9/24/2013	Natural
Sausal Creek – Reach	37.81575	-122.20148	9/24/2013	Natural
Arroyo Viejo – Reach B	37.75422	-122.19363	10/3/2013	Concrete
Arroyo Viejo – Reach C	37.75814	-122.18754	10/8/2013	Concrete
Arroyo Viejo – Reach G	37.75784	-122.18378	10/3/2013	Concrete
Arroyo Viejo – Reach H	37.7617	-122.17672	10/3/2013	Mostly natural
Arroyo Viejo – Reach I	37.76316	-122.17512	10/3/2013	Concrete
Arroyo Viejo – Reach J	37.76185	-122.17192	10/3/2013	Concrete
Arroyo Viejo – Reach K	37.76106	-122.1676	10/3/2013	Partially natural
Arroyo Viejo – Reach M	37.76172	-122.16251	10/8/2013	Partially natural
Arroyo Viejo – Reach N	37.75977	-122.15704	10/8/2013	Natural
Arroyo Viejo – Reach P	37.75318	-122.15057	10/8/2013	Natural
Arroyo Viejo – Reach Q	37.75734	-122.14059	10/9/2013	Natural
Arroyo Viejo – Reach R	37.75704	-122.13371	10/9/2013	Natural
Glen Echo – Reach C	37.81963	-122.25925	9/24/2013	Mostly Natural
Glen Echo – Reach D	37.82143	-122.2573	9/24/2013	Mostly Natural
Glen Echo – Reach F	37.82394	-122.25311	9/24/2013	Mostly Natural
Glen Echo – Reach L	37.83028	-122.24651	10/8/2013	Partially Natural

Notes: 1. Coordinates represent the downstream starting point for each stream survey reach.

2.3.3 Criteria for Site Selection

All target sampling sites were selected by the ACCWP Program Manager, in coordination with others as described below. Specific considerations applied to selection of locations for the different parameters as described below:

Continuous Temperature

Each monitoring year, eight continuous water quality monitoring locations were chosen based on a combination of criteria. A predominant criterion in the selection of San Lorenzo Creek and Sausal Creek for continuous monitoring in WY2012 was that both streams have COLD beneficial use designation for which these parameters are important indicators. Based on available historical data for the San Lorenzo Creek watershed, simple temperature monitoring was chosen for the less urbanized portions of Crow Creek to complement the shorter-duration water quality monitoring in more urbanized reaches within Sausal Creek.

In the case of Sausal Creek, ACCWP took the opportunity to collaborate with FOSC in their effort to redesign a watershed monitoring program. ACCWP's temperature loggers were deployed at six sites recommended by Robert Leidy, an active FOSC Board member interested in assessment of different tributaries' suitability for trout.

In choosing sampling sites for WY2013, ACCWP included some Crow Creek sites to assist with SSID follow-up, and otherwise focused on Oakland watersheds with as many as possible of the following attributes:

- Significant natural resource quality, combined with COLD beneficial use; and
- Known or likely areas of perennial flow.

Sampling sites were adjusted in the field in order to deploy continuous monitoring equipment at locations where (1) water level was expected to be of sufficient depth to cover loggers over the course of the entire dry season, and (2) avoid highly trafficked areas.

General Water Quality

The goal of site selection for the three general water quality monitoring locations within the San Lorenzo Creek watershed in WY2012was to characterize the different water quality attributes present along an urban gradient. The placement of datalogging Sondes within these streams provided additional water quality information to use in assessing the creek's support of designated beneficial uses. The three monitoring locations were chosen as distinct in terms of land use characteristics. The Crow Creek site (204CRW030) has a tributary watershed comprising only suburban drainage and open space. The San Lorenzo Creek site (204SLO065) carries flows from mixed landuses of urban and non-urban areas. The Castro Valley Creek sampling site (204CVY005) is predominantly urban, and in previous toxicity testing by ACCWP

(Hansen, 1995) showed significant differences from the San Lorenzo site in close proximity but with differing tributary land use.

General water quality monitoring locations in WY2013 were chosen to complement the USA surveys or previous WY monitoring in Sausal Creek, with consideration of the following factors:

- Opportunities to compare different tributaries or portions of the main stem above and below tributary or storm drain inputs;
- Public access to portions of the creek;
- Stewardship interest by active creek groups or institutional managers (e.g. Mills College, Oakland Zoo); and
- Management questions of interest to the City of Oakland's Creek and Watershed program.

Pathogen Indicators

In WY2012, the five pathogen indicator sampling sites were all located within a 2.8km segment of Castro Valley Creek. Castro Valley is an urban watershed and several of the Castro Valley Creek reaches have public access.

In WY2013 the candidate pathogen indicator sampling sites were selected in consultation with City of Oakland staff to evaluate management concerns or corrective actions from past illicit discharges. Due to access problems, the locations of some sites had to be adjusted in the field.

Stream Survey

Surveyed reaches in WY2012 targeted the most urban lower portions of San Lorenzo Creek, and the heavily urbanized Castro Valley and Chabot Creeks. The remaining urban portions of San Lorenzo and Crow Creeks were assessed in WY2013, together with portions of four Oakland Creeks: . Gaps within surveyed reaches were unable to be assessed due to a variety of reasons, including unsafe conditions due to unwadable water depths or unrestrained animals, overgrown areas, and reaches enclosed by private property where access permission was unobtainable within the survey period. ACCWP will continue surveys on additional reaches on these creeks in WY2014, subject to access permissions.

3 Monitoring Methods

3.1 Data Collection Methods

Field data were collected in accordance with SWAMP-comparable methods and procedures described in the BASMAA RMC Quality Assurance Project Plan (QAPP) (BASMAA 2012a) and Standard Operating Procedures (SOP) (BASMAA 2012b), together with revisions to both QAPP and SOPs. These documents were provided in final draft form to the Water Board with earlier RMC Monitoring Status Reports and were finalized in 2013 to reflect lessons learned through 2012 implementation (BASMAA, 2014); these revisions also incorporated updated data Quality Assurance procedures consistent with added data checking functions of the RMC database to supplement the tools available from SWAMP[5]. The SOPs relevant to the monitoring discussed in this report are listed in Table 3-1.

Table 3-1: Standard Operating Procedures for to BASMAA RMC Monitoring at Targeted Sites.

SOP #	SOP Title
FS-1	BMI and Algae Bioassessments, and Physical Habitat Measurements
FS-2	Water Quality Sampling for Chemical Analysis, Pathogen Indicators, and Toxicity
FS-3	Field Measurements, Manual
FS-4	Field Measurements, Continuous General Water Quality
FS-5	Temperature, Automated, Digital Logger
FS-7	Field Equipment Cleaning Procedures
FS-8	Field Equipment Decontamination Procedures
FS-9	Sample Container, Handling, and Chain of Custody Procedures
FS-10	Completion and Processing of Field Datasheets
FS-11	Site and Sample Naming Convention
FS-12	Ambient Creek Status Monitoring Site Evaluation
FS-13	QA/QC Data Review
N/A	Unified Stream Assessment: A User's Manual, v2.0

This section provides a brief overview of methods employed to measure each parameter in the targeted monitoring design. Greater detail on each method is included in the referenced SOPs.

3.1.1 Continuous Temperature Monitoring

All sampling conformed to protocols identified in the RMC QAPP and SOPs (Table 3-1).

[5] Available at http://www.waterboards.ca.gov/water_issues/programs/swamp/docs/qapp/qaprp082209.pdf

3.1.1.1 Continuous Water Temperature Monitoring in Water Year 2012

Field crews deployed digital temperature loggers at eight sites according to those dates specified in Table 3-2. Temperature loggers were programmed to record temperature data at sixty-minute intervals.

Table 3-2. Water Year 2012 Continuous Water Temperature Monitoring at Alameda County Targeted Monitoring Locations.

Site Code (RMC No)	Watershed	Latitude	Longitude	Install Date	Mid-term download	Removal Date
204CRW030	Crow Creek	37.70056	-122.05500	April 26	June 28	Sept 25
204CRW050	Crow Creek	37.71750	-122.03750	April 26	June 28	Sept 25
204SAU035	Sausal Creek	37.79126	-122.22140	April 30	June 28	Oct 4
204SAU070	Sausal Creek	37.80745	-122.21589	April 30	June 28	Oct 4
204SAU090*	Sausal Creek	37.81197	-122.21391	July 10	June 28	Oct 4
204SAU100	Sausal Creek	37.81735	-122.21061	April 30	June 28	Oct 4
204SAU110	Sausal Creek	37.81894	-122.20756	April 30	June 28	Oct 4
204SAU200	Sausal Creek	37.81903	-122.20748	April 30	June 28	Oct 4

* Logger was noted missing on June 28. Logger was replaced July 10, 2012.

3.1.1.2 Continuous Water Temperature Monitoring in Water Year 2013

Field crews deployed digital temperature loggers at eight sites according to those dates specified in Table 3-2. Temperature loggers were programmed to record temperature data at sixty-minute intervals.

Table 3-3. Water Year 2013 Continuous Water Temperature Monitoring at Alameda County Targeted Monitoring Locations.

Site Code (RMC No)	Watershed	Latitude	Longitude	Install Date	Removal Date
204AVJ020	Arroyo Viejo	37.76261	-122.17526	4/16/13	10/3/13
204AVJ080	Arroyo Viejo	37.75489	-122.15235	4/16/13	7/19/13
204AVJ110	Arroyo Viejo	37.77724	-122.14774	4/16/13	10/3/13
204AVJ140	Arroyo Viejo	37.75589	-122.14088	4/16/13	10/3/13
204LIO050	Lion Creek	37.78022	-122.17876	4/23/13	9/20/13
204LIO130	Lion Creek	37.79201	-122.17945	4/16/13	10/3/13
204CUL010	Cull Creek	37.70270	-122.05539	4/22/13	9/24/13
204CRW020	Crow Creek	37.70012	-122.05506	4/22/13	9/24/13
204CRW030	Crow Creek	37.70017	-122.05523	4/22/13	9/25/13

3.1.2 General Water Quality Measurements

3.1.2.1 General Water Quality Monitoring in Water Year 2012

General water quality monitoring included continuous measurements for temperature, DO, pH and specific conductivity at three sites: 204CVY005, 204CRW030 and 204SLO065. Parameters were measured for a period of between one and two weeks twice per year, once during the spring index period for bioassessment sampling and again during the August – September timeframe (Table 3-4). All sampling conformed to protocols identified in the RMC QAPP and SOPs.

Automated monitoring equipment (YSI 6600 Sonde) was deployed with the data recorded automatically at fifteen-minute intervals.

Table 3-4. General Water Quality Monitoring at Alameda County Targeted Monitoring Locations, WY2012.

Site Code (RMC No)	Watershed	Latitude	Longitude	Spring Monitoring	Early Fall Monitoring
204CVY005	Castro Valley Creek	37.67846	-122.08011	6/7/12 - 6/19/12	8/29/12 - 9/11/12
204CRW030	Crow Creek	37.70056	-122.05500	5/23/12 - 6/5/12	9/13/12 - 9/25/12
204SLO065 – Spring*	San Lorenzo Creek	37.67795	-122.08014	6/7/12 - 6/19/12	NA
204SLO065 – Fall*	San Lorenzo Creek	37.67801	-122.08066	NA	8/29/12 - 9/11/12

*slight adjustments to the 204SLO065 monitoring site were made to optimize water depth over the unit at differing flows in Spring and Fall.

3.1.2.1 General Water Quality Monitoring in Water Year 2013

General water quality monitoring included continuous measurements for temperature, DO, pH and specific conductivity at four sites: 204AVJ080, 204AVJ130, 204LIO080 and 204LIO050. Parameters were measured for a period of between one and two weeks twice per year, once during the spring and again during the August – September timeframe (Table 3-4). All sampling conformed to protocols identified in the RMC QAPP and SOPs.

Automated monitoring equipment (YSI 6600 Sonde) was deployed with the data recorded automatically at fifteen-minute intervals.

Table 3-5. General Water Quality Monitoring at Alameda County Targeted Monitoring Locations, WY2013.

Site Code (RMC No.)	Watershed	Latitude	Longitude	Spring Monitoring	Fall Monitoring
204AVJ080	Arroyo Viejo	37.75489	-122.15235	4/16/13 – 4/26/13	8/27/13 – 9/6/13
204AVJ130	Arroyo Viejo	37.75318	-122.14936	4/16/13 – 4/26/13	NA
204LIO080	Lion Creek	37.78240	-122.18030	5/13/13 – 5/24/13	9/10/13 – 9/20/13
204LIO050	Lion Creek	37.78026	-122.17886	NA	9/10/13 – 9/20/13

3.1.3 Pathogen Indicators Sampling

Single samples were collected for pathogen indicator enumeration in accordance with the requirements of the permit during WY2012 and WY2013. It should be noted that this sampling

strategy is different to the USEPA sampling protocol where a series of five samples are collected in order to estimate a geometric mean.

Field crews conducted pathogen indicator sampling using the RMC SOPs (Table 3-1). Sampling techniques included direct filling of containers, and immediate transfer of samples to analytical laboratories within specified holding time requirements.

3.1.3.1 Pathogen Indicator Sampling in Water Year 2012

Field crews collected water samples for analysis of pathogen indicators, specifically *Escherichia coli* (*E. coli*) and fecal coliform, at five sites on July 11, 2012. The sampling sites were 204CVY020, 204CVY080, 204CVY120, 204CVY140 and 204CVY150.

3.1.3.2 Pathogen Indicator Sampling in Water Year 2013

Field crews collected water samples for analysis of pathogen indicators, specifically *Escherichia coli* (*E. coli*) and fecal coliform, at five sites on August 14, 2013. The sampling sites were 204AVJ080, 204TEM100, 204SAU090, 204LIO050, and 204LIO070. Single samples were collected for pathogen indicator enumeration in accordance with the requirements of the permit.

3.1.4 Stream Surveys

Field crews conducted stream surveys using the *Unified Stream Assessment: A User's Manual* (Center for Watershed Protection, 2005) with data forms modified by SCVURPPP to better reflect conditions in urbanized streams (SCVWD, 2005). The Unified Stream Assessment (USA) uses visual observations and limited measurements taken during a continuous walk of accessible portions of the targeted creek corridor to rapidly evaluate creek conditions, problems, and opportunities for improvement within the urban creek corridor.

In order to increase survey efficiency and be consistent with previous investigations performed for the ACCWP (e.g., EOA 2006), minor modifications were made to the standard USA protocol in the way in which assessed information was recorded. Modified versions of several impact forms were used when less detailed data were needed for the purposes of the assessment. For example, in place of using a separate sheet to record each occurrence of an outfall, stream crossing, and utility within a reach, field crews compiled information for multiple occurrences of these on a single form.

The USA protocol includes separating the creek corridor into survey reaches. Each reach represents a relatively uniform set of conditions within the creek corridor. Factors that contribute to delineating a reach include land use in the immediate vicinity, elevation, creek order, access, and total length. In this study, reaches were identified and delineated by the ACCWP Program Coordinator, began and ended at major creek crossings or grade changes. Creek sections that were inaccessible (due to factors such as culverts, vegetation, or access permission not granted) were not assessed.

A single overall reach assessment was conducted for each reach. The reach level assessment qualitatively evaluated characteristics such as base flow, dominant substrate, water clarity, biota, shading, and active channel dynamics. In addition, each reach was ranked for overall creek condition and overall buffer and floodplain condition based on eight subcategories:

- instream habitat;
- vegetative protection;
- bank erosion;
- floodplain connection;
- vegetated buffer width;
- floodplain vegetation, floodplain habitat; and
- floodplain encroachment.

Each subcategory was given a score on a 20-point scale. The subcategory scores were summed to give a total reach score ranging from zero (poor condition) to 160 (optimal condition).

Per the USA protocol, field datasheets were completed to identify within each reach the locations and general characteristics of seven potential creek impacts:

- erosion;
- channel modification;
- outfalls;
- creek crossings;
- trash/debris;
- utilities; and
- miscellaneous features.

3.1.4.1 Stream Surveys in Water Year 2012

All survey work was completed between September 26, 2012 and October 12, 2012. Approximately 8.6 miles of the targeted nine miles were assessed during the effort. Inability to complete the full nine creek miles was due to private property access issues and stream reaches that were not wadable. The remaining 0.4 miles were completed in WY2013.

3.1.4.2 Stream Surveys in Water Year 2013

All survey work was completed between September 17, 2013 and October 9, 2013. Approximately 10.96 miles were assessed during the effort. An additional 1.96 miles (above the MRP-required 9 per year) were added on to make up for the targeted miles that were not completed during the WY2012 ACCWP USA surveys, and to complete full assessments of the streams that were surveyed this 2013 field season.

3.1.5 Quality Assurance/Quality Control

Data quality assessment and quality control procedures are described in detail in the BASMAA RMC QAPP (BASMAA 2012a). Data Quality Objectives (DQOs) 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. The qualitative goals include representativeness and comparability. The quantitative goals include specifications for completeness, sensitivity (detection and quantization limits), precision, accuracy, and contamination. To ensure consistent and comparable field techniques, pre-survey field training and *in-situ* field assessments were conducted. Data were collected according to the procedures described in the relevant SOPs, including appropriate documentation of data sheets and samples, and sample handling and custody. Laboratories providing analytical support to the RMC were selected based on demonstrated capability to adhere to specified protocols.

3.2 Data Quality Assessment Procedures

Following completion of the field and laboratory work, the field data sheets and laboratory reports were reviewed by the Local Monitoring Coordinator or Quality Assurance Officer, and compared both against the methods and protocols specified in the SOPs and QAPP. The findings and results then were evaluated against the relevant DQOs to provide the basis for an assessment of programmatic data quality. The data quality assessment included the following elements:

- Conformance with field and laboratory methods as specified in SOPs and QAPP, including sample collection and analytical methods, sample preservation, sample holding times, etc.;
- Numbers of measurements/samples/analyses completed vs. planned, and identification of reasons for any missed samples;
- Results of duplicate analyses based on calculation of relative percent differences (precision results);
- Results of field blanks associated with filtered samples (bias results);
- Results of spiked sample analyses based on spike percent recovery (accuracy results); and
- Identification of any contamination issues based on analyses of lab blanks and field blanks.

3.3 Data Analysis and Interpretation

Continuous temperature and general water quality data were plotted as box plots[6] for each site during each deployment.

[6]A box plot splits the data set into quartiles. The body of the plot consists of a "box", which goes from the first quartile to the third quartile. Within the box, a vertical line is drawn at the median of the data set. Two horizontal lines, called whiskers, extend from the front and back of the box. The front whisker goes from the first quartile to the smallest non-outlier in the data set, and the back whisker goes from the third quartile to the largest non-outlier. If the data set includes one or more outliers, they are plotted separately as points.

The hourly water temperature measurements were calculated as daily arithmetic means over a 24-hour period from midnight to 11:00 PM. Seven-day "rolling" average stream temperatures were calculated for each day, beginning on deployment Day 7, by averaging temperatures collected at fifteen-minute intervals throughout the previous seven days. Seven-day rolling averages for general water quality parameters were calculated in a similar fashion, although the frequency of measurements was higher (15 minutes for general water quality vs. one hour for continuous temperature)

Targeted monitoring data were evaluated against Water Quality Objectives (WQO) or other applicable thresholds, as described in Table 5-1, to determine whether results may "trigger" a potential stressor/source identification monitoring project (per MRP Provision C.8.d.i). Sites that meet trigger criteria for one or more parameters may be eligible for consideration as a Stressor/Source Identification project per MRP Provision C.8.d.i.

4 Results

This section presents monitoring results based on each program component. Each section addresses the study question:

> *What are the ranges of general water quality, continuous water temperature, pathogen indicators, and stream ecosystem conditions at locations sampled in the Program area?*

4.1 Statement of Data Quality

Field data sheets and laboratory reports were reviewed by the local Monitoring Coordinator or Program Quality Assurance Officer, and the results evaluated against the relevant DQOs as described in the QAPP (BASMAA, 2012a) and SOPs (BASMAA, 2012b). Results were compiled for the qualitative metrics (representativeness and comparability), as well as the quantitative metrics (completeness, sensitivity [detection and quantization limits], precision, accuracy, and contamination). The following sections (4.1.1 - 4.1.6) provide summaries of all pertinent data quality issues from the WY2012 and WY2013 and corrective actions to address data quality issues.

4.1.1 Method Deviations

4.1.1.1 Method Deviations in Water Year 2012

There were no deviations from the methods provided in the QAPP with the exception of pathogen indicator analyses where Standard Methods 9221 was used instead of the IDEXX Quantitray method. Both use a most probable number (MPN) analysis and therefore have comparable results. Corrective action: QAPP DQOs associated with analysis of fecal indicator bacteria will be reviewed and revised prior to 2013 Creek Status Monitoring implementation to ensure consistency of methods with QAPP requirements.

4.1.1.1 Method Deviations in Water Year 2013

There were no deviations from the methods provided in the QAPP. In WY2012, a method deviation occurred with regards to the analysis for fecal indicator bacteria. Through corrective action, this was resolved for in WY2013.

4.1.2 Number of Measurements Taken Compared to Planned

4.1.2.1 Number of Measurements in Water Year 2012

There were no deviations from the planned number of samples collected described in the QAPP with the exception of:

- Stream Survey miles – a total of 8.6 stream miles were surveyed during the WY2012 instead of the target of nine miles due to issues regarding accessing target stream reaches. Corrective action: additional stream miles were collected in WY2013 in order to compensate.

- Water temperature loggers – Due to the theft of the data logger at Site 204SAU090, there are no data reported for the period May 6, 2012 through July 16, 2012, when a replacement logger was installed. Corrective action: none in WY2012; a ninth temperature logger was deployed in WY2013.

- Bacteria pathogen indicator data – laboratory blanks and duplicates were not collected for the bacteria analysis. Therefore results for *E. coli* and fecal coliforms are qualified with VQCA, VQCP flags for not meeting measurement quality objectives (MQO) for accuracy and precision. Corrective action: laboratory duplicates and blanks will be conducted on 5% of future samples.

4.1.2.2 Number of Measurements Water Year 2013

There were no deviations from the planned number of samples collected described in the QAPP with the exception of:

- A total of 10.96 miles of Stream Survey were completed in WY2013. The additional 1.96 miles (above the MRP-required 9 per year) were added on to make up for the targeted 0.8 miles that were not completed during the WY2012 ACCWP USA surveys, and to complete full assessments of the streams that were surveyed this WY2013 field season.

- Continuous temperature monitors were deployed at a total of nine locations, one more than the MRP requirement of eight locations, to account for potential loss or failure. At time of retrieval, one unit deployed at site 204AVJ080 was unable to be located after multiple attempts at retrieval. At this site, an early season storm event had mobilized a large volume of silt and sand, which had covered the deployment location and restricted visibility when trying to locate it. Additionally, due to the bedrock substrate present, the monitor was secured to a large cobble rather than earth anchor, which may have led to its being mobilized downstream. Data was retrieved from this site at time of mid-season maintenance conducted in mid-July.

4.1.3 Non-detects – Reporting Limits Not Met

All QA/QC measures listed in the QAPP were met. There were no issues with non-detects reported.

4.1.4 Precision Results

Bacterial pathogen enumeration results were flagged with the VQCP qualifier as noted in Section 4.1.2 during WY2012.

In WY2013, one continuous temperature monitoring unit deployed at site 204AVJ110 was found by sampling personnel at time of retrieval to be very close to the surface. Staff was not able to determine if the unit was exposed during deployment, as the creek was very turbid and the earth anchor setup was disturbed during the process of locating the unit. Temperatures at this location do exhibit questionable results, with temperature spikes above 35°C.

4.1.5 Accuracy Results

No matrix spike samples were found to be outside of acceptable percent recovery range collected during WY2012 or WY2013.

4.1.6 Contamination Issues

There were no contamination issues observed in any of the samples, as determined by field and laboratory blanks collected during WY2012 and WY2013.

4.2 Continuous Water Temperature Monitoring

Data were collected over a five-month period with measurements recorded at 60-minute intervals. In WY2012, continuous temperature monitoring was conducted at eight locations within two watersheds: Crow Creek and Sausal Creek. In WY2013, continuous temperature monitoring was conducted at nine locations within the following creek systems: Arroyo Viejo, Lion Creek, Cull Creek and Crow Creek.

4.2.1 Crow and Cull Creeks

In WY2012, continuous monitoring was conducted from April 26th through September 25th, 2012 at two sites within the Crow Creek sub-watershed (204CRW030 and 204CRW050). In WY2013, monitoring was conducted at three sites (204CRW020, 204CRW030 and 204CUL010) between April 22nd and September 24th, 2013.

Figure 4-1 presents the results of the continuous monitoring results for WY2012, while Figure 4-2 presents the results of continuous temperature monitoring for WY2013. Box plots of the WY2012 temperature data are shown in Figure 4-3.

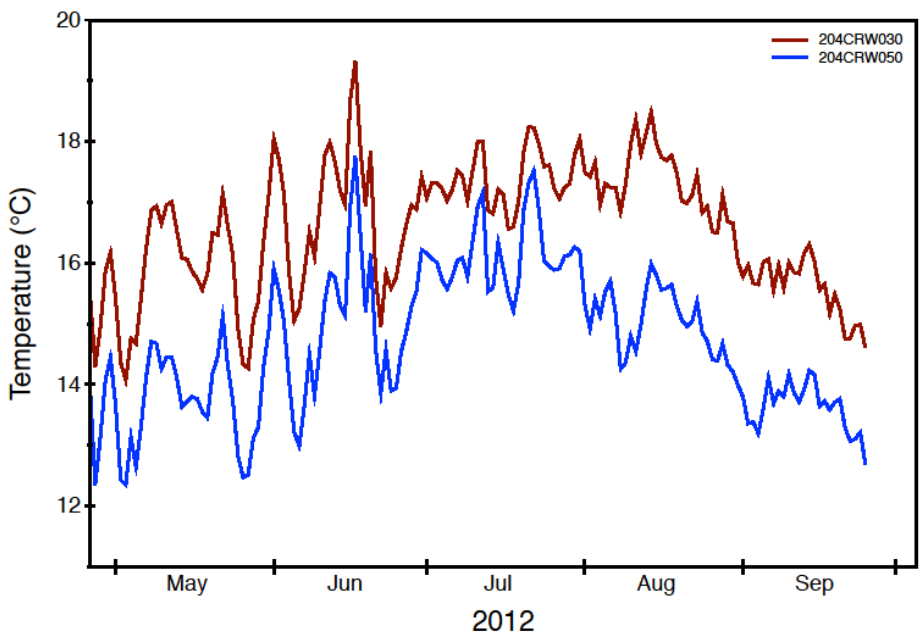

Figure 4-1. Temperature (7 Day Rolling Average Calculated Daily) Line Graph at Crow Creek, May 2 through September 25, 2012.

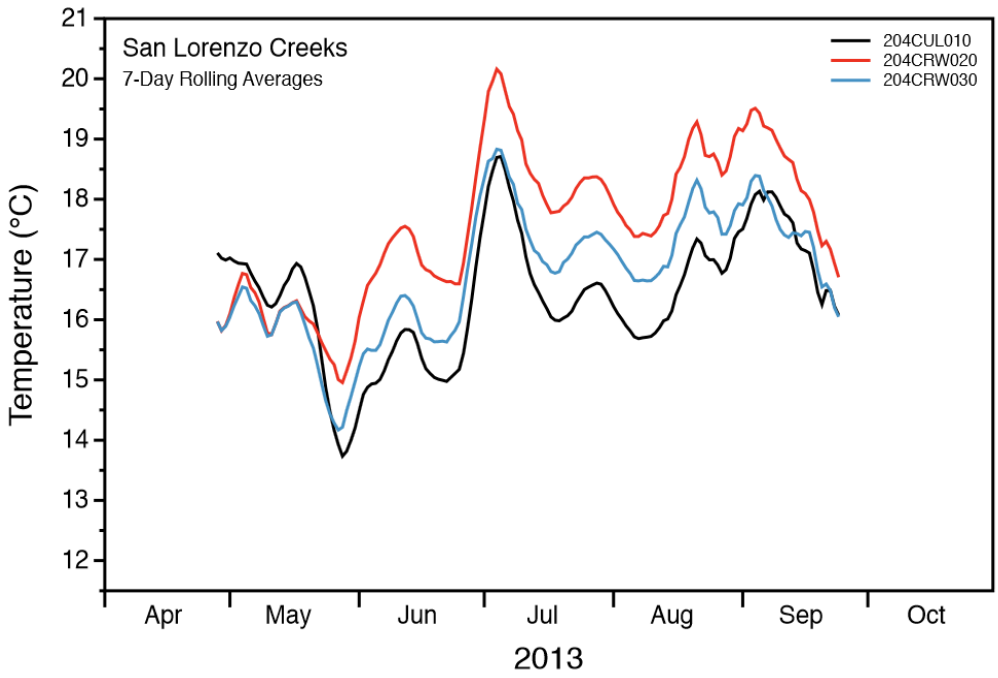

Figure 4-2. Temperature (7 Day Rolling Average Calculated Daily) Line Graph at Crow and Cull Creek, April 22 through September 24, 2013.

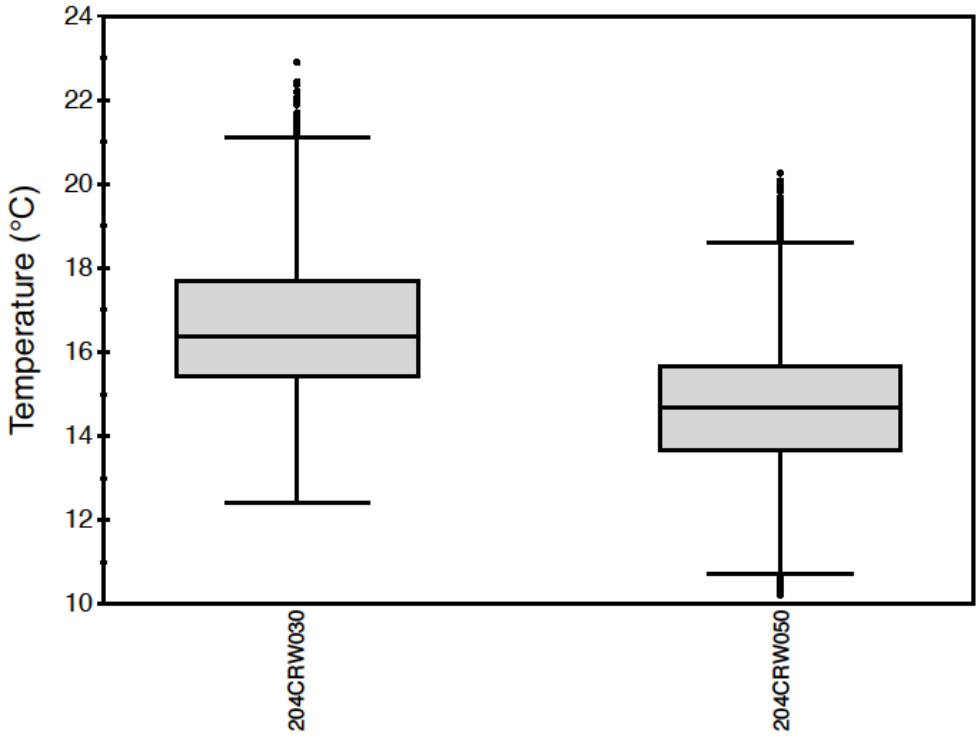

Figure 4-3. Temperature Box Plot at Crow Creek, May 2 through September 25, 2012.

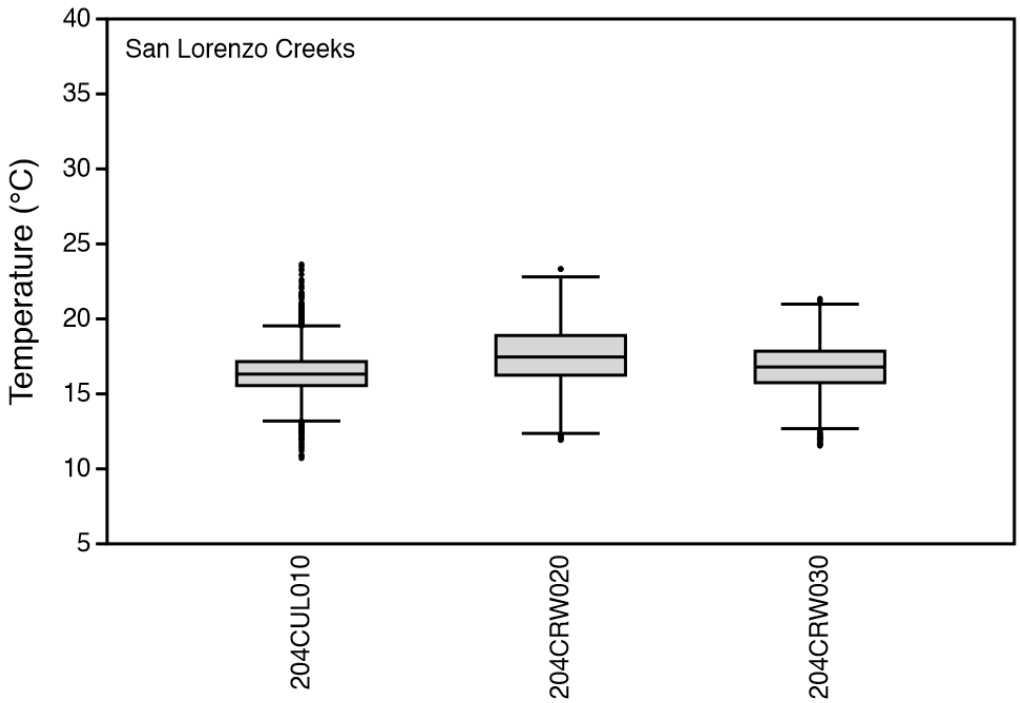

Figure 4-4. Temperature Box Plot at Crow and Cull Creeks, April 22 through September 24, 2013.

Summary results for both WY2012 and WY2013 are presented for sampling locations within Crow and Cull Creeks in Table 4-1.The highest temperature was recorded at 204CUL010 on September 24, 2013. The lowest temp was recorded at 204CRW050 on April 25, 2012. Average temperatures ranged from 14.72°C to 17.54°C.

Table 4-1. Summary of Temperature Data from Cull and Crow Creek Sampling Locations

	WY2012		WY2013		
Temperature(°C)	**CRW030**	**CRW050**	**CUL010**	**CRW020**	**CRW030**
Min	12.41	10.22	10.71	11.93	11.54
Max	22.90	20.27	23.64	23.33	21.34
Range	10.48	10.05	12.93	11.40	9.80
Mean	16.60	14.72	16.41	17.54	16.73
Stdev	1.73	1.56	1.47	2.00	1.55

4.2.2 Sausal Creek

Continuous monitoring was conducted at six locations within the Sausal Creek sub-watershed (204SAU035, 204SAU070, 204SAU090, 204SAU100, 204SAU110 and 204SAU200) in WY2012. Monitoring was conducted between April 30 and September 25, 2012. Average

temperatures ranged between 14.3°C and 15.6°C. The minimum temperature recorded was 10.7°C at sites 204SAU070 and 204SAU110. The maximum temperature recorded was 20.6°C, at Site 204SAU035.

Figure 4-5 shows the results of the continuous monitoring results for locations within the Sausal Creek sub-watershed. Box plots of the temperature data are shown in Figure 4-6.

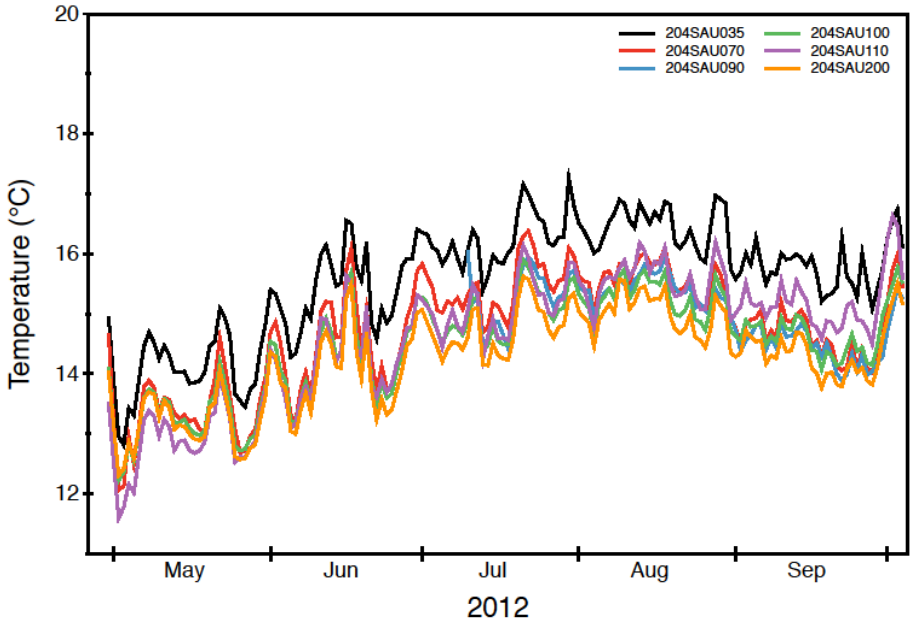

Figure 4-5. Temperature (7 Day Rolling Average Calculated Daily) Line Graph at Sausal Creek, May 6 through September 25, 2012.

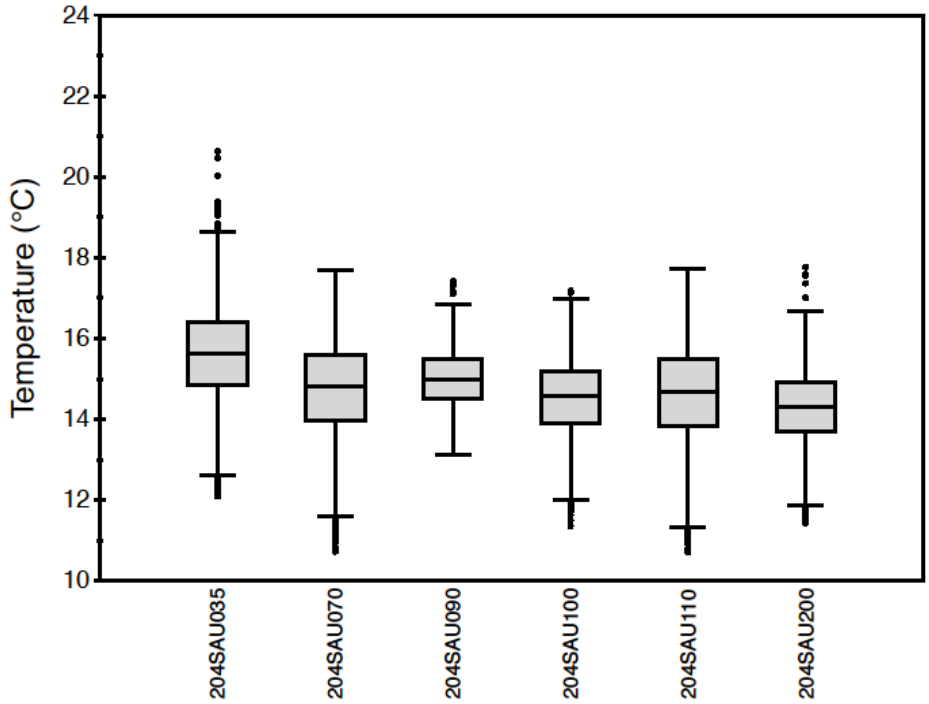

Figure 4-6. Temperature Box Plot at Sausal Creek, May 6 through September 25, 2012.

Summary results for temperature data from WY2012 are presented in Table 4-2. The highest average temperatures were recorded at 204SAU035 while lowest average temperatures were recorded at 204SAU200. The highest overall recorded temperature of 20.63°C was recorded at Site 204SAU035 on October 8th, 2012. The lowest temperature (10.71°C) was recorded at Site 204SAU110 on April 25th, 2012.

Table 4-2. Summary of Temperature Data from WY2012 at Sausal Creek Sampling Locations

Temperature (°C)	204SAU035	204SAU070	204SAU090	204SAU100	204SAU110	204SAU200
Min	12.10	10.74	13.14	11.37	10.71	11.44
Max	20.63	17.68	17.42	17.18	17.72	17.77
Range	8.53	6.94	4.28	5.81	7.01	6.33
Mean	15.60	14.71	15.01	14.49	14.61	14.26
St dev	1.25	1.24	0.70	1.03	1.31	0.97

4.2.3 Arroyo Viejo and Lion Creeks

Continuous monitoring was conducted from April 16th through September 20th2013 at four sites within the Arroyo Viejo sub-watershed (204AVJ020, 204AVJ080, 204AVJ110 and 204AVJ140). Two sites within Lion Creek were monitored from April 23rd through September 20th (204LIO050) and October 3rd (204LIO130).

Mid-term data retrieval was conducted between July 8th and 19th. At the mid-term retrieval, one unit was misplaced (Site 204AVJ020) and those data were not retrieved. At the time of final data retrieval, one unit was unable to be located (Site 204AVJ080).

Figure 4-7 presents the results of the continuous monitoring results for those six locations. Box plots of the temperature data are shown in Figure 4-8.

Summary results are presented in Table 4-3.

On retrieval of the unit at Site 204AVJ110, staff found the equipment very close to the water surface. The creek was very turbid and the earth anchor setup was disturbed during the process of locating the unit. The elevated temperatures at this location indicate the possibility that the equipment was above the surface of the water at times.

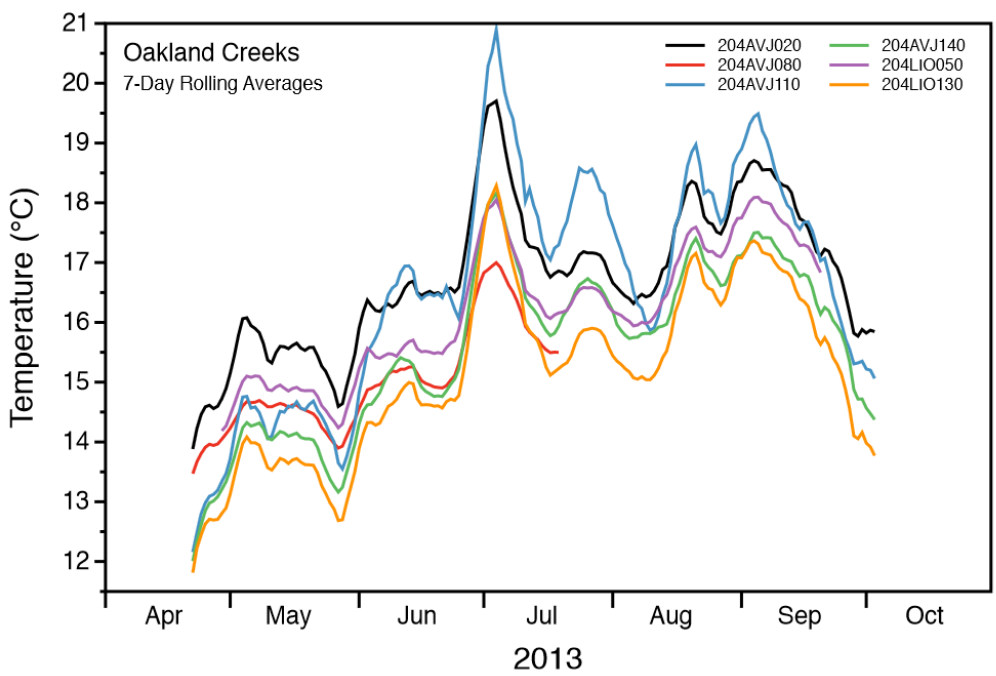

Figure 4-7. Temperature (7 Day Rolling Average Calculated Daily) Line Graph at Arroyo Viejo and Lion Creeks, April 16 through October 3, 2013.

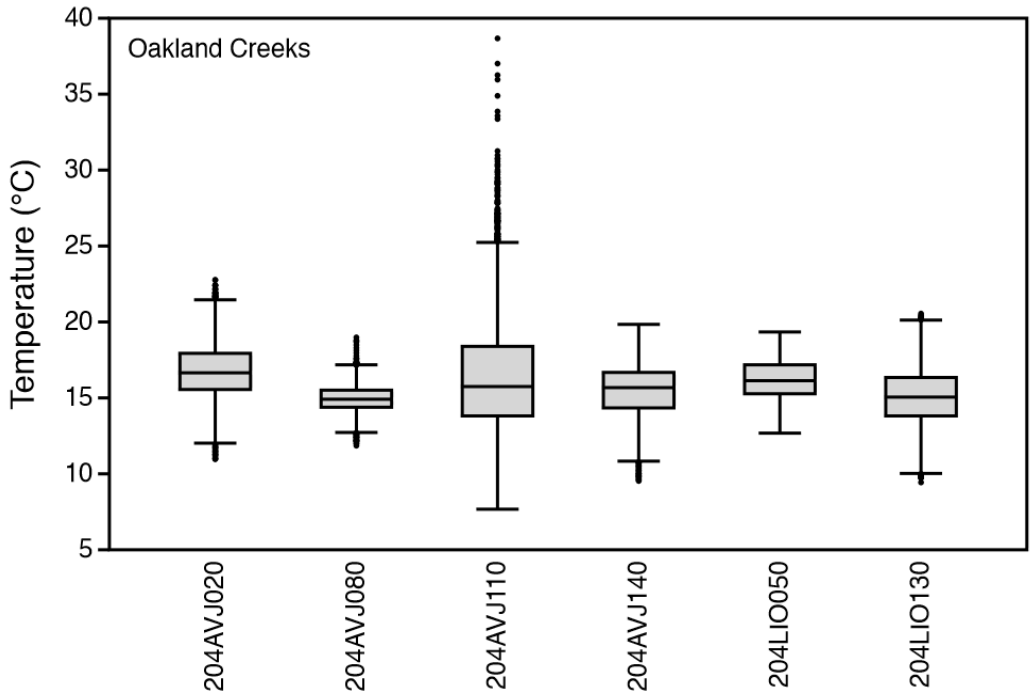

Figure 4-8. Temperature Box Plot at Arroyo Viejo and Lion Creeks, April 16 through October 3, 2013.

Table 4-3. Summary of Temperature Data from Arroyo Viejo and Lion Creek Sampling Locations in WY2013

Temperature (°C)	204AVJ020	204AVJ080	204AVJ110	204AVJ140	204LIO050	204LIO130
Min	10.98	11.86	7.67	9.53	12.68	9.44
Max	22.78	18.99	38.67*	19.84	19.34	20.56
Range	11.80	7.13	31.00	10.31	6.66	11.12
Mean	16.71	14.98	16.53	15.50	16.18	15.08
St dev	1.77	1.00	3.97	1.66	1.30	1.83

* Monitoring equipment may have been above the water at times, leading to elevated discrepancies in temperatures.

The highest temperature (38.67°C) was recorded at 204AVJ110 on October 3rd, 2013. The monitoring equipment at this site was found to be close to, or above, the water level, which may have led to elevated temperature readings and may not be accurate. The lowest temperature (7.67°C) was recorded at Site 204AVJ110 on April 4th 2013. The highest average temperature (16.71°C) was recorded at Site 204AVJ020.

4.3 General Water Quality Measurement

General water quality measurements of temperature, DO, pH and specific conductivity were taken at locations during two periods: spring (May and/or June) and late summer to fall (August and/or September). In WY2012, these data were collected from:

- 204SLO065 – San Lorenzo Creek above confluence with Castro Valley;
- 204CVY005 – Castro Valley Creek above confluence with San Lorenzo; and
- 204CRW030 – Crow Creek below confluence with Cull Creek.

In WY2013, these data were collected from:

- 204AVJ080;
- 204AVJ130 (spring only);
- 204LIO050 (summer only); and
- 204LIO080.

The following sections are compiled based on results from each watershed.

4.3.1 San Lorenzo Creek

Monitoring in the Spring period fell more into the summer months at Site 204SLO065; water temperatures were higher than those recorded at other sites a few months earlier (Figure 4-9). Temperatures fell approximately 2°C on average by the Fall sampling period. Dissolved oxygen (DO) and pH remained approximately the same between the two sampling periods (Table 4-4).

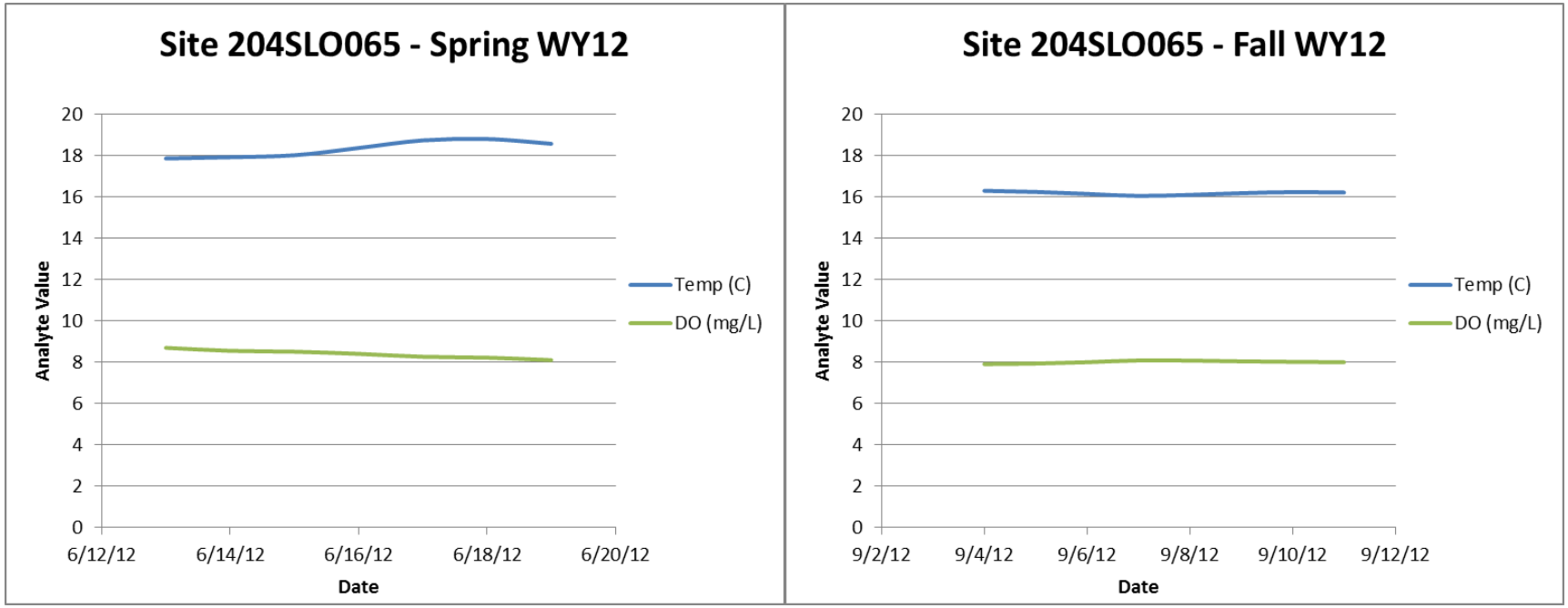

Figure 4-9. General Water Quality Monitoring7-day Rolling Averages for 204SLO065 in Spring and Fall, WY2012.

Table 4-4. General Water Quality 7-day Rolling Averages at Site 204SLO065, WY2012

June 2012				September 2012			
Date	Temp (°C)	pH	DO (mg/L)	Date	Temp (°C)	pH	DO (mg/L)
6/13/12	17.85	8.17	8.70	9/4/12	16.29	7.92	7.91
6/14/12	17.91	8.14	8.55	9/5/12	16.24	7.93	7.93
6/15/12	18.01	8.13	8.51	9/6/12	16.14	7.93	8.00
6/16/12	18.36	8.11	8.41	9/7/12	16.05	7.94	8.09
6/17/12	18.73	8.09	8.27	9/8/12	16.10	7.95	8.08
6/18/12	18.80	8.09	8.22	9/9/12	16.18	7.95	8.04
6/19/12	18.57	8.07	8.10	9/10/12	16.23	7.95	8.02

4.3.2 Castro Valley Creek

At Site 204CVY005, monitoring in June showed water temperatures averaging between 16 and 18°C (Figure 4-10), reaching slightly higher levels than during September. Dissolved oxygen and pH remained static between the two monitoring periods.

Table 4-5. General Water Quality 7-day Rolling Averages at Site 204CVY005, WY2012

June				September			
Date	Temp (°C)	pH	DO (mg/L)	Date	Temp (°C)	pH	DO (mg/L)
6/13/12	16.62	8.27	9.41	9/4/12	16.80	8.26	9.39
6/14/12	16.69	8.31	9.37	9/5/12	16.50	8.24	9.39
6/15/12	16.79	8.32	9.34	9/6/12	16.37	8.23	9.43
6/16/12	17.16	8.31	9.24	9/7/12	16.34	8.22	9.46
6/17/12	17.56	8.31	9.12	9/8/12	16.40	8.22	9.44
6/18/12	17.58	8.30	9.08	9/9/12	16.38	8.21	9.41
6/19/12	17.32	8.30	9.10	9/10/12	16.35	8.21	9.42

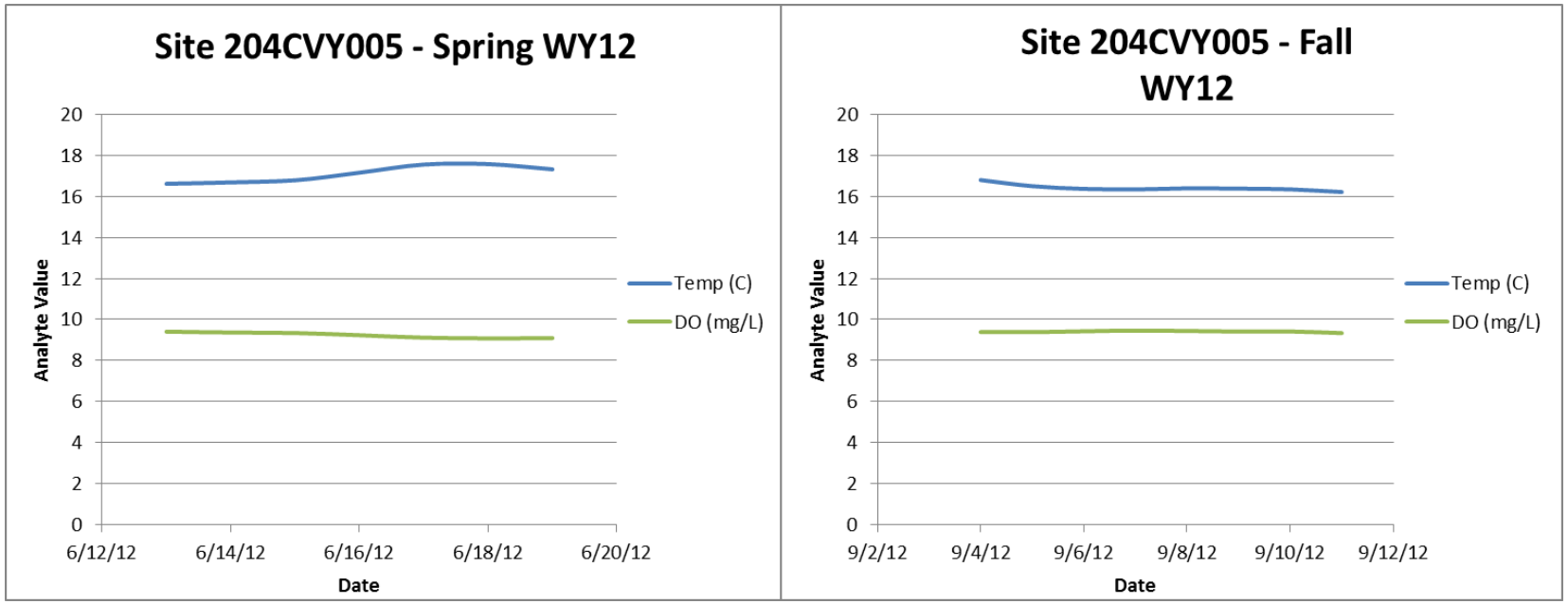

Figure 4-10. General Water Quality Monitoring 7-Day Rolling Averages for 204CVY005 in Spring and Fall, WY2012.

4.3.3 Crow Creek

Site 204CRW030 was monitored in Crow Creek. Due to a malfunction in the monitoring equipment reliable data were not recorded for part of the September monitoring period (Figure 4-11), preventing calculation of the 7-day rolling average for half of the time. pH was consistent at around 8.4 in June and 8.1 in September (Table 4-6).

Temperatures in both monitoring periods were between 14 and 18°C. The most significant trend observed at Site 204CRW030 was in the Fall monitoring when DO dropped to below 7mg/L.

Table 4-6. General Water Quality 7-day Rolling Averages at Site 204CRW030, WY2012

May/June				September			
Date	Temp (°C)	pH	DO (mg/L)	Date	Temp (°C)	pH	DO (mg/L)
5/29/12	15.40	8.40	9.51	9/19/12	N/A	N/A	N/A
5/30/12	15.19	8.40	9.58	9/20/12	N/A	N/A	N/A
5/31/12	15.34	8.40	9.58	9/21/12	N/A	N/A	N/A
6/1/12	15.78	8.41	9.53	9/22/12	N/A	N/A	N/A
6/2/12	16.26	8.42	9.45	9/23/12	15.59	8.11	6.86
6/3/12	16.68	8.43	9.37	9/24/12	15.47	8.11	6.65
6/4/12	16.78	8.42	9.27	9/25/12	15.40	8.11	6.65

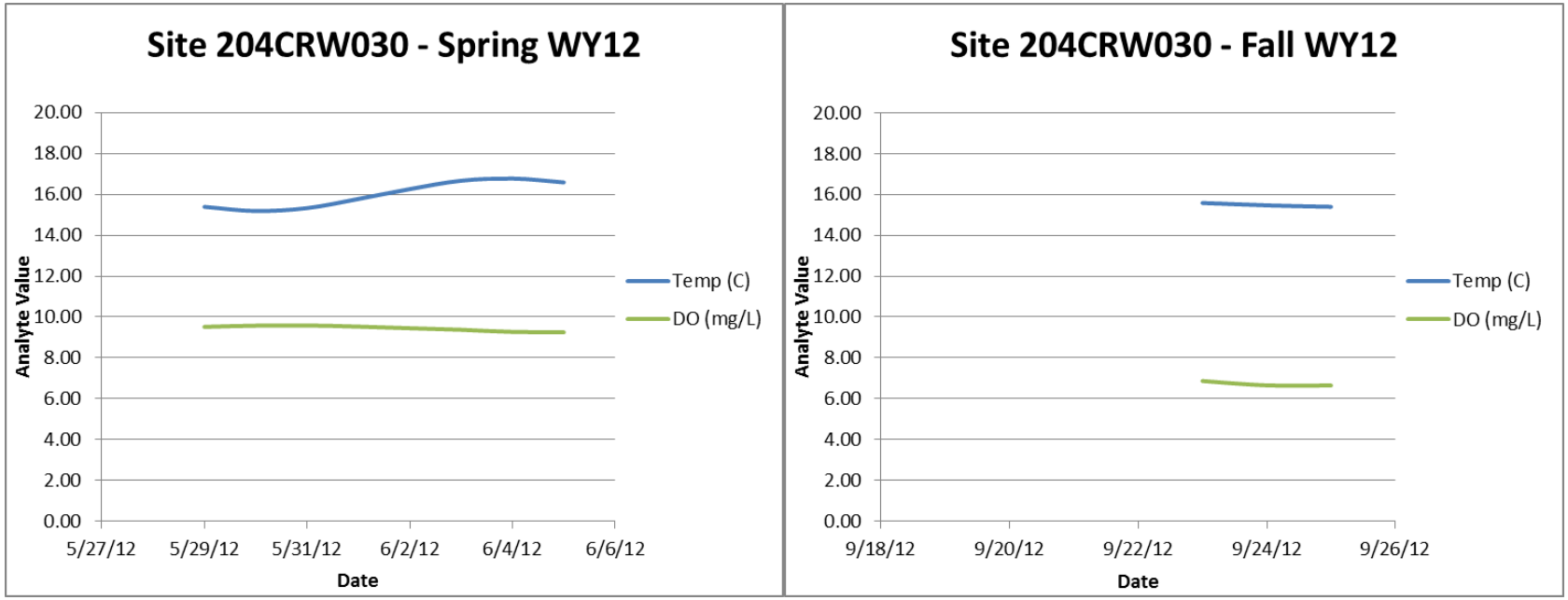

Figure 4-11. General Water Quality Monitoring 7-Day Rolling Averages for 204CRW030 in Spring and Fall, WY2012.

4.3.4 Arroyo Viejo and Lion Creeks

The Arroyo Viejo Site 204AVJ080, was monitored in both April and September in 2013. The 7-day rolling average results of this monitoring indicated differences in water temperature between the two sampling periods of over 3°C, with Spring temperatures around 14°C and Fall temperatures of around 17°C (Figure 4-12). pH stayed static around 8 during both monitoring periods (Table 4-8). However, DO showed a significant drop during the September deployment, with concentrations of below 2mg/L for prolonged periods of time.

Table 4-7. General Water Quality 7-day Rolling Averages at Site 204AVJ080, WY2012

April				September			
Date	Temp (°C)	pH	DO (mg/L)	Date	Temp (°C)	pH	DO (mg/L)
4/22/13	13.43	8.06	10.29	9/2/13	16.68	7.73	2.34
4/23/13	13.63	8.07	10.20	9/3/13	16.75	7.72	1.61
4/24/13	13.77	8.08	10.13	9/4/13	16.81	7.71	1.42
4/25/13	13.87	8.08	10.09	9/5/13	16.84	7.70	1.91
4/26/13	13.89	8.09	10.07	9/6/13	16.79	7.72	3.03

Due to unanticipated drying out of Site 204AVJ130 it could only be monitored in April, and Site 204LIO080 was used as the alternative location for September monitoring. Figure 4-13 shows the 7-day rolling average April results for Site 204AVJ130 and September results for Site 204LIO080. Temperature and pH results for both sites are consistent with other monitoring sites. However, DO decreased during April at Site 204AVJ130 to concentrations below 7mg/L. During this monitoring period 20% of the rolling averages were below 7mg/L (Table 4-8). At Site 204LIO050, DO was consistently above 8mg/L.

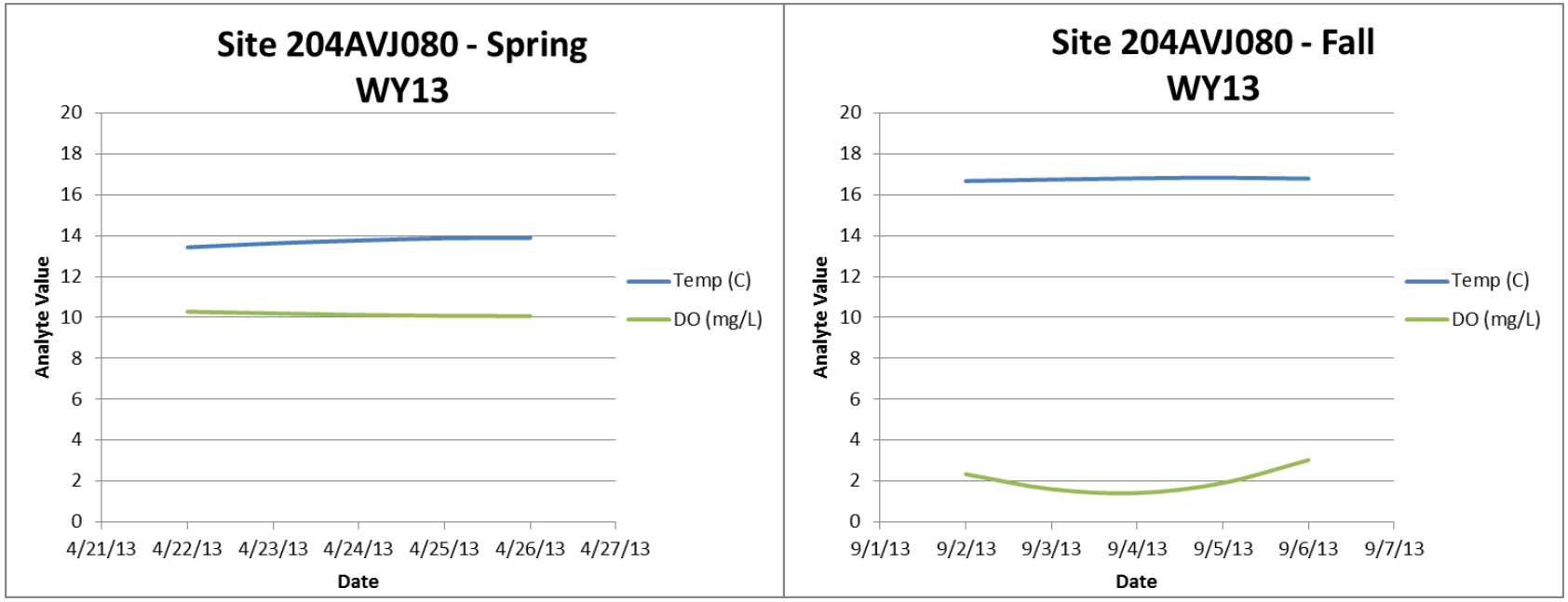

Figure 4-12. General Water Quality Monitoring 7-Day Rolling Averages for 204AVJ080 in Spring and Fall, WY2013.

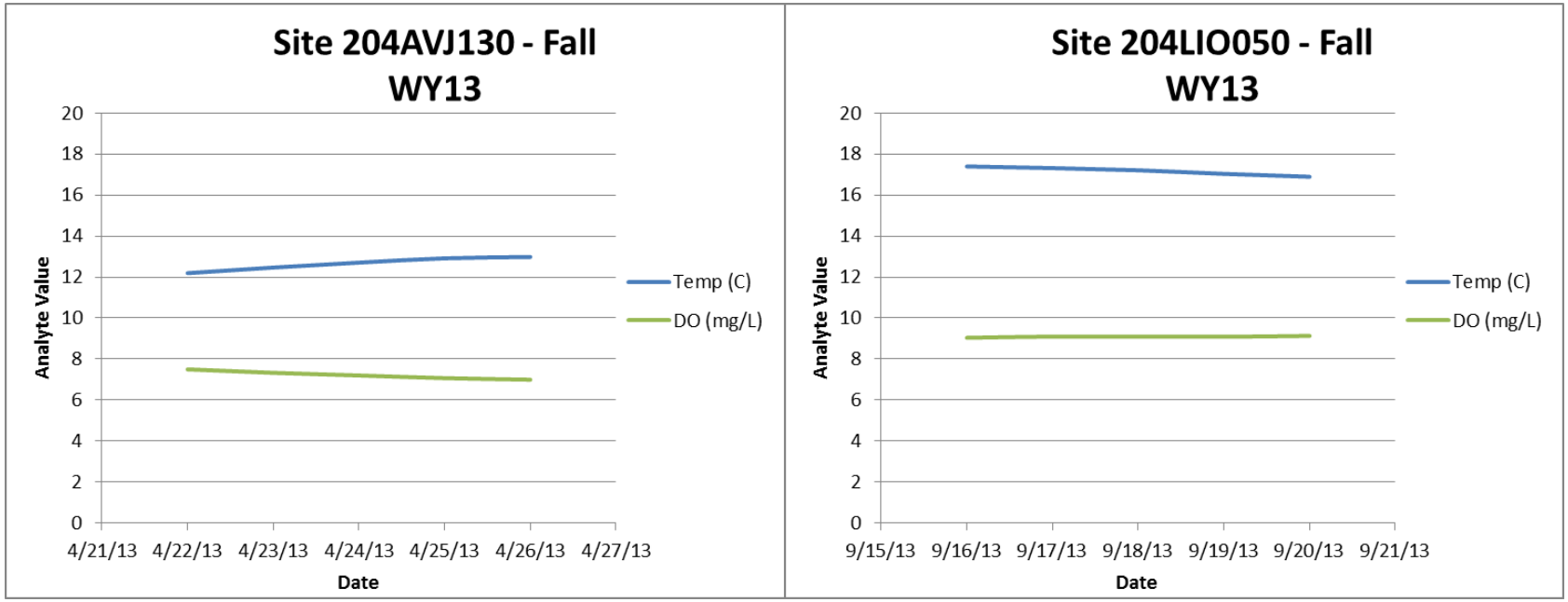

Figure 4-13. General Water Quality Monitoring 7-Day Rolling Averages for 204AVJ130 and 204LIO080 in Spring and Fall, WY2013.

Table 4-8. General Water Quality 7-day Rolling Averages at Site 204AVJ130 and 204LIO050, WY2012

April (204AVJ130)				September (204LIO050)			
Date	Temp (°C)	pH	DO (mg/L)	Date	Temp (°C)	pH	DO (mg/L)
4/22/13	12.19	7.86	7.50	9/16/13	17.40	7.71	9.04
4/23/13	12.47	7.86	7.32	9/17/13	17.32	7.72	9.10
4/24/13	12.71	7.86	7.20	9/18/13	17.21	7.73	9.09
4/25/13	12.92	7.86	7.06	9/19/13	17.04	7.73	9.09
4/26/13	12.98	7.86	6.99	9/20/13	16.90	7.73	9.13

Results of the monitoring at Site 204LIO080 are presented in Figure 4-13 and Table 4-9. Results of this monitoring showed that temperature and pH were similar between the two seasons and consistent with other monitoring locations in the region. Dissolved oxygen, however, decreased significantly during September 2013.

At Site 204LIO080, none of the spring rolling averages met trigger criteria with the exception of dissolved oxygen which was below COLD beneficial use levels 16.7% of the time. In summer, 100% of rolling averages were below both the WARM and COLD beneficial use criteria for DO (Table 4-9).

Table 4-9. General Water Quality 7-day Rolling Averages at Site 204LIO080, WY2012

May, WY2013				September, WY2013			
Date	Temp (°C)	pH	DO (mg/L)	Date	Temp (°C)	pH	DO (mg/L)
5/19/13	16.33	7.73	7.86	9/16/13	16.66	6.99	0.28
5/20/13	16.29	7.74	7.91	9/17/13	16.64	6.98	0.20
5/21/13	16.43	7.78	8.30	9/18/13	16.52	6.98	0.17
5/22/13	16.38	7.79	8.24	9/19/13	16.32	6.99	0.15
5/23/13	16.10	7.70	7.09	9/20/13	16.14	6.99	0.13

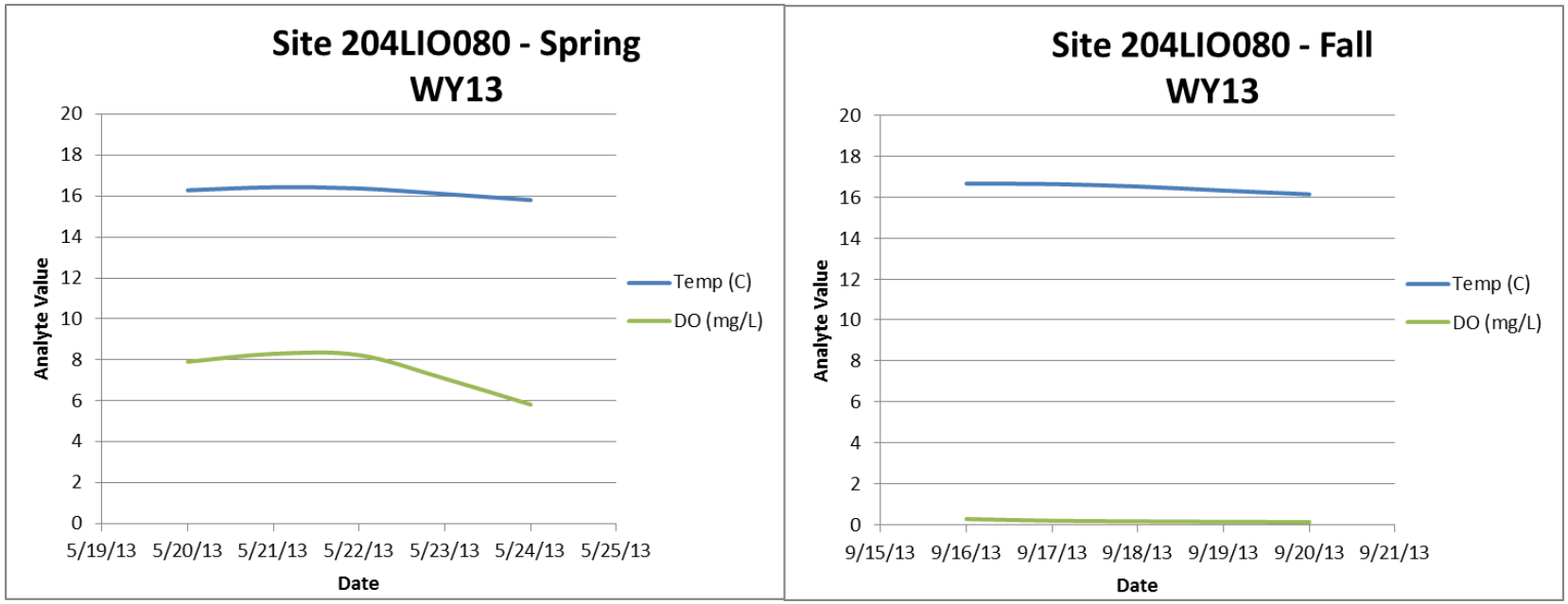

Figure 4-14. General Water Quality Monitoring 7-Day Rolling Averages for 204LIO080 in Spring and Fall, WY2013.

4.4 Pathogen Indicators

In WY2012, grab water samples for pathogen indicators were taken at five locations in the greater Castro Valley Creek watershed on July 11, 2012. *E. coli* and fecal coliform were enumerated as individual grab samples as presented in Table 4-10. With the exception of one sample, the bacteria concentrations at each of the sampling sites were greater than or equal to 900MPN/100mL.

Elevated fecal indicator bacteria concentrations were found at Site 204CVY140 (greater than or equal to 16,000MPN/100mL). These results were 800m upstream of Site 204CVY120 where elevated bacteria concentrations were also found (1,700MPN/100mL). Because the concentrations of fecal indicator bacteria at Site 204CVY140 were outside the reporting limits of the dilution series used for enumeration, it is not possible to quantify the magnitude of the elevated values.

Table 4-10. Fecal coliform and *E. coli* enumerations at San Lorenzo Creek Watershed Monitoring Sites.

Site ID	Site Description	Creek Name	Fecal Coliform (MPN*/100mL)	*E. coli* (MPN*/100 mL)
204CVY020	Chabot Creek at Carlos Bee Park	Chabot Creek	900	900
204CVY080	Castro Valley Creek above confluence with Chabot Creek	Castro Valley Creek	900	900
204CVY120	CV Creek Park at Castro Valley Library	Castro Valley Creek	1,700	1,700
204CVY140	Castro Valley Creek North side of Berdina Rd	Castro Valley Creek	>/= 16,000	>/= 16,000
204CVY150	Castro Valley Creek North side of Heyer Ave	Castro Valley Creek	500	500

*Most Probable Number

In WY2013, the highest concentrations of fecal coliforms and *E. coli* were found at 204TEM100 where both fecal coliform and *E. coli* numbers were 3,000MPN (See Table 4-11). Moderately elevated concentrations were also found at Sites 204AVJ080 (500MPN/100mL) and 204LIO050 (700MPN/100mL). The City of Oakland is home to many aging sanitary sewer lines and City staff have recorded much higher bacterial counts in the vicinity of illicit connections or sewer breaks. In contrast pathogen results similar to those in Table 4-11 are commonly found when conducting confirmation sampling after repairs or abatement of the wastewater releases.

Table 4-11. Fecal coliform and *E. coli* enumerations at Five Watershed Monitoring Sites.

Site ID	Site Description	Creek Name	Fecal Coliform (MPN*/100mL)	*E. coli* (MPN*/100 mL)
204AVJ080	Along Golf Links Dr. just west of I-580	Arroyo Viejo	500	500
204LIO050	Chimes Creek at Mills	Lion Creek	700	700
204LIO070	Lion Creek near Wetmore Ave bridge	Lion Creek	230	230
204SAU090	Below Leimert Ave. bridge	Sausal Creek	8	8
204TEM100	Near Broadway Terrace and Duncan	Temescal Creek	3000	3000

*Most Probable Number

4.5 Stream Survey

The following section provides a summary of the Stream Survey portions of the Creek Status monitoring documented in AMS (2013, 2014). The section provides summary stream assessment data for:

- San Lorenzo Creek (Section 4.5.1) surveyed in WY2012 and WY2013;
- Castro Valley Creek (Section 4.5.2) surveyed in WY2012;
- Chabot Creek (Section 4.5.3) surveyed in WY2012;
- Crow Creek (Section 4.5.4) surveyed in WY2013;
- Sausal Creek (Section 4.5.5) surveyed in WY2013;
- Arroyo Viejo (Section 4.5.6) surveyed in WY2013; and
- Glen Echo (Section 4.5.7) surveyed in WY2013.

Attachments A through G provide more detailed maps of the surveyed reaches.

In WY2013, approximately 10.96 miles were assessed. The additional 1.96 miles (above the MRP-required 9 per year) were added on to make up for the targeted miles that were not completed during the WY2012 ACCWP USA surveys, and to complete full assessments of the streams that were surveyed this 2013 field season. Surveys in WY2013 were conducted between September 17 and October 9, 2013.

4.5.1 San Lorenzo Creek

In WY2012, stream survey assessment in main stem San Lorenzo Creek was conducted between September 26 and 28, 2012, with a total assessed reach length of 24,147 feet or 4.57 miles. In WY2013, stream survey assessment in the upper San Lorenzo Creek was conducted between October 1 and 2, 2013, with a total of 11,514 feet or 2.18 miles of reach length assessed.

The general characteristics of the surveyed creek are presented in Table 4-12.

The majority of the lower creek is a federal flood control channel with a rectangular concrete (vertical wall) cross section with an average valley slope of 0.3%. Above Foothill Boulevard the creek retains a natural alignment with average slope of 0.55%.

The stream assessment scores are provided in Table 4-13 and illustrated in Figure 4-17 and Figure 4-18. The average score for the stream assessment within these reaches was 44.9, with Reaches P and Q having the highest score of 74 and Reaches D and I having the lowest score of 26. The San Lorenzo impact assessment summary is provided in Table 4-14 and Table 4-15. Slope failure was observed at one location in Reach C and some trash was observed during assessment (including diapers, large electronics and some spray and chemical bottles). The majority of trash was found in Reaches B, E, and I.

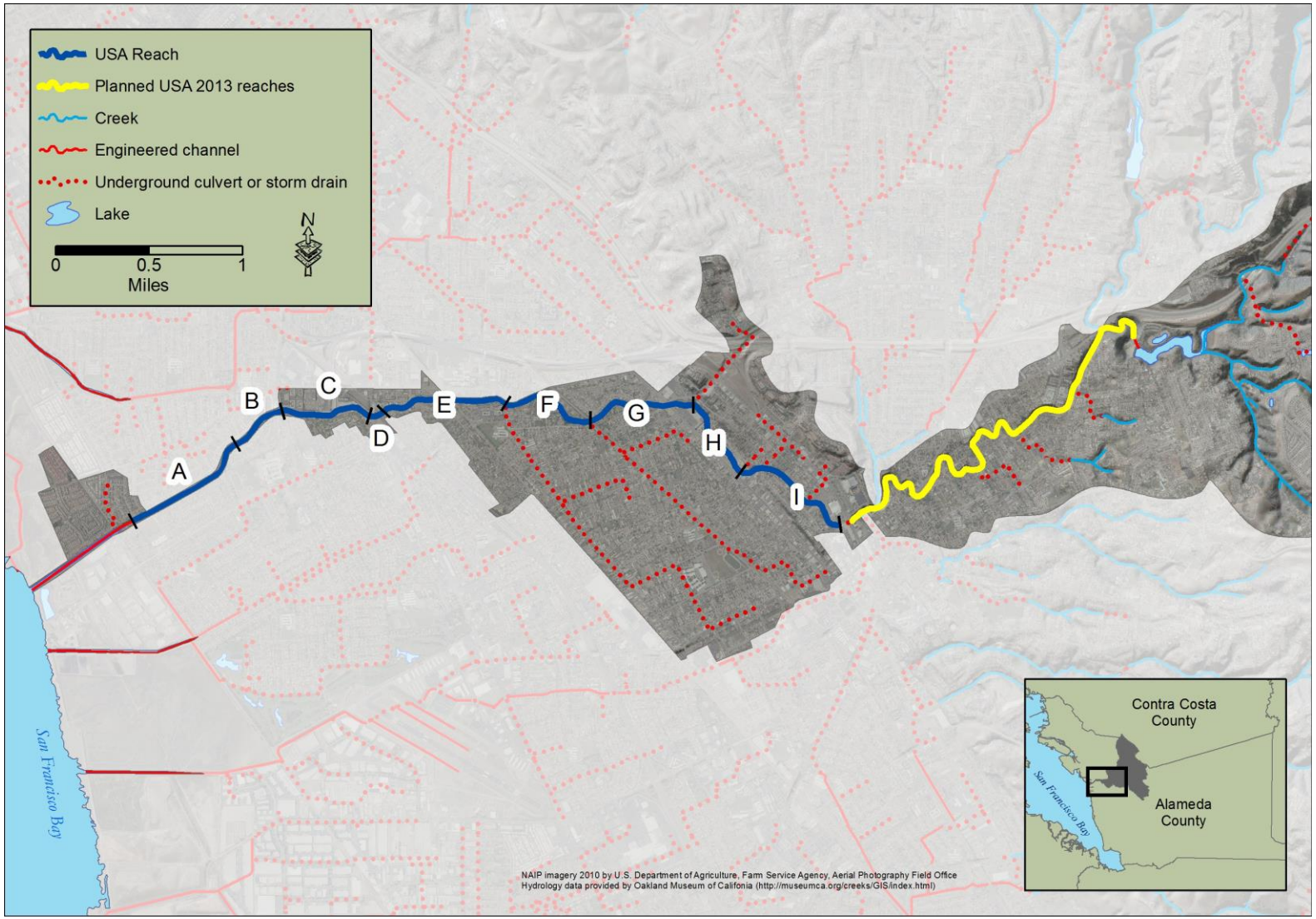

Figure 4-15. San Lorenzo Creek Subwatershed and USA Reaches surveyed in WY 2012.

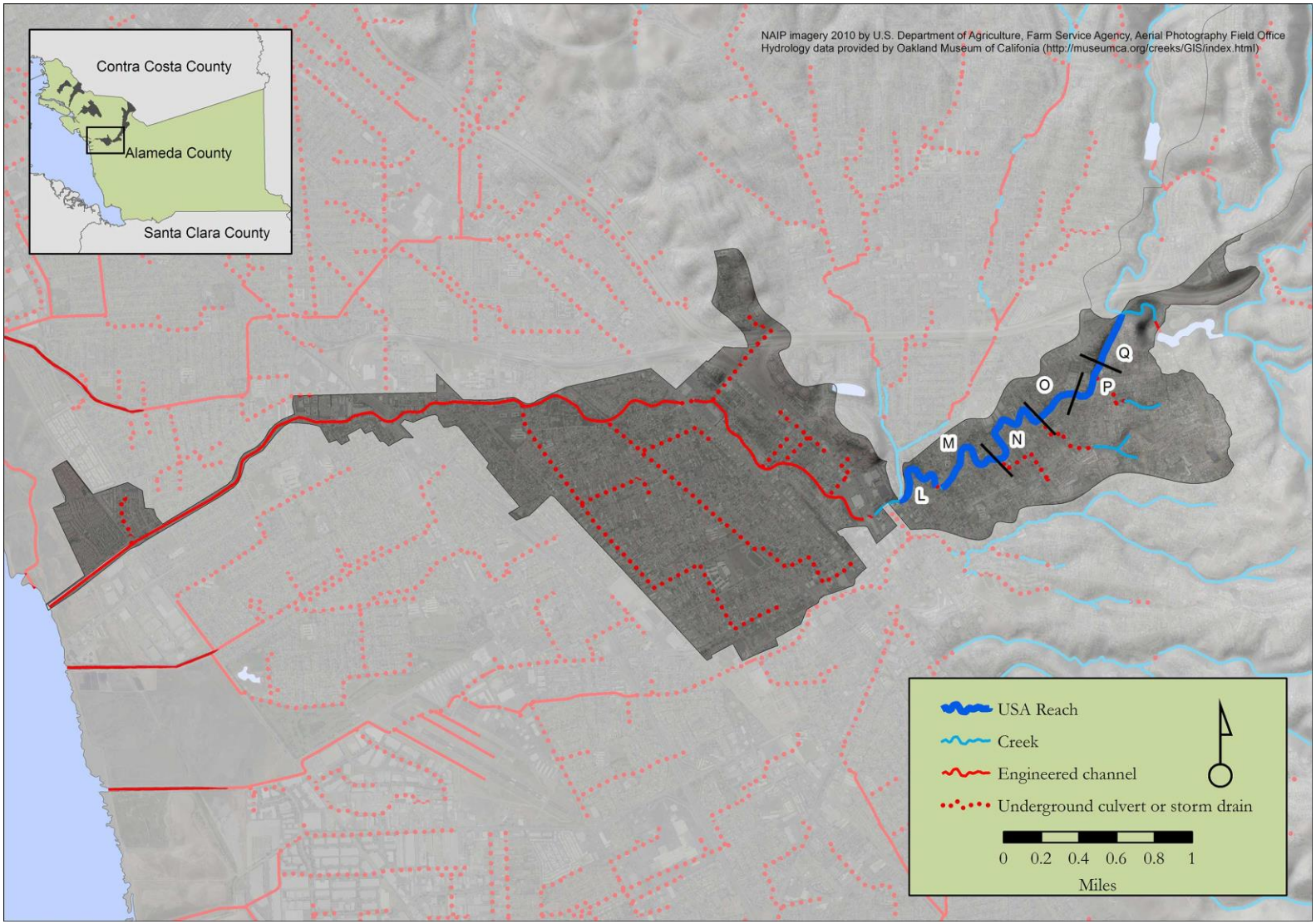

Figure 4-16. San Lorenzo Creek Subwatershed and USA Reaches surveyed in WY 2012.

Table 4-12. Surveyed Reaches, San Lorenzo Creek

Reach	Geographic Extent	Reach Length (ft)	Valley Slope (%)	General Characteristics
A	Beginning to end of trapezoidal concrete channel.	3,787	0.1%	Concrete trapezoidal channel
B	Beginning of concrete vertical channel to east side of Via Alamitos.	1,680	0.3%	Concrete vertical channel
C	East side of Via Alamitos to the west side of Hesperian Blvd.	2,625	0.4%	Concrete vertical channel
D	West side of Hesperian Blvd. to the north east of Nimitz Freeway.	464	0.3%	Concrete vertical channel
E	North east side of Nimitz Freeway to the east of Meekland Ave.	3,612	0.3%	Concrete vertical channel
F	East side of Meekland Ave. to west side of train tracks.	2,761	0.4%	Concrete vertical channel
G	West side of train tracks to approx. 450 ft east of Mission Blvd.	3,172	0.4%	Concrete vertical channel
H	Approx. 450 feet E of Mission Blvd. to east of Grove Way.	2,445	0.4%	Concrete vertical channel
I	East of Grove Way to west of City Center Drive.	3,603	0.4%	Concrete vertical channel
K	East of Mission Blvd to confluence with Castro Valley Creek	--	--	Natural Chanel - Not surveyed due to water depth and safety issues.
L	Confluence with Castro Valley Creek to east edge of A Street crossing	2828	1.13%	Natural
M	East edge of A street crossing to outfall 2-B-9 on south bank, ~33" diameter RCP	2872	0.08%	Primarily Natural
N	Outfall 2-B-9 on south bank, ~33" diameter RCP to outfall 2-B-11 on south bank at Arlette Ave., ~42" diameter RCP	3028	0.53%	Natural
O	Outfall 2-B-11 on south bank at Arlette Ave., ~42" diameter RCP to southeast side of Center St crossing	1318	0.17%	Primarily Natural
P	Southeast side of Center Street to west of Bayview Ave.	1389	0.85%	Natural
Q	West of Bayview Ave. to northwest side of Grove Way crossing	1383	0.54%	Natural

Table 4-13. San Lorenzo Creek Unified Stream Assessment Scores for Each Reach by Assessment Parameter, Subtotals for Instream Condition and Floodplain/Buffer Condition and Total Reach Score.

Reach Number	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**L**	**M**	**N**	**O**	**P**	**Q**
Overall Stream Condition															
Instream Habitat	5	1	1	0	1	1	1	1	1	10	11	12	13	14	14
Vegetative Protection (LB)	0	1	1	0	1	1	1	1	0	6	6	3	7	8	8
Vegetative Protection (RB)	0	1	1	0	1	1	1	1	0	6	6	5	7	8	8
Bank Erosion (LB)	10	10	10	10	10	10	10	10	9	7	6	8	8	8	8
Bank Erosion (RB)	10	10	9	10	10	10	10	10	9	7	6	8	8	8	8
Floodplain Connection	2	1	1	1	1	1	1	1	1	7	7	7	7	8	8
Instream Habitat Total Score	27	24	23	21	24	24	24	24	20	43	42	43	50	54	54
Overall Buffer and Floodplain Condition															
Vegetative Buffer Width (LB)	1	1	2	1	2	1	3	1	2	3	3	3	3	4	4
Vegetative Buffer Width (RB)	1	1	1	1	2	1	3	1	1	3	3	3	3	4	4
Floodplain Vegetation	4	2	2	1	1	2	3	2	1	6	6	6	6	7	7
Floodplain Habitat	2	1	1	1	1	1	1	1	1	3	3	3	3	3	3
Floodplain Encroachment	2	1	1	1	1	1	2	1	1	3	3	3	3	2	2
Floodplain and Buffer Total Score	10	6	7	5	7	6	12	6	6	18	18	18	18	20	20
Reach Assessment Total Score	**37**	**30**	**30**	**26**	**31**	**30**	**36**	**30**	**26**	**61**	**60**	**61**	**68**	**74**	**74**

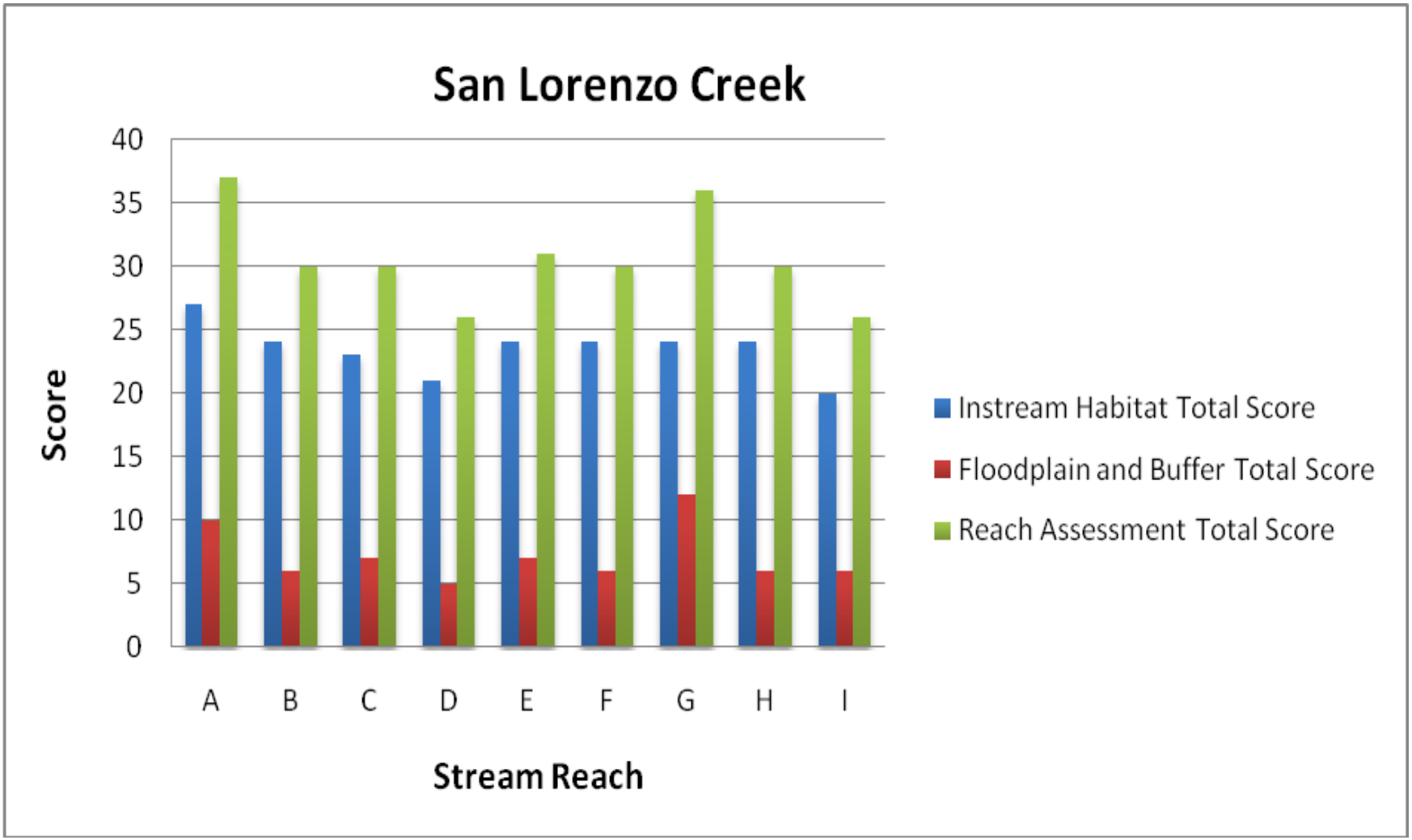

Figure 4-17. Bar Graph (3 bars/reach) of San Lorenzo Creek Unified Stream Assessment Scores: Total Reach Assessment, Instream Habitat Condition, Buffer and Floodplain Condition (WY2012).

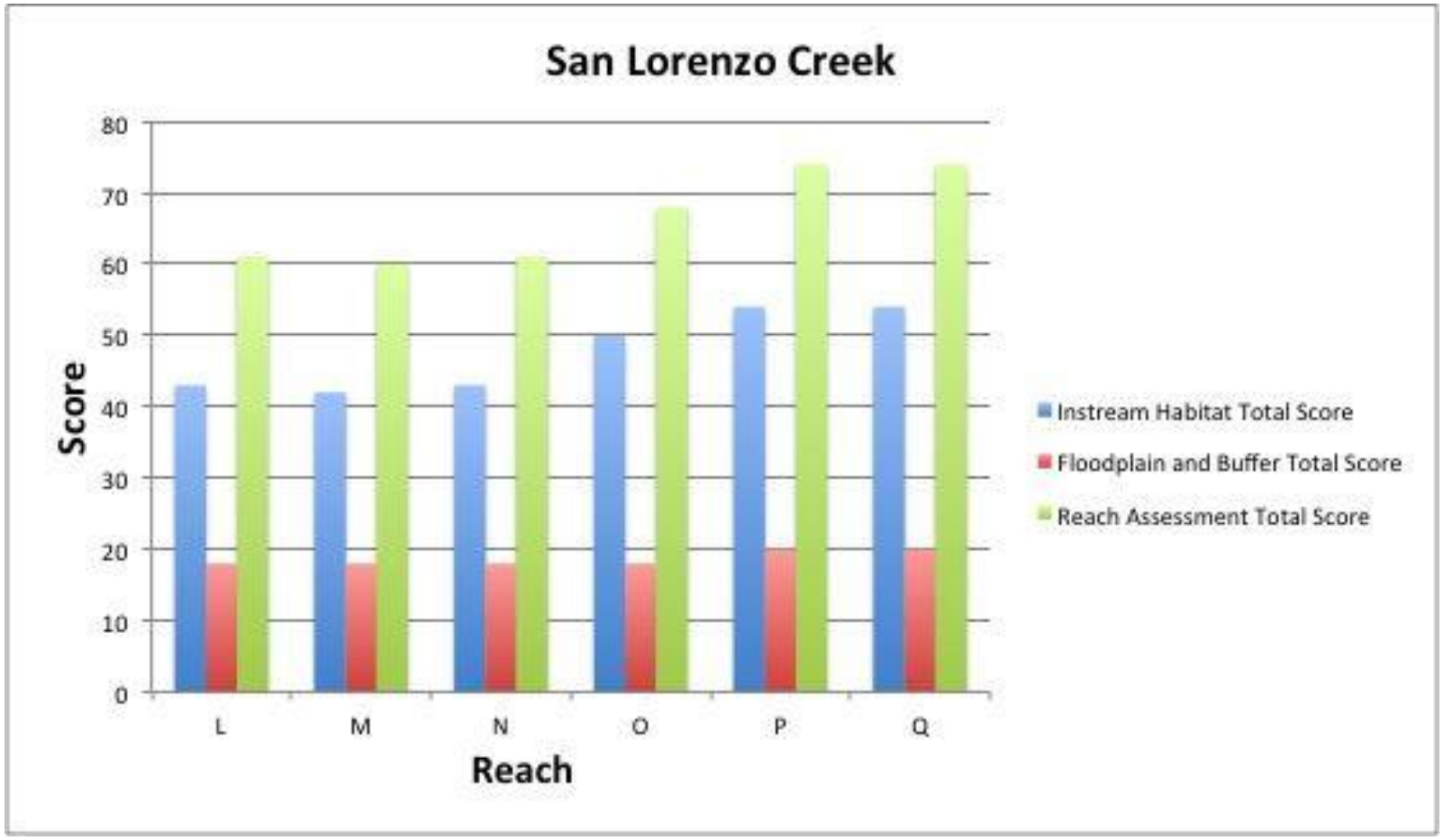

Figure 4-18. Bar Graph (3 bars/reach) of San Lorenzo Creek Unified Stream Assessment Scores: Total Reach Assessment, Instream Habitat Condition, Buffer and Floodplain Condition (WY2013).

Table 4-14. San Lorenzo Creek Impact Assessment Summary of the Unified Stream Assessment Survey. Part A

Reach Number	A	B	C	D	E	F	G	H	I
Reach Length (ft)	3,787	1,680	2,625	464	3,612	2,761	3,172	2,445	3,603
Outfalls									
Storm Drain Outfalls (8-24 inch diameter)	1	2	6	7	13	12	6	7	17
Other Outfalls (1-6 inch diameter)	0	0	0	0	1	0	0	0	0
Total Outfalls	1	2	6	7	14	12	6	7	17
Total per mile	1	6	12	80	20	23	10	15	25
Total Outfalls with dry weather flow	1	1	0	0	1	0	0	0	0
Channel Modification									
Channelization	X	X	X	X	X	X	X	X	X
Bank_Armoring	X	X	X	X	X	X	X	X	X
Hardened Bed	X	X	X	X	X	X	X	X	X
Drop Structure									
Total Length Modified	3787	1680	2625	464	3612	2761	3172	2445	3603
Percent Reach Modified	100	100	100	100	100	100	100	100	100
Erosion									
Downcutting									
Widening									
Slope Failure			X						
Aggrading									
Total Length	0	0	100	0	0	0	0	0	0
Percent Reach Eroded (%)	0	0	0	0	0	0	0	0	0
Stream Crossings									
Grade Control									
Fish Barrier (T-total; P-partial)									
Total Number of Crossings	1	1	1	3	3	1	3	1	1
Total Length Crossing	9	77	76	337	116	10	400	42	41
Percent Reach Crossing	0%	5%	3%	73%	3%	0%	13%	2%	1%
Trash									
Total Number of Trash Sites	0	1	0	0	1	0	0	0	1
Source: L-Litter; ID-Illegal Dumping; A-Accumulation	NA	L	NA	NA	L	NA	NA	NA	L
Recreation									
Total Number of Rec Sites	0	0	0	0	0	0	0	0	0
Access: Pub- Public; Pvt-Private									
Swimming Potential: Hi; Med; Low									

Table 4-15. San Lorenzo Creek Impact Assessment Summary of the Unified Stream Assessment Survey. Part B

Reach Number	**L**	**M**	**N**	**O**	**P**	**Q**
Reach Length (ft)	2828	2872	3028	1318	1389	1383
Outfalls						
Storm Drain Outfalls (8-24 inch dia)	5	3	2	1	2	3
Storm Drain Outfalls (>24 inch dia)	0	0	2	1	1	0
Other Outfalls (1-6 inch dia)	0	2	0	0	0	0
Total Outfalls	5	5	4	2	3	3
Total per mile	9	9	7	8	11	11
Total Outfalls with dry weather flow	0	0	2	1	1	1
Channel Modification						
Channelization	X	X	X	X	X	X
Bank Armoring	X	X	X	X	X	X
Hardened Bed			X			
Drop Structure			X			
Total Length Modified (ft)	930	1321	1729	356	194	111
Percent Reach Modified (%)	32.9	46.0	57.1	27.0	14.0	8.0
Erosion						
Downcutting						
Widening						
Slope Failure						
Aggrading						
Bank Erosion						
Total Length (ft)	0	0	0	0	0	0
Percent Reach Eroded (%)	0	0	0	0	0	0
Stream Crossings						
Grade Control						
Fish Barrier (T-total; P-partial)						
Total Number of Crossings	2	0	0	1	0	1
Total Length Crossing (ft)	95	0	0	36	0	111
Percent Reach Crossing (%)	3.4	0	0	2.7	0	8.0
Trash						
Total Number of Trash Sites	0	0	0	0	0	0
Source: L-Litter; ID-Illegal Dumping; A-Accumulation	NA	NA	NA	NA	NA	NA
Recreation						
Total Number of Rec Sites	0	0	2	0	0	0
Access: Pub- Public; Pvt-Private	NA	NA	Pvt	NA	NA	NA
Swimming Potential: Hi; Med; Low	NA	NA	Med	NA	NA	NA

4.5.2 Castro Valley Creek

Stream survey assessment in Castro Valley Creek was conducted between October 3 and 13, in WY2012 with a total assessed reach length of 13,126 feet or 2.49 miles (Figure 4-19). Details of the surveyed reaches in Castro Valley are provided in Table 4-16. The majority of the creek is comprised of trapezoidal concrete channel, with some natural channel. The average valley slope was determined to be 1.8%. The stream assessment scores are provided in Table 4-17 and illustrated in Figure 4-20. The highest stream assessment score (86) was observed in Reach I. The lowest stream assessment score of 31 was observed in Reach C. The impact assessment summary for Castro Valley streams is provided in Table 4-18. Channel modification is prevalent throughout the reaches with slope failure noted in Reach A. Reach A was also noted as having potential recreational use.

Table 4-16. Surveyed Reaches, Castro Valley Creek

Reach	Geographic Extent	Reach Length (ft)	Valley Slope (%)	General Characteristics
A	Confluence of San Lorenzo and Castro Valley Creek south of City Center Drive to confluence with Chabot Creek east of North 3rd St. and Knox St.	1,384	1.7%	Natural channel
B	Confluence with Chabot Creek to south side of Grove Way	--	--	Natural channel. Not surveyed in 2012 due to access issues.
C	North of Grove Way to East of Redwood Rd	968	0.6%	Trapezoidal concrete channel
E	North east of Redwood Rd to southwest of Watson St	769	0.2%	Trapezoidal concrete channel
H	North of 580 Freeway to southwest of Norbridge Ave.	500	0.8%	Trapezoidal concrete channel
I	North of Norbridge Ave to southwest of Castro Valley Blvd	933	0.2%	Trapezoidal concrete channel
K	121 ft northeast of Castro Valley Blvd to 108 ft south of Catalina Dr.	328	1.4%	Natural channel
M	East of Meadowlark Ct to south of Heyer Ave	2,478	0.1%	Concrete channel
N	South of Heyer Ave to south of Seven Hills Rd	2,068	3.4%	Concrete channel / natural channel
O	South of Seven Hills Rd to south of Seaview Ave	1,066	3.0%	Concrete channel
P	South of Seaview Ave to 518 ft north of Seaview Ave	822	3.0%	Concrete channel
Q	18457 Madison Ave to 17823 Madison Ave	871	2.4%	Natural channel
R	18457 Madison Ave to 17580 Commons Rd	940	4.5%	Natural channel

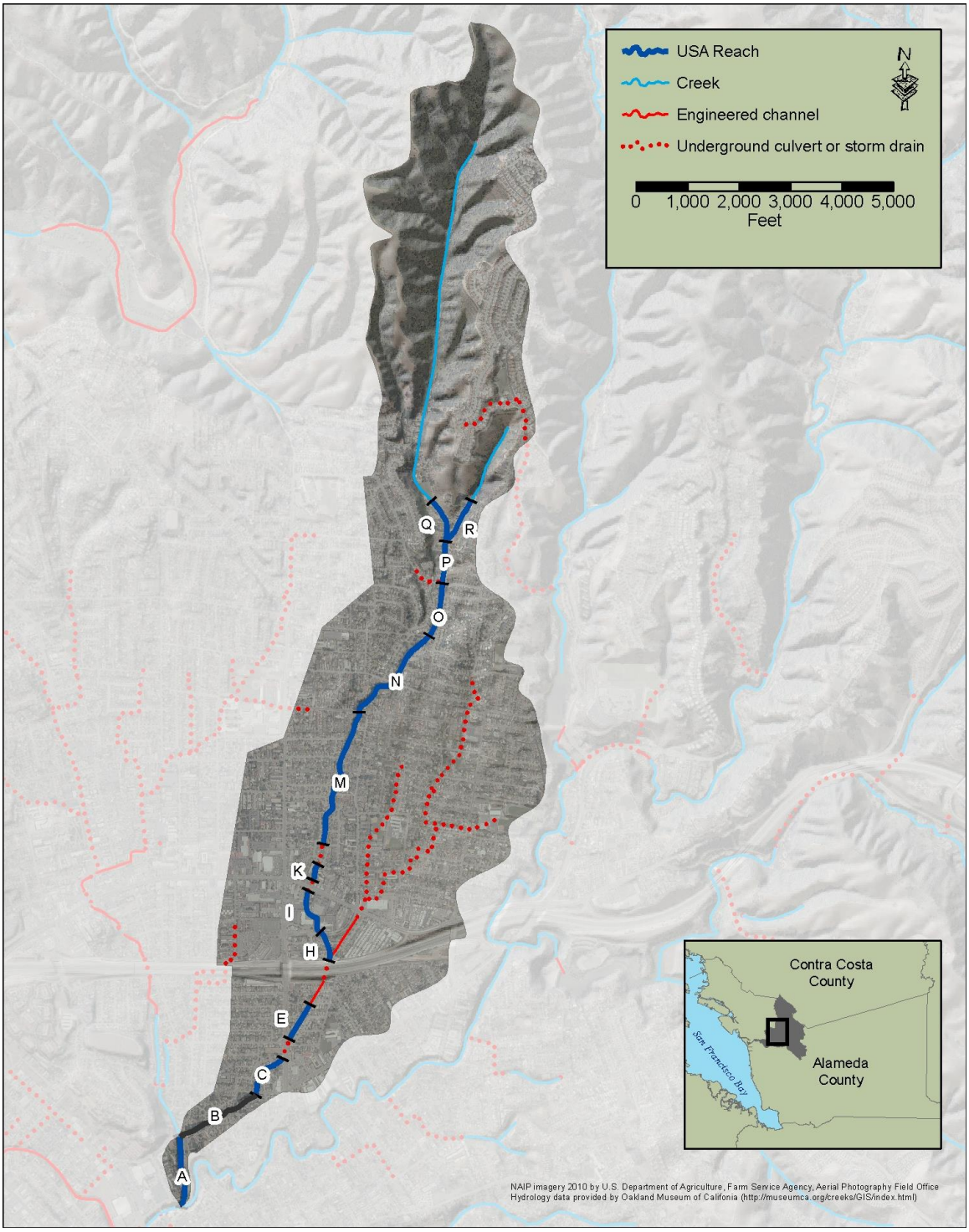

Figure 4-19. Castro Valley Subwatershed USA Assessment Reaches.

Table 4-17. Castro Valley Creek Unified Stream Assessment Scores for Each Reach by Assessment Parameter, Subtotals for Instream Condition and Floodplain/Buffer Condition and Total Reach Score.

Reach Number	**A**	**C**	**E**	**H**	**I**	**K**	**M**	**N**	**O**	**P**	**Q**	**R**
Overall Stream Condition												
Instream Habitat	13	1	2	2	14	2	8	10	3	12	8	12
Vegetative Protection (LB)	4	1	1	0	8	1	4	2	2	7	3	6
Vegetative Protection (RB)	4	1	1	0	8	1	4	2	2	5	2	5
Bank Erosion (LB)	8	10	9	10	7	9	8	9	9	8	7	7
Bank Erosion (RB)	8	10	9	10	7	9	7	9	9	8	7	7
Floodplain Connection	9	3	4	3	15	4	10	13	11	17	19	14
Instream Habitat Total Score	46	26	26	25	59	26	41	45	36	57	46	51
Overall Buffer and Floodplain Condition												
Vegetative Buffer Width (LB)	4	1	1	1	4	1	4	4	2	4	2	5
Vegetative Buffer Width (RB)	4	1	1	1	5	1	5	4	2	4	4	5
Floodplain Vegetation	3	1	2	1	7	2	3	6	3	4	3	5
Floodplain Habitat	1	1	2	1	6	1	2	3	2	2	2	3
Floodplain Encroachment	6	1	1	1	5	1	4	5	3	5	4	5
Floodplain and Buffer Total Score	18	5	7	5	27	6	18	22	12	19	15	23
Reach Assessment Total Score	**64**	**31**	**33**	**30**	**86**	**32**	**59**	**67**	**48**	**76**	**61**	**74**

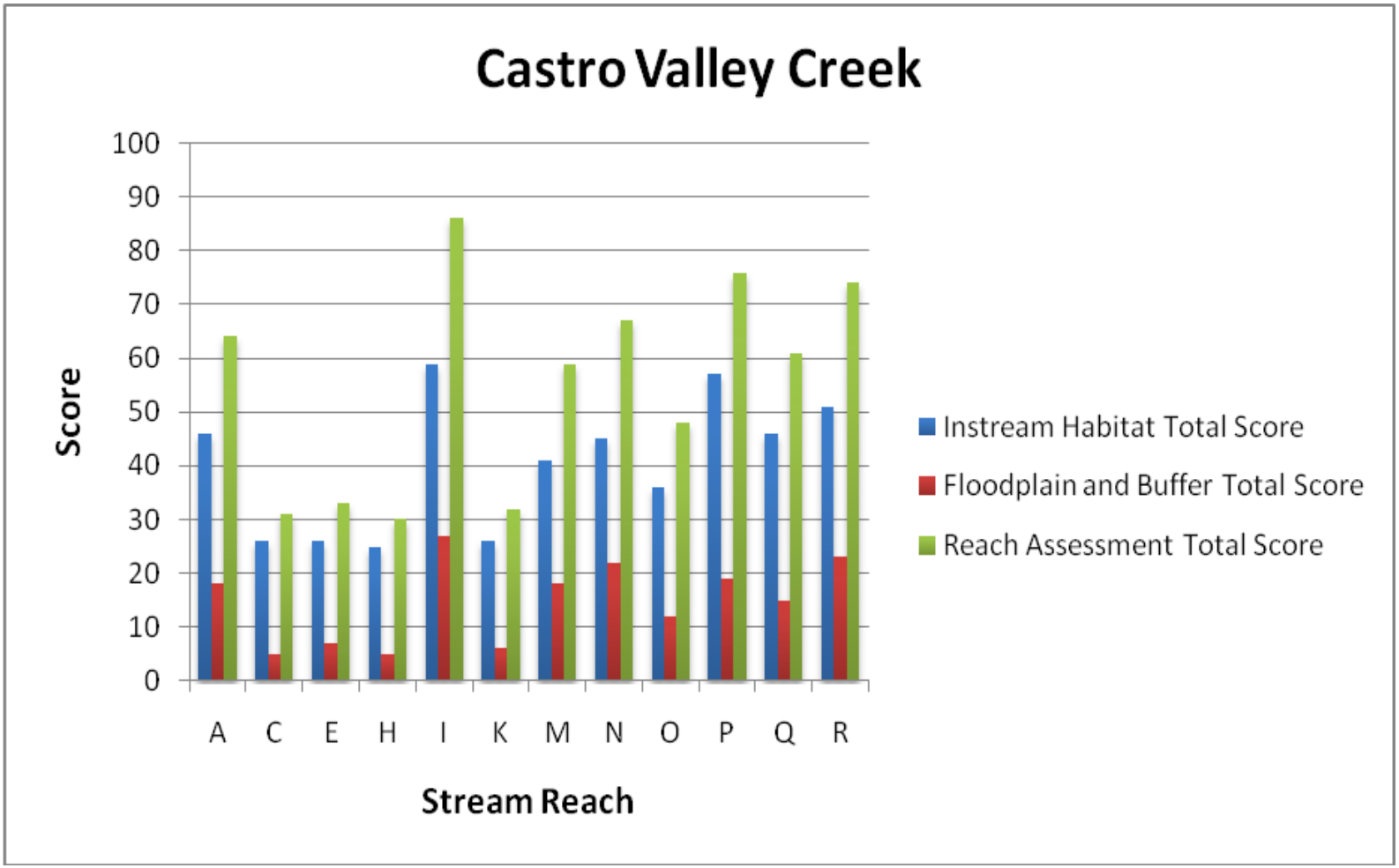

Figure 4-20. Bar Graph (3 bars/reach) of Castro Valley Creek Unified Stream Assessment Scores: total reach assessment, instream habitat condition, buffer and floodplain condition.

Table 4-18.Castro Valley Creek Impact Assessment Summary of the Unified Stream Assessment Survey.

Reach Number	A	C	E	H	I	K	M	N	O	P	Q	R
Reach Length (ft)	1384	968	769	500	933	328	2478	2068	1066	822	871	940
Outfalls												
Storm Drain Outfalls (8-24 inch diameter)	1	6	2	2	6	1	10	5	2	1	3	0
Other Outfalls (1-6 inch diameter)	0	0	0	0	0	0	0	0	0	0	2	0
Total Outfalls	1	6	2	2	6	1	10	5	2	1	5	0
Total per mile	4	33	14	21	34	16	21	13	10	6	30	0
Total Outfalls with dry weather flow	0	1	0	0	0	0	0	0	0	0	1	0
Channel Modification												
Channelization	X	X	X	X		X	X	X	X		X	
Bank_Armoring	X	X	X	X		X	X	X	X		X	
Hardened Bed		X	X	X		X			X			
Drop Structure							X					
Total Length Modified	NR	968	769	500	0	328	1283	2068	1066	0	35	0
Percent Reach Modified (%)	NA	100	100	100	0	100	52	100	100	0	4	0
Erosion												
Downcutting												
Widening												
Slope Failure	X											
Aggrading												
Total Length	99	0	0	0	0	0	0	0	0	0	0	0
Percent Reach Eroded	7	0	0	0	0	0	0	0	0	0	0	0
Stream Crossings												
Grade Control												
Fish Barrier (T-total; P-partial)												
Total Number of Crossings	1	3	1	3	2	1	3	3	3	0	5	5
Total Length Crossing	8	438	29	186	140	40	91	129	94	0	65	81
Percent Reach Crossing	1	45	4	37	15	12	4	6	9	0	7	9
Trash												
Total Number of Trash Sites	0	0	0	0	0	0	0	0	0	0	0	0
Source: L-Litter; ID-Illegal Dumping; A-Accumulation	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Recreation												
Total Number of Rec Sites	1	0	0	0	0	0	0	0	0	0	0	0
Access: Pub- Public; Pvt-Private	Pub											
Swimming Potential: Hi; Med; Low	Med											

4.5.3 Chabot Creek

Stream survey assessment in Chabot Creek was conducted between October 3 and 13, 2012, with a total assessed reach length of 6,395 feet or 1.21 miles (Figure 4-21). Half the surveyed reaches were natural channel and half were trapezoidal concrete channel. The average valley slope was determined to be 0.6%. Details of the surveyed reaches in Chabot Creek are provided in Table 4-19. The stream assessment scores are provided in Table 4-20 and illustrated in Figure 4-22. The highest score (59) was attributed to Reach B, while the lowest score (32) was found in Reaches G and E.

The impact assessment summary for Castro Valley streams is provided in Table 4-21. The creek was found to have approximately 30 outfalls per mile. Public access was found in Reach A with medium swimming potential. Slope failure was observed in Reaches A, B and C with much of the creek channelized.

Table 4-19. Surveyed Reaches, Chabot Creek

Reach	Geographic Extent	Reach Length (ft)	Valley Slope (%)	General Characteristics
A	East of North3rd St. and Knox St. to 60 ft. south of Grove Way	995	1.4%	Natural channel
B	Approx. 122 ft south of Grove Way to approx. 197 ft north of Meg Ct.	1,443	0.0%	Natural channel to concrete channel
C	Approx. 197 ft north of Meg Ct. to south of Strobridge Ave.	764	0.7%	Natural / concrete channel
E	South of Strobridge Ave. to southwest of Castro Valley Blvd.	1,544	0.5%	Trapezoidal concrete channel
G	Southwest of Castro Valley Blvd. to 103 ft northeast of Lake Chabot Rd	548	0.6%	Trapezoidal concrete channel
H	103 ft northeast of Lake Chabot Rd to west of Anita Ave.	1,101	0.5%	Trapezoidal concrete channel

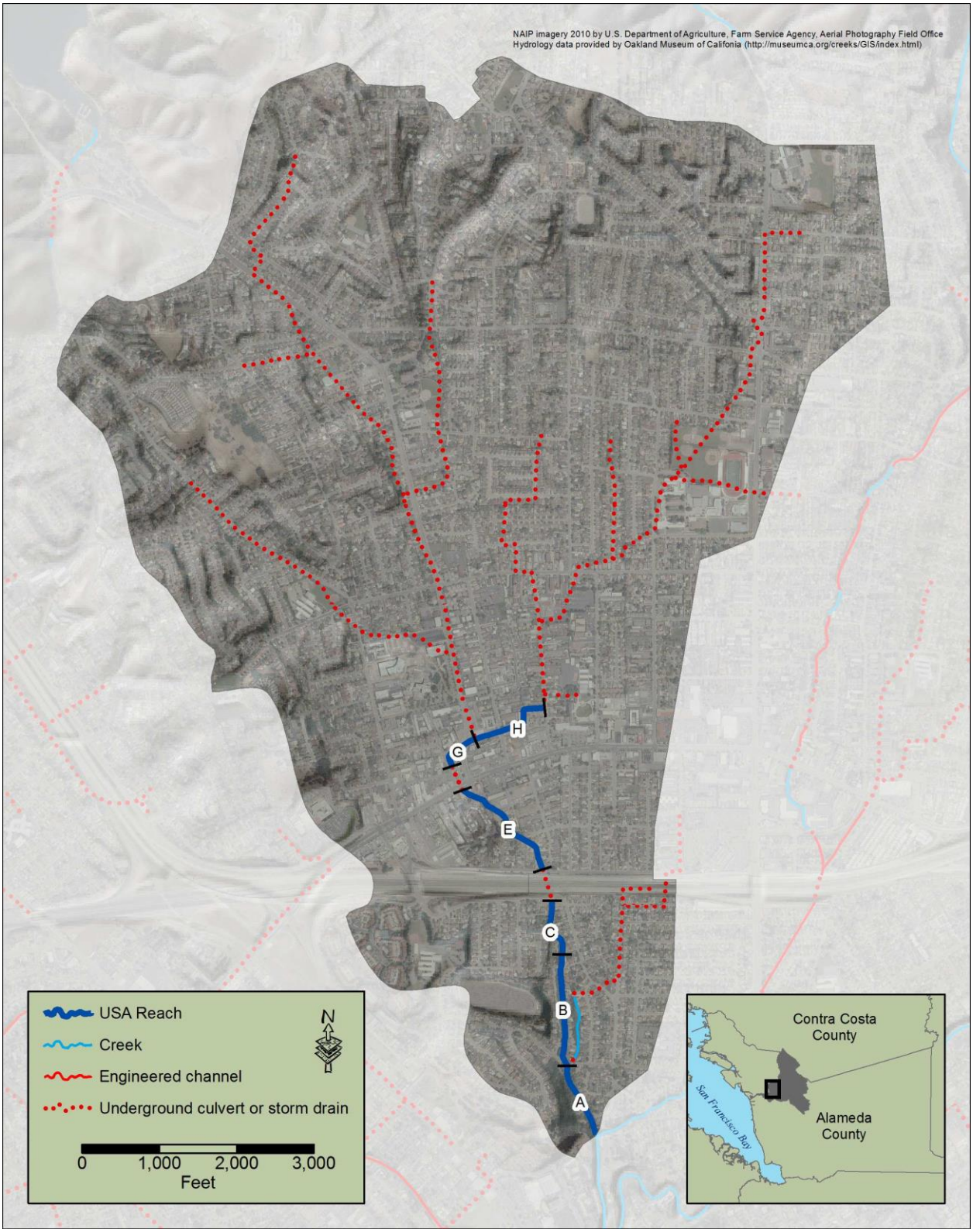

Figure 4-21. Chabot Creek Subwatershed USA Assessment Reaches

Table 4-20. Chabot Creek Unified Stream Assessment Scores for Each Reach by Assessment Parameter, Subtotals for Instream Condition and Floodplain/Buffer Condition and Total Reach Score.

Reach Number	**A**	**B**	**C**	**E**	**G**	**H**
Overall Stream Condition						
Instream Habitat	14	13	10	1	2	3
Vegetative Protection (LB)	3	5	4	1	1	1
Vegetative Protection (RB)	3	4	4	1	1	1
Bank Erosion (LB)	5	7	7	10	10	10
Bank Erosion (RB)	6	6	6	10	10	10
Floodplain Connection	10	7	5	2	2	5
Instream Habitat Total Score	41	42	36	25	26	30
Overall Buffer and Floodplain Condition						
Vegetative Buffer Width (LB)	3	4	4	1	1	2
Vegetative Buffer Width (RB)	3	4	4	1	1	2
Floodplain Vegetation	3	2	3	2	2	2
Floodplain Habitat	1	2	3	1	1	3
Floodplain Encroachment	6	5	5	2	1	2
Floodplain and Buffer Total Score	16	17	19	7	6	11
Reach Assessment Total Score	**57**	**59**	**55**	**32**	**32**	**41**

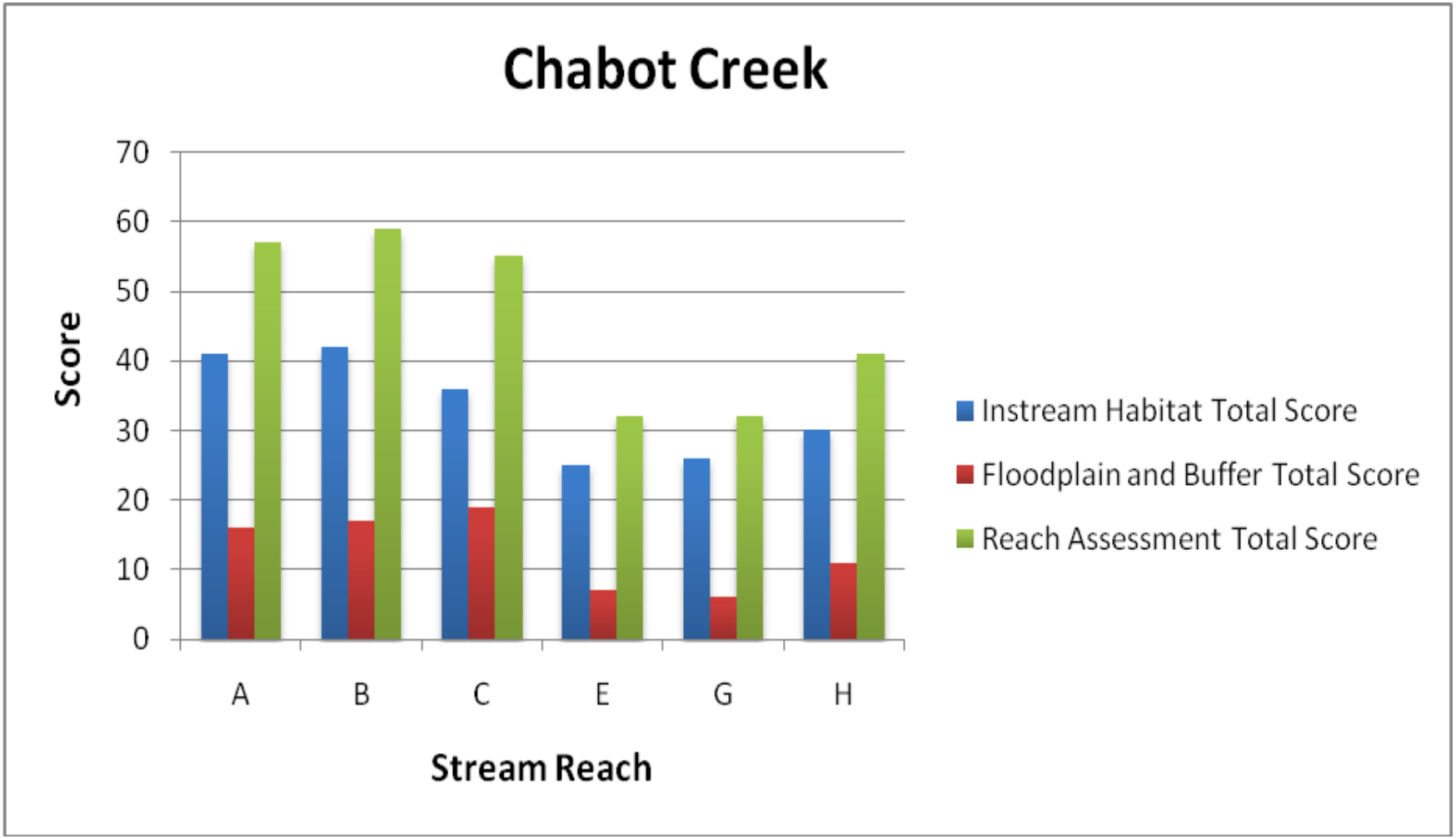

Figure 4-22. Bar Graph (3 bars/reach) of Chabot Creek Unified Stream Assessment Scores: total reach assessment, instream habitat condition, buffer and floodplain condition.

Table 4-21. Chabot Creek Impact Assessment Summary of the Unified Stream Assessment Survey.

Reach Number	A	B	C	E	G	H
Reach Length (ft)	995	1443	764	1544	548	1101
Outfalls						
Storm Drain Outfalls (8-24 inch diameter)	4	5	1	14	4	8
Other Outfalls (1-6 inch diameter)	0	0	0	0	0	0
Total Outfalls	4	5	1	14	4	8
Total per mile	21	18	7	48	39	38
Total Outfalls with dry weather flow	1	1	0	0	1	0
Channel Modification						
Channelization	X	X	X	X	X	X
Bank Armoring	X	X	X	X	X	X
Hardened Bed			X	X	X	X
Drop Structure	X	X	X			
Total Length Modified (ft)	50	263	60	1544	548	1101
Percent Reach Modified (%)	5	18	79	100	100	100
Erosion						
Downcutting						
Widening						
Slope Failure	X	X	X			
Aggrading						
Total Length	241	539	6	0	0	0
Percent Reach Eroded	24	37	1	0	0	0
Stream Crossings						
Grade Control						
Fish Barrier (T-total; P-partial)						
Total Number of Crossings	2	11	0	4	1	1
Total Length Crossing (ft)	50	139	0	487	120	64
Percent Reach Crossing (%)	5	10	0	32	22	6
Trash						
Total Number of Trash Sites	0	0	0	0	0	0
Source: L-Litter; ID-Illegal Dumping; A-Accumulation	NA	NA	NA	NA	NA	NA
Recreation						
Total Number of Rec Sites	1	0	0	0	0	0
Access: Pub- Public; Pvt-Private	Pub					
Swimming Potential: Hi; Med; Low	Med					

4.5.4 Crow Creek

Stream survey assessment in Crow Creek was conducted between September 17 and 19, 2013, in WY2013 with a total assessed reach length of 11,514 feet or 2.18 miles (Figure 4-19). Details of the surveyed reaches in Crow Creek are provided in Table 4-22. The majority of the creek is comprised of natural channel with some concrete. The average valley slope was determined to be 1.57%. The stream assessment scores are provided in Table 4-23 and illustrated in Figure 4-23.

The highest stream assessment score (89) was observed in Reach E. The lowest stream assessment score of 45 was observed in Reach D. The impact assessment summary for Crow Creek streams is provided in Table 4-24. Channel modification is prevalent throughout the reaches with some slope failure and bank erosion.

Table 4-22. Surveyed Reaches, Crow Creek

Reach	Geographic Extent	Reach Length (ft)	Valley Slope (%)	General Characteristics
A	Base of Crow confluence with San Lorenzo Creek beneath Grove Way crossing to north side of E Castro Valley Blvd.	1092	0.69%	Natural
B	North side of E Castro Valley Blvd. to southeast corner of Earl Warren Park	2334	0.76%	Natural
C	Southeast corner of Earl Warren Park to confluence with Cull Creek at Bay Trees Park	1775	1.53%	Mostly natural
D	Confluence with Cull Creek at Bay Trees Park to bottom end of culvert at SW side of Crow Canyon Rd	198	4.46%	Concrete / partially open
E	Entrance to culvert on south side of Crow Canyon Rd, just east of Crow Creek Rd., to west (upstream) side of Crow Canyon Rd. crossing just south of 5560 Crow Canyon Rd.	3820	0.59%	Concrete and natural
F	West (upstream) side of Crow Canyon Rd. crossing just south of 5560 Crow Canyon Rd., to stream crossing under Crow Canyon Rd at 37.710421, -122.040324.	2295	1.41%	Natural

Table 4-23. Reach Assessment Scores, Crow Creek

Crow Creek Reach	**A**	**B**	**C**	**D**	**E**	**F**
Overall Stream Condition						
Instream Habitat	8	12	13	1	16	9
Vegetative Protection (LB)	2	5	5	0	8	2
Vegetative Protection (RB)	3	5	5	0	8	2
Bank Erosion (LB)	7	8	5	9	8	7
Bank Erosion (RB)	6	8	4	9	8	5
Floodplain Connection	8	8	8	3	9	8
Instream Habitat Total Score	34	46	40	22	57	33
Overall Buffer & Floodplain Condition						
Vegetative Buffer Width (LB)	7	7	7	6	3	3
Vegetative Buffer Width (RB)	7	7	7	4	3	9
Floodplain Vegetation	2	12	12	8	16	13
Floodplain Habitat	3	4	3	1	4	4
Floodplain Encroachment	6	8	8	4	6	4
Floodplain and Buffer Total Score	25	38	37	23	32	33
Reach Assessment Total Score	59	84	77	45	89	66

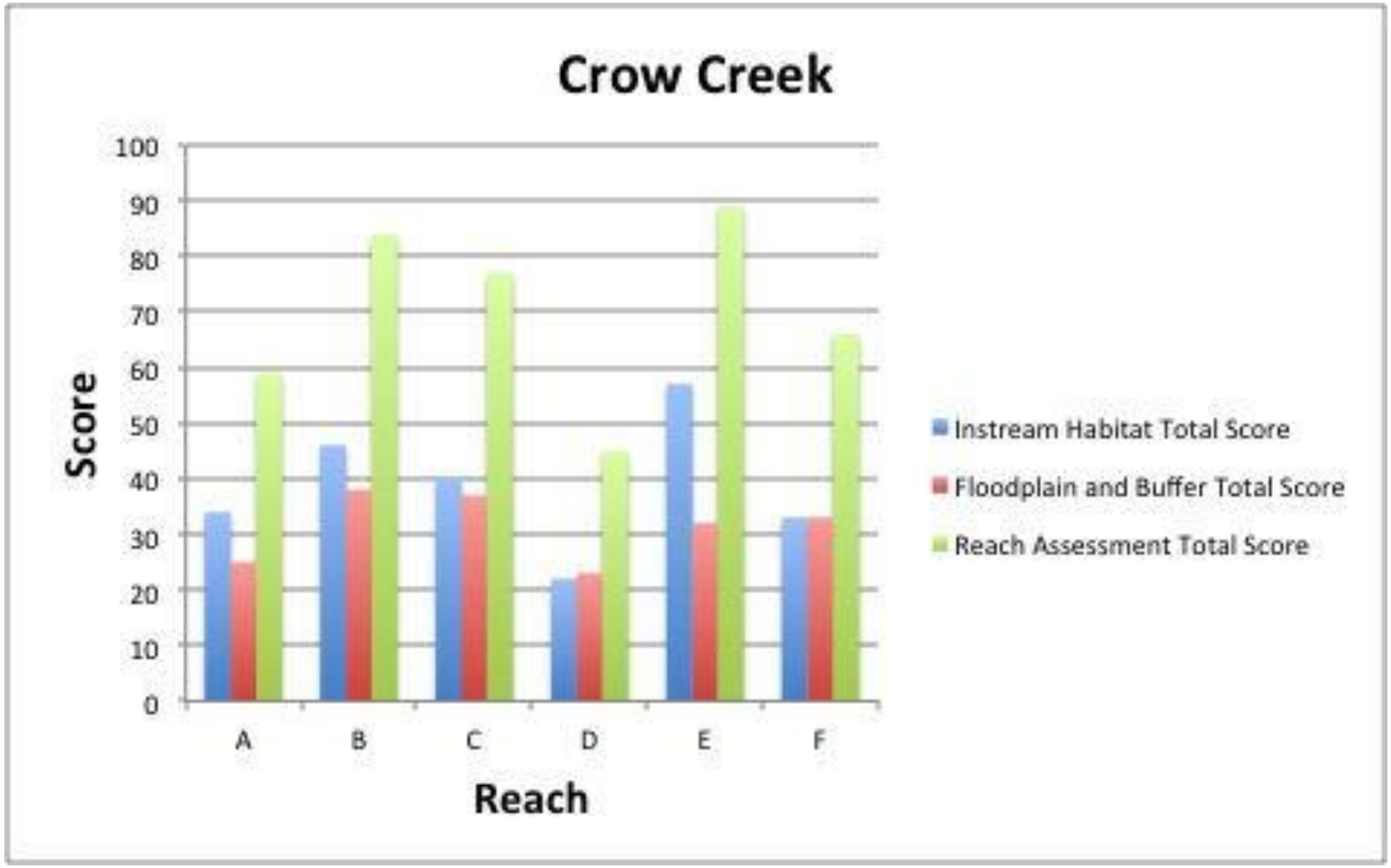

Figure 4-23. Summary of Unified Stream Assessment Scores for Crow Creek Reaches

Table 4-24. Summary of Impact Assessments, Crow Creek Reaches

Reach Number	**A**	**B**	**C**	**D**	**E**	**F**
Reach Length (ft)	1092	2334	1775	198	3820	2295
Outfalls						
Storm Drain Outfalls (8-24 inch dia)	0	1	3	0	3	5
Storm Drain Outfalls (>24 inch dia)	0	0	0	0	0	1
Other Outfalls (1-6 inch dia)	0	0	0	0	0	0
Total Outfalls	0	1	3	0	3	6
Total per mile	0	2	9	0	4	14
Total Outfalls with dry weather flow	0	0	2	0	1	2
Channel Modification						
Channelization	X	X	X		X	X
Bank Armoring	X	X	X		X	X
Hardened Bed					X	
Drop Structure						
Total Length Modified (ft)	303	110	143	0	787	363
Percent Reach Modified (%)	27.7	4.7	8.1	0	20.6	15.8
Erosion						
Downcutting						
Widening						
Slope Failure		X				
Aggrading						
Bank Erosion			X			X
Total Length (ft)	0	130	213	0	0	43
Percent Reach Eroded (%)	0	5.6	12	0	0	1.9
Stream Crossings						
Grade Control						
Fish Barrier (T-total; P-partial)						
Total Number of Crossings	3	0	2	0	5	1
Total Length Crossing (ft)	449	0	40	0	176	60
Percent Reach Crossing (%)	41.1	0	2.3	0	4.6	2.6
Trash						
Total Number of Trash Sites	0	0	0	0	0	0
Source: L-Litter; ID-Illegal Dumping; A-Accumulation	NA	NA	NA	NA	NA	NA
Recreation						
Total Number of Rec Sites	0	0	0	0	0	0
Access: Pub- Public; Pvt-Private	NA	NA	NA	NA	NA	NA
Swimming Potential: Hi; Med; Low	NA	NA	NA	NA	NA	NA

4.5.5 Sausal Creek

Stream survey assessment in Sausal Creek was conducted between September 23 and 24, in WY2013 with a total assessed reach length of 12,338 feet or 2.34 miles. Details of the surveyed reaches in Sausal Creek are provided in Figure 4-24 and Table 4-25. The creek is comprised of

natural channel. The average valley slope was determined to be 4.98%. The stream assessment scores are provided in Table 4-26 and illustrated in Figure 4-25. The highest stream assessment score (110) was observed in Reach Y. The lowest stream assessment score of 49 was observed in Reach I. The impact assessment summary for Crow Creek streams is provided in Table 4-27.

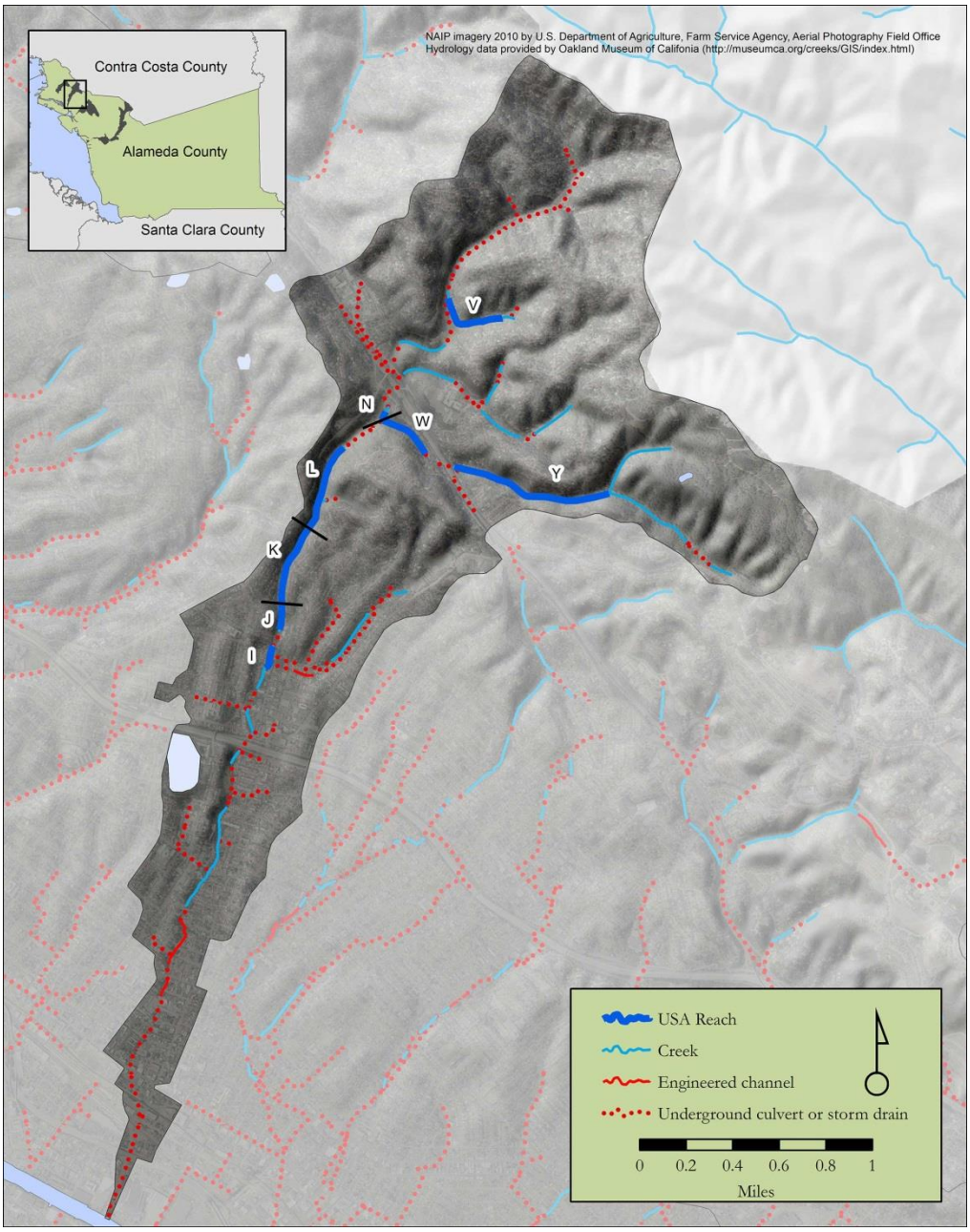

Figure 4-24. Sausal Creek Watershed and USA Reaches surveyed in WY 2012.

Table 4-25. Surveyed Reaches, Sausal Creek

Reach	Geographic Extent	Reach Length (ft)	Valley Slope (%)	General Characteristics
I	Southern end of Dimond Park to entrance to culvert at Rec Center	503	0.91%	Natural / partially open
J	Entrance to culvert at Dimond Park Rec Center to North side of El Cerrito Ave. crossing	730	3.67%	Natural
K	North side of El Cerrito Ave. crossing to under Leimert Ave bridge	1981	1.41%	Natural
L	Under Leimert Ave. bridge to culvert under driving range at Montclair Golf and Restaurant	2078	4.72%	Natural
N	Entrance of culvert under golf course to culvert under SR 13	200	5.20%	Natural
V	Entrance of culvert going under Shepherd Canyon Rd to end of creek, south of Escher Dr. and west of Bagshotte Dr.	1776	6.85%	Natural
W	Confluence at Sausal-N (at Montclair Golf and Restaurant) to culvert under SR 13	1260	7.30%	Natural
Y	East entrance of culvert under SR13 to confluence with Cinderella Creek (trail crossing at Sinawik cabin site)	3810	9.78%	Natural

Table 4-26. Reach Assessment Scores, Sausal Creek Reaches

Sausal Creek Reach	I	J	K	L	N	V	W	Y
Overall Stream Condition								
Instream Habitat	8	10	13	13	13	13	14	14
Vegetative Protection (LB)	4	2	7	8	8	8	7	8
Vegetative Protection (RB)	4	5	7	8	8	4	7	8
Bank Erosion (LB)	5	8	9	9	9	6	9	9
Bank Erosion (RB)	5	8	9	9	9	8	9	9
Floodplain Connection	8	8	8	8	8	7	8	7
Instream Habitat Total Score	34	41	53	55	55	46	54	55
Overall Buffer & Floodplain Condition								
Vegetative Buffer Width (LB)	1	1	6	8	7	9	8	9
Vegetative Buffer Width (RB)	1	1	6	8	7	2	8	9
Floodplain Vegetation	7	8	13	15	12	10	11	17
Floodplain Habitat	3	3	3	3	4	4	4	4
Floodplain Encroachment	3	3	10	15	6	10	8	16
Floodplain and Buffer Total Score	15	16	38	49	36	35	39	55
Reach Assessment Total Score	49	57	91	104	91	81	93	110

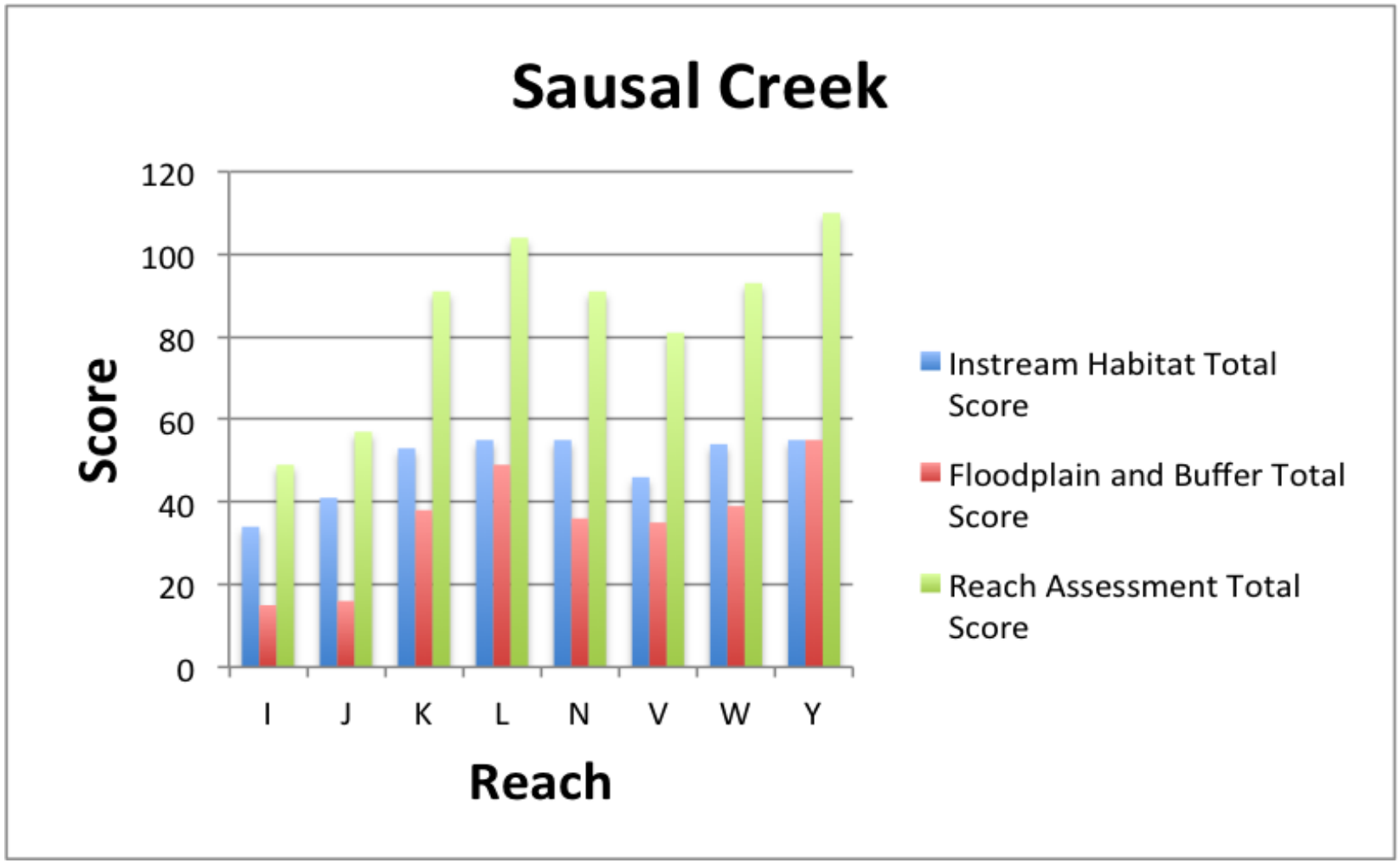

Figure 4-25. Summary of Unified Stream Assessment Scores for Sausal Creek Reaches

Table 4-27. Summary of Impact Assessments, Sausal Creek Reaches

Reach Number	**I**	**J**	**K**	**L**	**N**	**V**	**W**	**Y**
Reach Length (ft)	503	730	1981	2078	200	1776	1260	3810
Outfalls								
Storm Drain Outfalls (8-24 inch dia)	1	1	0	2	0	1	0	0
Storm Drain Outfalls (>24 inch dia)	0	0	0	0	0	0	0	1
Other Outfalls (1-6 inch dia)	0	0	0	0	0	1	0	1
Total Outfalls	1	1	0	2	0	2	0	2
Total per mile	11	7	0	5	0	6	0	3
Total Outfalls with dry weather flow	0	0	0	1	0	0	0	0
Channel Modification								
Channelization	X	X	X	X		X	X	
Bank Armoring	X	X	X	X		X	X	
Hardened Bed				X				
Drop Structure	X		X	X			X	X
Total Length Modified (ft)	73	155	350	1532	0	95	1	3
Percent Reach Modified (%)	14.5	21.2	17.7	73.7	0	5.3	0.1	0.1
Erosion								
Downcutting								
Widening								
Slope Failure								
Aggrading								
Bank Erosion								
Total Length (ft)	0	0	0	0	0	0	0	0
Percent Reach Eroded (%)	0	0	0	0	0	0	0	0
Stream Crossings								
Grade Control								
Fish Barrier (T-total; P-partial)								
Total Number of Crossings	0	1	1	0	0	2	2	0
Total Length Crossing (ft)	0	60	72	0	0	12	44	0
Percent Reach Crossing (%)	0	8.2	3.6	0	0	0.7	3.5	0
Trash								
Total Number of Trash Sites	0	0	0	0	0	0	0	0
Source: L-Litter; ID-Illegal Dumping; A-Accumulation	NA	NA	NA	NA	NA	NA	NA	NA
Recreation								
Total Number of Rec Sites	0	0	0	0	0	0	0	0
Access: Pub- Public; Pvt-Private	NA	NA	NA	NA	NA	NA	NA	NA
Swimming Potential: Hi; Med; Low	NA	NA	NA	NA	NA	NA	NA	NA

4.5.6 Arroyo Viejo

Stream survey assessment in Arroyo Viejo was conducted between October 3 through 9, in WY2013 with a total assessed reach length of 19,322 feet or 3.65miles. Details of the surveyed reaches in Arroyo Viejo are provided in Table 4-28. The creek is comprised of concrete and natural channel (Figure 4-26). The average valley slope was determined to be 1.93%. The stream

assessment scores are provided in Table 4-29 and illustrated in Figure 4-27. The highest stream assessment score (97) was observed in Reach R. The lowest stream assessment score of 20 was observed in Reaches B, C and D. The impact assessment summary for Arroyo Viejo is provided in Table 4-30.

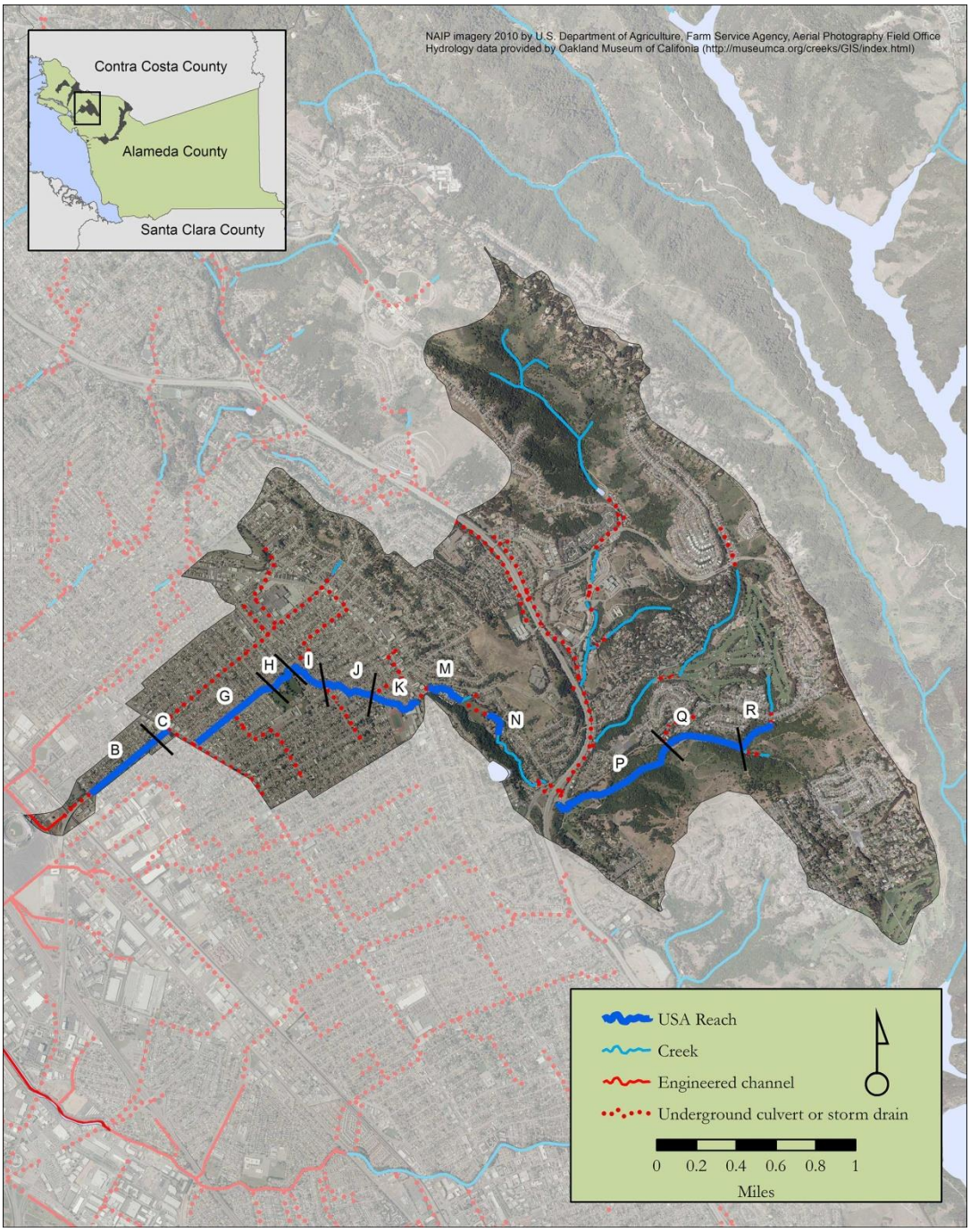

Figure 4-26. Arroyo Viejo Watershed and USA Reaches Surveyed in WY2013.

Table 4-28. Surveyed Reaches, Arroyo Viejo

Reach	Geographic Extent	Reach Length (ft)	Valley Slope (%)	General Characteristics
B	Entrance to culvert in middle of Hegenberger Blvd, even with 2 cut off ends of Hawley St. to start of culverted section under curve of Hegenberger Blvd	2,225	0.25%	Concrete
C	End of gated extension/driveway north from Rudsdale St. to start of culverted section at International Blvd.	376	0.47%	Concrete
G	Entrance to culvert above International Blvd. (E. 14th St) to Arroyo Viejo Park, near cut-off end of 78th Ave north of Arthur St.	2,508	0.41%	Concrete
H	Arroyo Viejo Park, near cut-off end of 78th Ave north of Arthur St. to start of engineered channel between end of Olive St. and intersection of Halliday & 77th Aves.	727	0.89%	Mostly Natural
I	Start of engineered channel between end of Olive St. and intersection of Halliday & 77th Aves. to above Bancroft Ave crossing	1073	1.42%	Concrete
J	Above Bancroft Ave crossing to Southeast of 82nd Ave crossing, opposite intersection Hillside St.	1417	0.05%	Concrete
K	Southeast of 82nd Ave crossing, opposite intersection Hillside St. to start of culverted section at MacArthur Blvd	1427	1.16%	Partially Natural
M	Entrance to culvert just north of EC Reems Court to start of culverted section between end of EC Reems Ct and Arroyo Viejo-N	1030	2.56%	Partially Natural
N	Entrance to culvert south of Golf Links Rd between Blandon &Glenly Rds to start of culverted section AVJ-O under I-580	735	1.10%	Natural
P	Entrance to culvert under Golf Links & I-580 west of Zoo entrance gate (reach crosses under driveway), to entrance to culvert north side of Golf Links Rd crossing east of Elysian Fields Dr.	4248	3.09%	Natural
Q	Entrance to culvert north side of Golf Links Rd crossing east of Elysian Fields Dr. to confluence of branch coming from north, into line along Golf Links Rd.	2487	4.25%	Natural
R	Confluence of branch coming from north, into line along Golf Links Rd. to last bend northward where channel crosses back lot line for 271 Elysian Fields Dr.	1,069	7.46%	Natural

Table 4-29. Reach Assessment Scores, Arroyo Viejo Reaches

Arroyo Viejo Reach	**B**	**C**	**G**	**H**	**I**	**J**	**K**	**M**	**N**	**P**	**Q**	**R**
Overall Stream Condition												
Instream Habitat	0	0	0	10	5	2	3	7	15	16	16	16
Vegetative Protection (LB)	0	0	0	3	1	1	1	2	9	6	8	8
Vegetative Protection (RB)	0	0	0	3	1	1	1	2	9	6	8	8
Bank Erosion (LB)	10	10	10	8	9	10	10	9	9	8	8	9
Bank Erosion (RB)	10	10	10	8	9	10	10	9	9	8	9	9
Floodplain Connection	0	0	0	5	2	1	0	1	4	3	4	4
Instream Habitat Total Score	20	20	20	37	27	25	25	30	55	47	53	54
Overall Buffer & Floodplain Condition												
Vegetative Buffer Width (LB)	0	0	0	1	0	0	0	1	4	6	1	9
Vegetative Buffer Width (RB)	0	0	0	1	0	0	0	1	4	6	8	7
Floodplain Vegetation	0	0	0	2	0	0	0	1	11	13	11	13
Floodplain Habitat	0	0	0	3	1	0	0	1	3	5	4	4
Floodplain Encroachment	0	0	0	3	1	0	0	1	5	9	10	10
Floodplain and Buffer Total Score	0	0	0	10	2	0	0	5	27	39	34	43
Reach Assessment Total Score	20	20	20	47	29	25	25	35	82	88	87	97

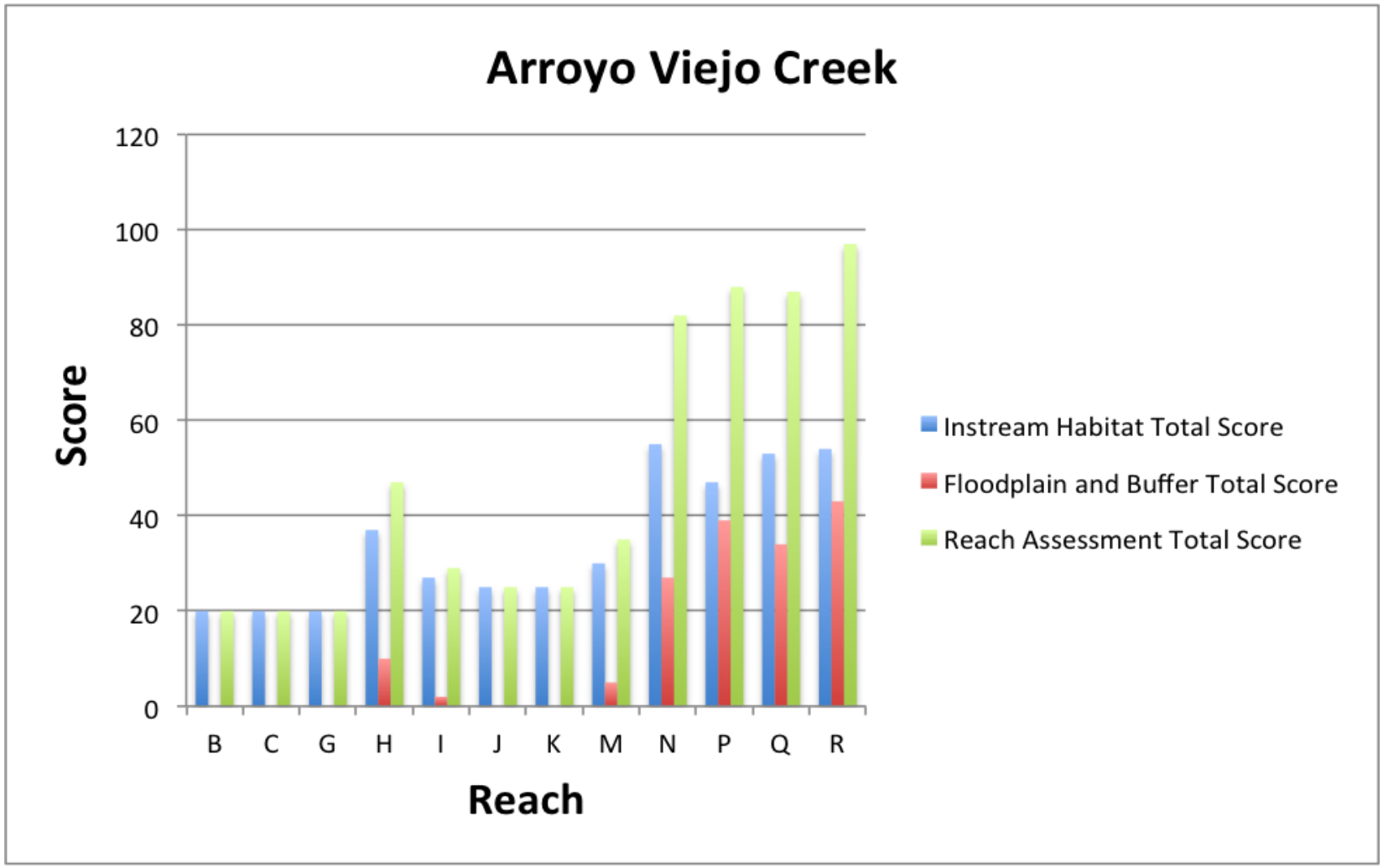

Figure 4-27. Summary of Unified Stream Assessment Scores for Arroyo Viejo Reaches

Table 4-30. Summary of Impact Assessments, Arroyo Viejo Reaches

Reach Number	**B**	**C**	**G**	**H**	**I**	**J**	**K**	**M**	**N**	**P**	**Q**	**R**
Reach Length (ft)	2225	376	2508	727	1073	1417	1427	1030	735	4248	2487	1069
Outfalls												
Storm Drain Outfalls (8-24 inch dia)	11	1	8	1	6	5	4	1	0	4	3	2
Storm Drain Outfalls (>24 inch dia)	0	0	1	0	1	1	0	0	0	0	0	0
Other Outfalls (1-6 inch dia)	0	1	1	0	1	1	0	0	0	1	0	1
Total Outfalls	11	2	10	1	8	7	4	1	0	5	3	3
Total per mile	26	28	21	7	39	26	15	5	0	6	6	15
Total Outfalls with dry weather flow	0	0	0	0	1	1	0	1	0	1	0	1
Channel Modification												
Channelization	X	X	X	X	X	X	X	X		X	X	X
Bank Armoring	X	X	X	X	X	X	X	X		X	X	X
Hardened Bed	X	X	X			X		X		X	X	X
Drop Structure								X			X	
Total Length Modified (ft)	2,225	376	2508	360	204	1417	1427	981	0	189	206	NR
Percent Reach Modified (%)	100	100	100	49.5	19	100	100	95.2	0	4.4	8.3	NR
Erosion												
Downcutting												
Widening												
Slope Failure												
Aggrading												
Bank Erosion												
Total Length (ft)	0	0	0	0	0	0	0	0	0	0	56	0
Percent Reach Eroded (%)	0	0	0	0	0	0	0	0	0	0	2.3	0
Stream Crossings												
Grade Control												
Fish Barrier (T-total; P-partial)												
Total Number of Crossings	3	0	5	2	1	1	0	4	1	4	0	0
Total Length Crossing (ft)	538	0	447	30	334	NR	0	125	270	197	0	0
Percent Reach Crossing (%)	24.2	0	17.8	4.1	31.1	NR	0	12.1	36.7	4.6	0	0

Reach Number	B	C	G	H	I	J	K	M	N	P	Q	R
Trash												
Total Number of Trash Sites	0	0	0	0	0	0	0	0	0	0	0	0
Source: L-Litter; ID-Illegal Dumping; A-Accumulation	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Recreation												
Total Number of Rec Sites	0	0	0	0	0	0	0	0	0	1	0	0
Access: Pub- Public; Pvt-Private	NA	NA	NA	NA	NA	NA	NA	NA	NA	Pub	NA	NA
Swimming Potential: Hi; Med; Low	NA	NA	NA	NA	NA	NA	NA	NA	NA	Low	NA	NA

4.5.7 Glen Echo Creek

Stream survey assessment in Glen Echo Creek was conducted between September 24 and October 8, in WY2013 with a total assessed reach length of 1853 feet or 0.35 miles. Details of the surveyed reaches in Glen Echo Creek are provided in Table 4-31. The creek is comprised of mostly natural channel. The average valley slope was determined to be 2.01%. The stream assessment scores are provided in Table 4-32 and illustrated in Figure 4-29. The highest stream assessment score (59) was observed in Reach F. The lowest stream assessment score of 45 was observed in Reach L. The impact assessment summary for Glen Echo Creek is provided in Table 4-33.

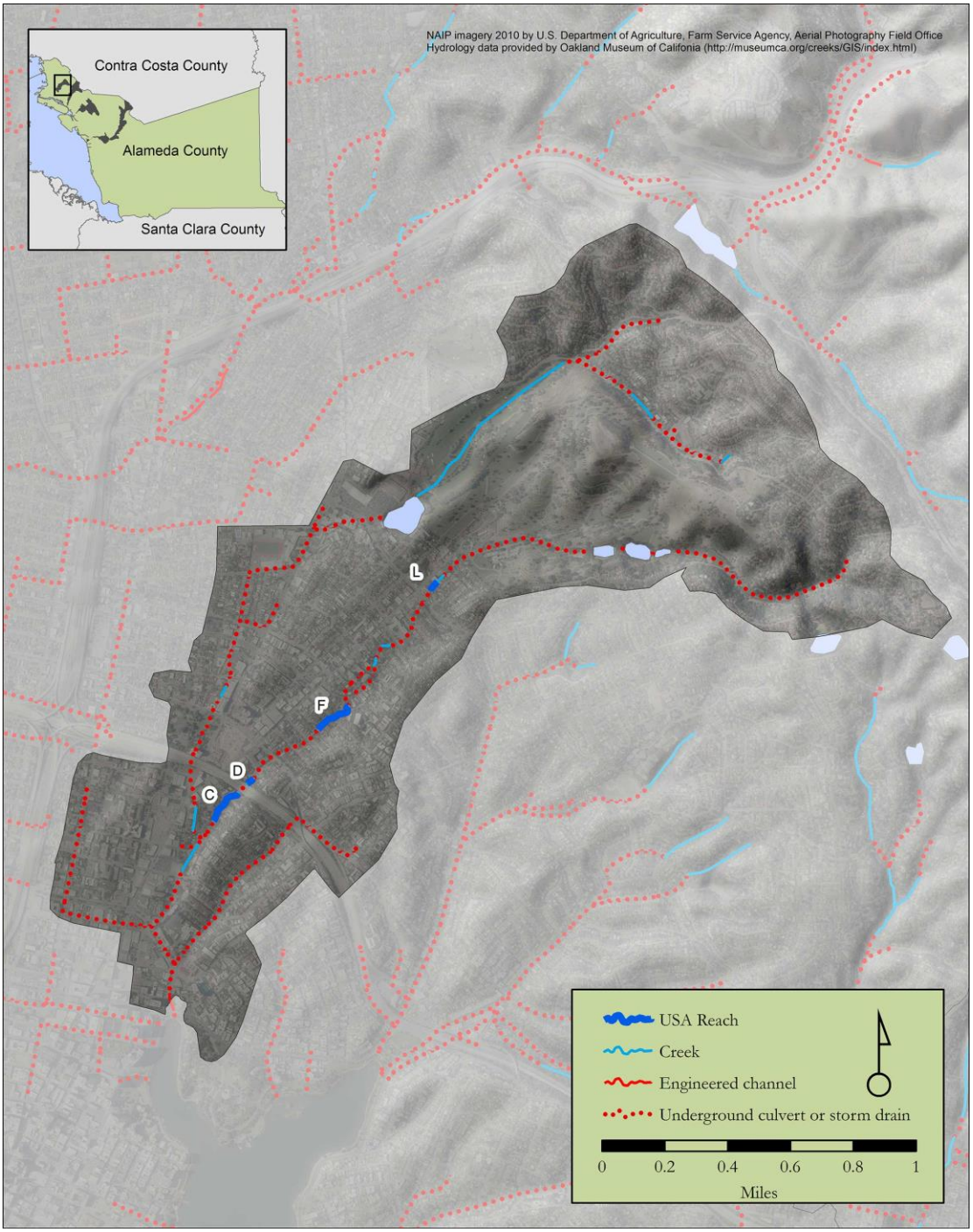

Figure 4-28. Glen Echo Creek Watershed and USA Reaches Surveyed in WY2013.

Table 4-31. Surveyed Reaches, Glen Echo Creek

Reach	Geographic Extent	Reach Length (ft)	Valley Slope (%)	General Characteristics
C	Start of section between 2 halves of Richmond Blvd, between Randwick Ave. &Frisbie St., to start of open section north of 580 freeway overpass	710	1.93%	Mostly Natural
D	Start of open section north of 580 freeway overpass to culvert SE of Richmond Blvd.	148	1.92%	Mostly Natural
F	Start of open section north of Montell St. to culvert south of Glen Ave.	625	1.63%	Mostly Natural
L	Behind 4417 or 4431 Pleasant Valley Court to behind 4466 Piedmont Ave.	370	2.57%	Partially Natural

Table 4-32. Reach Assessment Scores, Glen Echo Creek Reaches

Glen Echo Creek Reach	C	D	F	L
Overall Stream Condition				
Instream Habitat	7	6	6	11
Vegetative Protection (LB)	3	3	6	4
Vegetative Protection (RB)	3	3	6	4
Bank Erosion (LB)	5	8	8	9
Bank Erosion (RB)	5	8	8	9
Floodplain Connection	7	7	7	2
Instream Habitat Total Score	30	35	41	39
Overall Buffer & Floodplain Condition				
Vegetative Buffer Width (LB)	4	4	3	0
Vegetative Buffer Width (RB)	4	4	3	0
Floodplain Vegetation	6	6	6	2
Floodplain Habitat	4	4	4	2
Floodplain Encroachment	2	1	2	2
Floodplain and Buffer Total Score	20	19	18	6
Reach Assessment Total Score	50	54	59	45

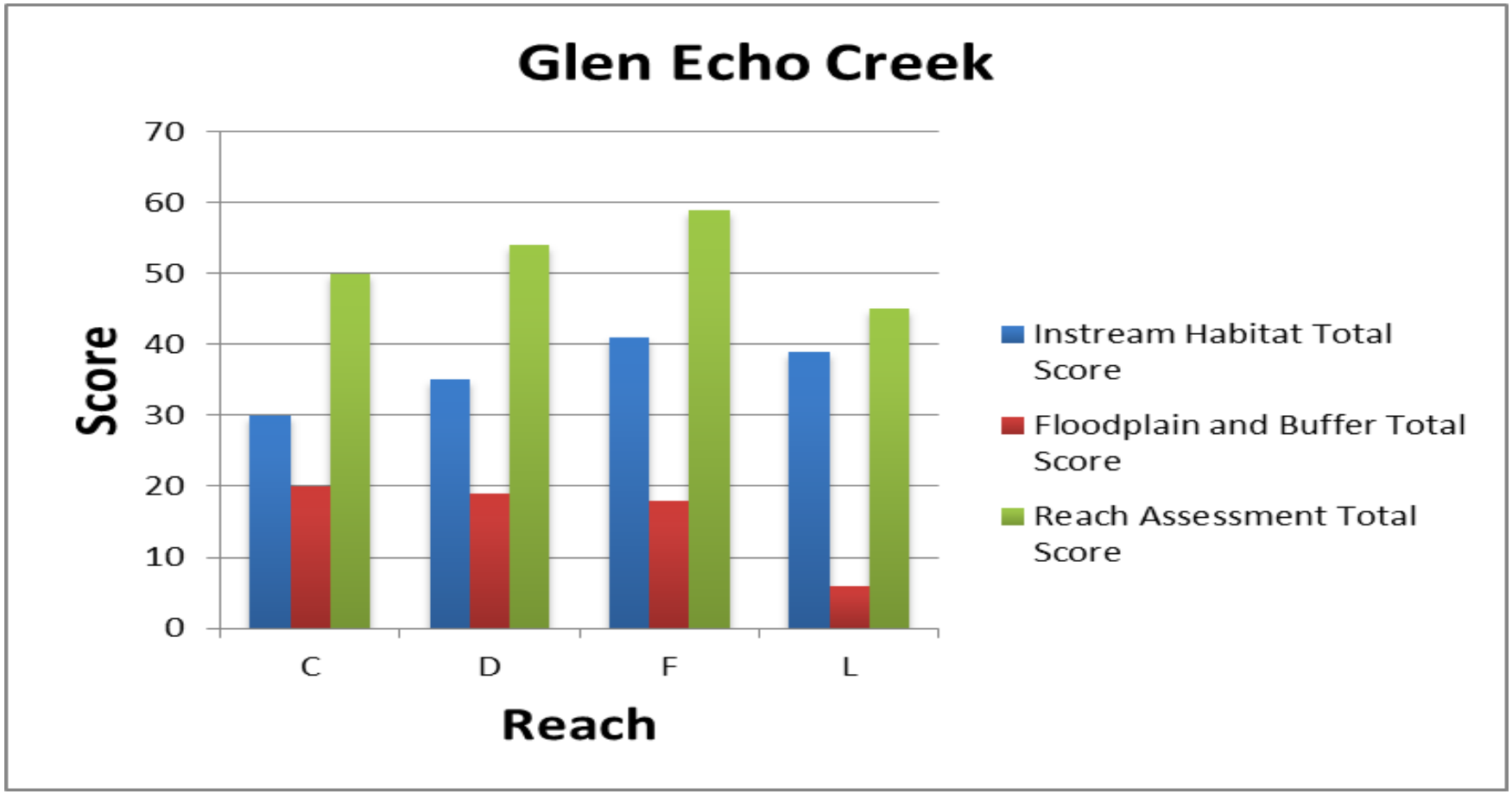

Figure 4-29. Summary of Unified Stream Assessment Scores for Glen Echo Creek Reaches

Table 4-33. Summary of Impact Assessments, Glen Echo Creek Reaches

Reach Number	**C**	**D**	**F**	**L**
Reach Length (ft)	710	148	625	370
Outfalls				
Storm Drain Outfalls (8-24 inch dia)	4	0	3	1
Storm Drain Outfalls (>24 inch dia)	0	0	0	0
Other Outfalls (1-6 inch dia)	0	0	0	5
Total Outfalls	4	0	3	6
Total per mile	30	0	25	86
Total Outfalls with dry weather flow	0	0	0	0
Channel Modification				
Channelization	X	X	X	X
Bank Armoring	X	X	X	X
Hardened Bed				
Drop Structure				
Total Length Modified (ft)	88	28	454	218
Percent Reach Modified (%)	12.4	18.9	72.6	59.0
Erosion				
Downcutting				
Widening				
Slope Failure				
Aggrading				
Bank Erosion				
Total Length (ft)	0	0	0	0
Percent Reach Eroded (%)	0	0	0	0
Stream Crossings				
Grade Control				
Fish Barrier (T-total; P-partial)				
Total Number of Crossings	1	0	3	0
Total Length Crossing (ft)	14	0	103	0
Percent Reach Crossing (%)	2.0	0	16.5	0
Trash				
Total Number of Trash Sites	0	0	0	0
Source: L-Litter; ID-Illegal Dumping; A-Accumulation	NA	NA	NA	NA
Recreation				
Total Number of Rec Sites	0	0	0	0
Access: Pub- Public; Pvt-Private	NA	NA	NA	NA
Swimming Potential: Hi; Med; Low	NA	NA	NA	NA

4.5.8 Reach Assessment Summary

The overall reach assessment scores (including both WY2012 and WY2013) ranged from 20 to 110. Sausal Creek had the highest average score of 85, with a more complex instream habitat, vegetated banks and less floodplain encroachment. Crow Creek had the second highest average

score of 70, with the most natural creek mileage and more optimal instream habitat. San Lorenzo Creek was distinctive in that the lower reaches had a low average score (31) while the upper reaches had higher scores (average of 65). Chabot Creek also had a low average score of 46 with poor instream habitat complexity, sparse vegetation and deeply entrenched streams.

4.5.9 Impact Assessment Summary

The following impacts were noted during the stream surveys:

Outfalls: The largest number of outfalls per mile occurred in Glen Echo Creek (approximately 35 per mile), while Sausal Creek had the fewest number of outfalls per mile at only four per mile. The majority of outfalls were classified as storm drains. The majority of outfalls (over 90%) had no dry weather flow, and the remaining outfalls had very low or moderate flow. No discharge of odor or oily substances was observed, however an outfall in Crow Creek Reach F was observed to be releasing a rust-like discharge into the stream during WY2013 monitoring.

Channel modification: All lower reaches (A-I) in San Lorenzo Creek were 100% modified, and comprised concrete channels. In Arroyo Viejo 56% of the creek had channel modification. In the Castro Valley Creek just over 50% of reaches were modified primarily by concrete retaining walls and check dams. The Chabot Creek reaches were over 60% modified, primarily by bank hardening and one weir. The less urbanized Crow Creek had the least amount of channel modification (approx. 13%). Most of the channel modifications were to banks. However concrete channel beds, check dams, and instream trash grates and bollards were also observed. The bank armoring materials typically used were concrete, sandbags and gabion material.

Erosion: A minimal amount of bank erosion / bank failure was found in the reaches surveyed. The observed bank erosion was likely from historical channel incision that resulted in steeper channel gradients and steeper bank slopes, as well as storm damage to banks that were sparsely vegetated. Only Arroyo Viejo and Crow Creek had any notable erosion occurring. In Crow Creek Reach B, one instance of slope failure was observed and the issue was communicated to Alameda County Flood Control Water Conservation District (ACFCWCD) personnel for evaluation.

Stream Crossings: Castro Valley Creek had the greatest total length of stream crossings, followed by San Lorenzo Creek, and then Chabot Creek. Glen Echo Creek had the lowest total length of stream crossings. Most stream crossings were vehicle overpasses, footbridges, or driveways. None of the stream crossings encountered was fish barriers or performed grade control.

Trash: There was little accumulated trash observed during the WY2012 surveys and none observed in WY2013. The only notable trash found was in San Lorenzo Creek in reaches B, E,

and I. The types of trash found included diapers, chemical bottles, spray cans, and large electronics.

Recreation: Multiple recreation sites with creek access were observed during WY2013 surveys. Some recreation sites were public, such as a worn footpath found leading down to Sausal Creek Reach J from a nearby playground. Private recreation access was found in San Lorenzo Creek Reach N and Arroyo Viejo Reach P. These creek reaches flowed behind private property, where homeowners had built access stairs from their homes down to the creek.

The only recreational sites observed in WY2012 were in Reach A of Castro Valley Creek and Reach A of Chabot Creek. Both of these sites have little flow in the summer, making the creeks less likely to experience heavy swimming pressure. No recreational sites were observed in San Lorenzo Creek.

Utilities: Both Castro Valley Creek and Chabot Creek had 13 utility impacts observed in the surveyed reaches, while San Lorenzo Creek only had one observed utility. All impacts were utility pipes with the exception of an Alameda County gaging station in Reach E of Chabot Creek. None of the utility pipes had any observed discharge or were fish barriers.

Miscellaneous: Arroyo Viejo had the most miscellaneous impacts observed (ten), and Glen Echo Creek had the fewest observed (one). Both San Lorenzo Creek and Chabot creek had five miscellaneous impacts observed in the surveyed reaches, and Castro Valley Creek had six impacts. Some of the impacts were safety concerns, such as a downed / abandoned electrical line in Reach B of Chabot Creek and a broken access ladder in Reach C of San Lorenzo Creek.

Other impacts of note included Arroyo Viejo Reach M where algal growth on the cement retaining wall was noted, coming from an unknown flow source above the retaining wall. Arroyo Viejo Reach M also had a dammed pool, caused by a fallen tree that was blocking downstream flow from the pool to the stream. A notable amount of suds were present in the pool, continually circulating and collecting due to the tree fall. These issues were communicated to ACFCWCD personnel for evaluation. The remaining miscellaneous impacts were not of immediate concern or restoration candidates.

5 Stressor Assessment

This section is a preliminary review of targeted monitoring data to identify samples with results that meet the "trigger" conditions for potential further investigation according to Table 8.1 of the MRP (see Table 5-1).

Table 5-1.Description of Triggers for Creek Status Targeted Parameters.

Monitoring Parameter	Trigger Description Per MRP Table 8.1
General Water Quality	20% of results in one water body exceed one or more water quality standards or established thresholds: • Dissolved Oxygen for WARM is 5.0 mg/l: 3-month median for DO shall not be less than 80 percent of the DO content at saturation. • Dissolved Oxygen Coldwater Beneficial Use: 7.0 mg/l • Water Temperature Warmwater Beneficial Use: see below • Water Temperature Coldwater Beneficial Use: see below • Conductivity: NA • pH: > 6.5 and <8.5; and controllable water quality factors shall not cause changes greater than 0.5 units in normal ambient pH levels.
Temperature	20% of results in one water body exceed applicable temperature thresholds: • The temperature of any cold or warm freshwater habitat shall not be increased by more than 5°F (2.8°C) above natural receiving water temperature; for designated COLD reaches, the maximum 7-day mean temperature should not exceed 26°C and should not exhibit spikes with no obvious natural explanation observed.
Pathogen Indicators	Fecal coliform: SFRWQCB (2011) Table 3.1 not applicable [7]. *E. coli:* SFRWQCB (2011) Table 3.2 for Water Contact Recreation in fresh water[8] Steady State: 126 colonies per 100 ml Moderately used area:< 298 colonies per 100 ml Lightly used area:< 406 colonies per 100 ml Infrequently used area:< 576 colonies per 100 ml (USEPA 1986)
Stream Survey	NA

[7] Water Quality Objectives listed in Table 3.1 of the Basin Plan for fecal coliform are based on five consecutive samples that are collected over an equally spaced 30-day period, which do not correspond to the sampling frequency in the MRP. The WQOs for Water Contact Recreation include concentrations for the calculated geometric mean (< 200 MPN/100ml) and the 90th percentile (< 400 MPN/100ml).

[8] Water Quality Objectives listed in Table 3.1 of the Basin Plan for *E. coli* are maximum values to "provide for a level of production based on the frequency of usage of a given water contact recreation area. For this reason the maximum criterion for "designated beach" and "Steady State" are not applicable to the creeks monitored.

5.1 Continuous Temperature

Continuous temperature 7-day averages were compared to two criteria established by USEPA (Brungs and Jones, 1977) for juvenile rainbow trout (*Onchorhynchus mykiss*)[9]:

- Maximum weekly average temperature (MWAT) for juvenile growth - 19°C
- Maximum short-term temperature for juvenile survival - 24°C

While the above thresholds were derived mainly from laboratory studies, they are reasonable in light of habitat characteristics for similar Bay Area salmonid populations (Leidy et al., 2005)[10]. No temperature triggers were observed during ACCWP monitoring in WY2012 or WY2013. The close matching of diurnal temperature changes from upstream to downstream locations indicates that runoff inputs were not causing significant elevation of ambient stream temperatures.

5.2 General Water Quality

Water quality triggers were compared against the results obtained during general water quality monitoring. A summary of the weekly 7-day rolling averages meeting trigger criteria is presented in Table 5-2. It can be seen that the only triggers observed in either monitoring year were for DO. A number of sites were found to be below the respective criterion DO concentrations for COLD and in some cases WARM beneficial uses. Low DO concentrations may have a detrimental impact on aquatic life.

[9] This species, in either the anadromous (steelhead) or resident (rainbow trout) form, is the only salmonid species that naturally occurs in the San Lorenzo and Sausal watersheds.

[10]Sullivan et al. (2000) is referenced in Table 8.1 of the MRP as a potential source for applicable thresholds to use for evaluating water temperature data for creeks that have salmonid fish communities, and illustrates the risk-based approach to evaluating temperature effects on salmonid communities in terms of relative reductions in growth at temperatures other than optimum. However, that study established its MWAT thresholds using data from salmonid populations in the Pacific Northwest and is likely overly conservative for steelhead in central California. Since fish growth is a function of both temperature and available food, optimum temperature and the incremental effect of temperature shifts on growth are ration-dependent and affected by other ecosystem factors, (for example see reviews in Myrick and Cech, 2001 and Atkinson et al., 2011). Streams in the Bay Area and Central California in general tend to be higher-nutrient systems than the glacially-derived geology of the Pacific Northwest, and can thus deliver the larger food supplies to support salmonid growth at warmer temperatures.

Table 5-2. Weekly 7-Day Rolling Averages Meeting Trigger Criteria for Sampling Locations Monitored in WY2012 and WY2013

		Trigger criterion and percentage reached				
Site ID	**Monitoring Season**	**Temperature > 19°C**	**pH < 6.5**	**pH > 8.5**	**DO < 5mg/L (WARM)**	**DO < 7mg/L (COLD)**
204CRW030	May/June 2012	0.0%	0.0%	0.0%	0.0%	0.0%
204CRW030	September 2012	0.0%	0.0%	0.0%	0.0%	**67.7%**
204CVY005	June 2012	0.0%	0.0%	0.0%	0.0%	0.0%
204CVY005	September 2012	0.0%	0.0%	0.0%	0.0%	0.0%
204SLO065	June 2012	0.0%	0.0%	0.0%	0.0%	0.0%
204SLO065	September 2012	0.0%	0.0%	0.0%	0.0%	0.0%
204AVJ080	April 2013	0.0%	0.0%	0.0%	0.0%	0.0%
204AVJ080	September 2013	0.0%	0.0%	0.0%	**100.0%**	**100.0%**
204AVJ130	April 2013	0.0%	0.0%	0.0%	0.0%	**20.0%**
204LIO080	June 2013	0.0%	0.0%	0.0%	0.0%	**16.7%**
204LIO080	September 2013	0.0%	0.0%	0.0%	**100.0%**	**100.0%**
204LIO050	September 2013	0.0%	0.0%	0.0%	0.0%	0.0%

BOLD: percentage of rolling averages meeting trigger criteria, if above zero.

5.3 Pathogen Indicators

Table 5-1 presents the United States Environmental Protection Agency (USEPA) criteria for ambient water quality bacteria concentrations as stipulated in Provision C.8 of the MRP. The Basin Plan includes two water quality standards that could potentially be used for comparison in determining triggers.

Table 3.1 of the Basin Plan references a USEPA assessment of public health risk that assumes multiple sampling at recreational bathing beaches and derives a statistical probability of illness from those assumptions. Under the provisions of the MRP, permittees collect single samples, once at each sampling location within that Water Year. As such, the monitoring frequency stipulated within the MRP is not consistent with the sampling requirements of the USEPA WQOs in Table 3, although it is the only comparison offered for fecal coliform bacteria, which may be derived from a wide range of sources and may not be indicative of pathogen risks to human health.

Table 3.2 of the Basin Plan references an alternative USEPA standard that is applicable for single samples of *E. coli* or the enterococci group, which are considered better predictors of human illness. Actual water contact by creek visitors is likely rare to sporadic at many of the sites sampled and does not correspond to the assumptions for human health risk assessment that were used to develop the water quality standard in Table 3.2 of the Basin Plan, which were based

on studies of users at bathing beaches that received direct bacteriological contamination from treated human wastewater. These criteria are, however, associated with presumptive recreational uses and so are used as benchmarks to define trigger criteria as required in the MRP; although the results of the monitoring are not an accurate indication of the risk to public health they may be used to derive coarse assessments of potential fecal pollution sources in watersheds.

Table 5-3 presents the results of the pathogen indicator enumeration with comparison against the USEPA criteria in Table 3.2 of the Basin Plan. All sites were found to have bacterial concentrations above the recommended thresholds for lightly and moderately used recreational areas. It should be noted that recreational usage, as defined by the EPA, cannot be directly reflected in appropriate usage within the sampled creeks. As a typical example, Castro Valley Creek is designated for both contact (REC-1) and non-contact (REC-2) recreation, although much of the creek system is inaccessible to the public. Two of the monitoring locations (204CVY020 and 204CVY120) do provide public access through parks and trails but there is little option for immersive swimming or contact recreation. Therefore actual recreational contact in this small creek is extremely limited and is not encouraged. Site 204CVY150, if assessed as an infrequently used site, would not be meet the trigger criterion for *E. coli*.

Of note was Site 204CVY140, where greater than or equal to 16,000MPN/100mL of both fecal coliforms and *E. coli* were found. Due to the July sampling date it is relatively unlikely that storm drain discharges were a significant contributor to the observed bacterial levels.

Table 5-3: Comparison of WY2012 Pathogen Indicator Concentrations to Water Quality Objectives and Triggers. BOLD font indicates result meets trigger conditions.

Site ID	Site Name	Creek Name	Fecal Coliform:	*E. coli**
204CVY020	Chabot Creek at Carlos Bee Park	Chabot Creek	**900**	**900**
204CVY080	Castro Valley Creek above confluence with Chabot Creek	Castro Valley Creek	**900**	**900**
204CVY120	CV Creek Park at Castro Valley Library	Castro Valley Creek	**1,700**	**1,700**
204CVY140	Castro Valley Creek North side of Berdina Rd	Castro Valley Creek	**>/= 16,000**	**>/= 16,000**
204CVY150	Castro Valley Creek North side of Heyer Ave	Castro Valley Creek	**500**	500**

*based on USEPA criteria
** only meets trigger criteria for moderately or lightly used.

In WY2013, fecal indicator bacteria concentrations were found to be elevated above trigger criteria (moderately used 400MPN/100mL) at a number of sites:

- 204TEM100 had concentrations of 3,000MPN/100mL
- 204LIO050 had concentrations of 700MPN/100mL
- 204AVJ080 had concentrations of 500MPN/100mL

Table 5-4: Comparison of WY2013 Pathogen Indicator Concentrations to Water Quality Objectives and Triggers. BOLD font indicates result meets trigger conditions.

Site ID	Site Description	Creek Name	Fecal Coliform (MPN*/100mL)	*E. coli* (MPN*/100 mL)
204AVJ080	Along Golf Links Dr. just west of I-580	Arroyo Viejo	**500**	**500**
204LIO050	Chimes Creek at Mills	Lion Creek	**700**	**700**
204LIO070	Lion Creek near Wetmore Ave bridge	Lion Creek	230	230
204SAU090	Below Leimert Ave. bridge	Sausal Creek	8	8
204TEM100	Near Broadway Terrace and Duncan	Temescal Creek	**3,000**	**3,000**

*Most Probable Number

6 Next Steps

All sites identified in Section 5 and Table 5-3 as meeting trigger conditions will be reviewed by RMC programs to determine follow-up actions pursuant to MRP Provision C.8.d.i, Stressor/Source Identification (SSID). ACCWP initiated three SSID projects developed through the RMC selection process in FY2013-14, which together with those proposed by other RMC participants comprised the regional collaborative limit of 10 projects for the permit term as stipulated in provision C.8.d.i(5) of the MRP. Where triggers or potential trigger conditions have been identified in WY2012 and WY2013 results, ACCWP will also work with local stormwater managers to identify appropriate follow-up activities, which may either be incorporated in WY 2014 Creek Status Monitoring or be conducted outside the scope of MRP C.8.c.

7 References

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8 Attachments

Attachment A San Lorenzo Creek - USA Surveyed Reaches 2012 and 2013

Attachment B Castro Valley Creek - USA Surveyed Reaches 2012

Attachment C Chabot Creek - USA Surveyed Reaches 2012

Attachment D Crow Creek - USA Surveyed Reaches 2013

Attachment E Sausal Creek - USA Surveyed Reaches 2013

Attachment F Arroyo Viejo - USA Surveyed Reaches 2013

Attachment G Glen Echo Creek - USA Surveyed Reaches 2013

Attachment A. San Lorenzo Creek - USA Surveyed Reaches 2012 and 2013

Figure A-1. San Lorenzo Creek Reaches A and B

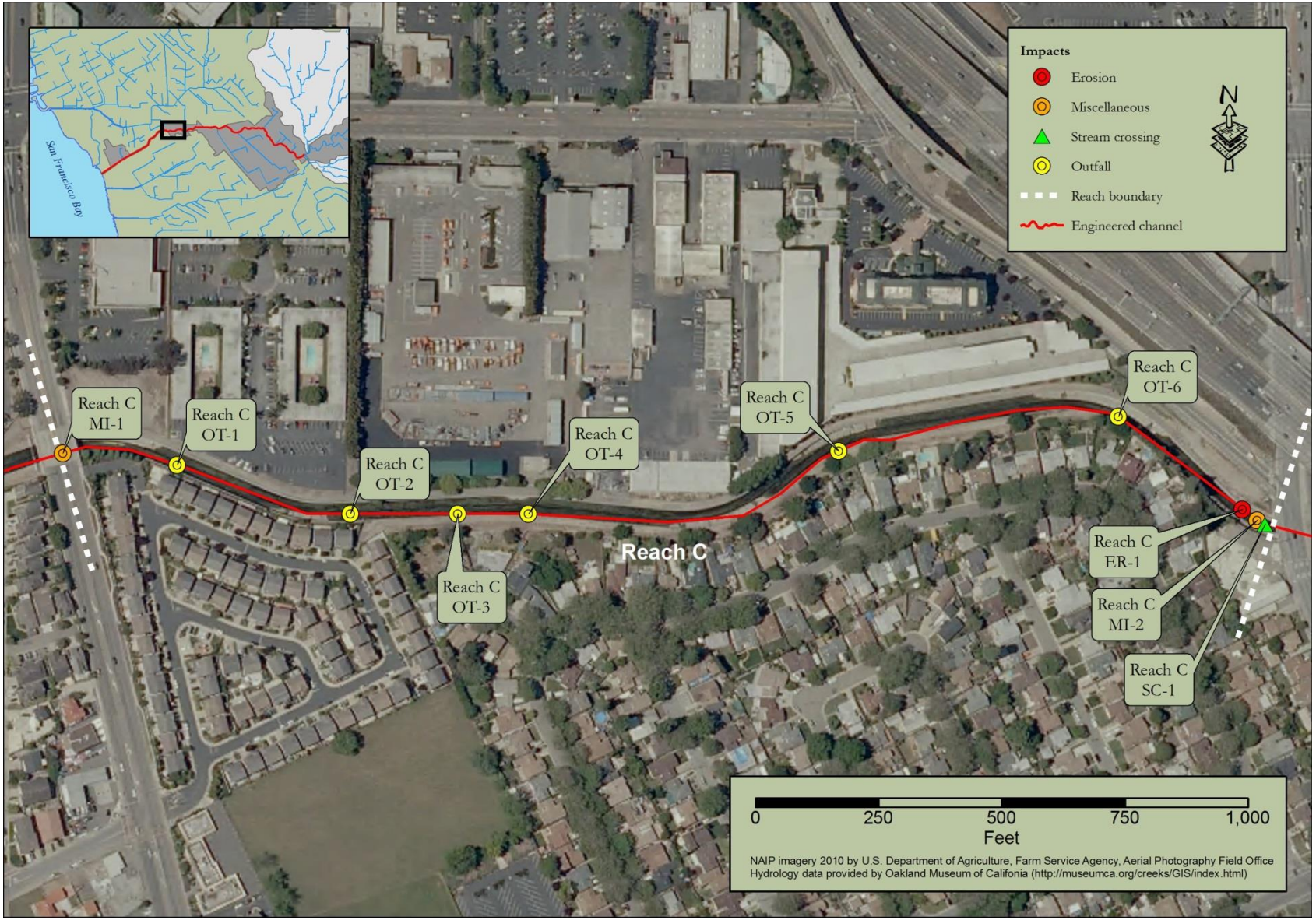


Figure A-2. San Lorenzo Creek Reach C

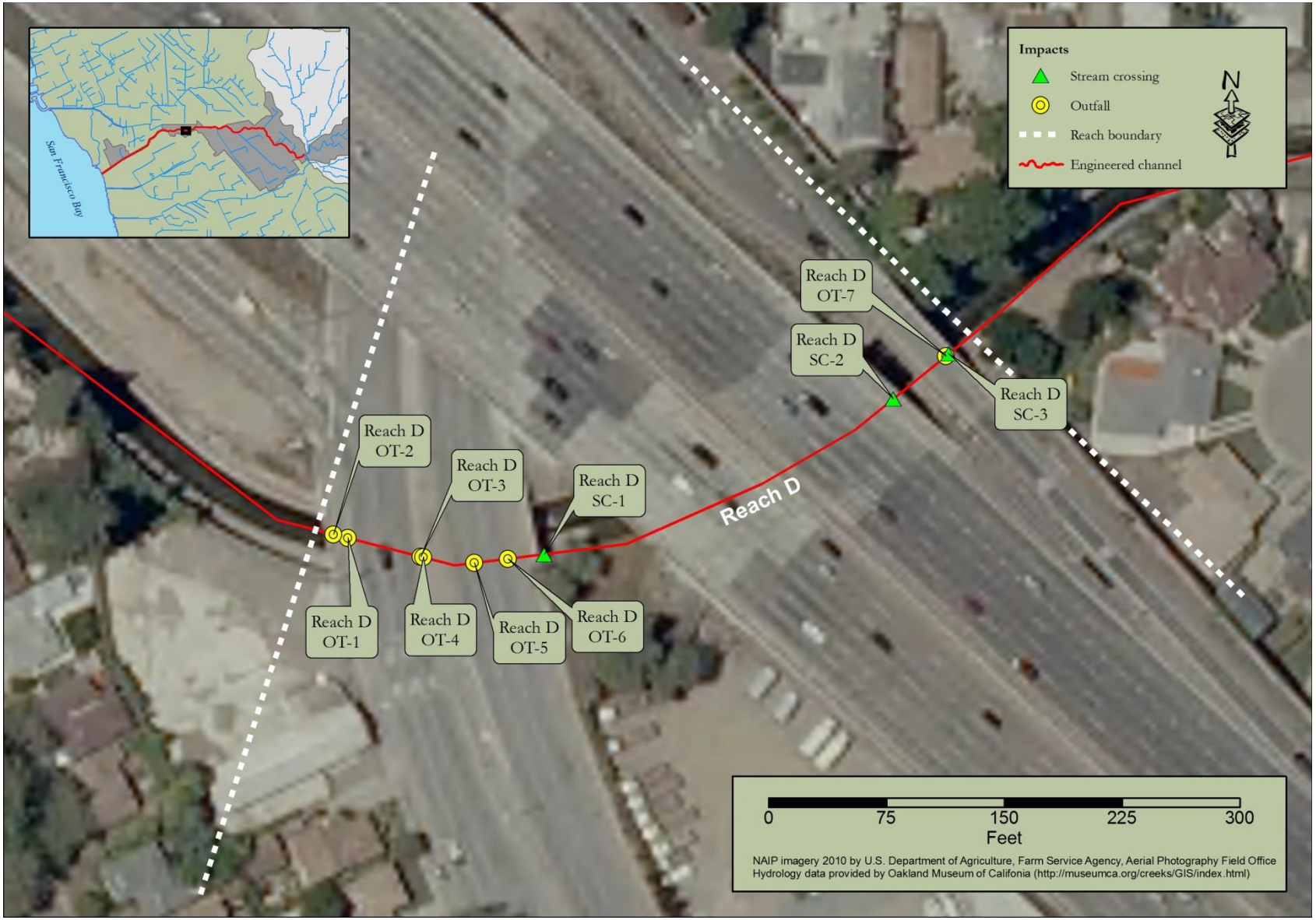


Figure A-3. San Lorenzo Creek Reach D

Figure A-4. San Lorenzo Creek Reach E

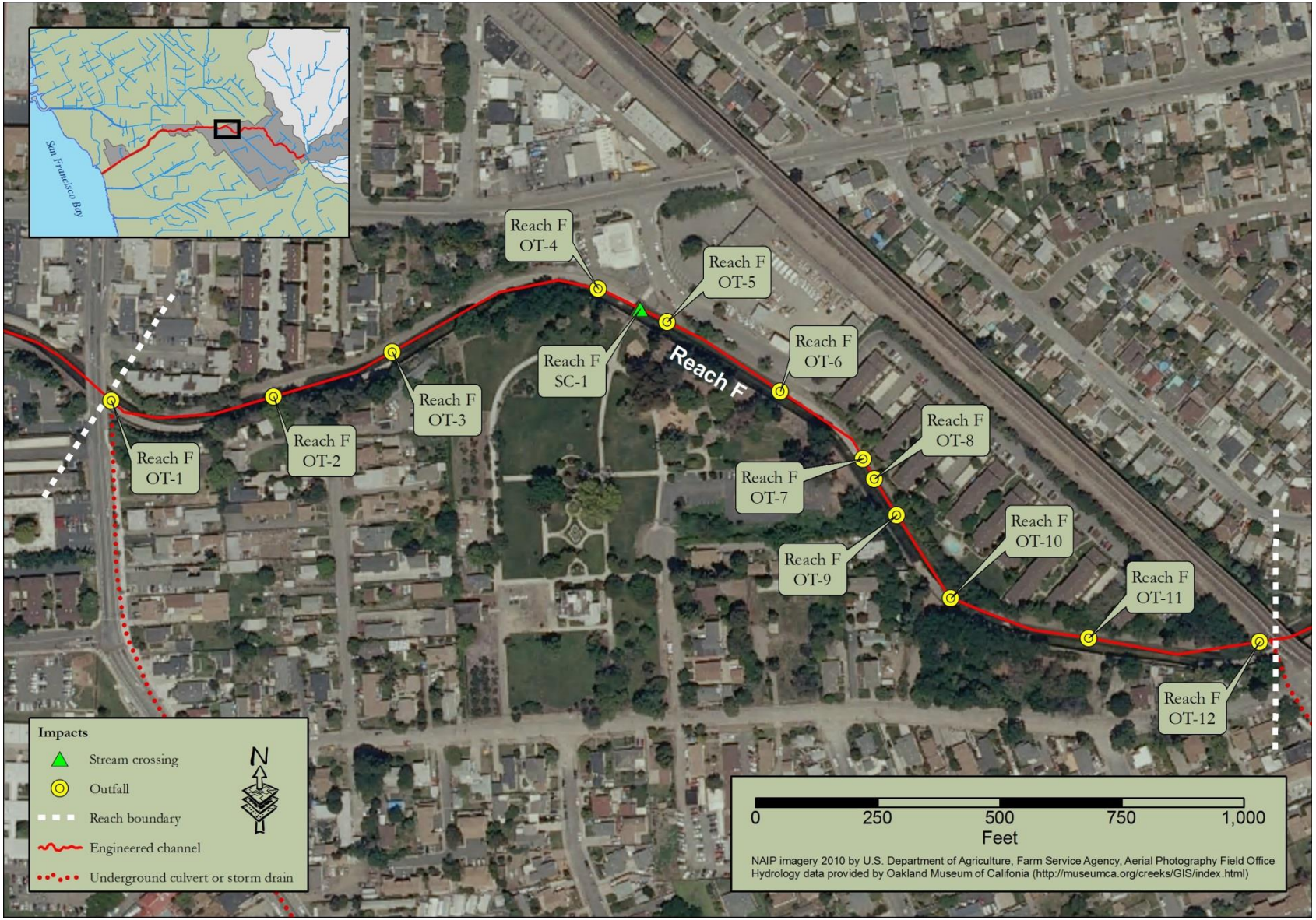


Figure A-5. San Lorenzo Creek Reach F

Figure A-6. San Lorenzo Creek Reach G

Figure A-7. San Lorenzo Creek Reach H

Figure A-8. San Lorenzo Creek Reach I

Figure A-9. San Lorenzo Creek Reach L

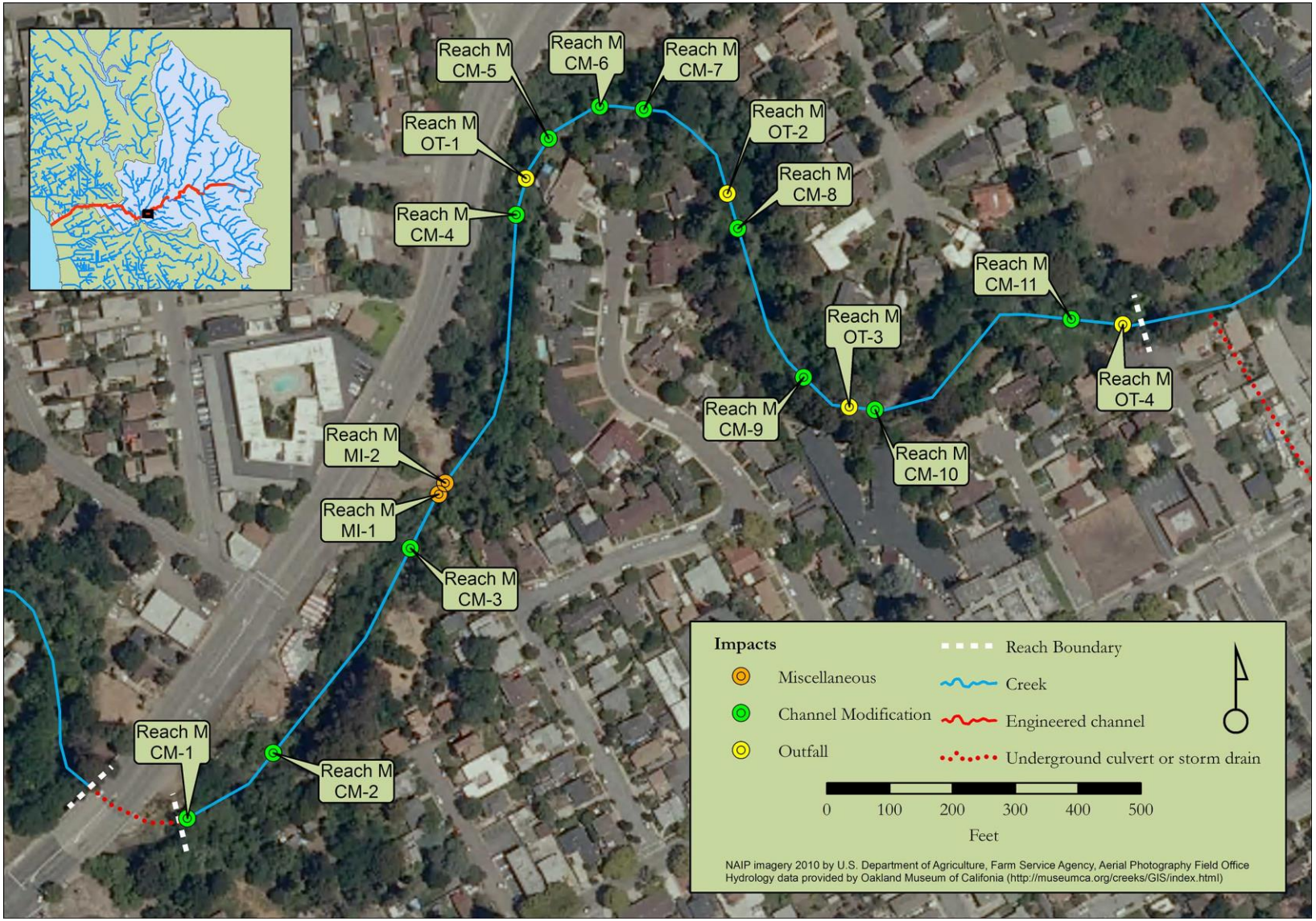
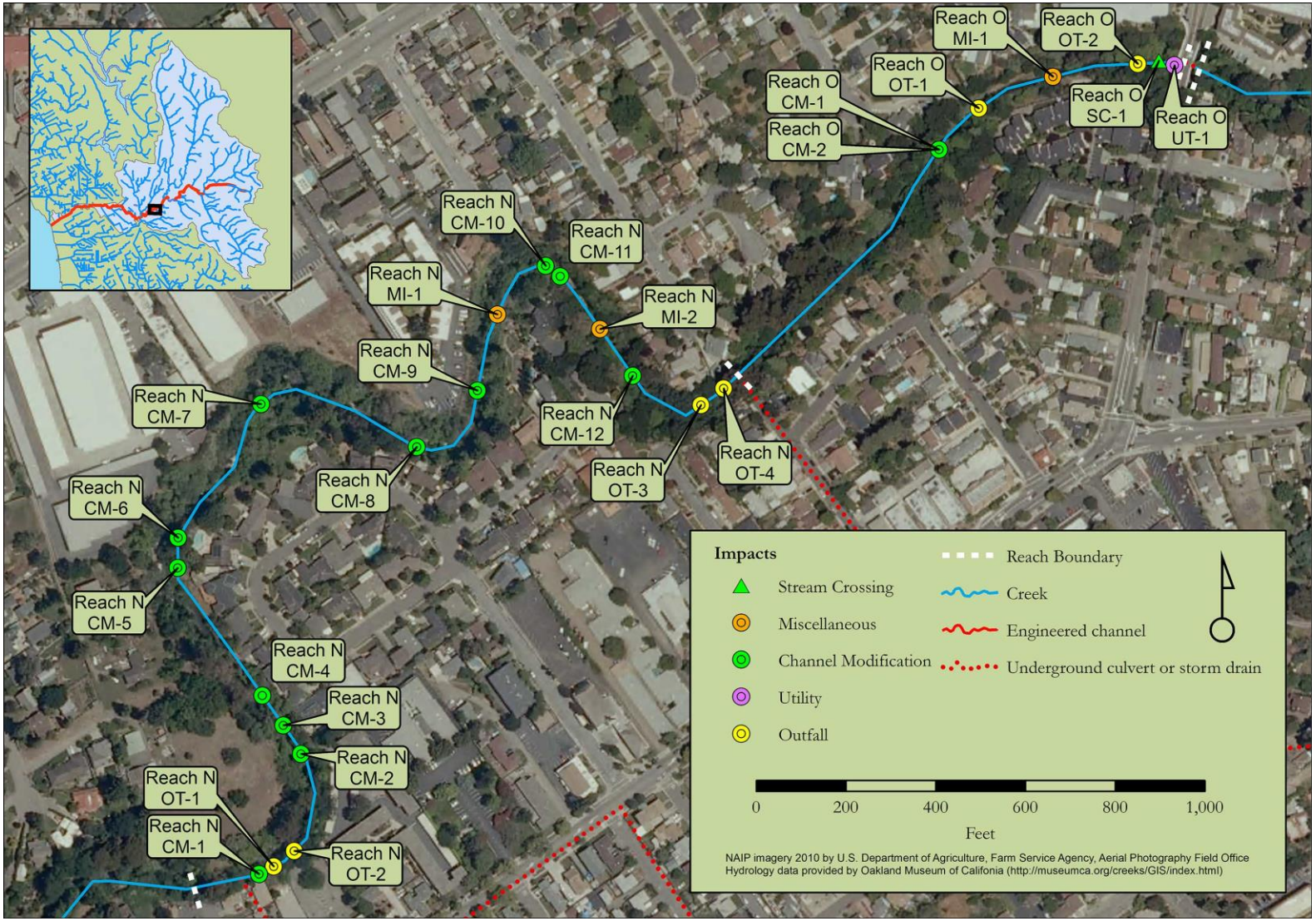


Figure A-10. San Lorenzo Creek Reach M



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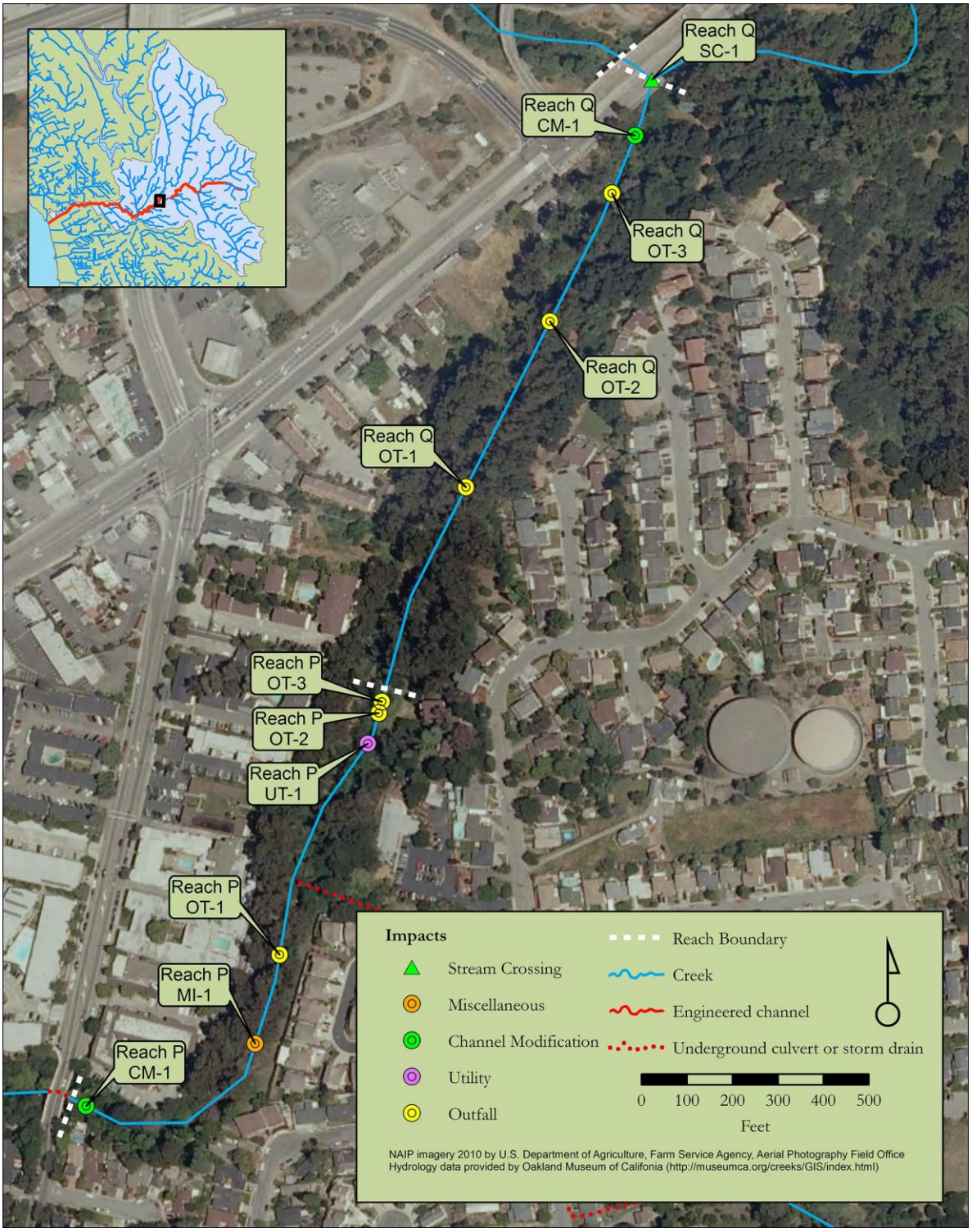

Figure A-12. San Lorenzo Creek Reaches P and Q

Attachment B. Castro Valley Creek - USA Surveyed Reaches 2012

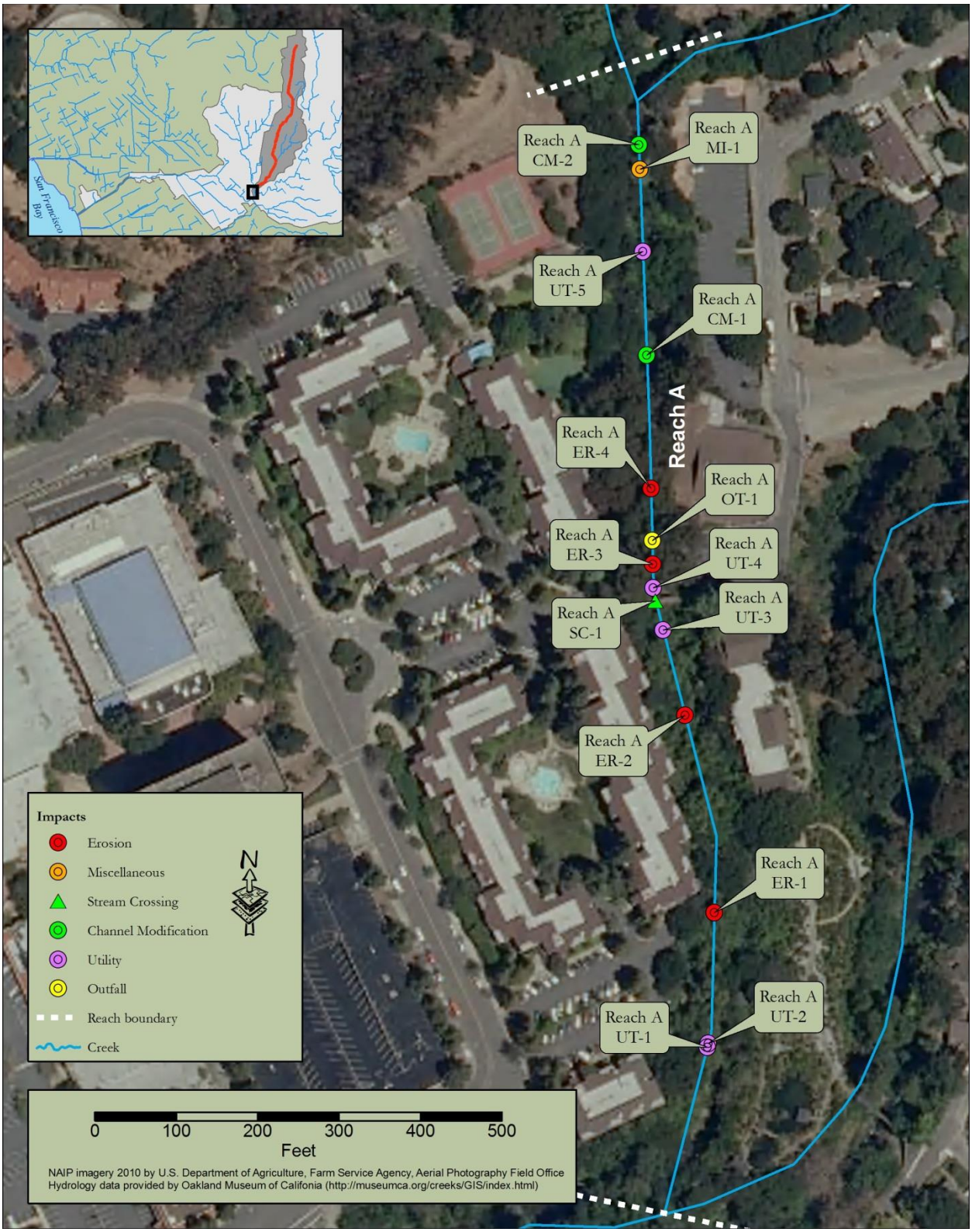

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Figure B-5. Castro Valley Creek Reach M

Figure B-6. Castro Valley Creek Reach N

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Figure B-8. Castro Valley Creek Reach P

Figure B-9. Castro Valley Creek Reaches Q and R

Attachment C Chabot Creek - USA Surveyed Reaches 2012

Figure C-1. Chabot Creek Reach A

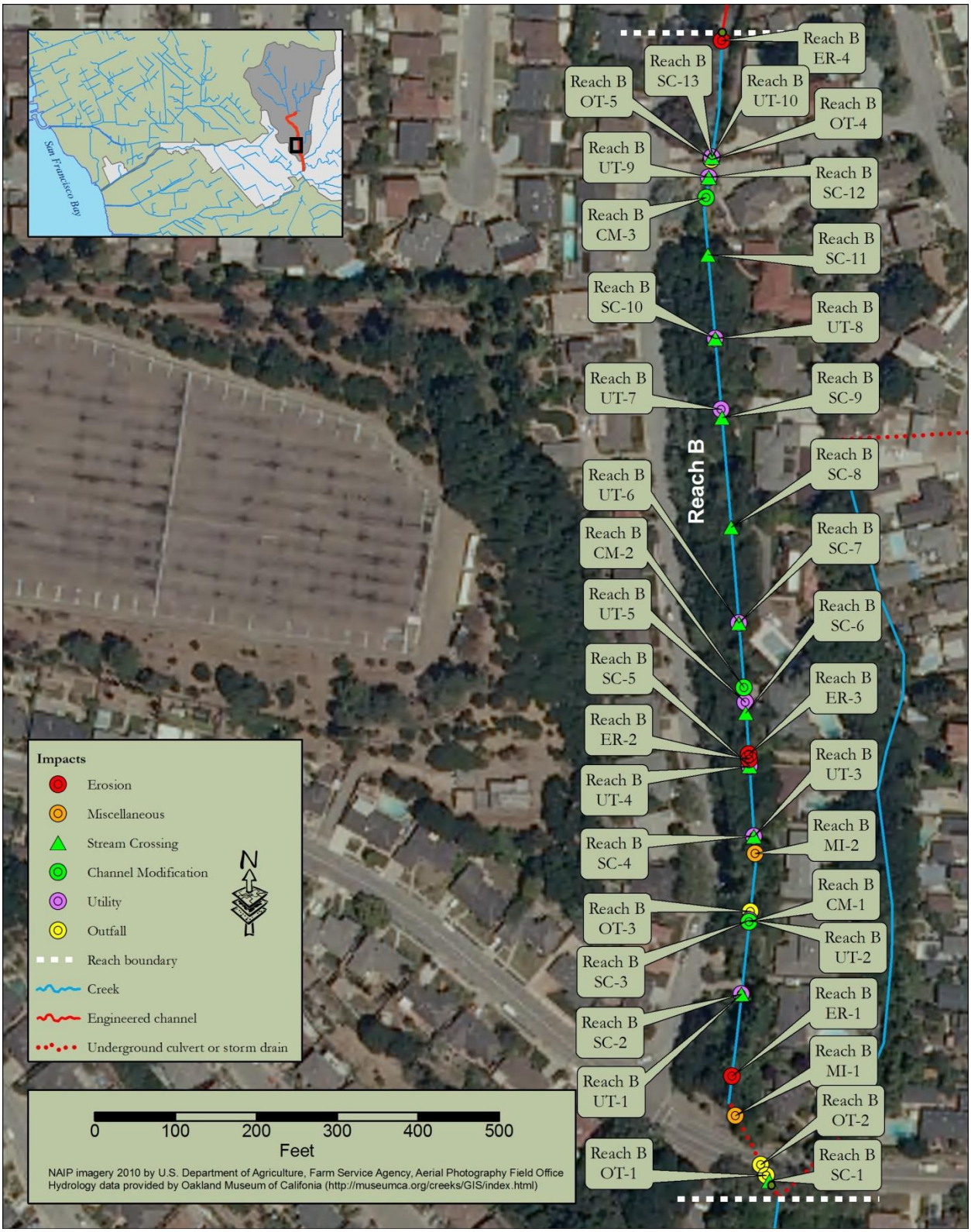

Figure C-2. Chabot Creek Reach B

Figure C-3. Chabot Creek Reach C

Figure C-4. Chabot Creek Reach E

Figure C-5. Chabot Creek Reach G

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Attachment D. Crow Creek - USA Surveyed Reaches 2013

Figure D-1. Crow Creek Reach A

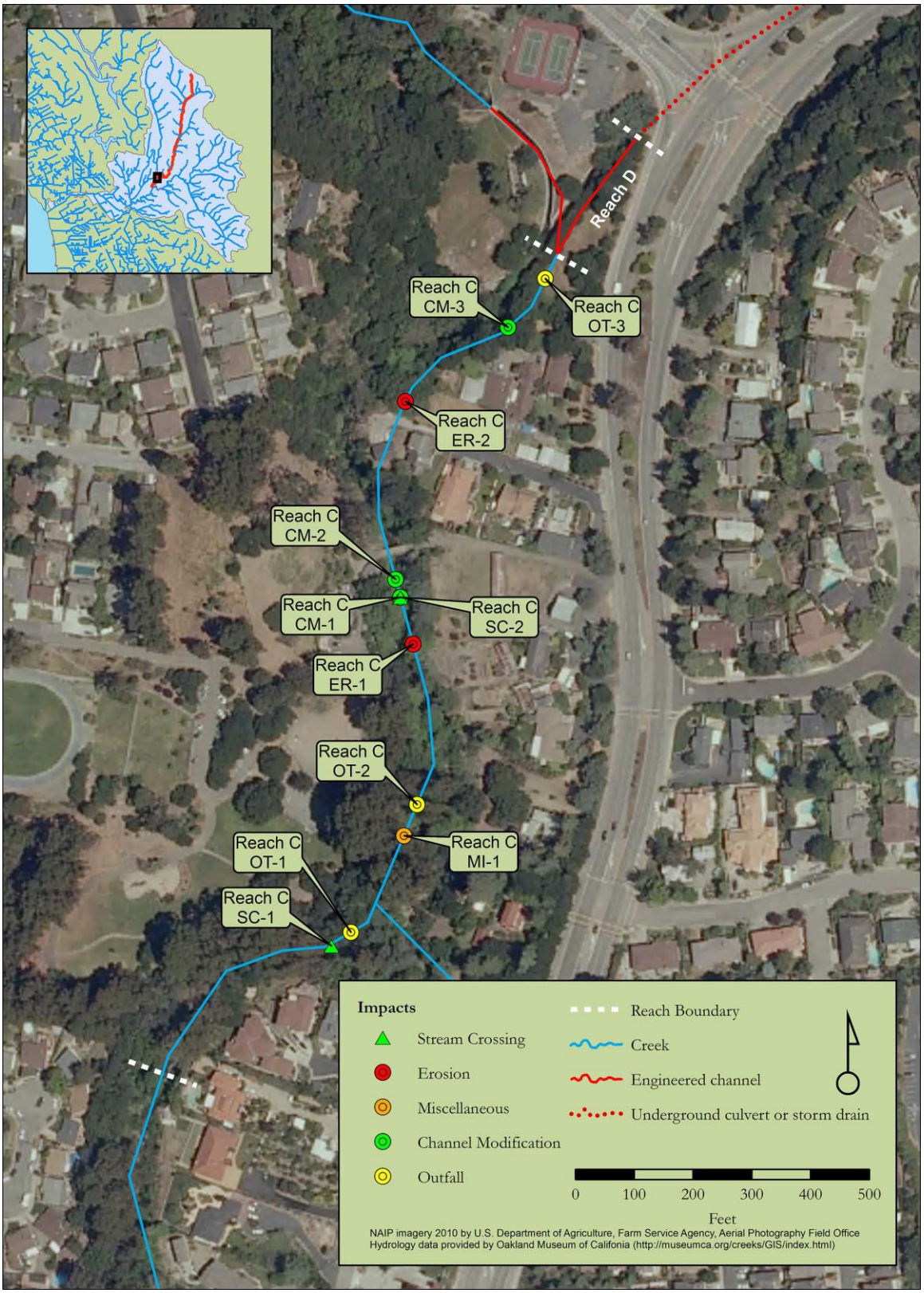


Figure D-2. Crow Creek Reach C

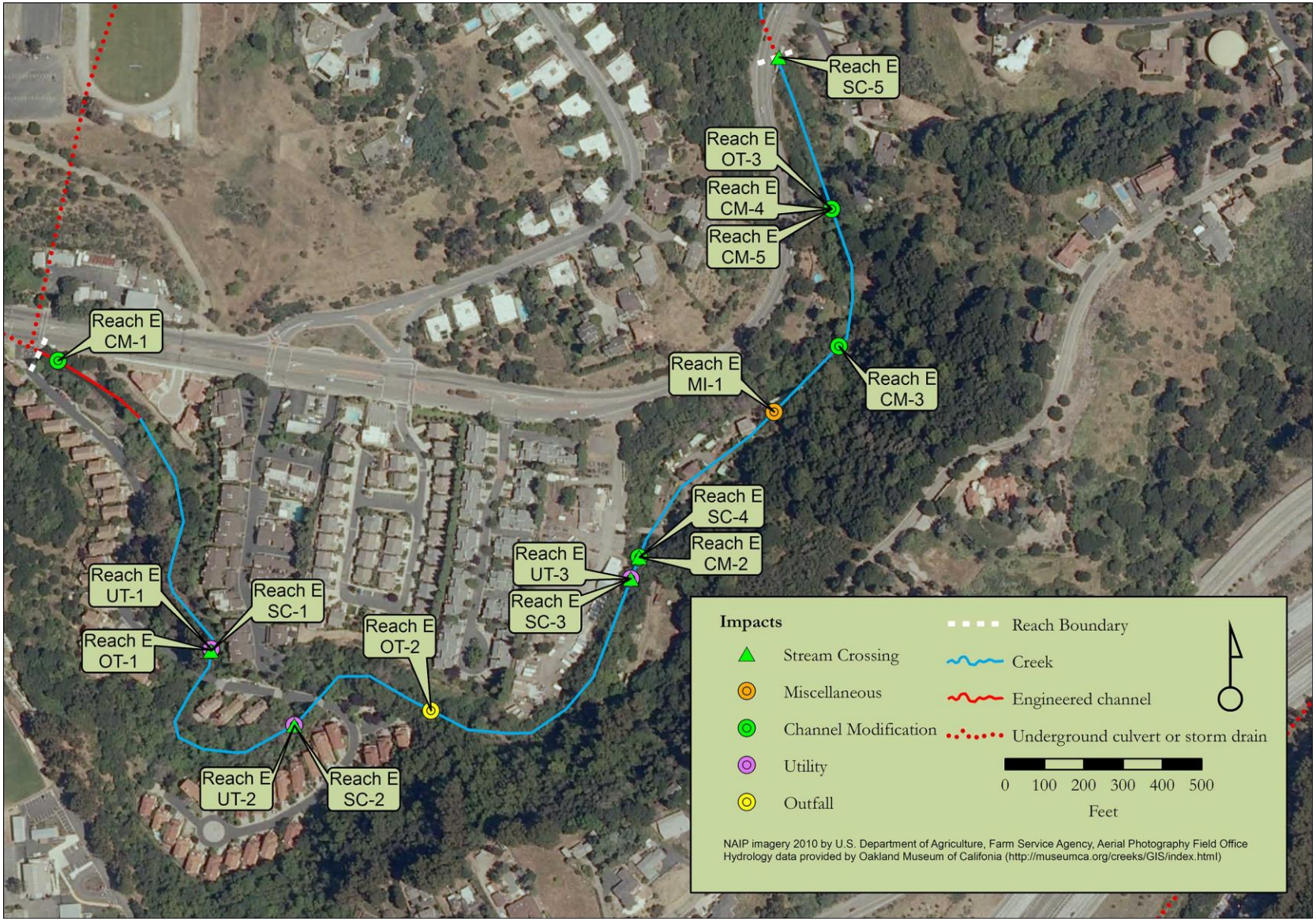


Figure D-3. Crow Creek Reach E

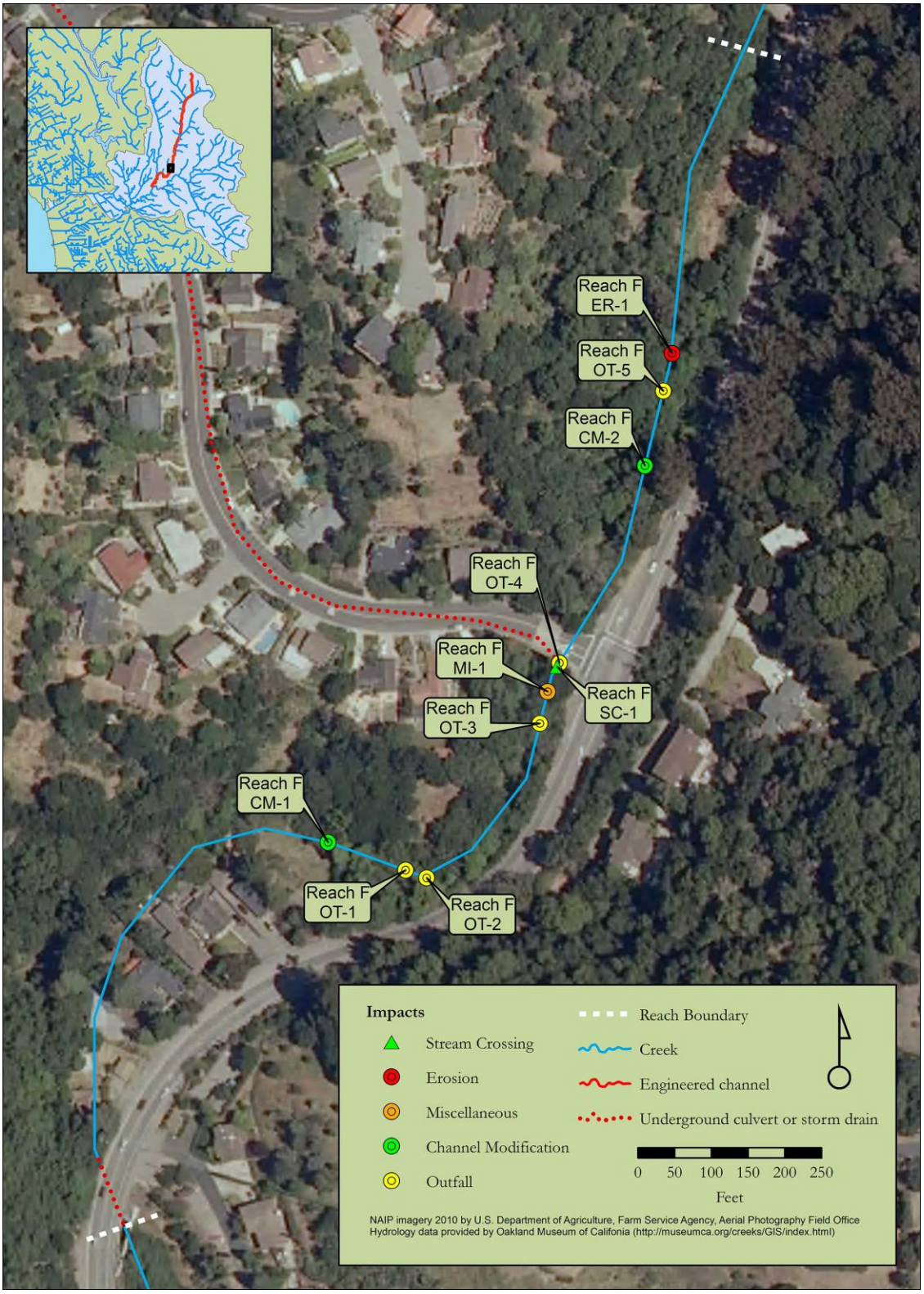
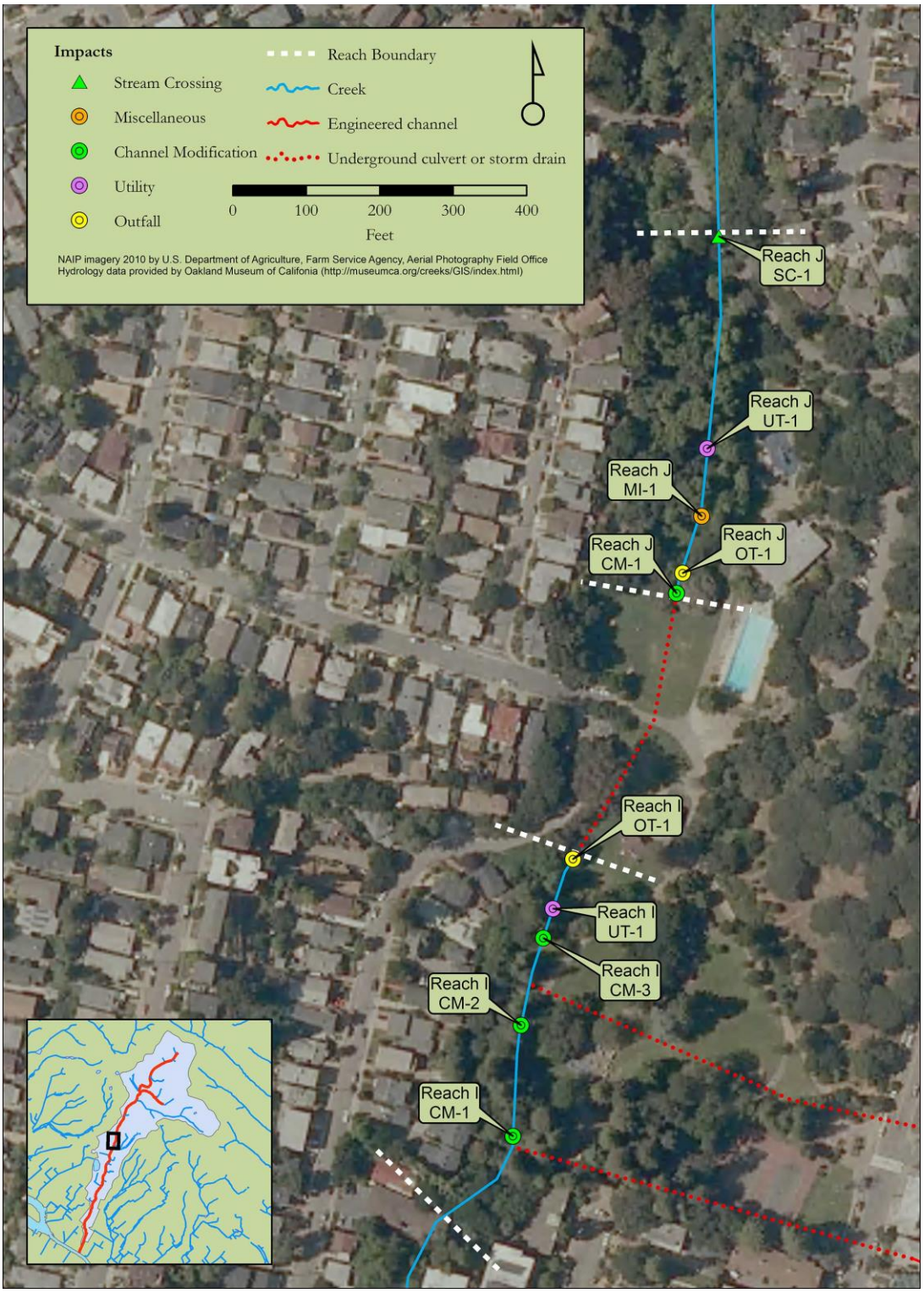


Figure D-4. Crow Creek Reach F

Attachment E. Sausal Creek - USA Surveyed Reaches 2013



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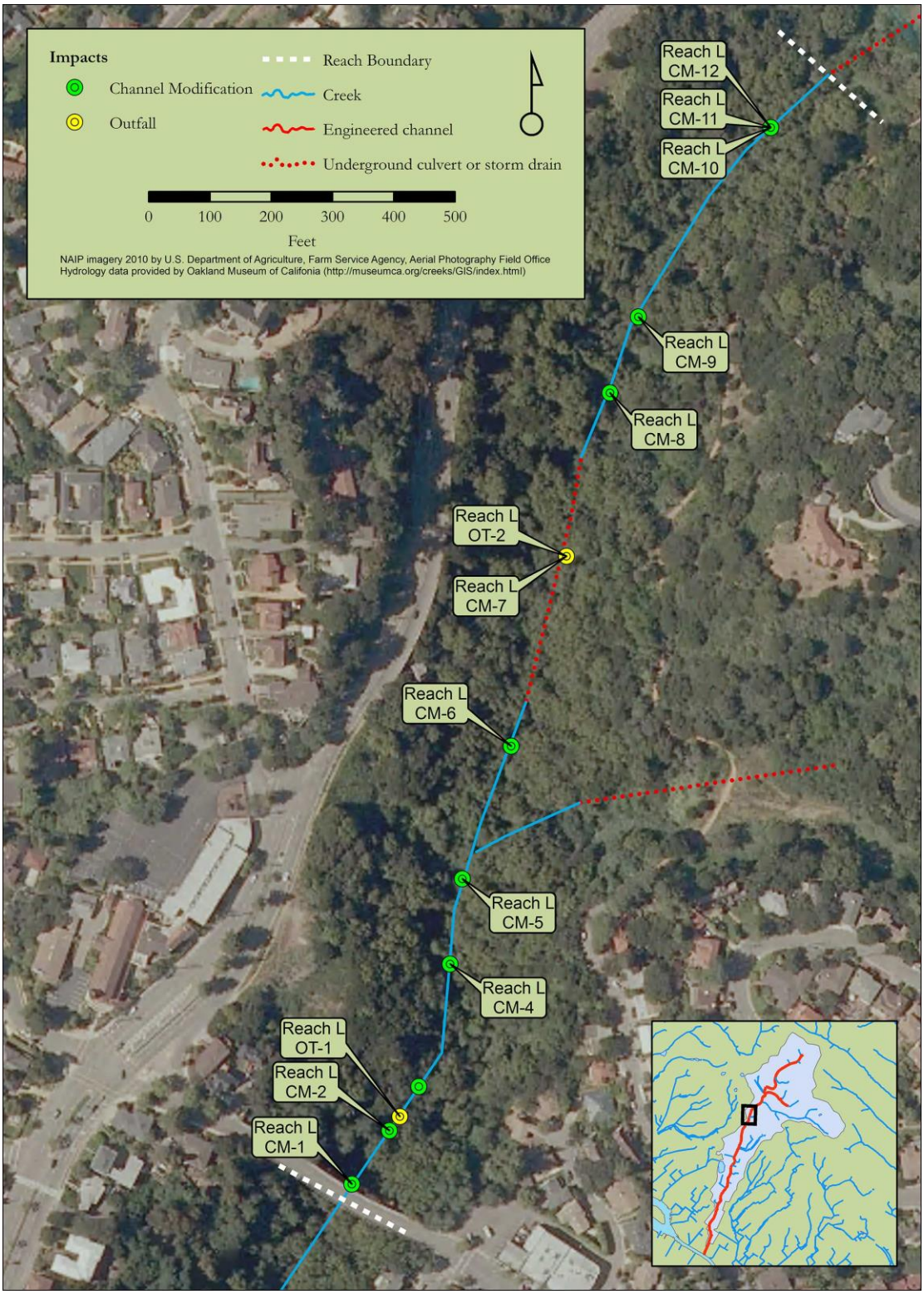
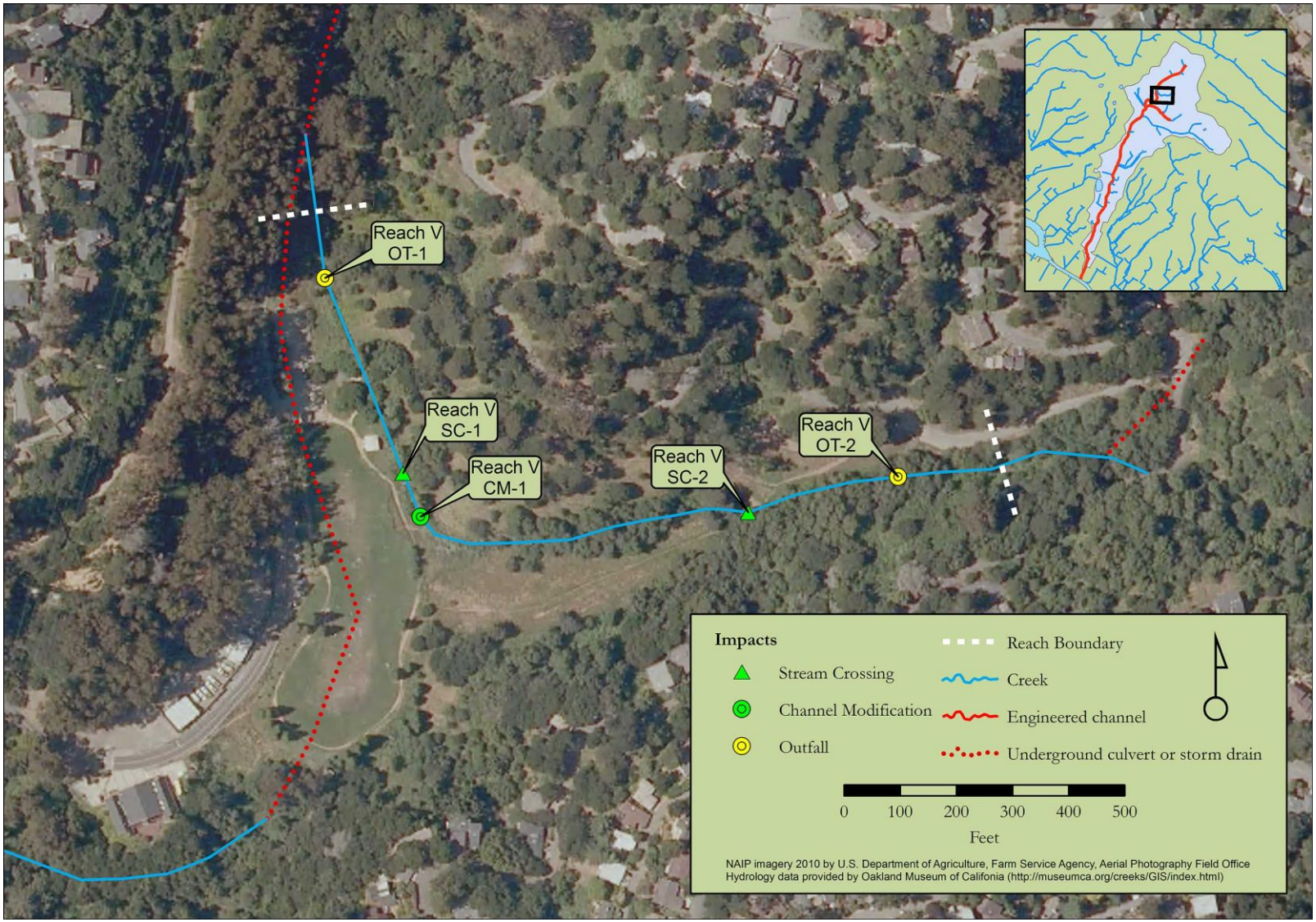


Figure E-3. Sausal Creek Reach L



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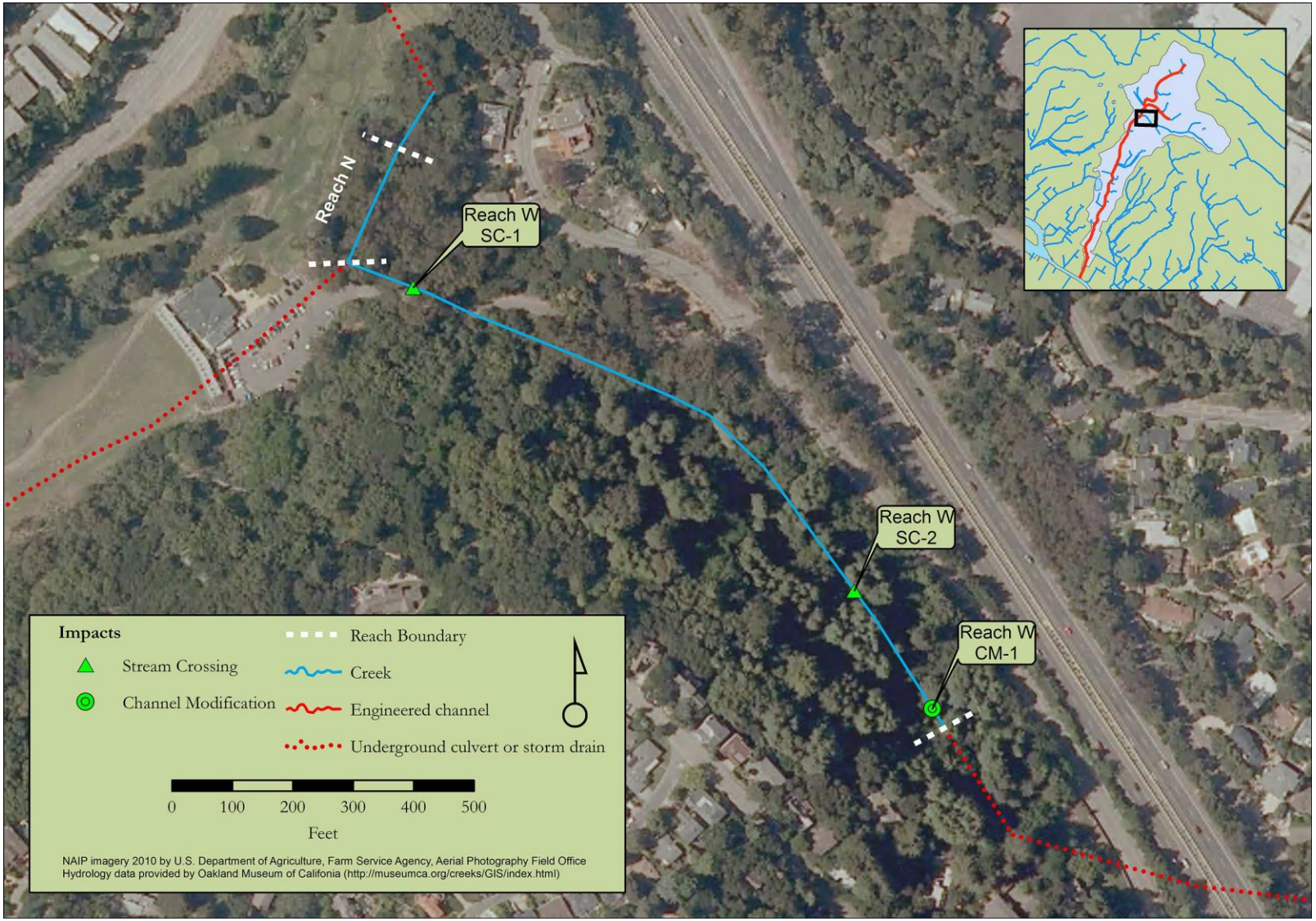

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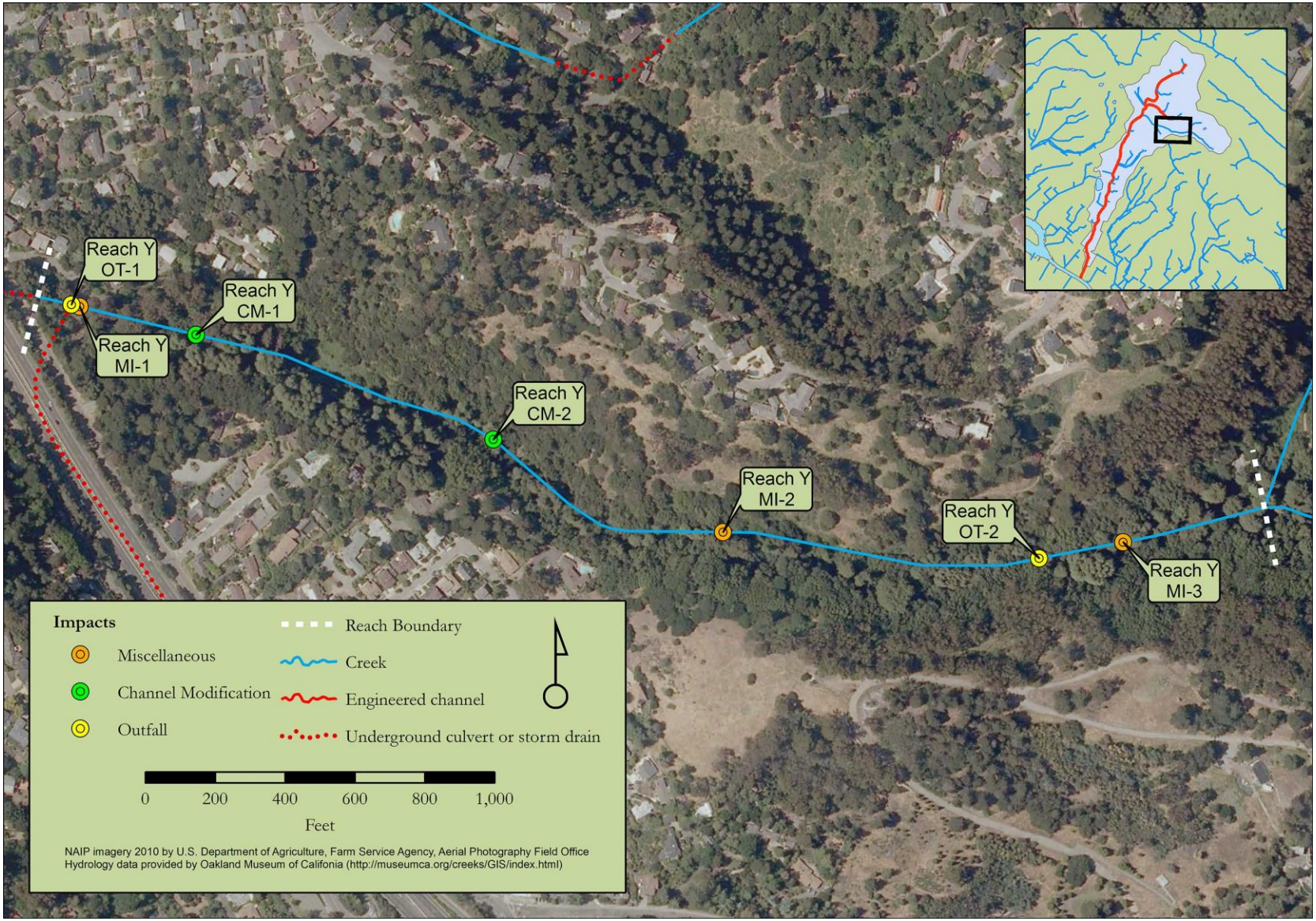

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Attachment F. Arroyo Viejo - USA Surveyed Reaches 2013

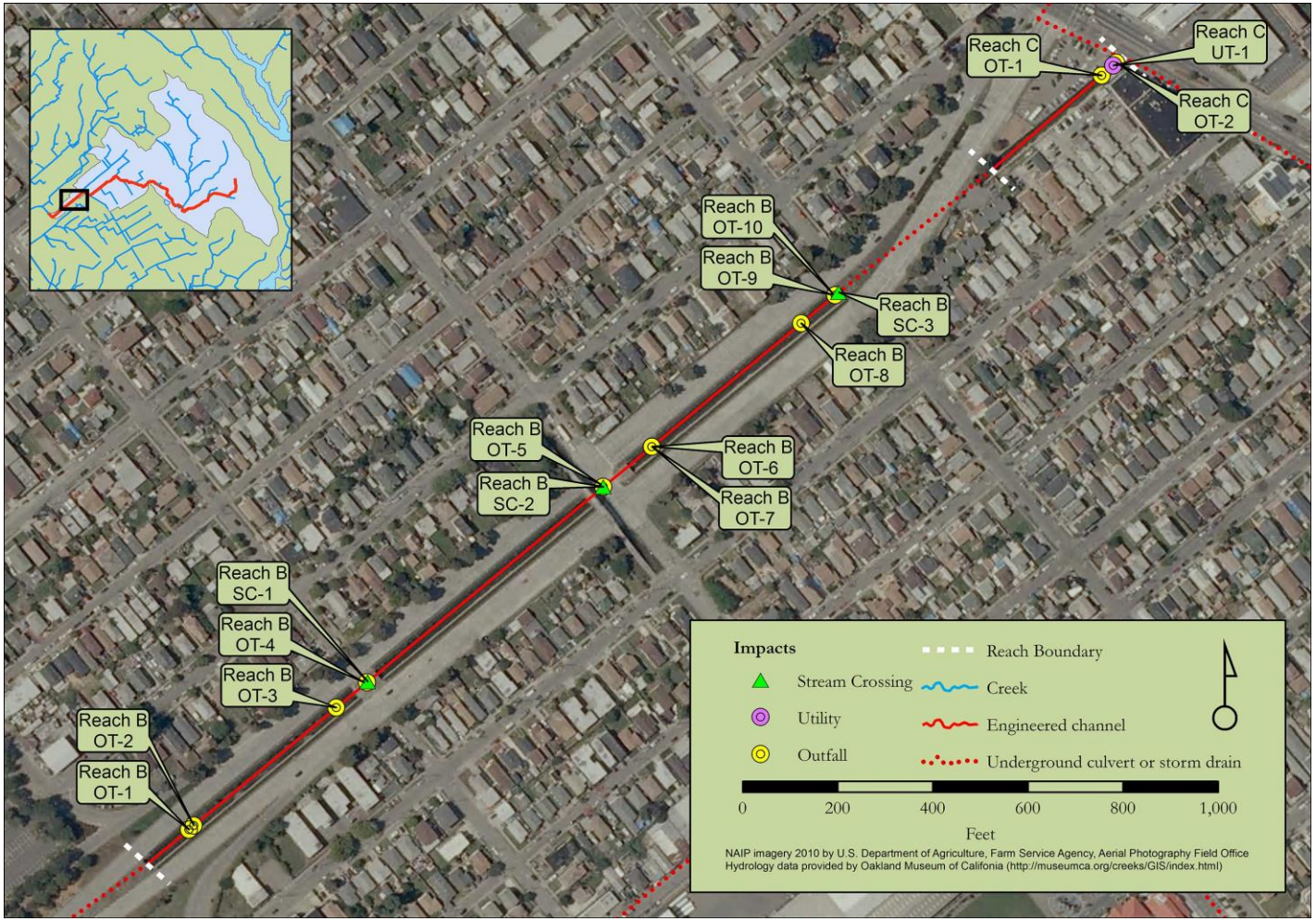


Figure F-1. Arroyo Viejo Reaches B and C

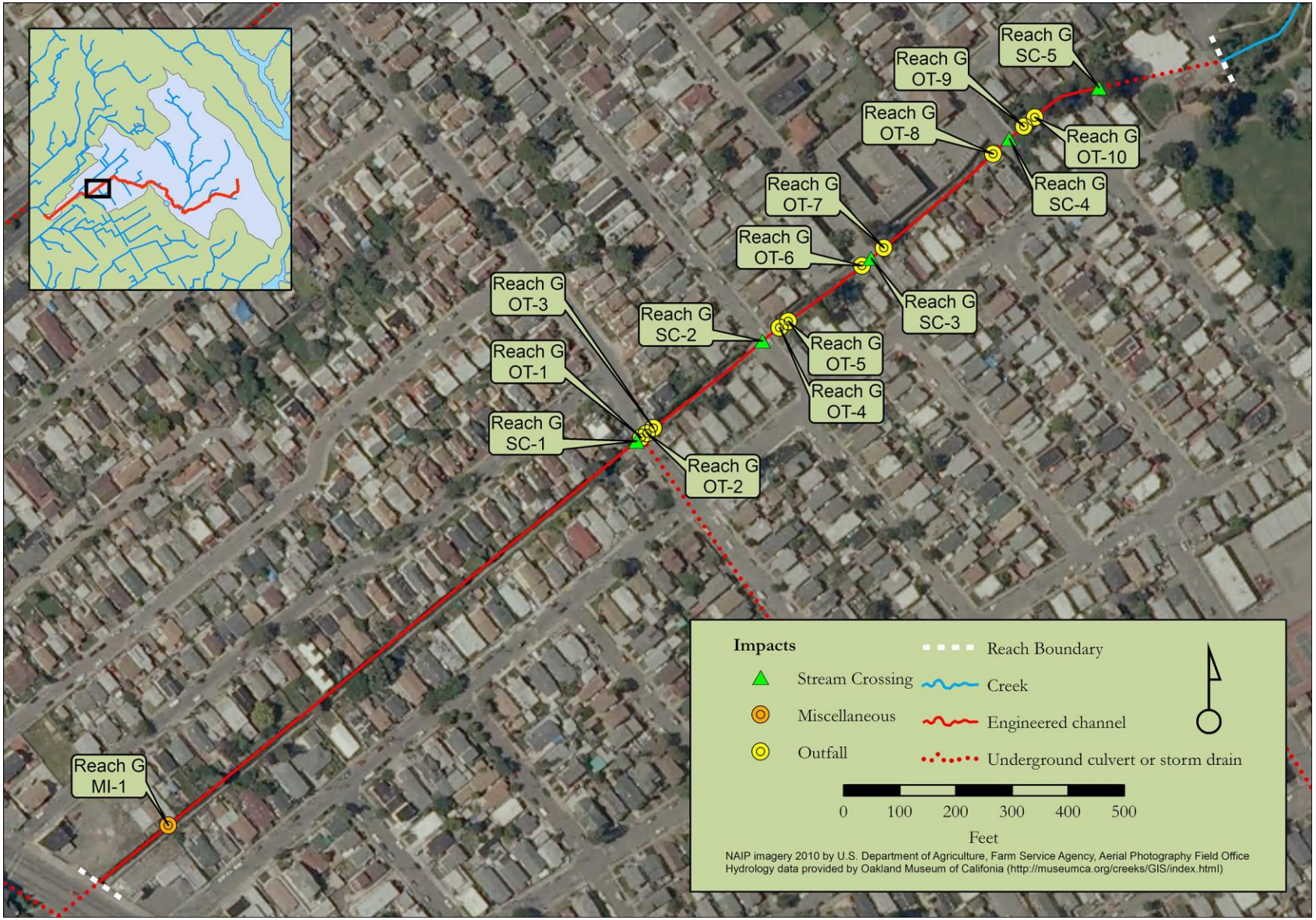
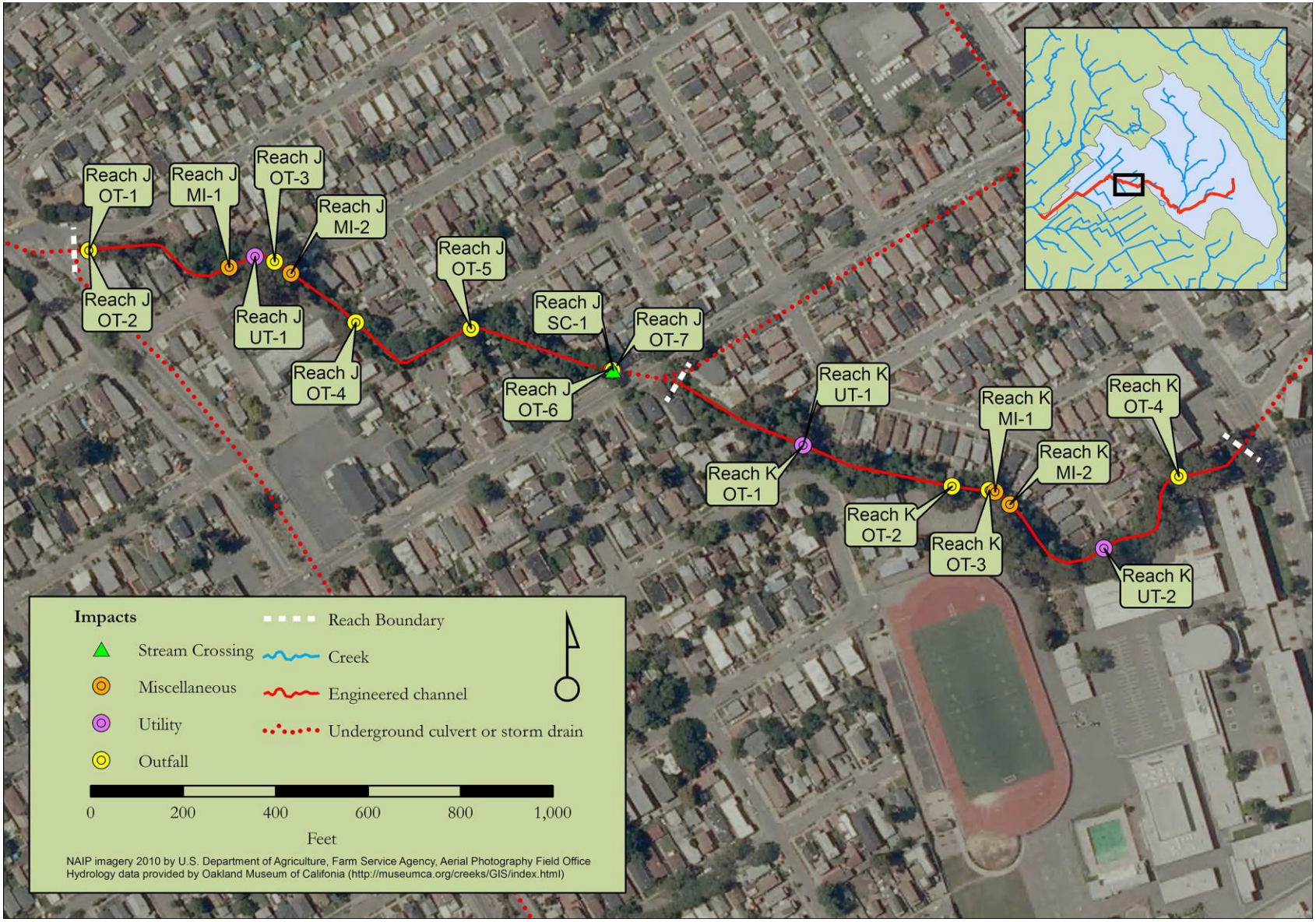


Figure F-2. Arroyo Viejo Reach G

Figure F-3. Arroyo Viejo Reaches H and I



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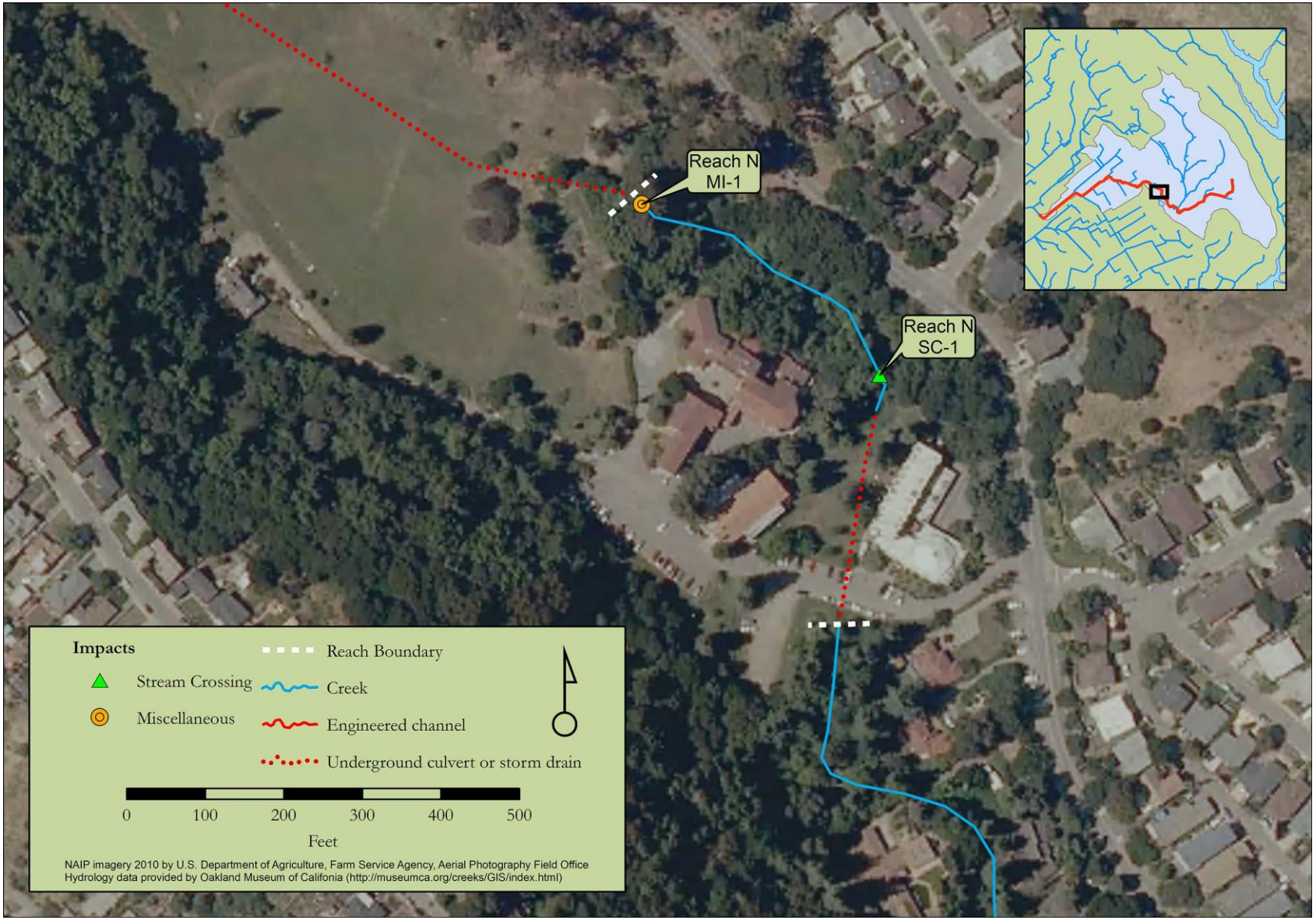
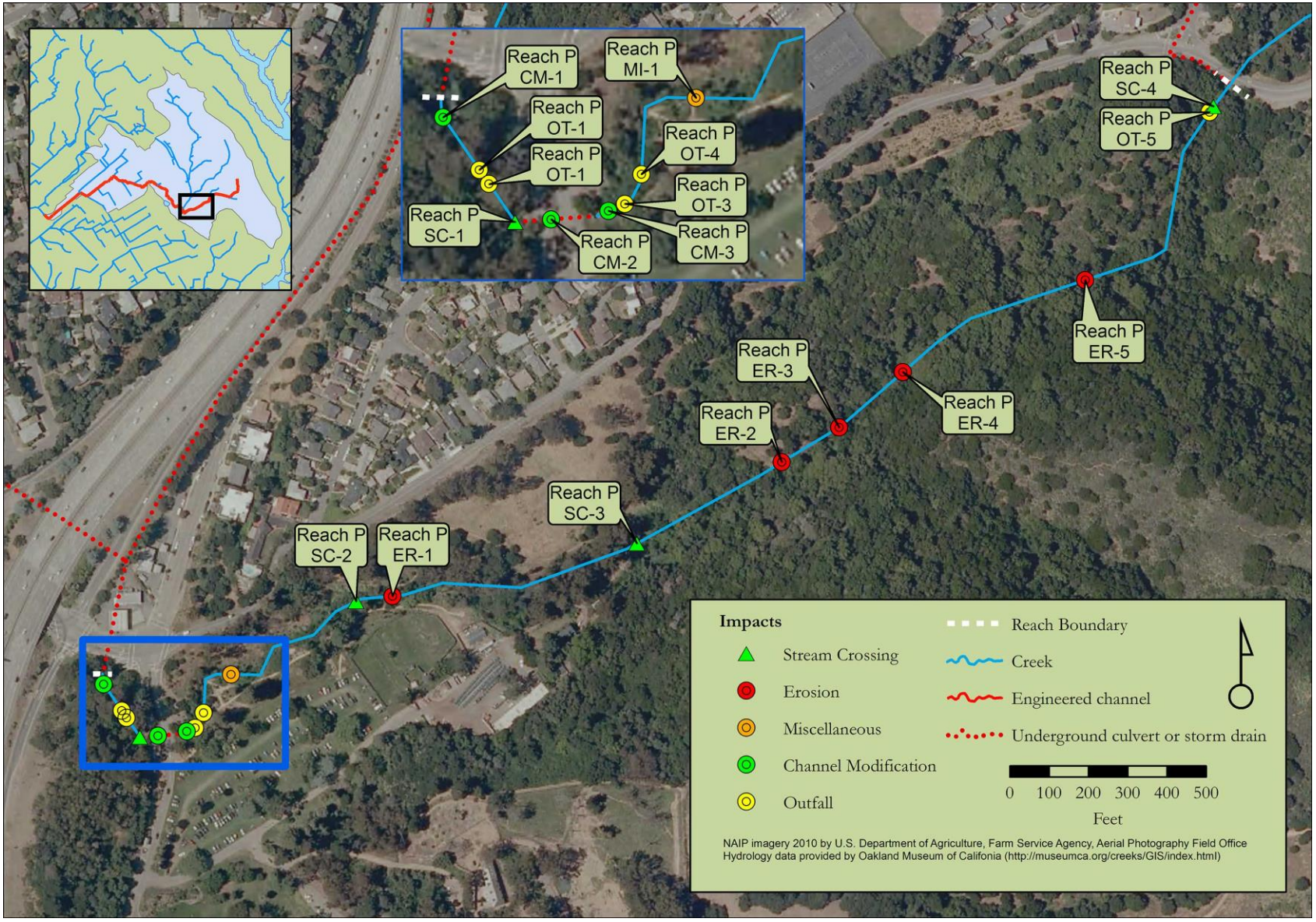


Figure F-6. Arroyo Viejo Reach N



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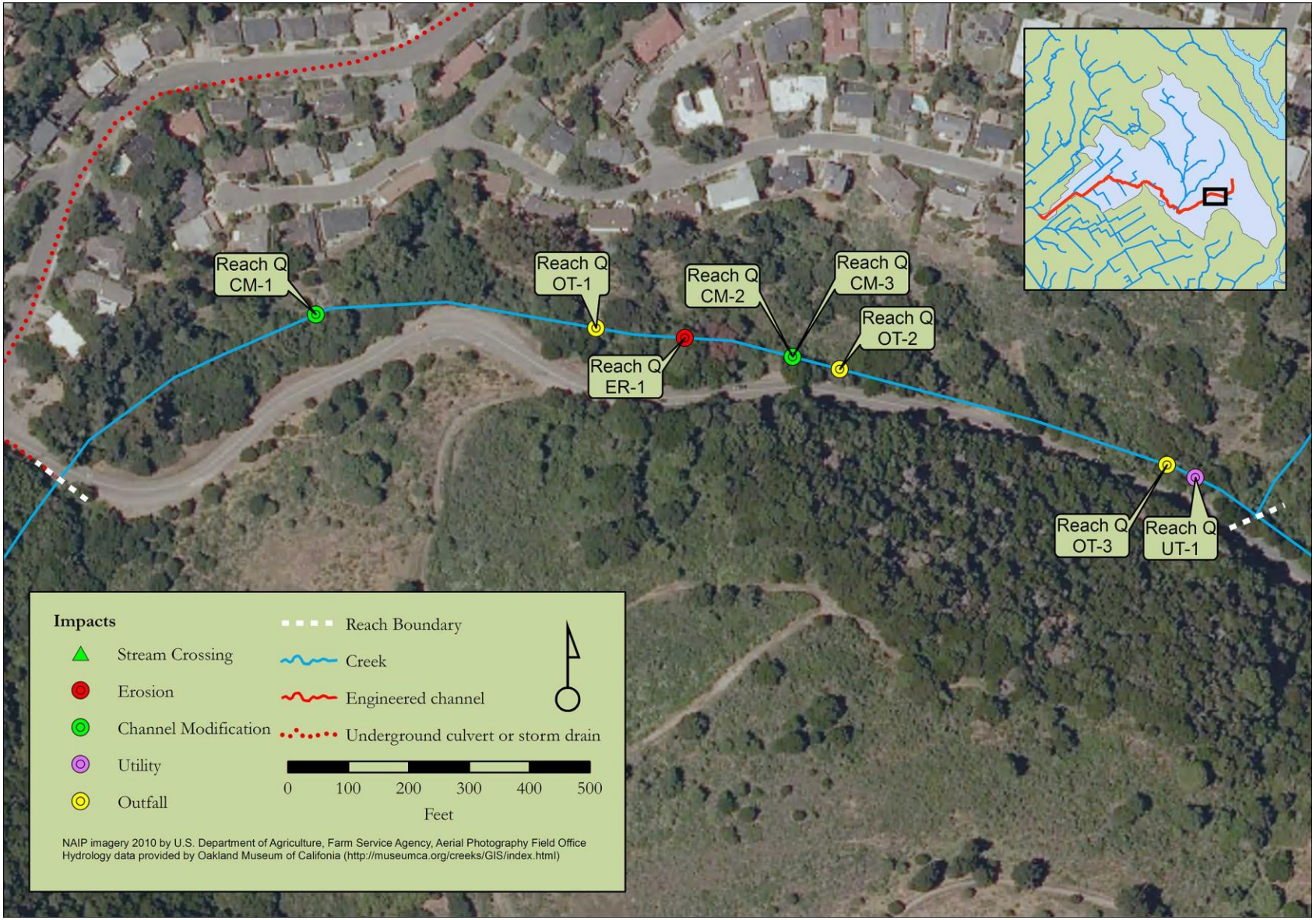

Figure F-8. Arroyo Viejo Reach Q

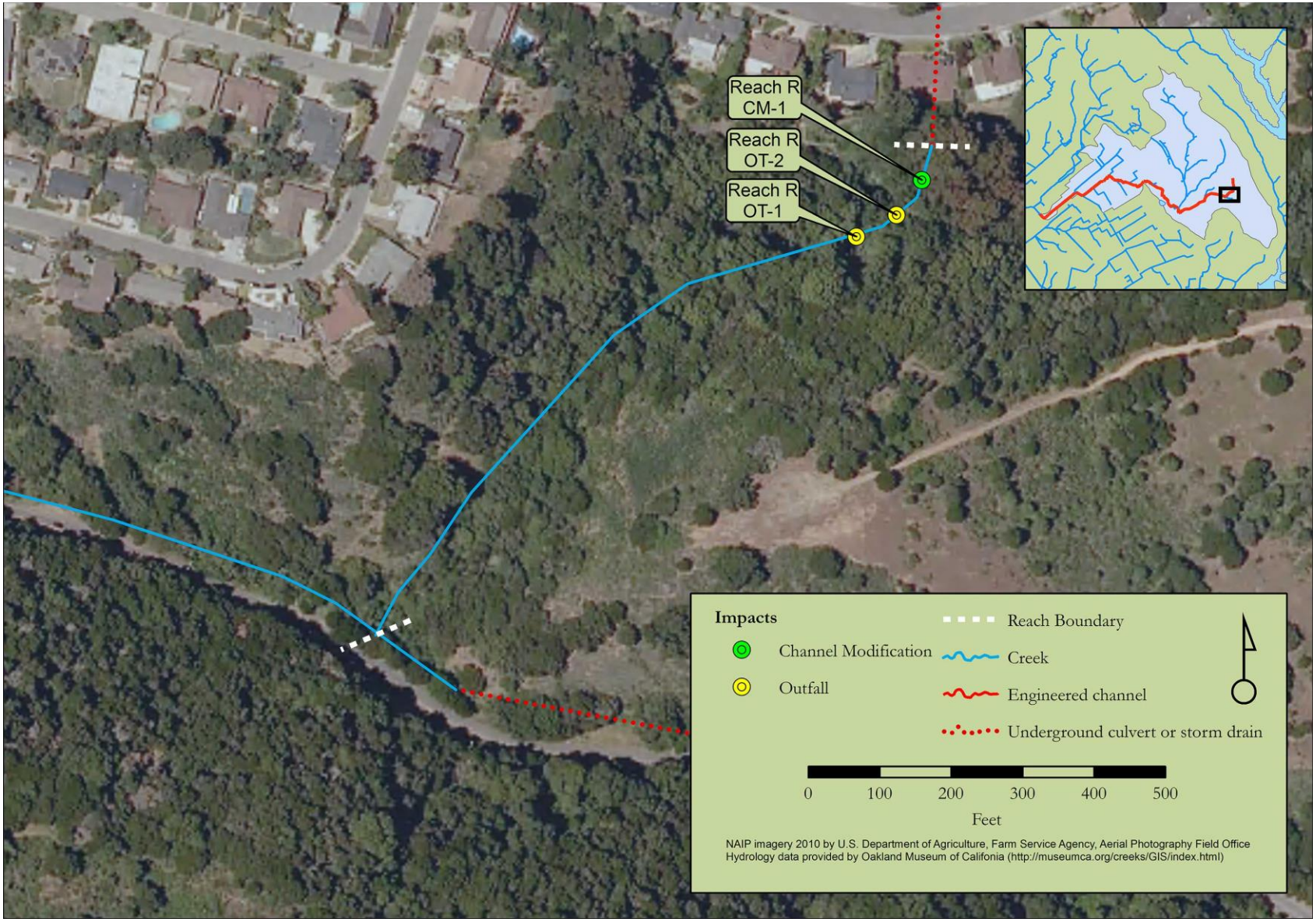

Figure F-9. Arroyo Viejo Reach R

Attachment G. Glen Echo Creek - USA Surveyed Reaches 2013

Figure G-1. Glen Echo Creek Reaches C and D

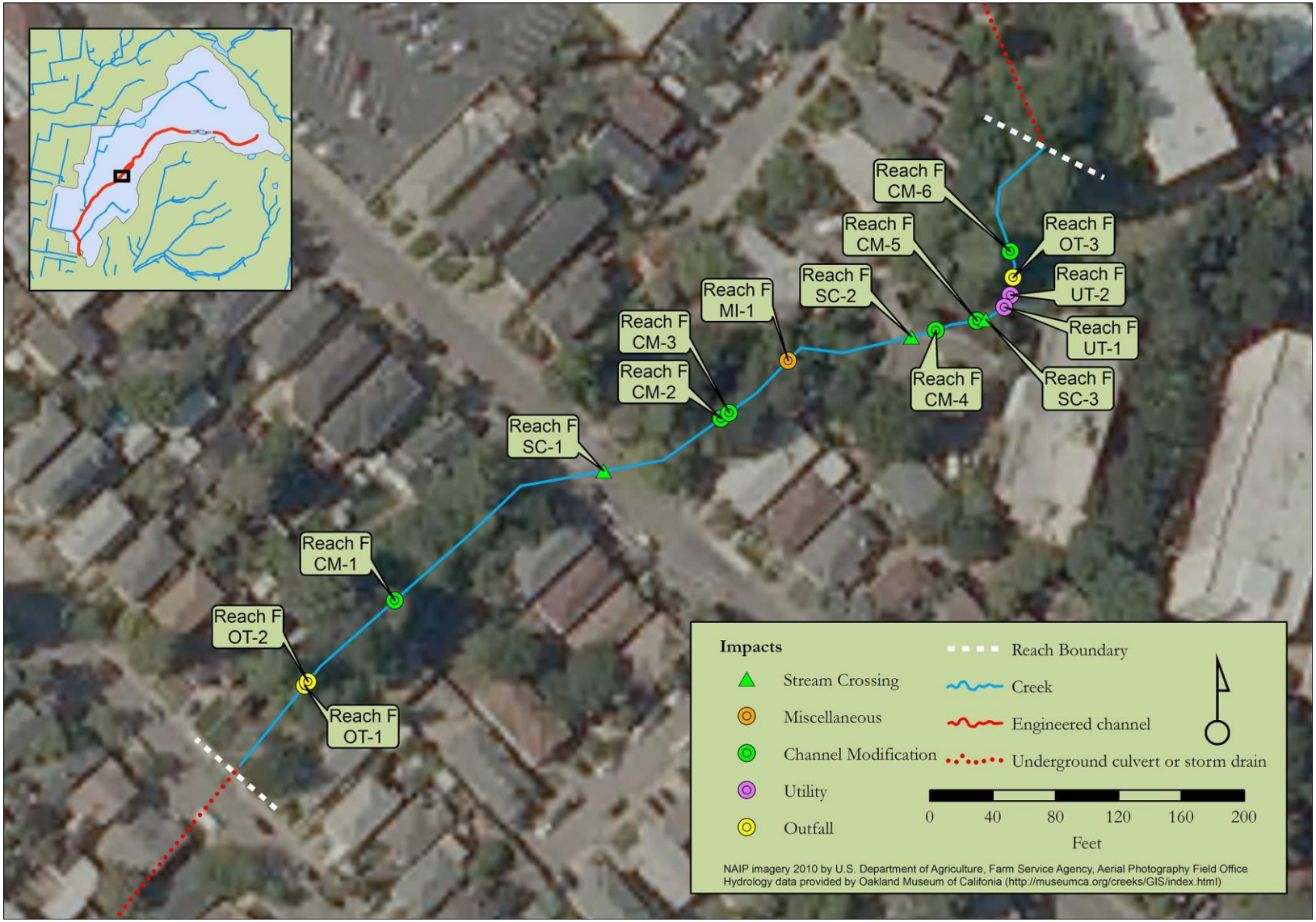

Figure G-2. Glen Echo Creek Reach F

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ALAMEDA COUNTYWIDE CLEAN WATER PROGRAM

STRESSOR / SOURCE IDENTIFICATION PROJECT: DUBLIN CREEK SITE 204R00084 – BIOLOGICAL COMMUNITY AND SEDIMENT QUALITY

WATER YEAR 2013 PROGRESS REPORT

INTEGRATED MONITORING REPORT, PART A - APPENDIX A.4A

MEMBER AGENCIES:

Alameda
Albany
Berkeley
Dublin
Emeryville
Fremont
Hayward
Livermore
Newark
Oakland
Piedmont
Pleasanton
San Leandro
Union City
County of Alameda
Alameda County Flood Control and Water Conservation District
Zone 7 Water Agency

Report prepared by

Alameda Countywide Clean Water Program
399 Elmhurst Street,
Hayward, California 94544

Submitted to:

California Regional Water Quality Control Board, San Francisco Bay Region

FINAL

March 13, 2014

Protecting Alameda County Creeks, Wetlands & the Bay

List of Acronyms

Acronym	Definition
AMS	Applied Marine Sciences
ACCWP	Alameda Countywide Clean Water Program
BASMAA	Bay Area Stormwater Management Agencies Association
BMP	Best Management Practice
CSCI	California Stream Condition Index
DQO	Data Quality Objective
I-	Interstate Highway
IBI	Index of Biotic Integrity
LUCMP	Local Urban Creek Monitoring Program
MRP	Municipal Regional Stormwater Permit
NPDES	National PollutantDischarge Elimination System
PAH	Polycyclic Aromatic Hydrocarbon
PEC	Probable Effects Concentration
QAPP	Quality Assurance Project Plan
RMC	Regional Monitoring Coalition
RMP	Regional Monitoring Program
RWQCB	Regional Water Quality Control Board
SFBRWQCB	San Francisco Bay Regional Water Quality Control Board
SSID	Stressor/Source Identification
SoCal	Southern California
SOP	Standard Operating Procedure
SPoT	Stream Pollutant Trends
SWAMP	Surface Water Ambient Monitoring Program
TEC	Threshold Effect Concentration
TOC	Total Organic Carbon
USA	Unified Stream Assessment
WY	Water Year

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Executive Summary

Stressor/Source Identification (SSID) Projects are required by Provision C.8.d.i of the Municipal Regional Stormwater Permit (MRP). SSID projects are initiated as a result of triggers as indicated in MRP Table 8.1.

In Water Year (WY) 2012, three sites within Alameda County were identified as candidates for ACCWP SSID projects based on analysis of results for stressor triggers. This report presents the initial results of a site-specific Stressor Source Identification (SSID) into potential sources of stressors affecting habitat and sediment quality at the Dublin Creek Site 204R00084.

The Stressor Identification process may be iterative, and, if the stressor cannot be adequately identified in the first attempt, the process may continue with collection of better data or testing other suspected stressors (USEPA, 2000).

During WY2012 monitoring this site was found to have slight elevations in PAHs and pesticides, elevated nickel and zinc and a "Very Poor" IBI score. These results suggested the need for an assessment of potential sources of known stressors.

In order to assess the potential stressor sources in this study area, five sediment samples were collected on July 9, 2013. The samples were analyzed for:

- Polycyclic aromatic hydrocarbons (PAHs);
- Organochlorine pesticides;
- Pyrethroids;
- Metals (including mercury);
- Total organic carbon (TOC); and
- Percent fines

In addition, a bioassessment investigation was undertaken at Site 204DUB040.

The following findings are based on the results of this preliminary monitoring:

- Pyrethroids: Bifenthrin was the only pyrethroid recorded at concentrations above detection limits in this study. This is consistent with published literature which finds bifenthrin to be the most common pyrethroid in sediments (Anderson *et al*, 2012). Compared with DPR investigations, the results presented here are very much lower than average concentrations found in other Californian sediments (Zhang, 2010). There was no observed difference between concentrations of pyrethroids at the three sites monitored.

- Organochlorine pesticides: In comparison with sediment results published in the literature, the results from the Dublin study suggest low concentrations of organochlorine pesticide presence (Kinnetic Laboratories and EOA, 2002 and Anderson *et al*, 2012). Of the Dublin sites investigated, Site 204DUB060 recorded the highest organochlorine pesticide concentrations.
- Metals: In general, metal concentrations were similar to average concentrations found in the SPoT program (Anderson *et al*, 2012). Mercury concentrations were much lower than averages recorded in the Joint Agency Program from 2002 (Kinnetic Laboratories and EOA, 2002). Compared with the other sites investigated in this study, Sites 204DUB005 and 204DUB080 had higher concentrations of metals compared with other sites monitored in WY2013.
- PAHs: PAH concentrations were lower than those averages reported in the SPoT program (Anderson *et* al, 2012) and the Alameda County Sediment sampling program results from 2002 (ACCWP, 2002). In comparison to the other sites investigated in this study, Site 204DUB080 had higher concentrations of PAHs.
- Bioassessment: Sites in different zones of the watershed all showed relatively low condition scores compared to undeveloped reference conditions. Habitat modification due to urbanization is the main source of biological community alteration, especially for highly modified channels but also where natural channels have experienced changes due to increased watershed imperviousness and nearby roads (e.g. Schuler, 2004, SFBRWQCB 2012).

ACCWP will review these initial results with affected Permittees and other watershed stakeholders to identify additional sources of data or information, and clarify roles and responsibilities for further steps in the SSID project.

1 Introduction

The Alameda Countywide Clean Water Program (ACCWP) conducts Creek Status Monitoring as required by Provision C.8.c of the Municipal Regional Stormwater Permit (MRP, SFBRWQCB Order R2009-0074). ACCWP's 17 member agencies have joined with 56 other MRP Permittees to form the BASMAA Regional Monitoring Coalition (RMC), a regional collaborative to coordinate monitoring conducted pursuant to MRP Provision C.8. The RMC prepared a Quality Assurance Project Plan (QAPP, BASMAA 2012a and 2014a) and Standard Operating Procedures (SOPs, BASMAA 2012b and 2014b) to standardize monitoring methods and ensure comparability of monitoring data with the state's Surface Water Ambient Monitoring Program (SWAMP) see Table 1-1.

Table 1-1. Standard Operating Procedures Pertaining to BASMAA RMC Creek Status Monitoring.

SOP #	SOP Title
FS-1	BMI and Algae Bioassessments, and Physical Habitat Measurements
FS-2	Water Quality Sampling for Chemical Analysis, Pathogen Indicators, and Toxicity
FS-3	Field Measurements, Manual
FS-4	Field Measurements, Continuous General Water Quality
FS-7	Field Equipment Cleaning Procedures
FS-8	Field Equipment Decontamination Procedures
FS-9	Sample Container, Handling, and Chain of Custody Procedures
FS-10	Completion and Processing of Field Datasheets
FS-11	Site and Sample Naming Convention
FS-12	Ambient Creek Status Monitoring Site Evaluation
FS-13	QA/QC Data Review
N/A	Unified Stream Assessment: A User's Manual, v2.0

The RMC's Creek Status and Long-Term Trends Monitoring Plan (BASMAA, 2011) which assigns each of the Creek Status monitoring parameters listed in MRP Table 8.1 to one of two sub-design components:

- Regional: ambient monitoring to assess the condition of aquatic life in creeks across the San Francisco Bay Area. Candidate monitoring sites were drawn from a probabilistically generated master list that included all perennial and non-perennial creeks and rivers within the applicable portions of the five participating counties. Sites from the RMC master list are identified by an alphanumeric code in which the last 6 characters are "Rnnnnn" with "R" designating the RMC probabilistic design and "nnnnn" the site's numeric sequence number generated through the RMC master draw[1]. RMC sites can also be assigned an alternative ID using the SWAMP naming procedure described in RMC SOP FS-11.
- Targeted: monitoring design and site selection address local watershed management questions. The last six characters of each Site ID reflect the watershed and numbering from the base of the watershed per the RMC SOP FS-11.

Creek Status Monitoring was initiated in WY2012 (October 2011 through September 2012) and reported in the Urban Creeks Monitoring Report (UCMR, BASMAA 2013) submitted to the (RWQCB) in March 2013. The UCMR evaluated all data against "trigger criteria" listed for each parameter in MRP Table 8.1, which identifies potential follow-up actions, including Stressor/Source Identification (SSID) projects as required by Provision C.8.d.i of the Municipal Regional Stormwater Permit (MRP), subject to several conditions[2]:

1. Creek Status Monitoring results meet one or more trigger criteria in MRP Table 8.1
2. When conducting monitoring through a regional collaborative, Permittees are collectively required to initiate no more than ten SSID projects during the Permit term (ACCWP's proportionate share is assumed to be three projects out of the 10).
3. If results indicate toxicity, at least 2 of the 10 SSID projects must be for toxicity
4. No need to repeat for continuing or recurring occurrences of the trigger in later results from the same receiving water limitations, unless directed to do so by the Water Board
5. No need to follow up on trigger results that are caused by Pollutants of Concern which are already being addressed by other portions of the MRP (e.g. pesticides).

[1] As recommended for SWAMP data compatibility per RMC SOP FS-11, all site ID codes begin with a 3 digit Hydrologic Unit Code.

The RMC programs developed a collaborative decision-making process for selecting sites for SSID follow-up. Program representatives reviewed the previous year's creek status monitoring results which reached "trigger" criteria, and prioritized sites for SSID follow-up based on several criteria including environmental significance of the trigger results and the feasibility of completing the project steps outlined in the MRP (see below). After consultation with affected Permittee(s), the RMC confirmed the candidate SSID project list with Water Board staff in April 2012 and individual programs planned implementation of SSID studies in their areas for FY 2013-14.

The MRP lists four steps for an SSID project. ACCWP and other Countywide Programs will lead the technically oriented steps 1 and 4 and collaborate with relevant Permittees on step 2: Permittee(s) will be the lead on step 3 to the extent that effective stormwater Best Management Practices (BMPs) are within their power and jurisdiction.

(1) Conduct a site specific study (or non-site specific if the problem is wide-spread) to identify and isolate the cause(s) of the trigger stressor/source. If the trigger stressor or source is already known (e.g. toxicity), proceed directly to step 2;
(2) Identify and evaluate the effectiveness of options for controlling the cause(s) of the trigger stressor/source;
(3) Implement one or more controls; and
(4) Confirm the reduction of the cause(s) of trigger stressor/source.

This report documents ACCWP planning and implementation activities for a site-specific study as step 1 in development of a SSID project for the Dublin Creek watershed through December 2013. Further evaluation and project planning will continue in 2014.

The outline of this initial study is based on the Stressor Identification steps identified by the Causal Analysis/Diagnosis Decision Information System (CADDIS), an Internet-based tool[3] based on USEPA guidance (USEPA 2000)[4]:

1. Define the Case;
2. List Candidate Causes;
3. Evaluate Data from the Case;

[3] http://www.epa.gov/caddis/index.html

[4] The CADDIS is intended to be initiated following observations of a biological effect; however in this case the sediment quality concerns were triggered by chemical concentrations that were not accompanied by significant toxicity.

4. Evaluate Data from Elsewhere; and

5. Identify Probable Causes.

The Stressor Identification process may be iterative, and if the stressor cannot be adequately identified in the first attempt, the process may continue with collection of better data or testing other suspected stressors (USEPA, 2000).

2 Study Area &Background

This section provides background information regarding the Dublin Creek Watershed and its beneficial uses, as well as the RMC pollutant triggers reported from WY2013.

2.1.1 Dublin Creek

Site 204R00084 is located on Dublin Creek just west of the junction of Interstate Highways (I-) 580 and 680 in Dublin. At this location, Dublin Creek is within an area of mixed landuse and contains a variety of channel structures, both natural and artificial.

To the west (upstream) of Donlon Way, near the junction of Interstate Highway (I-) 580 and San Ramon Road the channel is predominantly natural, with some engineered channels interspersed within some residential housing developments. This upper portion of the creek includes two main branches that drain low density residential and rural landuses in portions of Dublin, Pleasanton and unincorporated Alameda County; it also crosses under I-580 twice and thus receives considerable runoff from the freeway. East of Donlon Way the creek is an engineered channel designated as the Zone 7 flood control channel “Line T”.

2.1.2 Beneficial Uses

Beneficial uses (SFRWQCB, 2011) assigned to Dublin Creek include:

- Warm freshwater habitat (WARM);
- Wildlife habitat (WILD); and
- Water Contact and Non-contact Recreation (REC-1 and REC-2). Public parks or other facilities allow access or approaches to sections of Dublin Creek.

2.2 Trigger Results from Water Year 2012 Creek Status Monitoring

Comparison of WY2012 sampling results with MRP trigger criteria are presented in

Table 2-1. Triggers for sediment quality were based on calculation of Threshold Effects Concentration (TEC) and Probable Effects Concentration (PEC) for each analyte as determined following MacDonald et al. (2000). It should be noted that there are some limitations in the MacDonald method as discussed in Appendix A.2 of IMR Part A, and partially reproduced below:

In assessing the effect of using one-half of the MDL in place of one-half of the MRL to estimate ND results for statistical purposes, relatively large differences were observed in some cases for the WY2012 assessments reported in the UCMR (BASMAA 2013), which have been recalculated for WY2013. Calculated TEC quotients for individual and total PAHs were lower across-the-board using the MDL due to the relatively large proportion of non detects and the difference between MDLs and MRLs reported. It should be noted that WY2012 analyses are predominantly non-detects, and therefore that the TEC quotients calculated are driven by the MDL rather than quantified laboratory results.

While MacDonald (2000) generated PECs for multiple trace element, PAH, organochlorine pesticide, and pyrethroid pesticide parameters, there was insufficient data at time of its publication to evaluate the consensus PECs generated as to their predictive ability for associated sediment toxicity for each of the analytes reported. Analytes for which predictive ability is particularly uncertain include various PAH (anthracene, fluorine, and fluoranthene) and organochlorine pesticide (dieldrin, DDDs, DDTs, endrin, heptachlor epoxide, and lindane) parameters (MacDonald, 2000).

When examining pyrethroids concentrations, a similar degree of uncertainty exists. Weston (2005) reported that predictions of sediment toxicity to *H. azteca* were supported by observed results for sites with TU ratios below one (little or no mortality) and above four (high or full mortality). For TUs between one and four, however, the predictive ability of the TU is less certain (Weston 2005).

Table 2-1. MRP Trigger(s) for potential follow-up and their environmental significance

Trigger type	Trigger status at site	Comment
"Triad" - bioassessment indication of alteration	IBI score Very Poor	Widespread in region, generally driven by habitat alteration
"Triad" - sediment chemistry	12 chemicals > Threshold Effects Concentration	TEC and PEC contributions by chemical groups: • PAHs - slightly elevated, • Pesticides (organochlorine) all somewhat elevated • Metals - slightly elevated for nickel, zinc, others
	Probable Effects Concentration: average Quotient not > 0.5	
	Pyrethroids calculated 1.06 >1 Toxic Unit Equivalent	
"Triad" - sediment toxicity	Not present or triggered	Pyrethroids likely not significant
Chlorine in water column	Low: 0.10 mg/l >0.08 on one of 2 occasions	Widespread in region; result is near limit of method detection
Toxicity in water column	Not present or triggered	Pyrethroids likely not significant
General Water Quality - DO	Not sampled	
General WQ - other	Not sampled	
Temperature	Not sampled	
Pathogen Indicators	Not sampled	

2.3 Review of Creek Status Data from Water Year 2012

Data collected during WY2012 Creek Status monitoring indicated elevated total metals based on MRP trigger criteria (Table 2-2). The highest metal concentrations were copper, lead and zinc.

Table 2-2. Creek Status Monitoring Results (WY2012) for Total Metals at Site 204R00084 (aka 204DUB005)

Total metal (mg/Kg dry weight)	Result
Mercury	0.13
Arsenic	5.4
Cadmium	0.62
Chromium	33

Copper	22
Lead	21
Nickel	30
Zinc	95

In addition, data from the 2012 RMC monitoring also indicated elevated concentrations of some organochlorine pesticides and bifenthrin (a pyrethroid) as indicated in Table 2-3.

Table 2-3. Creek Status Monitoring Results (WY2012) for Pesticides (Organochlorine and Pyrethroids) at Site 204R00084 (aka 204DUB005)

Organochlorine Pesticides	Result
4,4'-DDD (ng/g dry weight)	17
4,4'-DDT (ng/g dry weight)	9.2
Bifenthrin (ng/g dry weight)	2.5

PAHs were identified as being "somewhat elevated" in the MRP WY2012 monitoring, however this was based statistical evaluation of half the MRL being used in place of a non-detect result.

2.4 Preliminary Literature Review

This section is a preliminary summary of selected available data relating to sediment chemistry in California and provides an initial reference for data collected in the Dublin Creek SSID.

2.4.1 Alameda County Watershed 2000-2001 Sediment Sampling Program

This study reported on the results of a two year investigation (2000 and 2001) by ACCWP into sediment characteristics at 25 locations in Alameda County (ACCWP, 2002). Samples were analyzed for PCBs, total mercury, PAHs, selected pesticides and particle size. The study was designed to compile baseline data on pollutants of concern, identify sites for follow-up and as a potential assessment for sources and loads in the County watersheds.

Table 2-4. Summary of 2001 ACCWP Sediment Sampling Program (ACCWP, 2002)

Analyte	Minimum	Maximum	Average
PCBs (ug/kg)	0.5	762.6	119.9
Mercury (ng/g)	0.07	4.29	0.73
PAHs (ug/kg)	66	13,680	4710

Fines (%)	5.1	79.5	37.8

2.4.2 Joint Agency Sediment Sampling Program 2002

This program was a similar design to the ACCWP program described above but undertaken by six agencies (Kinnetic Laboratories Inc and EOA, 2002). The study focused on contaminants of concern associated with storm drains. A total of 61 samples were collected in the first year and 70 samples were collected in the second year. A summary of selected analytes is presented as average results in Table 2-5.

Table 2-5. Selected Summary of 2000 Joint Agency Sediment Sampling Program by Landuse (Kinnetic and EOA, 2002)

Analyte	Industrial	Residential/Commercial	Mixed	Open
Average Total PCBs (ug/kg)	4,460	2,220	720	9.4
Average Total Mercury (ng/g)	2.4	4.6	1.3	0.9
Average Total DDT	880	240	120	-

2.4.3 Stream Pollutant Trends (SPoT) Program

The Stream Pollutant Trends (SPoT) program (Hunt *et al*, 2012) is designed to measure long term trends in stream pollution in California. The study assesses land use types in relation to pollutants of concern and, over time, spatial and temporal trends. The summary report prepared in 2012 contains key findings that align with initial observations obtained from sediment analyses at the Dublin Creek SSID site.

- Total metal concentrations associated with urban runoff were generally found to be on average approximately 250ug/g (cadmium, copper, lead and zinc) compared with less than 200ug/g for agricultural and other landuses;
- Mercury concentrations in sediments associated with urban watersheds were approximately 0.1ug/g;
- DDT and PCB concentrations in urban watersheds were found to be approximately an order of magnitude higher than those found in agricultural watersheds;
- PAH concentrations were found to be, on average, approximately 1200ng/g in urban watersheds compared to averages of less than 50ng/g in agricultural watersheds;
- Bifenthrin was the most commonly detected pyrethroid in SPoT samples;

- Organic chemicals and fine sediments showed a significant correlation with TOC; and
- Trace metals tended to associate with finer sediments.

In addition, summary results from 2008-2010 were made available (Anderson *et al*, 2012) and are summarized in Table 3-1.

Table 2-6. Average Analyte Concentrations Detected Between 2008 and 2010 in SPoT Program (Anderson *et al*, 2012)

Analyte	Year	Average Concentration
Pyrethroids (ng/g)	2008	16.9
	2009	12.8
	2010	30.4
DDT (ng/g)	2008	31.8
	2009	77.8
	2010	12.1
PAHs (ng/g)	2008	757
	2009	1457
	2010	293
Metals (sum of cadmium, copper, lead, zinc) (µg/g)	2008	241
	2009	226
	2010	202

Overall findings of the SPoT program to date are that increased urban cover led to increased stream toxicity and higher concentrations of total DDTs, total PCBs, total PAHs metals and pyrethroids.

2.4.4 Department of Pesticide Regulation Study

Department of Pesticide Regulations (DPR) prepared data summaries pertaining to pesticide presence in California sediments and water (Zhang, 2010). The data were collected between 1993 and 2010 with a total of 8,834 water and 2,010 sediment data points collated. An overview summary of those sediment data are presented in Table 2-7.

Table 2-7. Summary of Detections of Pyrethroid in Sediments of California's urban waters (Zhang, 2010)

Analyte Name (ng/g)	Detection rate (%)	Minimum concentration detected	Maximum concentration detected
Bifenthrin	85.2	1.0	1,211
Cyfluthrin	55.0	1.1	992
Cypermethrin	41.4	0.6	940
Deltamethrin	35.6	1.1	78

Esfenvalerate	11.8	1.0	17
Fenpropathrin	0.9	14.7	14.7
Lamba-cyhalothrin	42.0	1.0	67
Permethrin	68.8	1.0	701
Resmethrin	5.9	3.6	8.9

2.4.5 Caltrans

Roadway runoff data collated by Caltrans, in "A Review of the Contaminants and Toxicity Associated with Particles in Stormwater Runoff, (Caltrans, 2003a) suggest that particle size fraction is strongly correlated with concentrations of contaminants. In the Caltrans study, copper, lead and zinc were found to be strongly associated with particulate fraction, with concentrations of these metals generally increasing with decreasing particle size. Only cadmium was found to be uniformly distributed throughout different particle sizes.

3 Study Design and Monitoring Methods

3.1 Study Questions

The study questions presented in Table 3-1 are based on the preliminary conceptual model and review of historical data relevant to the site.

Table 3-1. Study Questions Developed for the Dublin Creek Stressor Source Identification Study

Question	Study Method	Expected outcome
Do available data identify potential sources of stressors?	Addressed as desk top only. Assessed available data and recorded temporal and spatial trends.	Understanding of data gaps, historical trends, and previous analysis methods. Understanding of potential stressors identified in previous studies/monitoring.
Is the freeway a significant source of stressors such as metals and PAHs, in comparison to the rest of the urban area?	Addressed through sediment sampling at seven sites and comparison of bioassessment from two sites (one assessed in WY12 and one in WY13).	Addresses hypothesis that freeway indicators (metals, PAHs) will be higher at downstream sites (i.e. 204DUB040 and 204DUB005) compared with rural/urban landuse sites (i.e. 204DUB060). Assesses hypothesis that differences in bioassessment may be attributable to the freeway (assuming channel hydromodification differences can be eliminated as cause)
Are sources of legacy pesticides more associated with urban or rural landuse areas?	Addressed through sediment sampling and bioassessment.	Addresses hypothesis that landuse will contribute varying concentrations of pollutants.

3.1.1 Conceptual Model of Sources and Processes in the Dublin Watershed

As part of the initial project scoping, a conceptual model was outlined for relevant processes and potential sources in the watershed draining to the original creek status monitoring site. Purposes of the conceptual model included:

- Generation of hypotheses to be tested in the site-specific study; and
- Provide information for preliminary SSID project planning.

Figure 3-1 presents a schematic of the creek system in Dublin with illustration of channelization and hydromodification as well as general watershed landuses.

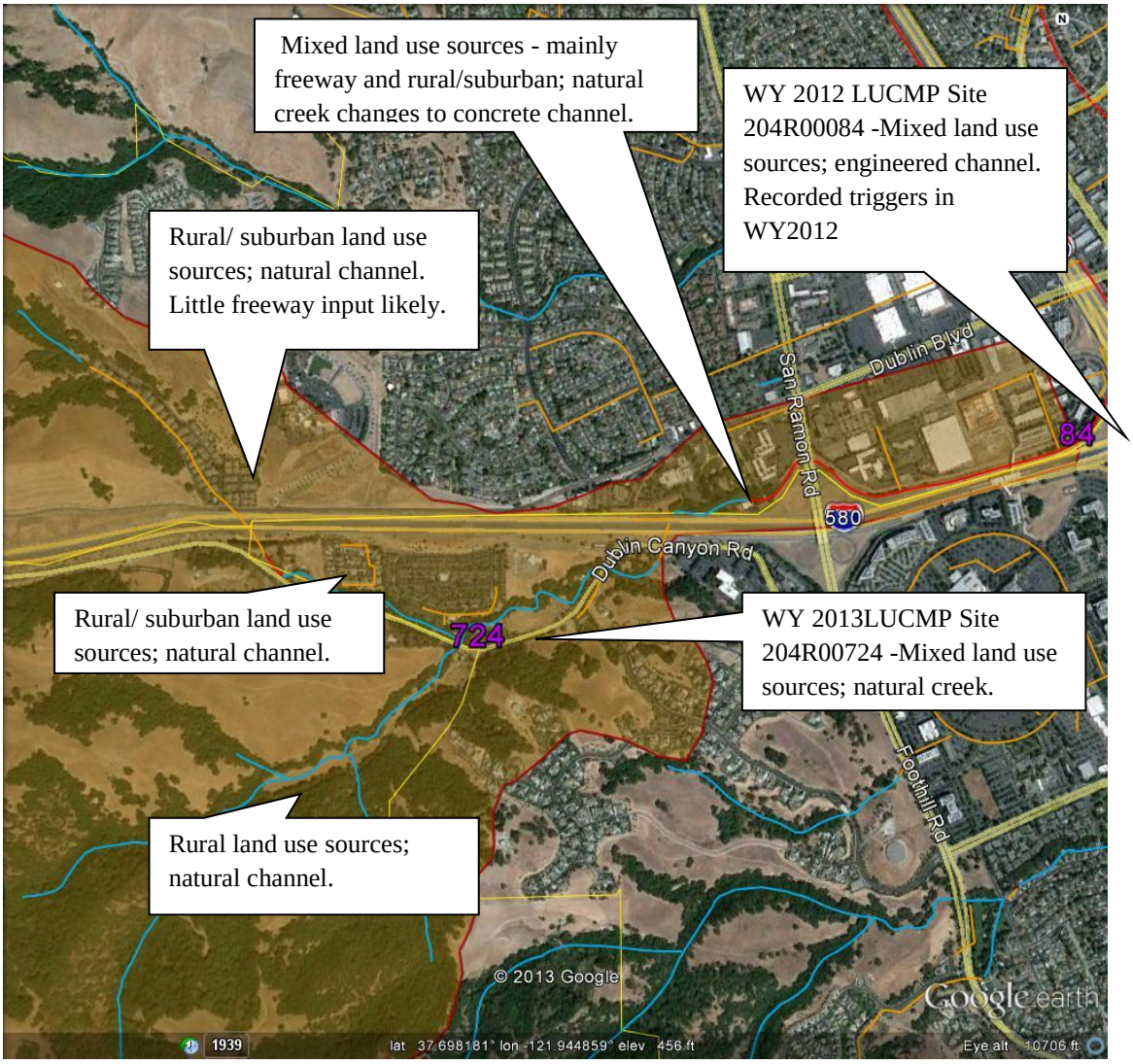

Figure 3-1. Conceptual Model of Candidate Causal Stressors for Site 204R00084

Figure 3-2 presents an initial conceptual model of potential causes, process, potential impacts and observed impacts developed for the Dublin Creek SSID project. The conceptual model is developed based on the guidance provided in CADDIS. The potential stressors identified in the watershed leading to the study area were mixed landuse discharges, urban runoff, freeway runoff and hydromodification of the channel. Discharges from these identified sources could lead to the observed sediment characteristics observed in WY2012.

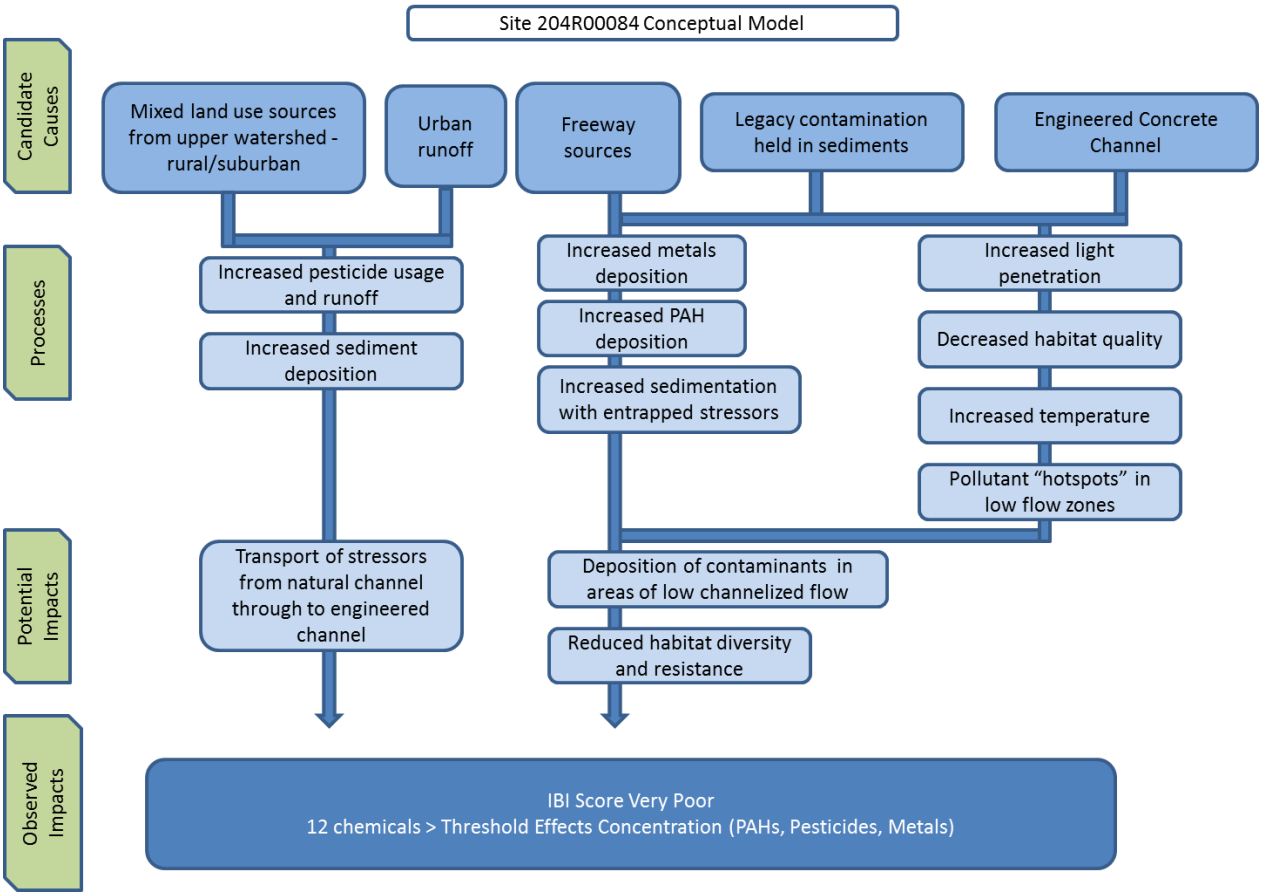

Figure 3-2. Conceptual Model and Processes for Site 204R00084

3.2 Monitoring and Sampling Locations

Based on the conceptual models proposed in Section 3.1.2, the following sampling plan was designed to assess the potential source stressors initially identified at the Dublin Creek Site 204R00084. The sampling locations and sampling strategies in the Dublin Creek Watershed in WY2013 are presented in Table 3-2 and Table 3-3 respectively.

Table 3-2. Monitoring Locations and Sampling for Dublin Creek SSID.

Site	Site Description
204DUB005 (aka 204R00084)	Original RMC sampling location: also known as 204204R00084. Mixed commercial and industrial landuses (downtown area) adjacent to engineered channel at base of watershed
204DUB030	Slightly upstream of, but similar to, 204DUB005. Mixed landuse adjacent to concrete channel
204DUB040	Uppermost main stem site downstream of the lower culverted segment under freeway. Limited adjacent area of commercial, industrial and park land uses; mixed rural and suburban sources to culvert from upper watershed; natural channel.
204DUB055	2013 RMC Creek Status Site 204R00724 on main stem just downstream of confluence with Devaney Canyon branch; integrates land use sources from the branches at 204DUB060 and 204DUB080. Natural channel confluence with Devaney Canyon branch
204DUB060	Devaney Canyon branch above its confluence with main stem; unincorporated agricultural and former agricultural land use. Mostly natural channel (sediment sample composited from culvert under Dublin Canyon Rd. and pool downstream of culvert).
204DUB080	Main stem Dublin Creek above confluence with Devaney Canyon. Mixed rural and medium density residential landuse, and freeway runoff sources
204DUB090	Main stem Dublin Creek downstream of upper culvert under freeway-- sources from upper watershed include mixed residential and open landuses. For comparison with 204DUB040. Only to be analyzed if downstream sites show variability.

Table 3-3. Monitoring Locations and Sampling for Dublin Creek SSID.

			Sediment sampling							
Site Code	**Latitude**	**Longitude**	**Available sampling and notes for 2013 sampling**	**Pyrethroids**	**Total metals + mercury**	**Organochlorine pesticides**	**Polycyclic Aromatic Hydrocarbons (PAHs)**	**% fines**	**Total Organic Carbon (TOC)**	**Bioassessment**
204DUB005 (aka 204R00084)	37.70100	-121.92537	RMC data WY12 for sediments and bio-assessment + WY13 sediment		X		X	X		
204DUB030	37.69932	-121.93290	WY13	X	X	X	X	X	X	
204DUB040	37.69921	-121.93824	WY13	X	X	X	X	X	X	X
204DUB055	37.69496	-121.94837	WY13	X	X	X	X	X		
204DUB060	37.69473	-121.94862	WY13		X	X	X	X		
204DUB080	37.69522	-121.94890	WY13		X	X	X	X	X	
204DUB090	37.69655	-121.9530	WY13 (archived sample)		X	X	X	X		

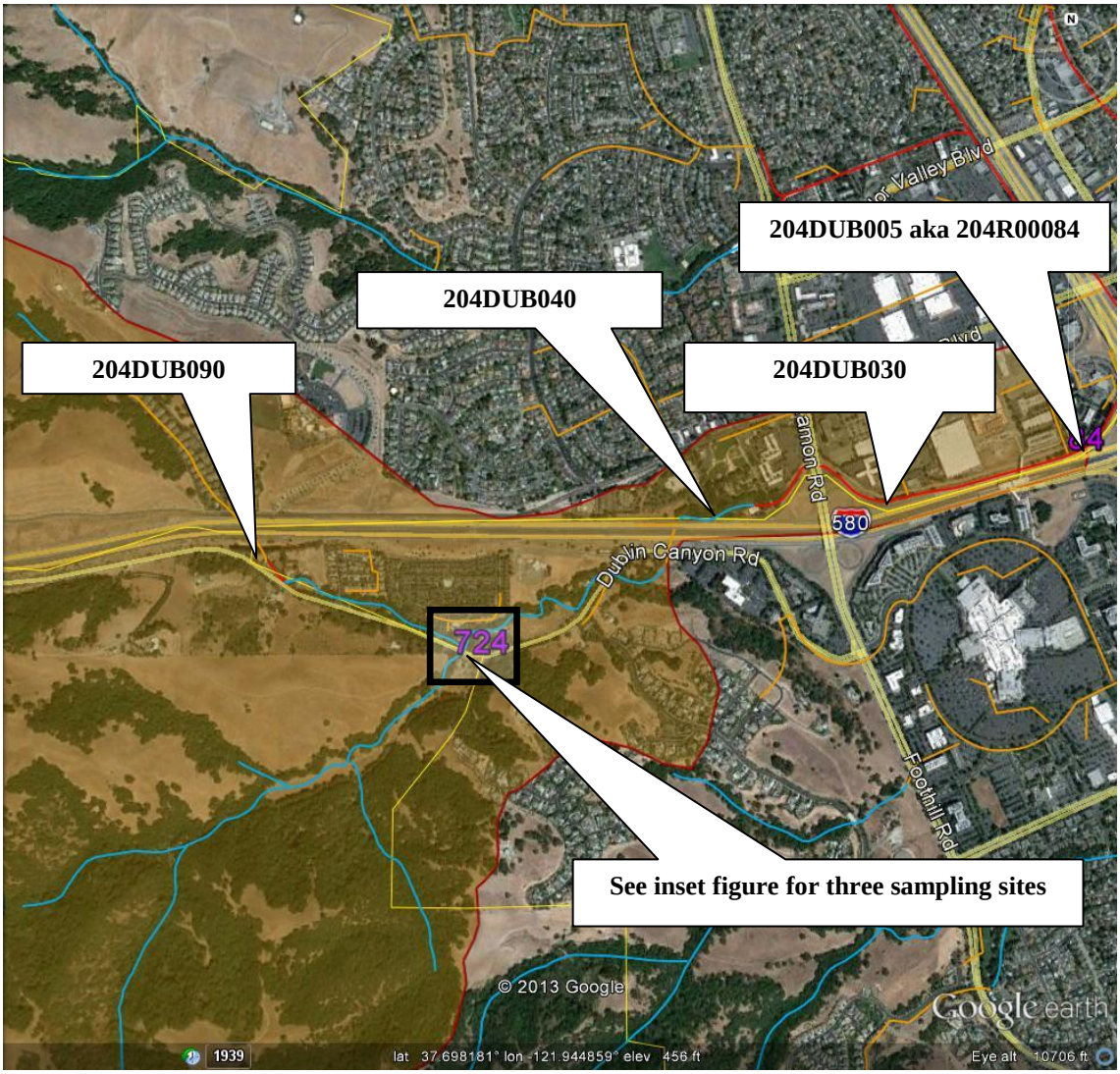

Figure 3-3. Monitoring Locations for Source Identification in Dublin Watershed

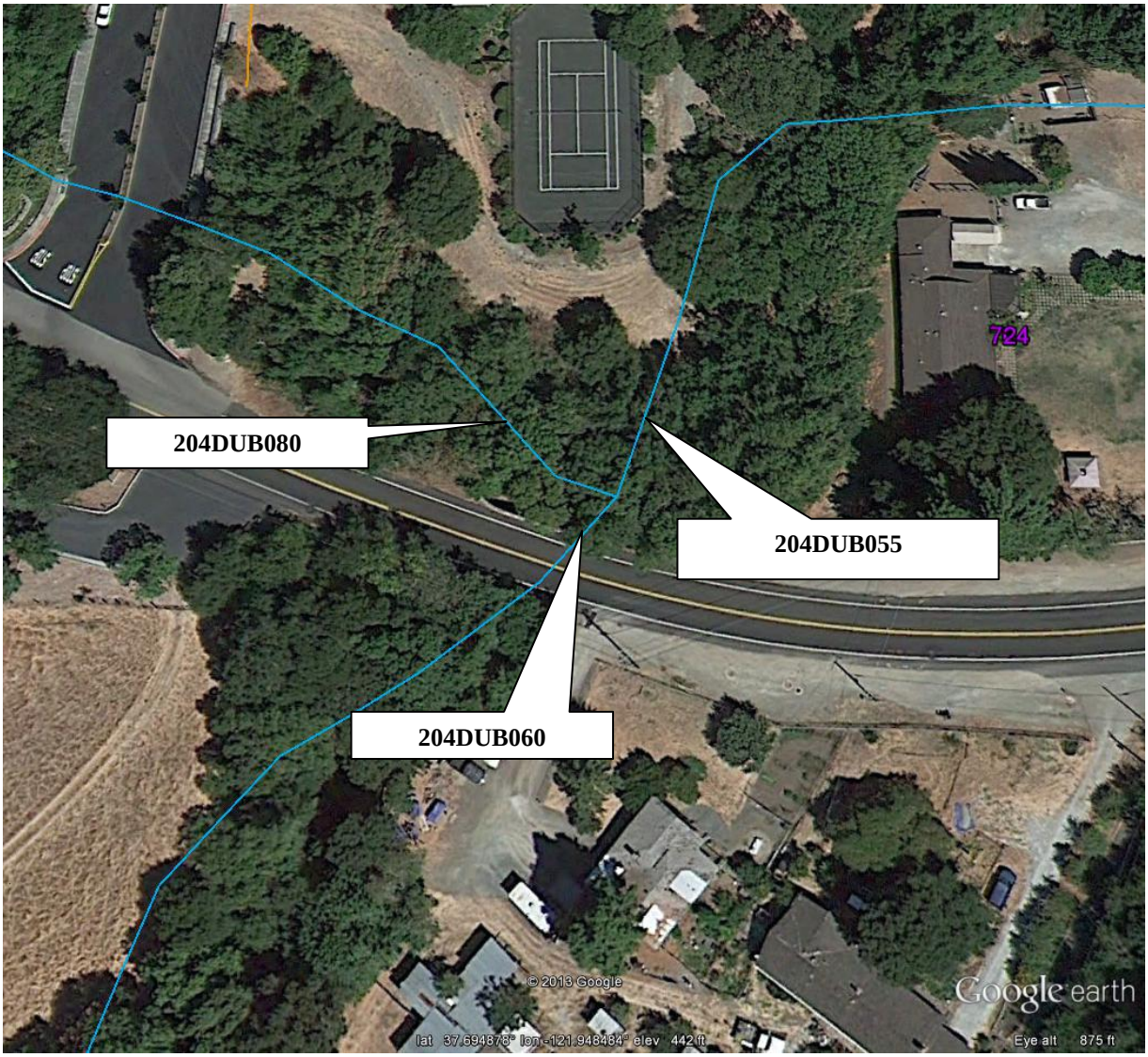

Figure 3-4. Inset Monitoring Locations for 204DUB055, 204DUB060 and 204DUB080

3.3 Data Collection Methods

Field data were collected in accordance with SWAMP-comparable methods and procedures described in the BASMAA RMC QAPP BASMAA 2012a, 2014a) and SOP (BASMAA 2012b, 2014b). These documents were provided in final draft form to the Water Board with earlier RMC Monitoring Status Reports and were revised in WY2013 to reflect lessons learned through WY2012 implementation; these revisions also incorporate updated data Quality Assurance

procedures consistent with added data checking functions of the RMC database to supplement the tools available through SWAMP. RMC Standard Operating Procedures (SOPs) are listed in Table 1-1.

This section provides a brief overview of methods employed to measure each parameter in the targeted monitoring design. Greater detail on each method is included in the referenced SOPs.

Biological assessment sampling was conducted on May 21, 2013 at Site 204R00724 as part of the RMC probabilistic sampling design for Creek Status Monitoring. Bioassessment sampling was conducted on May 30, 2013 at 204DUB040 solely for the purpose of this project and was limited to benthic macroinvertebrate sampling (i.e. no algae sampling). All bedded sediment sampling was performed on July 9, 2013.

All samples were processed and sent to the same laboratories as those used in the RMC program. Data were analyzed and reported per SWAMP-comparable methods as described in the RMC QAPP (BASMAA 2012a and BASMAA 2014a). Analytical laboratory methods, reporting limits and holding times for chemical water quality parameters are also reported in BASMAA (2012a and 2014a).

3.4 Data Quality Assessment Procedures

Following completion of the field and laboratory work, the field data sheets and laboratory reports were reviewed by ACCWP and compared both against the methods and protocols specified in the SOPs and Quality Assurance Project Plan (QAPP) (BASMAA, 2012a, BASMAA 2012b, BASMAA 2014a and BASMAA 2014b).

3.5 Data Analysis and Interpretation

Sediment chemistry results were evaluated spatially (in comparison with results collected within this study at different sites) and temporally (in comparison with sampled collected in WY2012) to test hypotheses regarding the contributions from potential stressor sources in the conceptual model.

Biological community condition indices and sediment chemistry results were evaluated in comparison with other sites and available data to test the initial hypotheses regarding the contributions from potential stressor sources in the conceptual model. Refer to Sections 4 and 5 respectively.

4 Results

4.1 Statement of Data Quality

Field data sheets and laboratory reports were reviewed by ACCWP and the results evaluated against the relevant Data Quality Objectives (DQOs) as described in the QAPP (BASMAA, 2012a, 2014a) and SOPs (BASMAA, 2012b, 2014b).

4.2 Monitoring Results

This section provides summaries of the results of sediment analysis are Dublin Creek sampling locations. Full data are provided in Attachment A.

4.2.1 Sediment Particle Size Distribution

Analysis of the particle size distribution present in the Dublin Creek system at the various sampling locations (Figure 4-1) indicated that highest percentages of small grain size (silts and clays) were found at the downstream Site 204DUB005 (aka 204204R00084) in both 2012 and 2013. A high proportion of small grain sizes was also found at Site 204DUB060, which receives predominantly rural discharges. The highest proportions of larger grain sizes (pebbles and granules) were found at Site 204DUB080, an upstream location which has mixed rural and low density residential landuse. Site 204DUB005, the furthest downstream sampling location, had the highest proportions of finer silts clays and sands. Overall, the sites within the Dublin systems were characterized as predominantly sands and silts.

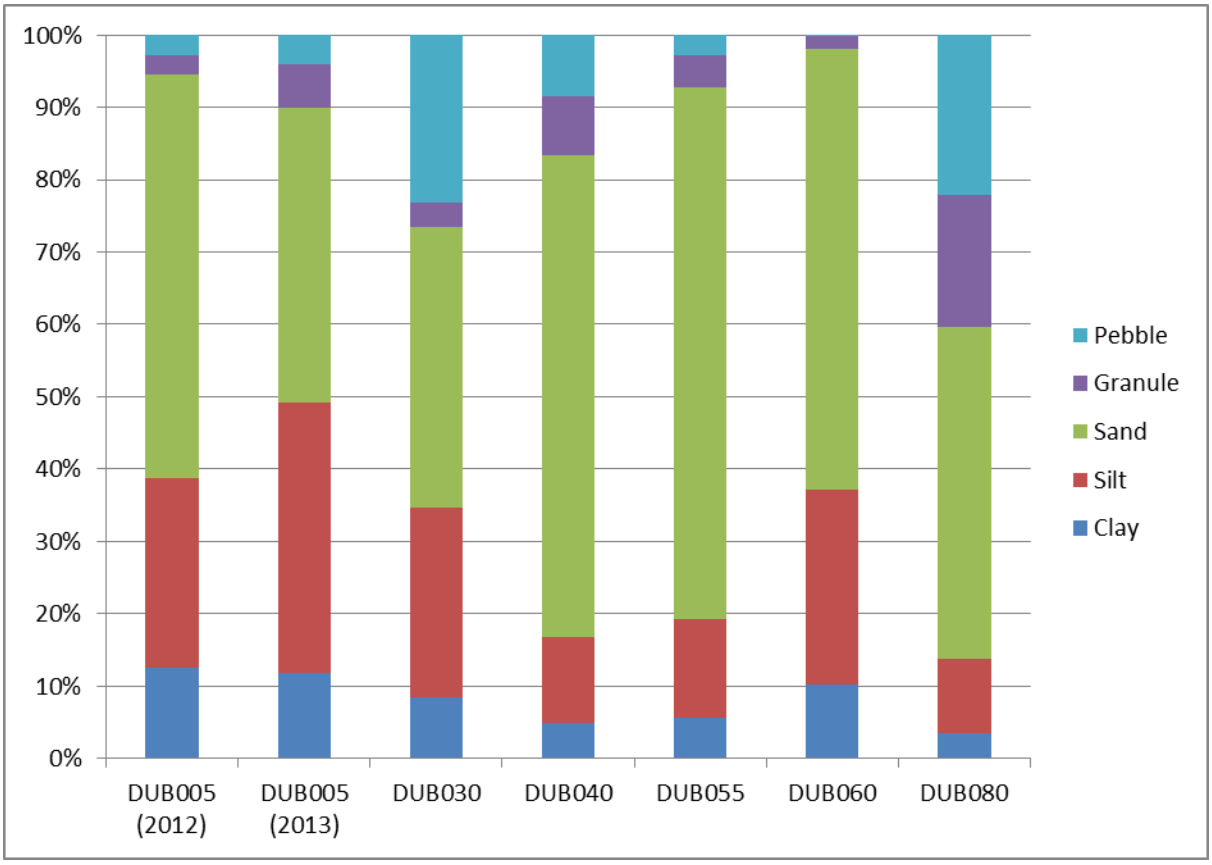

Figure 4-1. Distribution of Particle Sizes at Dublin Creek Sampling Sites.

4.2.2 Bioassessment

Taxonomic results were used to calculate condition scores according to the Southern California (SoCal) Benthic Macroinvertebrate Index of Biotic Integrity (B-IBI) and the California Stream Condition Index (CSCI) as described in more detail in IMR Appendix A.1. Descriptive categories are assigned to various ranges of B-IBI or CSCI scores but at this point the scores are not associated with regulatory outcomes or water quality standards.

Bioassessment condition scores for both the SoCal B-IBI and CSCI were lower for Site 204R00084, reflecting its highly modified channel in contrast to relatively natural conditions at the other two sites. The SoCal B-IBI reflected this difference in assigning a condition category of "Very Poor" to Site 204R00084 while Site 204DUB040 and Site 204R00724 were considered "Poor". However, the CSCI condition category was "Fair" for all three sites. The numeric score for Site 204R00724 was slightly lower than Site 204DUB040 for both the SoCal B-IBI and CSCI. While this difference may not be significant, the non-perennial flow status at Site 204R00724 may affect its condition scores since the IBI and CSCI methods were designed for perennial streams.

4.2.3 Total Organic Carbon

Three sites were chosen for Total Organic Carbon (TOC) analysis in order to assess potential impact of residential and commercial landuse (Table 4-1). The lowest TOC was associated with an upstream, low density residential and rural landuse location, Site 204DUB080, which recorded 0.75 % dry weight. The highest TOC percentage was associated with the downstream mixed commercial landuse within an engineered concrete channel (Site 204DUB030) was recorded as 2.1% dry weight. Site 204DUB040 was located between these two sites and recorded a result of 0.85 % dry weight. These results are in line with those recorded at Site 204DUB005 (Site 204R00084) in WY2012 and indicate little difference between the upstream sites.

Table 4-1. Total Organic Carbon Results

Sample Identification	TOC (% dry weight)
204204R00084 (2012)	1.3
204DUB030	2.1
204DUB040	0.85
204DUB080	0.75

4.2.4 Pyrethroids

All pyrethroids were below detection limits, with the exception of bifenthrin (as presented in Table 4-2). The results suggest that there is a uniform distribution of low concentrations of bifenthrin in the Dublin Creek system with a trend towards lower concentrations upstream of the site (Site 204R00084) initially targeted for SSID investigation. The pyrethroid concentrations reported in the Dublin Creek analyses are lower than the averages reported in the literature (Anderson *et al*, 2012 and TDC, 2010) as well as at the Castro Valley Creek site 204R00047 (See Appendix A.4B to IMR Part A for additional review of results from other regional and state sediment samples).

Table 4-2. Pyrethroid Results

Pyrethroid (ng/g)	204DUB005 (204R00084) (2012)	204DUB030	204DUB040	204DUB055
Bifenthrin	2.5	0.49	0.5	0.32

4.2.5 Total Metals

Total metal concentrations are presented in Table 4-3. At the downstream site, Site 204DUB005, the results of the WY2012 and WY2013 sampling indicated higher concentrations of chromium, mercury, nickel, copper and lead compared to other upstream sites. The highest concentrations of arsenic, cadmium, lead and zinc were found at the upstream site, Site 204DUB080. The combined totals of cadmium, copper, lead and zinc are lower than those averages found in the SPoT study (Anderson *et al*, 2012).

Table 4-3. Total Metal Results

Total Metal (mg/kg)	204DUB005 (204R00084) (2012)	204DUB005 (204R00084) (2013)	204DUB030	204DUB040	204DUB055	204DUB060	204DUB080
Arsenic	5.4	7.3	6.1	9.2	9.9	7.4	16
Cadmium	0.62	0.48	0.77	0.72	0.74	0.38	1.4
Chromium	33	38	31	30	32	31	32
Copper	22	27	23	19	21	22	21
Lead	21	29	24	17	24	16	31
Mercury	0.037	0.037	0.035	0.035	0.034	0.049	0.028
Nickel	30	42	39	39	41	33	40
Zinc	95	77	100	90	92	110	120

4.2.6 Organochlorine Pesticides

All organochlorine pesticide results above detection limits are presented in Table 4-4.The results suggest that the highest pesticide concentrations were associated with the upstream historically more rural sites such as 204DUB060.

Table 4-4. Organochlorine Pesticide Results

	204DUB005 (204R00084) (2012)	204DUB030	204DUB040	204DUB055	204DUB060	204DUB080
2,4'-DDE (ng/g)	17	ND	ND	ND	ND	ND
4,4'-DDD	ND	ND	1.9	1.8	22	ND
4,4'-DDE (ng/g)	ND	ND	3.6	ND	4.0	ND
4,4'-DDT (ng/g)	ND	ND	ND	ND	11	ND

4.2.7 PAHs

Polycyclic aromatic hydrocarbons (PAHs) reported above the detection limit are presented in Table 4-5. The results suggest that Site 204DUB080, the upstream rural landuse site, had slightly higher concentrations of PAHs compared to other sites.

Table 4-5. Polycyclic Aromatic Hydrocarbon Results

PAH (ng/g)	204DUB005 (204R00084) (2012)	204DUB005 (204R00084) (2013)	204DUB 030	204DUB 040	204DUB 055	204DUB 060	204DUB 080
Benzo(a)anthracene	ND	13	43	33	14	J13	110
Benzo(a)pyrene	ND	11	34	27	ND	ND	26
Benzo(a)fluoranthene	ND	5.2	48	42	14	ND	63
Benzo(a)pyrene	ND	7	30	29	12	ND	29
Benzo(g,h,i)perylene	ND	ND	55	39	ND	ND	36
Benzo(k)fluoranthene	ND	5.2	17	19	ND	ND	21
Chrysene	ND	23	66	55	15	ND	76
2,6-Dimethylnapthalene	ND	23	64	ND	ND	ND	ND
Fluoanthene	J62	21	94	69	17	ND	130

Indeno(1,2,3-cd)pyrene	ND	ND	39	36	ND	ND	26
Perylene	ND	ND	ND	J10	ND	ND	12
Phenanthrene	ND	9.5	25	17	J7.3	ND	17
Pyrene	J71	25	100	68	19	ND	130
Percent solids (%)	71	-	65	91	94	71	90

5 Discussion

5.1 Overall findings

The following general trends and overall findings are based on the results of this monitoring:

- Particle size: Site 204DUB060 (predominantly rural landuse) had the smallest overall grain sizes (clays, silts and sand) of the sites assessed. The largest grain sizes (pebbles and granules) were associated with the Site 204DUB080 (mixed low density, freeway and rural landuse).
- Total Organic Carbon: Highest TOC was recorded at Site 204R030. There was no substantial difference between TOC concentrations at the three sites assessed.
- Pyrethroids: Bifenthrin was the only pyrethroid recorded at concentrations above detection limits in this study. This is consistent with published literature which finds bifenthrin to be the most common pyrethroid in sediments (Anderson *et al*, 2012). Compared with DPR investigations, the results presented here are very much lower than average concentrations found in other Californian sediments (Zhang, 2010).There was no observed difference between concentrations of pyrethroids at the three sites monitored.
- Organochlorine pesticides: In comparison with sediment results published in the literature, the results from the Dublin study suggest low concentrations of organochlorine pesticide presence (Kinnetic Laboratories and EOA, 2002 and Anderson *et al*, 2012). Of the Dublin sites investigated, Site 204DUB060 recorded the highest organochlorine pesticide concentrations.
- Metals: In general metal concentrations were similar to average concentrations found in the SPoT program (Anderson *et al*, 2012). Mercury concentrations were much lower than averages recorded in the joint Agency Program from 2002. Compared with the other sites investigated in this study, Sites 204DUB005 and 204DUB080 had generally higher concentrations of metals compared with other sites monitored in WY2013.
- PAHs: PAH concentrations were lower than those averages reported in the SPoT program (Anderson *et* al, 2012) and the Alameda County Sediment sampling program results from 2002 (ACCWP, 2002). In comparison to the other sites investigated in this study, Site 204DUB080 had higher concentrations of PAHs.
- Bioassessment: Sites in different zones of the watershed all showed relatively low condition scores compared to undeveloped reference conditions. Habitat modification due to urbanization is the main source of biological community alteration, especially for highly modified channels but also where natural channels have experienced changes due to increased watershed imperviousness and nearby roads (e.g. Schuler, 2004, SFBRWQCB 2012).

5.1.1 Results by Sampling Location

204DUB005: This site is the most downstream location monitored in this study and receives runoff from freeway discharges and upstream rural landuse as well as residential and more local commercial areas. Two samples were compared at this site: one from WY2012 and the other from WY2013. PAHs, metals and TOC were compared at this site. The metals results indicated that, compared with results from WY2012, the WY2013 concentrations were higher for arsenic, cadmium, chromium, copper and lead. PAH results from WY2013 were generally higher than those detected during WY2013. These two samples, from the same site, accounted for the highest concentrations of chromium, copper, nickel and mercury of the total samples collected, suggesting downstream accumulation of mixed landuse discharges. Data from the SPoT program suggests that the prevalence of finer sediments at this downstream site might contribute to the migration of metals to this location.

204DUB030: This site is directly upstream of the 204DUB005 location and is an engineered channel. The landuse is characterized by freeway runoff, as well as adjacent commercial landuse downstream of San Ramon Road. There were higher proportions of larger grain sizes at this downstream site compared to upstream locations. This site was also found to have elevated levels of copper, lead, nickel and zinc compared with the other sites sampled. PAHs were generally higher at this site compared to the upstream locations. Overall, the results suggested that sediment chemistry at this downstream location was impacted by a combination of upstream sources including commercial, freeway and residential landuses.

204DUB040: This site is a natural channel located upstream of Site 204DUB030 and collects runoff from adjacent freeway discharges as well as from rural and suburban discharges. Grain size at this site was found to be a mix of predominantly sand-sized particles. This site had the lowest TOC and was in the mid-range (of the sampled sites) for metal, PAH and pesticide concentrations.

204DUB055: This site is below the confluence of the Devaney Canyon branch, below sites 204DUB060 and 204DUB080. It therefore receives both rural and low density residential flows. Results suggested the presence of PAHs, as well as elevated concentrations of some pesticides.

204DUB060: This site is predominantly rural landuse discharging into a natural channel. Notable results from this site included some elevated PAH results and some of the highest organochlorine pesticide concentrations. Metal concentrations were generally lower than those reported at other sites.

204DUB080: This site is a natural channel with runoff from rural land as well as some suburban properties. This site reported some of the highest PAH concentrations. In addition, the highest concentrations of arsenic, cadmium, lead and zinc were recorded at this site. Interestingly, based on published findings, the larger particle size analysis would tend to be associated with lower

metal concentrations. The highest concentrations of lead and zinc were found at Site 204DUB080 where larger particle sizes were also found.

5.2 Assessment of Study Questions

Do available data identify potential sources of stressors?

Monitoring results from WY2012 suggest the presence of elevated nickel and zinc, as well as some elevation in PAHs. These are suggestive of sources from urbanized landuse. Comparison of data from WY2012 and WY2013 suggest some inconclusive differences in metals concentrations, and PAHs. Further temporal and spatial evaluation would be needed to definitively associate these pollutants with specific land uses. Bioassessment data support observations elsewhere that degradation of stream communities begins as watershed imperviousness reaches 5-10% (e.g. Schuler, 2004, SFBRWQCB 2012), which occurs prior to most urban development (Anderson *et al*, 2012). Studies of Southern California streams by Coleman et al. (2005) suggest that arid-climate ephemeral to intermittent streams are more sensitive to slight changes in impervious area within their watersheds, compared to perennial streams for which assessment indices such as the IBIs or CSCI are designed.

Is the freeway a significant source of stressors such as metals and PAHs, in comparison to the rest of the urban area?

The results of this study do not provide enough evidence to suggest that freeways are impacting surrounding water quality in Dublin Creek. Site 204DUB080 is downstream of a predominantly rural watershed and the I-580. The results from this site suggested elevated concentrations of PAHs and metals. However, other sites, downstream of further channel crossings with the freeway, did not record PAH or metals concentrations of similar elevation.

Caltrans has reported elevated metal concentrations in highway facilities with the majority of metals present in the particulate fraction (Caltrans, 2003). Caltrans studies found significant variation attributable to landuse with agriculture, transport and commercial contributing higher metal concentrations.

Are sources of legacy pesticides more associated with urban or rural landuse areas?

One site, 204DUB060, recorded elevated organochlorine pesticide concentrations. This site drains a predominantly rural subwatershed with present and past agricultural land uses as well as some urbanization.

Overall, the results of this preliminary investigation are inconclusive in terms of identifying sources. The concentrations of contaminants found in the sediments, in comparison with

published literature, suggest pollutant levels are similar to, or less than, those in other urbanized areas in California.

5.3 Next Steps

5.3.1 Site-Specific Study

ACCWP will review these initial results with affected Permittees and other watershed stakeholders to identify additional sources of data or information, and clarify roles and responsibilities for further steps in the SSID project.

Further technical studies may be implemented to support this review, and to identify measures of effectiveness to confirm reduction of the stressors or sources.

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7 Attachments

Attachment A: Full Analytical Data for Dublin Creek SSID

Metal	204DUB030	204DUB040	204DUB055	204DUB060	204DUB080
Arsenic	6.1	18.6	9.9	7.4	16
Cadmium	0.77	1.46	0.74	0.38	1.4
Chromium	31	63	32	31	32
Copper	23	42	21	22	21
Lead	24	50	24	16	31
Mercury	0.035	0.062	0.034	0.049	0.028
Nickel	39	81	41	33	40
Zinc	100	186	92	110	120
PAH	204DUB030	204DUB040	204DUB055	204DUB060	204DUB080
Acenaphthene	ND	ND	ND	ND	ND
Acenaphthylene	ND	ND	ND	ND	ND
Anthracene	ND	ND	ND	ND	ND
Benz(a)anthracene	43	61	14	13	110
Benzo(a)pyrene	34	42	ND	ND	26
Benzo(b)fluoranthene	48	67	14	ND	63
Benzo(e)pyrene	30	44	12	ND	29
Benzo(g,h,i)perylene	55	54	ND	ND	36
Benzo(k)fluoranthene	17	30	ND	ND	21
Chlordene, cis-	ND	ND	ND	ND	ND
Chlordene, trans-	ND	ND	ND	ND	ND
Chrysene	66	88	15	ND	76
Dibenz(a,h)anthracene	ND	ND	ND	ND	ND
Dibenzothiophene	ND	ND	ND	ND	ND
Dimethylnaphthalene, 2,6-	64	ND	ND	ND	ND
Fluoranthene	94	113	17	ND	130
Fluorene	ND	ND	ND	ND	ND
Indeno(1,2,3-c,d)pyrene	39	49	ND	ND	26
Methylnaphthalene, 1-	ND	ND	ND	ND	ND
Methylnaphthalene, 2-	ND	ND	ND	ND	ND
Methylphenanthrene, 1-	ND	ND	ND	ND	ND
Naphthalene	ND	ND	ND	ND	ND
Perylene	ND	3.5	ND	ND	12
Phenanthrene	25	26.9	7.3	ND	17
Pyrene	100	104	19	ND	130
Pyrthroids	**204DUB030**	**204DUB040**	**204DUB055**		

Bifenthrin	0.49	0.5	0.12		
Cyfluthrin, total	ND	0.23	ND		
Cyhalothrin, lambda, total	ND	ND	ND		
Cypermethrin, total	ND	ND	ND		
Deltamethrin/Tralomethrin	0.35	ND	ND		
Permethrin, cis-	ND	ND	ND		
Permethrin, trans-	ND	ND	ND		
Organochlorine Pesticides	**204DUB030**	**204DUB040**	**204DUB055**	**204DUB060**	**204DUB080**
DDD(o,p')	ND	ND	ND	ND	ND
DDD(p,p')	-2.3	3.7	1.8	22	ND
DDE(o,p')	ND	ND	ND	ND	ND
DDE(p,p')	ND	6.7	ND	4	ND
DDT(o,p')	ND	ND	ND	ND	ND
DDT(p,p')	ND	ND	ND	11	ND
Dieldrin	ND	ND	ND	ND	ND
Endrin	ND	ND	ND	ND	ND

ALAMEDA COUNTYWIDE CLEAN WATER PROGRAM

STRESSOR SOURCE IDENTIFICATION PROJECT: CASTRO VALLEY CREEK SITE 204R00047 – SEDIMENT QUALITY

WATER YEAR 2013 PROGRESS REPORT

INTEGRATED MONITORING REPORT, PART A - APPENDIX A.4B

Berkeley
Dublin
Emeryville
Fremont
Hayward
Livermore
Newark
Oakland
Piedmont
Pleasanton
San Leandro
Union City
County of Alameda
Alameda County Flood Control and Water Conservation District
Zone 7 Water Agency

Report prepared by
Alameda Countywide Clean Water Program
399 Elmhurst Street,
Hayward, California 94544

To Be Submitted to:
California Regional Water Quality Control Board, San Francisco Bay Region

FINAL
March 13, 2014

Protecting Alameda County Creeks, Wetlands & the Bay

List of Acronyms

Acronym	Definition
AMS	Applied Marine Sciences
ACCWP	Alameda Countywide Clean Water Program
BASMAA	Bay Area Stormwater Management Agencies Association
BMP	Best Management Practice
DPR	Department of Pesticide Regulation
DQO	Data Quality Objective
I-	Interstate Highway
IBI	Index of Biotic Integrity
LUCMP	Local Urban Creek Monitoring Program
MRP	Municipal Regional Stormwater Permit
NPDES	National Pollutant Discharge Elimination System
PAH	Polycyclic Aromatic Hydrocarbon
PEC	Probable Effects Concentration
QAPP	Quality Assurance Project Plan
RMC	Regional Monitoring Coalition
RMP	Regional Monitoring Program
RWQCB	Regional Water Quality Control Board
SFBRWQCB	San Francisco Bay Regional Water Quality Control Board
SSID	Stressor/Source Identification
SOP	Standard Operating Procedure
SPoT	Stream Pollutant Trends
SWAMP	Surface Water Ambient Monitoring Program
TEC	Threshold Effect Concentration
TOC	Total Organic Carbon
USA	Unified Stream Assessment
WY	Water Year

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Attachment A: Full Analytical Data for Castro Valley SSID

Executive Summary

Stressor/Source Identification (SSID) Projects are required by Provision C.8.d.i of the Municipal Regional Stormwater Permit (MRP). SSID projects are initiated as a result of triggers as indicated in MRP Table 8.1.

In Water Year (WY) 2012, three sites were identified as candidates for ACCWP SSID projects based on analysis of results for stressor triggers. This progress report presents the initial results of a site-specific Stressor Source Identification (SSID) into potential sources of stressors affecting sediment quality at the Castro Valley Site 204R00047.

The Stressor Identification process may be iterative, and, if the stressor cannot be adequately identified in the first attempt, the process may continue with collection of better data or testing other suspected stressors (USEPA, 2000).

In order to assess the potential stressor sources within the study area in the Castro Valley watershed, a sediment sampling event was undertaken on July 9, 2013. A total of five samples were collected and analyzed for:

- Pyrethroids;
- Total metals including mercury;
- Organochlorine pesticides;
- Polycyclic Aromatic Hydrocarbons (PAHs);
- Percent fines; and
- Total organic carbon.

The following findings are based on the results of this preliminary monitoring:

- Pyrethroids were slightly higher in the eastern (mostly culverted) branch of Castro Valley Creek suggesting sources from the urbanized areas upstream. These results are consistent with published findings that pyrethroid concentrations increase with urbanization (Anderson *et al*, 2012, TDC, 2010a and 2010b). Bifenthrin was the most commonly found pyrethroid in the watershed .This result is consistent with other state and regional findings. However, pyrethroid concentrations in this study were lower than those reported as average concentrations in the SPoT program (Anderson *et al*, 2010) and by DPR (Zhang, 2010).
- PAH concentrations were lower than the averages found in other parts of the Alameda County (ACCWP, 2002) but generally higher than those found in Castro Valley sediment samples in 1989-1991. In this study, the highest PAH concentrations were found in the most downstream site (Site 204CVY090).
- Metal concentrations were generally comparable to concentrations found in Castro Valley sediments in 1989-1991. Mercury concentrations were lower than those found in Alameda County sediments (ACCWP. 2002). The upper western branch of the Castro

Valley Creek, above the commercial landuse area, had higher metal concentrations compared with the eastern branch.

- Organochlorine pesticide concentrations were lower than those found in Castro Valley sediments in 1989-1991 and lower than averages found in the joint Agency sediment sampling program (Kinnetic Laboratories and EOA, 2002). Organochlorine pesticide concentrations were found to be slightly higher in the upper reaches of the western branch.

ACCWP will review these initial results with affected Permittees and other watershed stakeholders to identify additional sources of data or information, and clarify roles and responsibilities for further steps in the SSID project.

1 Introduction

The Alameda Countywide Clean Water Program (ACCWP) conducts Creek Status Monitoring as required by Provision C.8.c of the Municipal Regional Stormwater Permit (MRP, SFBRWQCB Order R2009-0074). ACCWP's 17 member agencies have joined with 56 other MRP Permittees to form the BASMAA Regional Monitoring Coalition (RMC), a regional collaborative to coordinate monitoring conducted pursuant to MRP Provision C.8. The RMC prepared a Quality Assurance Project Plan (QAPP, BASMAA 2012a and 2014a) and Standard Operating Procedures (SOPs, BASMAA 2012b and 2014b) to standardize monitoring methods and ensure comparability of monitoring data with the state's Surface Water Ambient Monitoring Program (SWAMP) see Table 1-1.

Table 1-1. Standard Operating Procedures Pertaining to BASMAA RMC Creek Status Monitoring.

SOP #	SOP Title
FS-1	BMI and Algae Bioassessments, and Physical Habitat Measurements
FS-2	Water Quality Sampling for Chemical Analysis, Pathogen Indicators, and Toxicity
FS-3	Field Measurements, Manual
FS-4	Field Measurements, Continuous General Water Quality
FS-7	Field Equipment Cleaning Procedures
FS-8	Field Equipment Decontamination Procedures
FS-9	Sample Container, Handling, and Chain of Custody Procedures
FS-10	Completion and Processing of Field Datasheets
FS-11	Site and Sample Naming Convention
FS-12	Ambient Creek Status Monitoring Site Evaluation
FS-13	QA/QC Data Review
N/A	Unified Stream Assessment: A User's Manual, v2.0

The RMC's Creek Status and Long-Term Trends Monitoring Plan (BASMAA, 2011) assigns each of the Creek Status monitoring parameters listed in MRP Table 8.1 to one of two sub-design components:

- Regional: ambient monitoring to assess the condition of aquatic life in creeks across the San Francisco Bay Area. Candidate monitoring sites were drawn from a probabilistically generated master list that included all perennial and non-perennial creeks and rivers within the applicable portions of the five participating counties. Sites from the RMC master list are identified by an alphanumeric code in which the last six characters are "Rnnnnn" with "R" designating the RMC probabilistic design and "nnnnn" the site's numeric sequence number generated through the RMC master draw[1]. RMC sites can also

[1] As recommended for SWAMP data compatibility per RMC SOP FS-11, all site ID codes begin with a 3 digit Hydrologic Unit Code.

be assigned an alternative, unique, identification (ID) code using the SWAMP naming procedure described in RMC SOP FS-11.

- Targeted: monitoring design and site selection address local watershed management questions. The last six characters of each Site ID reflect the watershed and numbering from the base of the watershed per the RMC SOP FS-11.

Creek Status Monitoring was initiated in Water Year 2012 (October 2011 through September 2012) and reported in the Urban Creeks Monitoring Report (UCMR, BASMAA, 2013) submitted to the (RWQCB) in March 2013. The UCMR evaluated all data against "trigger criteria" listed for each parameter in MRP Table 8.1, which identifies potential follow-up actions, including Stressor/Source Identification (SSID) projects as required by Provision C.8.d.i of the Municipal Regional Stormwater Permit (MRP), subject to several conditions[2]:

1. Creek Status Monitoring results meet one or more trigger criteria in MRP Table 8.1;
2. When conducting monitoring through a regional collaborative, Permittees are collectively required to initiate no more than ten SSID projects during the Permit term (ACCWP's proportionate share is assumed to be three projects out of the 10);
3. If results indicate toxicity, at least 2 of the 10 SSID projects must be for toxicity;
4. No need to repeat for continuing or recurring occurrences of the trigger in later results from the same receiving water limitations, unless directed to do so by the Water Board; and
5. No need to follow up on trigger results that are caused by Pollutants of Concern which are already being addressed by other portions of the MRP (e.g. pesticides).

The RMC programs developed a collaborative decision-making process for selecting sites for SSID follow-up. Program representatives reviewed the previous year's creek status monitoring results which reached "trigger" criteria, and prioritized sites for SSID follow-up based on several criteria including environmental significance of the trigger results and the feasibility of completing the project steps outlined in the MRP (see below). After consultation with affected Permittee(s), the RMC confirmed the candidate SSID project list with Water Board staff in April 2012 and individual programs planned implementation of SSID studies in their areas for FY 2013-14.

The MRP lists four steps for an SSID project. ACCWP and other Countywide Programs will lead the technically oriented steps 1 and 4 and collaborate with relevant Permittees on step 2: Permittee(s) will be the lead on step 3 to the extent that effective stormwater BMPs are within their power and jurisdiction.

(1) Conduct a site specific study (or non-site specific if the problem is wide-spread) to identify and isolate the cause(s) of the trigger stressor/source. If the trigger stressor or source is already known (e.g. toxicity), proceed directly to step 2;

(2) Identify and evaluate the effectiveness of options for controlling the cause(s) of the

trigger stressor/source;

(3) Implement one or more controls; and

(4) Confirm the reduction of the cause(s) of trigger stressor/source.

This report documents ACCWP planning and implementation activities for a site-specific study as Step 1 in development of a SSID project for the Castro Valley watershed through December 2013. Further evaluation and project planning will continue in WY2014.

The outline of this initial study is based on the Stressor Identification steps identified by the Causal Analysis/Diagnosis Decision Information System (CADDIS), an Internet-based tool[3] based on USEPA guidance (USEPA 2000):

1. Define the Case;
2. List Candidate Causes;
3. Evaluate Data from the Case;
4. Evaluate Data from Elsewhere; and
5. Identify Probable Causes.

The Stressor Identification process may be iterative, and if the stressor cannot be adequately identified in the first attempt, the process may continue with collection of better data or testing other suspected stressors (USEPA 2000).

It should be noted that the CADDIS is intended to be initiated following observations of a biological effect; however in this case the sediment quality concerns were triggered by chemical concentrations that were not accompanied by significant toxicity.

[3] http://www.epa.gov/caddis/index.html

2 Study Area & Background

This section provides background information regarding the Castro Valley Watershed and its beneficial uses, as well as the MRP pollutant triggers reported from WY2013.

2.1.1 Castro Valley Creek

Castro Valley Creek is a tributary to San Lorenzo Creek which covers an area of 5.5 square miles in an unincorporated area of Alameda County, located to the southeast of San Leandro in the western portion of the unincorporated area of Alameda County known as Castro Valley. The subwatersheds of interest in this study are presented in Figure 2-1. The landuse estimates for the targeted subwatersheds directly upstream of the area of interest are presented in Table 2-1 (Scanlin and Feng 1997).

Table 2-1. Estimated Land Use Percentages of Selected Subwatersheds of the Castro Valley Creek.

Subwatershed Code (per Map)	Area (acres)	Commercial	Open	Residential	Pervious Area
1	908	4%	52%	44%	80%
2	391	37%	3%	60%	41%

The site within Castro Valley for which trigger results were observed (Site 204R00047) is in an engineered channel receiving flows mixed commercial and residential land uses along with some non-urban areas in the upper watershed. There is also the potential for freeway impacts where Interstate-Highway (I-) 580 crosses the creek system a few hundred meters upstream of Site 204R00047.
At the site of interest, the creek is designated as a flood control channel of the ACFCWCD, i.e. Zone 2 Line I.

2.1.2 Beneficial Uses

Beneficial uses (SFRWQCB, 2011) assigned to Castro Valley Creek include:

- Cold Freshwater Habitat (COLD);
- Preservation of rare or endangered species (RARE);
- Warm freshwater habitat (WARM);
- Wildlife habitat (WILD); and
- Water Contact and Non-contact Recreation (REC-1 and REC-2). Public parks or other facilities allow access or approaches to sections of Castro Valley.

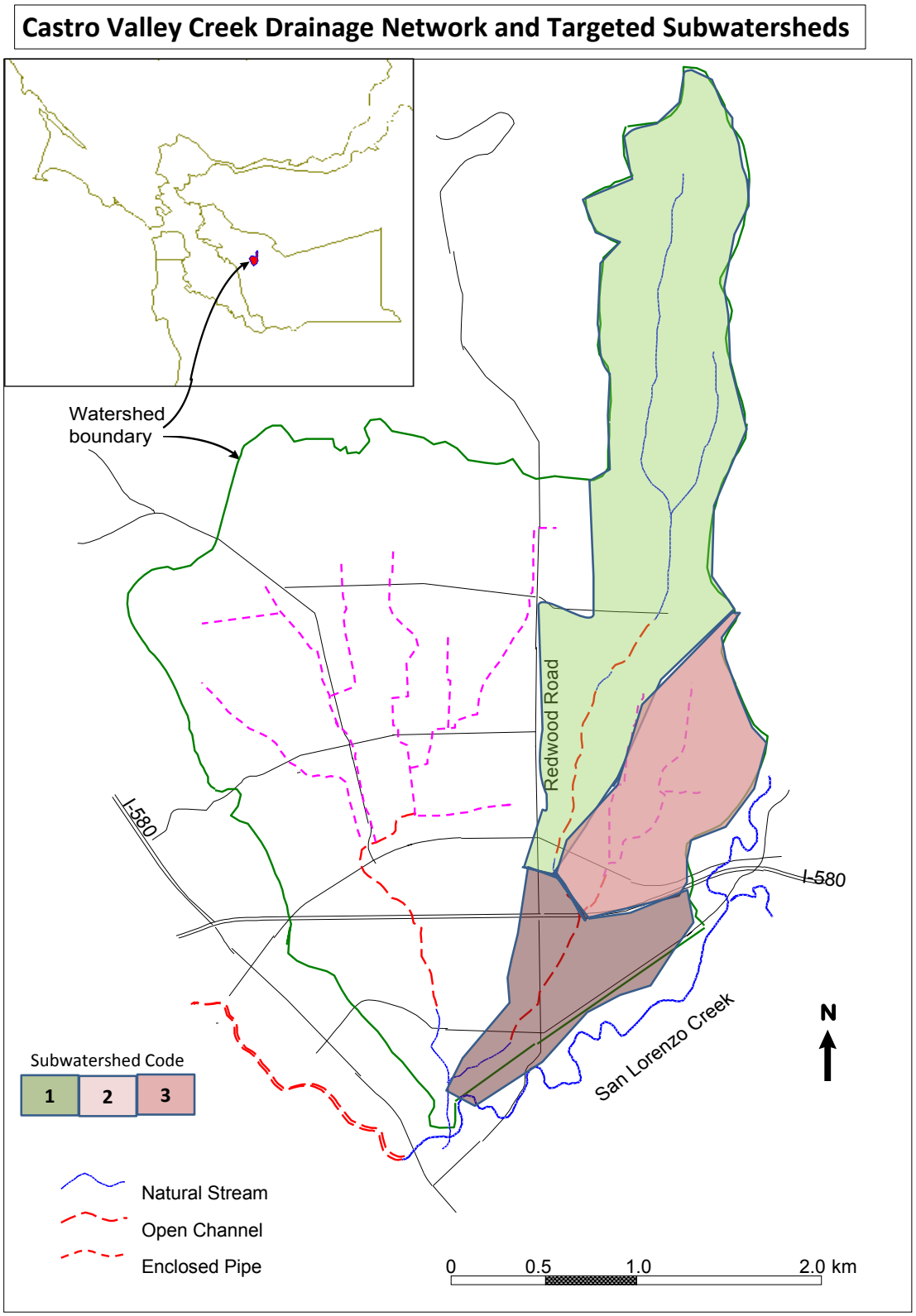

Figure 2-1. Map of the Castro Valley Creek Watershed and Targeted Subwatersheds.

2.2 Trigger Results from Water Year 2012 Creek Status Monitoring

Comparison of WY2012 sampling results with MRP trigger criteria are presented in Table 2-2. Triggers for sediment quality were based on calculation of Threshold Effects Concentration (TEC) and Probable Effects Concentration (PEC) for each analyte as determined following MacDonald et al. (2000). It should be noted that there are some limitations in the MacDonald method as discussed in Appendix A.2 of IMR Part A, and partially reproduced below.

Table 2-2. Water Year 2012 MRP Trigger(s) for Potential Follow-up and Their Environmental Significance:

Trigger type	Trigger status at site	Comment
"Triad" - bioassessment indication of alteration	**IBI score Poor** (Poor chosen as trigger)[need to clarify in footnote]	Widespread in region, generally driven by habitat alteration
"Triad" - sediment chemistry	**16 chemicals > Threshold Effects Concentration**	TEC and PEC contributions by chemical groups: • PAHs - somewhat elevated • Pesticides (organochlorine) all significantly elevated • Metals - slight elevated zinc
	Probable Effects Concentration: average Quotient > 0.5	
	Pyrethroids calculated 2.38 >1 TU Equivalent	
"Triad" - sediment toxicity	Not present or triggered	
Chlorine in water column	**Low: 0.12 mg/l >0.08 on one of 2 occasions**	Widespread in region; result is near limit of method detection
Toxicity in water column	Present but not triggered	Hyalella initial sample 48% of control, retest did not confirm
General Water Quality - DO	Not sampled	
General WQ - other	Not sampled	
Temperature	Not sampled	
Pathogen Indicators	Not sampled	

In assessing the effect of using one-half of the MDL in place of one-half of the MRL to estimate ND results for statistical purposes, relatively large differences were observed in some cases for the WY2012 assessments reported in the UCMR (BASMAA 2013), which have been recalculated for WY2013. Calculated TEC quotients for individual and total PAHs were lower across-the-board using the MDL due to the relatively large proportion of NDs and the difference between MDLs and MRLs reported. It should be noted that WY2012 analyses are predominantly non-detects, and therefore that the TEC quotients calculated are driven by the MDL rather than quantified laboratory results.

While MacDonald (2000) generated PECs for multiple trace element, PAH, OC pesticide, and pyrethroid pesticide parameters, there was insufficient data at time of its publication to evaluate the consensus PECs generated as to their predictive ability for associated sediment toxicity for each of the analytes reported. Analytes for which predictive ability is particularly uncertain

include various PAH (anthracene, fluorine, and fluoranthene) and OC pesticide (dieldrin, DDDs, DDTs, endrin, heptachlor epoxide, and lindane) parameters (MacDonald, 2000).

When examining pyrethroids concentrations, a similar degree of uncertainty exists. Weston (2005) reported that predictions of sediment toxicity to *H. azteca* were supported by observed results for sites with TU ratios below one (little or no mortality) and above four (high or full mortality). For TUs between one and four, however, the predictive ability of the TU is less certain (Weston 2005).

2.3 Review of Creek Status Data from Water Year 2012

Data collected during WY2012 Creek Status monitoring are summarized in this section for reference. Zinc concentrations were recorded as above TECs during the WY2012 monitoring (Table 2-3). Total organic carbon (TOC) was recorded as 2.5% dry weight. Pesticides were recorded as slightly elevated (Table 2-4). Polycyclic aromatic hydrocarbons (PAHs) were reported as being somewhat elevated (Table 2-5).

Table 2-3. Metal Concentrations Reported in Water Year 2012 Monitoring of Castro Valley Creek

Metal (total)	Result
Arsenic (mg/Kg)	3.1
Chromium (mg/Kg)	8.5
Copper (mg/Kg)	22
Zinc (mg/Kg)	170

Analysis of WY2012 metals data against TECs showed zinc as being slightly elevated with a TEC quotient of 1.40.

Table 2-4. Pyrethroid Concentrations Reported in Water Year 2012 Monitoring of Castro Valley Creek

Pyrethroid (ng/g dw)	Result
Bifenthrin	21
Cyfluthrin	5
Permethrin, cis-	5.4
Permethrin, Total	7

Analysis of WY2012 pyrethroid data against Toxicity Unit[4] (TU) equivalents showed bifenthrin as being elevated with a TEC quotient of 1.756.

[4] Pyrethroid toxicity is explained in terms of the sum of "toxic units". These are calculated based on the toxicity of each pyrethroid to a standard test organism *Hyalella Azteca* (50% mortality in sediment for a 10-day test period). A ratio of toxicity is then developed for each pyrethroid. (TDC, 2010a).

Table 2-5. Polycyclic Aromatic Hydrocarbon Concentrations Reported in Water Year 2012 Monitoring of Castro Valley Creek

Polycyclic Aromatic Hydrocarbon (ng/g)	Result
Fluoranthene	380
Pyrene	420

Analysis of WY2012 PAH data against TECs showed pyrene as being elevated with a TEC quotient of 2.15.

Organochlorine pesticide concentrations were all reported as non-detects in the raw data collected from WY2012 for the Castro Valley Creek sampling site. However, using the half value of the MDL for trigger calculations led to this group of analytes being reported as having a TEC quotient of ≥1.0.

2.4 Preliminary Literature Review

This section is a preliminary summary of selected available data relating to sediment chemistry in California and provides an initial reference for data collected in the Castro Valley Creek SSID.

2.4.1 Alameda County Watershed 2000-2001 Sediment Sampling Program

This study reported on the results of a two year investigation (2000 and 2001) by ACCWP into sediment characteristics at 25 locations in Alameda County (ACCWP, 2002). Samples were analyzed for PCBs, total mercury, PAHs, selected pesticides and particle size. The study was designed to compile baseline data on pollutants of concern, identify sites for follow-up and as a potential assessment for sources and loads in the County watersheds.

Table 2-6. Summary of 2001 ACCWP Sediment Sampling Program (ACCWP, 2002)

Analyte	Minimum	Maximum	Average
PCBs (ug/kg)	0.5	762.6	119.9
Mercury (ng/g)	0.07	4.29	0.73
PAHs (ug/kg)	66	13,680	4710
Fines (%)	5.1	79.5	37.8

2.4.2 Joint Agency Sediment Sampling Program 2002

This program was a similar design to the ACCWP program described above but undertaken by six agencies (Kinnetic Laboratories and EOA, 2002). The study focused on contaminants of concern associated with storm drains. A total of 61 samples were collected in the first year and 70 samples were collected in the second year. A summary of selected analytes is presented as average results in Table 2-7.

Table 2-7. Selected Summary of 2000 Joint Agency Sediment Sampling Program by Landuse (Kinnetic Laboratories and EOA, 2002)

Analyte	Industrial	Residential/Commercial	Mixed	Open
Average Total PCBs (ug/kg)	4,460	2,220	720	9.4
Average Total Mercury (ng/g)	2.4	4.6	1.3	0.9
Average Total DDT	880	240	120	-

2.4.3 Collated ACCWP Data for Castro Valley 1989 – 1991

A number of years ago, early ACCWP monitoring data were collated into database. In this section, a query for sediment sample results specifically collected from Castro Valley is summarized. The Castro Valley sampling site for these data was located at the Castro Valley Creek USGS gauge with sediment samples collected between 1989 and 1991. The following tables provide summary averages for selected pollutants from this database.

Table 2-8. Average Total Metal Concentrations Found in Sediments in Castro Valley 1989 - 1991

Analyte (total)	Average (mg/kg)
Arsenic	4.13
Cadmium	0.14
Chromium	31
Copper	30.5
Lead	810
Mercury	0.34
Nickel	30.75
Selenium	0.12
Zinc	118

Table 2-9. Selected Average Total Polycyclic Aromatic Hydrocarbon Concentrations Found in Sediments in Castro Valley 1989 - 1991

Analyte	Average (mg/kg)
Acenaphthene Total	1.23
Acenaphthylene Total	1.2
Anthracene Total	0.36
Benzo(a)anthracene Total	0.77
Chrysene Total	0.84
Fluoranthene Total	0.96
Naphthalene Total	1.13
Phenanthrene Total	4.36
Pyrene Total	1.08

Table 2-10. Selected Average Total Pesticide Concentrations Found in Sediments in Castro Valley 1989 - 1991

Analyte	Average (mg/kg)
4,4-DDD Total	9.66
4,4-DDE Total	7.33
4,4-DDT Total	6.33
Chlordane Total	186
Dieldrin Total	9.66

2.4.4 Diazinon Characterization Assessment in Castro Valley 1997

A study conducted by ACCWP was designed to assess and characterize diazinon presence in (Scanlin and Feng, 1997). Multiple locations were sampled during storm events in the Castro Valley watershed by ACCWP in 1995 and 1996. Event mean concentrations ranged from 180 to 820 ng/L and were observed in all sampled events. There was evidence of accumulation within watersheds prior to rain events with concentrations inversely proportional to water volume. There was also evidence of increased diazinon concentration with increased imperviousness.

2.4.5 Department of Pesticide Regulation Study

Department of Pesticide Regulations (DPR) prepared data summaries pertaining to pesticide presence in California sediments and water (Zhang, 2010). The data were collected between 1993 and 2010 with a total of 8,834 water and 2,010 sediment data points collated. An overview summary of those sediment data are presented in Table 2-11.

Table 2-11. Summary of Detections of Pyrethroid in Sediments of California's urban waters (Zhang, 2010)

Analyte Name (ng/g)	Detection rate (%)	Minimum concentration detected	Maximum concentration detected
Bifenthrin	85.2	1.0	1,211
Cyfluthrin	55.0	1.1	992
Cypermethrin	41.4	0.6	940
Deltamethrin	35.6	1.1	78
Esfenvalerate	11.8	1.0	17
Fenpropathrin	0.9	14.7	14.7
Lamba-cyhalothrin	42.0	1.0	67
Permethrin	68.8	1.0	701
Resmethrin	5.9	3.6	8.9

2.4.6 SPoT program

The Stream Pollutant Trends (SPoT) program (Hunt *et al*, 2012) is designed to measure long term trends in stream pollution in California. The study assesses land use types in relation to pollutants of concern and, over time, spatial and temporal trends. The summary report prepared in 2012 contains some findings that align with initial observations obtained from sediment analyses at the Castro Valley Creek SSID site, including:

- Total metal concentrations associated with urban runoff were generally found to be on average approximately 250ug/g (cadmium, copper, lead and zinc) compared with less than 200ug/g for agricultural and other landuses;
- Mercury concentrations in sediments associated with urban watersheds were approximately 0.1ug/g;
- DDT and PCB concentrations in urban watersheds were found to be approximately an order of magnitude higher than those found in agricultural watersheds;
- PAH concentrations were found to be, on average approximately 1200ng/g in urban watersheds compared to averages of less than 50ng/g in agricultural watersheds;
- Bifenthrin was the most commonly detected pyrethroid in SPoT samples;
- Organic chemicals and fine sediments showed a significant correlation with TOC; and
- Trace metals tended to associate with finer sediments.

In addition, SPoT summary results from 2008-2010 are summarized in Table 3-1 (Anderson *et al*, 2012).

Table 2-12. Average Analyte Concentrations Detected Between 2008 and 2010 in SPoT Program (Anderson *et al*, 2012)

Analyte	Year	Average Concentration
Pyrethroids (ng/g)	2008	16.9
	2009	12.8
	2010	30.4
DDT (ng/g)	2008	31.8
	2009	77.8
	2010	12.1
PAHs (ng/g)	2008	757
	2009	1457
	2010	293
Metals (sum of cadmium, copper, lead, zinc) (µg/g)	2008	241
	2009	226
	2010	202

2.4.7 Caltrans

Roadway runoff data collated by Caltrans, in "A Review of the Contaminants and Toxicity Associated with Particles in Stormwater Runoff, (Caltrans, 2003a) suggested that particle size fraction was strongly correlated with concentrations of contaminants. In the Caltrans study, copper, lead and zinc were found to be strongly associated with particulate fraction, with concentrations of these metals generally increasing with decreasing particle size. Only cadmium was found to be uniformly distributed throughout different particle sizes.

3 Study Design and Monitoring Methods

3.1 Study Questions

The study questions presented in Table 3-1 are based on the preliminary conceptual model and review of historical data relevant to the site.

Table 3-1. Study Questions Developed for Castro Valley Creek Stressor Source Identification Study

Question	Study Method	Expected outcome
Do available data identify potential sources of stressors?	Addressed as desk top study. Assess available data and analyze for temporal and spatial trends.	Assesses hypothesis that previous investigations have identified potential sources, such as those associated with freeway runoff. Understanding of data gaps, historical trends, and previous analysis methods.
Is the freeway a significant source of stressor pollutants in comparison to the rest of the urban area?	Addressed through sediment sampling at locations directly above and below freeway input.	Comparison data from upstream (Sites 204CVY100 and 204CVY105) and downstream (Site 204CVY090) of I-580 freeway.
Is commercial land use a significant source of stressor pollutants?	Addressed through sediment sampling at locations directly above and below commercial landuse input.	Comparison data from upstream (Site 204CVY130) and downstream (Site 204CVY125) of commercial sources.

3.1.1 Conceptual Model of Sources and Processes

As part of the initial project scoping, a conceptual model was outlined for relevant processes and potential sources in the watershed draining to the original creek status monitoring site. The purposes of the conceptual model included:

- Generation of hypotheses to be tested in the site-specific study; and
- Providing information for preliminary SSID project planning.

Figure 3-1 presents a schematic of the creek system in Castro Valley with illustration of channelization and hydromodifications as well as general watershed landuses. The percent impervious area within the watershed varies from approximately 40 to 80%.

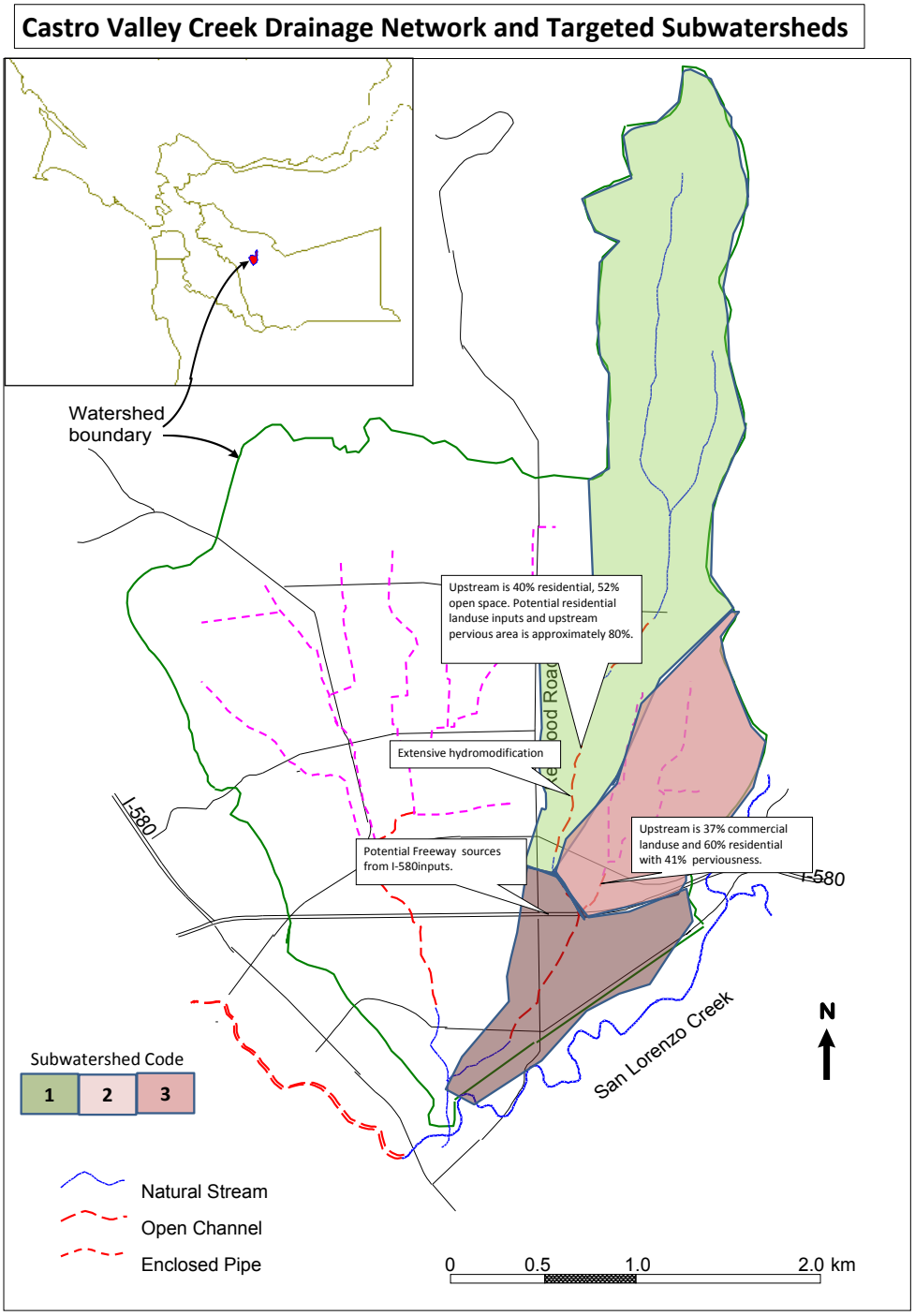

Figure 3-1. Conceptual Model of Candidate Causal Stressors (landuses based on Scanlin and Feng 1997).

Figure 3-2 presents a rudimentary categorization of the aspects of the conceptual model of potential causes, process, potential impacts and observed impacts developed for the Castro

Valley SSID project. The conceptual model was developed based on the overall guidance provided in CADDIS. The potential stressors identified in the watershed leading to the study area were commercial landuse discharges, residential sources, freeway sources, legacy pollutants and hydromodification of the channel. Discharges from these identified landuses could lead to the observed sediment characteristics observed in WY2012.

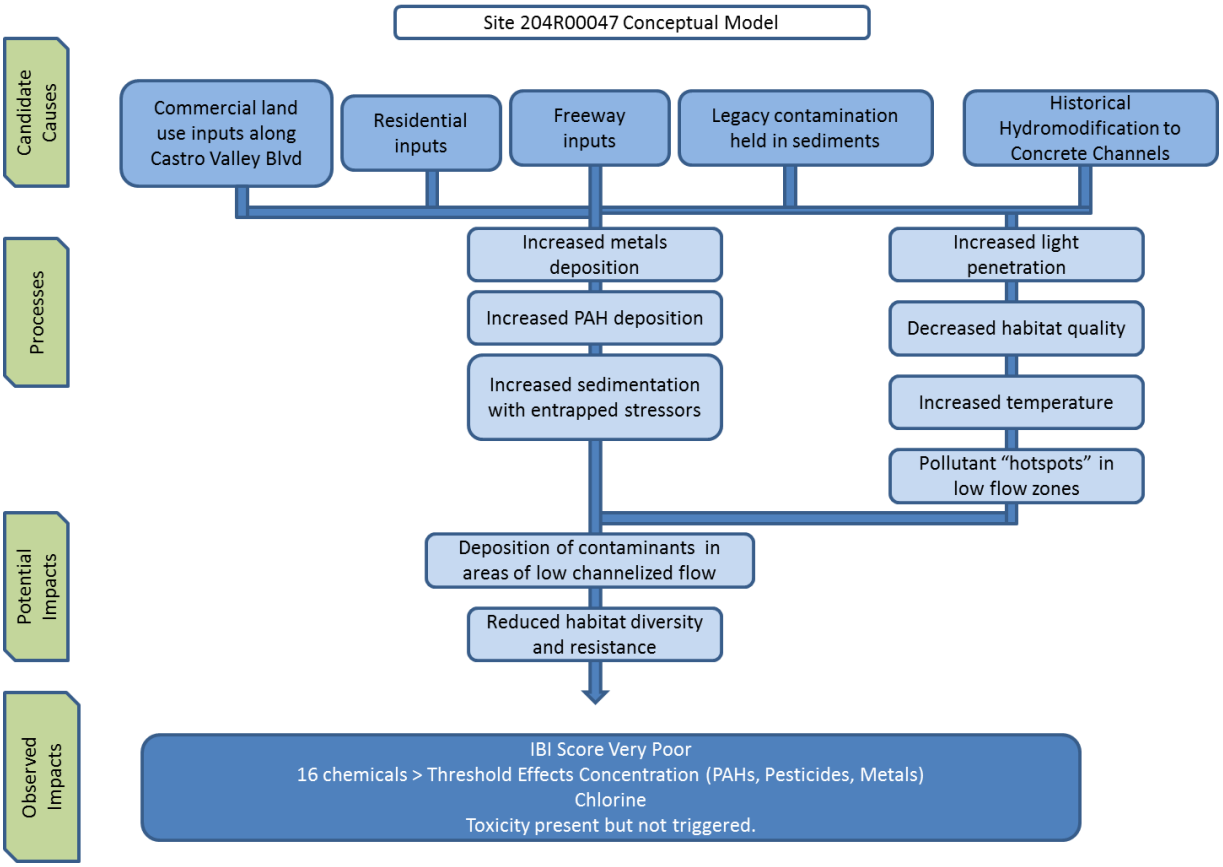

Figure 3-2. Conceptual Model and Processes for Site 204R00047

3.2 Monitoring and Sampling Locations

The WY2013 monitoring locations and site descriptions are presented in Table 3-2 and Figure 3-3.

At each of the five monitoring locations, sediment samples were collected and tested for:

- Pyrethroids;
- Total metals;
- Organochlorine pesticides;
- Polycyclic aromatic hydrocarbons;
- Percent fines; and
- Total organic carbon .

Samples were collected on July 9th, 2013.

Table 3-2. Monitoring Locations and Water Sampling for Castro Valley Creek SSID

Site Code	Description	Latitude	Longitude	Sediment sampling
204CVY090	"Alias" for Original RMC site 204R00047 near base of Castro Valley branch.	37.68744	-122.0730	X
204CVY105	Eastern branch Zone 2 Line I above freeway. Concrete channel off Aspen Ave, mostly culverted above.	37.69176	-122.07048	X
204CVY110	Western branch Zone 2 Line J above freeway. Concrete channel from Juniper St off Aspen Ave.	37.69170	-122.07082	X
204CVY125	Natural channel Zone 2 Line J – below commercial landuse along Castro Valley Blvd.	37.69405	-122.07227	X
204CVY135	Natural channel Zone 2 Line J - above commercial landuse, draining residential and open land uses only.	37.69759	-122.07135	X

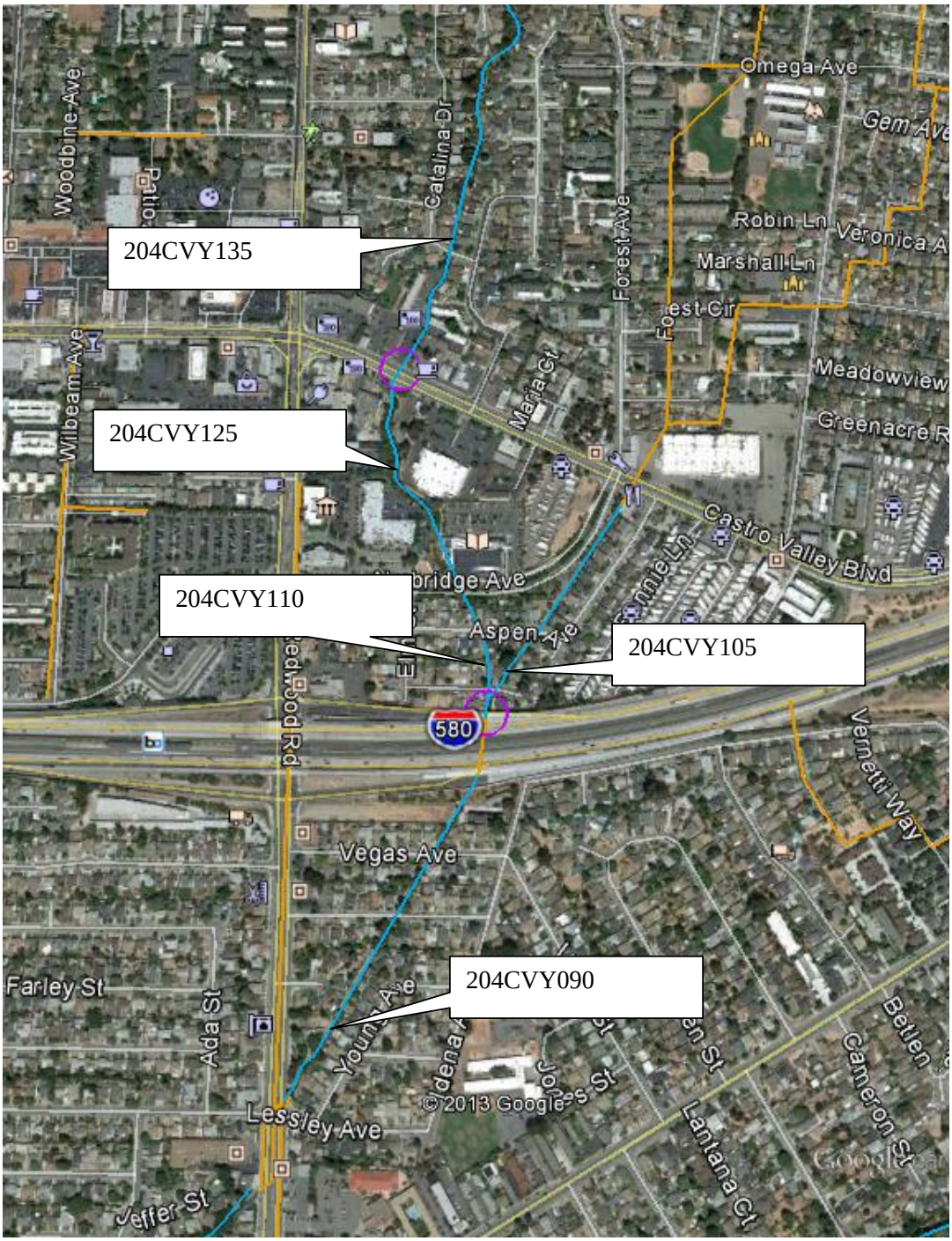

Figure 3-3. Monitoring Locations (as Site Codes) for Source Identification in Castro Valley

3.3 Data Collection Methods

Field data were collected in accordance with SWAMP-comparable methods and procedures described in the BASMAA RMC QAPP BASMAA (2012a, 2014a) and SOP (BASMAA 2012b,

2014b). These documents were provided in final draft form to the Water Board with earlier RMC Monitoring Status Reports and were revised in WY2013 to reflect lessons learned through WY2012 implementation; these revisions also incorporate updated data Quality Assurance procedures consistent with added data checking functions of the RMC database to supplement the tools available through SWAMP. RMC SOPs are listed in Table 1-1.

This section provides a brief overview of methods employed to measure each parameter in the targeted monitoring design. Greater detail on each method is included in the referenced SOPs.

All samples were processed and sent to the same laboratories as those used in the RMC program. Data were analyzed and reported per SWAMP-comparable methods as described in the RMC QAPP (BASMAA 2012a and BASMAA 2014a). Analytical laboratory methods, reporting limits and holding times for chemical water quality parameters are also reported in the BASMAA QAPP (2012a and 2014a).

3.4 Data Quality Assessment Procedures

Following completion of the field and laboratory work, the field data sheets and laboratory reports were reviewed by ACCWP and compared both against the methods and protocols specified in the SOPs and QAPP (BASMAA, 2012a, BASMAA 2012b, BASMAA 2014a and BASMAA 2014b).

3.5 Data Analysis and Interpretation

Sediment chemistry results were evaluated spatially (in comparison with results collected within this study at different sites) and temporally (in comparison with sampled collected in WY2012) to test hypotheses regarding the contributions from potential stressor sources in the conceptual model. Refer to Sections 4 and 5 respectively

4 Results

4.1 Statement of Data Quality

Field data sheets and laboratory reports were reviewed by ACCWP and the results evaluated against the relevant DQOs as described in the QAPP (BASMAA, 2012a, 2014a) and SOPs (BASMAA, 2012b, 2014b).

4.2 Monitoring Results

This section provides summaries of the results of sediment analysis are Castro Valley Creek sampling locations. Full data are provided in Attachment A.

4.2.1 Sediment Particle Size Distribution

Analysis of particle size was undertaken for each monitoring location (Figure 4-1). The majority of sites were characterized by the presence of high proportions of silts and clays. The exception was Site 204CVY090 - the most downstream location - where a larger proportion of granule and pebble sizes was found.

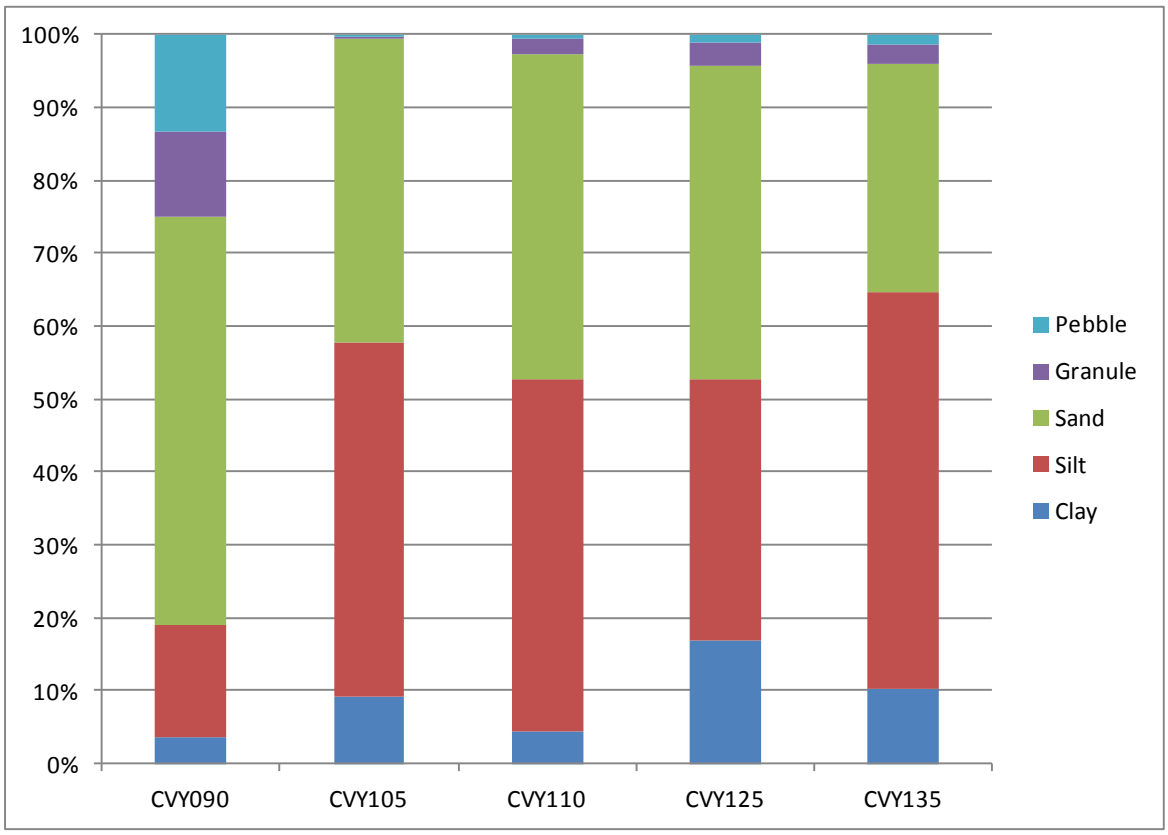

Figure 4-1. Distribution of Particle Size at Castro Valley Sampling Sites.

4.2.2 Total Organic Carbon

TOC analysis was performed at three locations (Table 4-1). The highest percent of TOC was found at the most upstream location, Site 204CVY135. The lowest concentration was found at Site 204CVY105, a side tributary receiving flows from commercial and residential landuse.

Table 4-1. Total Organic Carbon at Castro Valley Monitoring Sites

Site	204CVY105	204CVY110	204CVY135
TOC (% dw)	2	6.7	7.1

4.2.3 Polycyclic Aromatic Hydrocarbons

All PAH results above detection limits are reported in Table 4-2. The results suggest elevated PAH concentrations at the most downstream site (Site 204CVY090), and Site 204CVY125 (located directly below Castro Valley Blvd and associated commercial landuse areas). Of the sites investigated, the lowest PAH concentrations were generally recorded at Site 204CVY105, the eastern tributary branch to Castro Valley Creek.

Table 4-2. Polycyclic Aromatic Hydrocarbon Results at Castro Valley Monitoring Sites

PAHs (ng/g)	204CVY090	204CVY105	204CVY110	204CVY125	204CVY135
Anthacene	26	J6.7	J14	20	ND
Benzo(a)anthracene	68	83	57	160	44
Benzo(a)pyrene	59	37	26	69	130
Benzo(a)fluoranthene	110	53	73	110	36
Benzo(e)pyrene	73	27	J43	54	50
Benzo(g,h,i)perylene	ND	ND	ND	64	ND
Benzo(k)fluoranthene	46	22	J31	46	ND
Chrysene	230	90	140	200	160
Dibenzothiophene	J9.5	ND	ND	ND	ND
2,6-Dimethylnapthalene	150	150	660	ND	260
Fluoanthene	300	120	200	410	120
Perylene	J28	J9.6	ND	16	ND
Phenanthrene	160	31	100	150	43
Pyrene	240	130	180	390	120

4.2.4 Total Metals

Analysis of total metals, including mercury, is presented in Table 4-3, and Figure 4-2. The results show that the highest metals concentrations, of the sites monitored, were found at Site 204CVY135, with elevated arsenic, cadmium, lead and mercury. Of the sites evaluated, higher chromium, copper and nickel were found at the site immediately downstream (Site 204CVY125). In general, the lowest metals concentrations were reported at Site 204CVY110. Metals concentrations in Castro Valley are similar to those found in the SPoT study (Anderson *et al*, 2012). Mercury concentrations were much lower than those reported in stormdrain sediments samples collected in the joint Agency study (Kinnetic Laboratories, Inc and EOA, Inc, 2002). Zinc and nickel results were higher than average concentrations found in other Castro Valley sampling undertaken by ACCWP in 1989-1991 (Section 2.3.3).

Table 4-3. Total Metals Results from Castro Valley

Metal (mg/kg)	204CVY090	204CVY105	204CVY110	204CVY125	204CVY135
Arsenic	3.1	3.4	3.9	6.7	20
Cadmium	0.18	0.17	0.15	0.11	0.51
Chromium	20	19	11	30	24
Copper	29	42	11	46	25
Lead	15	20	10	26	92
Mercury	0.055	0.043	0.037	0.041	0.17
Nickel	27	22	14	30	20
Zinc	160	170	99	74	140

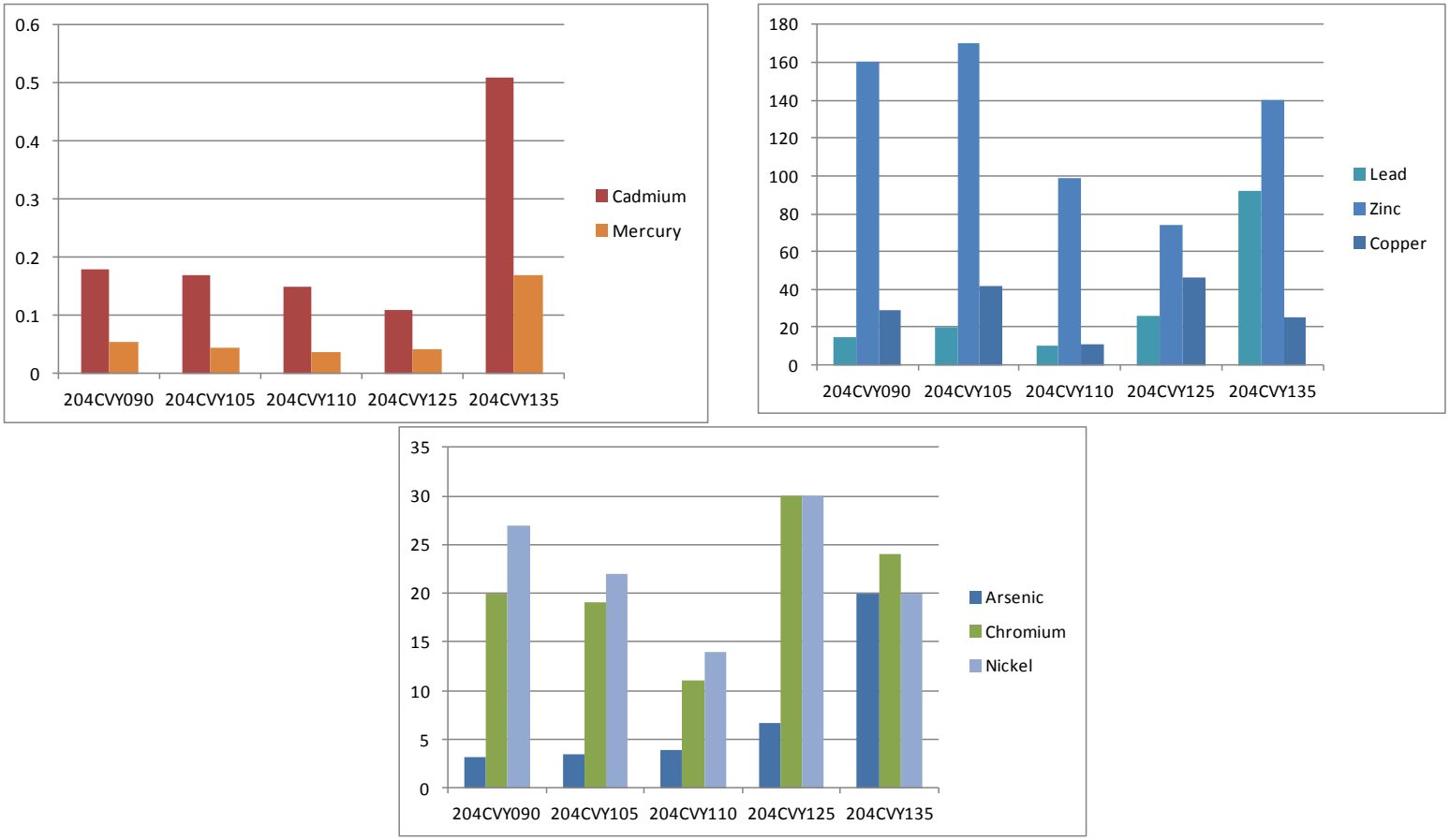

Figure 4-2. Metals Concentrations (mg/kg) from the Five Castro Valley Sampling Sites

4.2.5 Organochlorine Pesticides

With the exception of those reported in Table 4-4, all organochlorine pesticides were below detection limits. The most elevated concentrations of pesticides were found at the upstream sampling location (Site 204CVY135). In comparison to other sites in this study, elevated concentrations of chlordane, DDE and dieldrin were reported at this site. The lowest concentrations for most pesticides were reported at Site 204CVY110. Overall, organochlorine pesticide concentrations were lower in the Castro Valley Creek investigation than those found in the SPoT study (Anderson *et al*, 2012) and in the joint Agency study (Kinnetic Laboratories, Inc and EOA, Inc, 2002).

Table 4-4. Organochlorine Pesticide Results from Castro Valley Sampling Sites.

Organochlorine Pesticide	204CVY090	204CVY105	204CVY110	204CVY125	204CVY135
Gamma-Chlordane (trans) (ng/g)	2.4	3.3	ND	2.7	280
2,4'-DDD (ng/g)	5.6	ND	ND	ND	15
4,4'-DDD(ng/g)	3.7	4.5	ND	2.8	69
4,4'-DDE (ng/g)	6.4	8.6	ND	5.2	330
4,4'-DDT (ng/g)	ND	ND	2.2	ND	11
Dieldrin (ng/g)	ND	ND	ND	ND	200
Percent solids (%)	85	98	97	97	95

4.2.6 Pyrethroids

All pyrethroids, with the exception of those presented in Table 4-5, were below detection limit. The highest pyrethroid results, in comparison to other sampling sites, were found at the tributary branch sampling location at Site 204CVY105. Pyrethroid concentrations found in the Dublin sampling area are generally lower than those reported in Californian sediments as part of the SPoT program (Anderson *et* al, 2012).

Table 4-5. Pyrethroid Results from Castro Valley Sampling Sites.

Pyrethroid (ng/g)	204CVY090	204CVY105	204CVY110	204CVY125	204CVY135
Bifenthrin	5.6	7.8	2	2	1.2
Cyfluthrin, total	2.5	4.8	2	1	2.4
Cyhalothrin, lambda, total	0.52	1.1	0.31	ND	ND
Cypermethrin, total	0.67	0.41	ND	ND	ND
Permethrin, cis-	5.8	10	ND	0.93	J0.44
Permethrin, trans-	1.2	1.1	ND	ND	ND

5 Discussion

5.1 Overall findings

The following preliminary findings are based on the results of this monitoring:

- Pyrethroids were slightly higher in the eastern (mostly culverted) branch of Castro Valley Creek suggesting sources from the urbanized areas upstream. These results are consistent with published findings that pyrethroid concentrations increase with urbanization (Anderson *et al*, 2012, TDC, 2010a and 2010b). Bifenthrin was the most commonly found pyrethroid in the watershed. This result is consistent with other state and regional findings. Bifenthrin is stable in aquatic environments and is more commonly used in urbanized areas. However, pyrethroid concentrations in this study were lower than those reported as average concentrations in the SPoT program (Anderson *et al*, 2010) and by DPR (Zhang, 2010).
- PAH concentrations were lower than the averages found in other parts of the Alameda County (ACCWP, 2002) but generally higher than those found in Castro Valley sediment samples in 1989-1991. In this study the highest PAH concentrations were found in the most downstream site (Site 204CVY090).
- Metal concentrations were generally comparable to concentrations found in Castro Valley sediments in 1989-1991. Mercury concentrations were lower than those found in Alameda County sediments (ACCWP. 2002). The upper western branch of the Castro Valley Creek, above the commercial landuse area, had higher metal concentrations compared with the eastern branch.
- Organochlorine pesticide concentrations were lower than those found in Castro Valley sediments in 1989-1991 and lower than averages found in the joint Agency sediment sampling program (Kinnetic Laboratories and EOA, 2002). Organochlorine pesticide concentrations were found to be slightly higher in the upper reaches of the western branch.

5.1.1 Results by Sampling Location

The following analysis is based on summarized results for each sampling location.

Site 204CVY135: The creek at this sampling location is characterized by a natural channel located above a segment where adjacent landuse is predominantly commercial. The results reported at this site suggest that the sediment is characterized by mostly fine sands and silts with higher concentrations of total organic carbon. Of the sites assessed in this study, this site recorded the highest metals (arsenic, cadmium, lead and mercury) as well as the highest pesticides. Lower pyrethroid concentrations were recorded at this site compared with the other samples collected.

Site 204CVY125: This creek sampling location is in a natural channel below Site 204CVY135 and below the segment with nearby commercial landuse. The site was characterized by a mix of sands and silts and similar TOC concentrations to its upstream counterpart (Site 204CVY135). Lower PAH, organochlorine pesticide and pyrethroid concentrations were recorded at this site.

Site 204CVY110: This creek sampling location is on the western branch of the creek above the I-580 freeway. The site is in a concrete channel located within a residential area off Aspen Ave. The site had majority sands and silts and recorded the lowest metals concentrations of the five sites investigated. It also had lower PAH, pyrethroid and organochlorine pesticide results.

Site 204CVY105: This creek sampling location is in and below a concrete channel on the eastern branch of Castro Valley Creek. Samples from this site had the highest proportion of fines (sands and silts) of the five sampled sites. It also recorded lower TOC than the other two assessed sites. The characteristics of the sediments at this location appeared to differ to those of the western branch. This site had lower PAH concentrations but higher pyrethroid concentrations compared to the western branch.

Site 204CVY090: This site, near the lowest portion of the sampling watershed, was the original WY2012 sampling site (Site 204R00047) for which WY2012 results led to initiation of the SSID. The site is in a concrete channel receiving flows from both the western and eastern branches of the upper watershed, represented individually by Site 204CVY105 and Site 204CVY110. This site had the highest proportion of larger particle sizes of the five monitored sites consisting of pebbles, granules and sand. This site also recorded the highest concentrations of PAHs and high pyrethroids of the five sites investigated.

5.2 Next Steps

ACCWP will review these initial results with affected Permittees and other watershed stakeholders to identify additional sources of data or information, and clarify roles and responsibilities for further steps in the SSID project.

Further technical studies may be implemented to support this review, and to identify measures of effectiveness to confirm reduction of the stressors or sources.

6 References

Alameda County Clean Water Program. 2002. 2000-01 Alameda County Watershed Sediment Sampling Program: Two-Year Summary and Analysis. 37pp (with appendices).

Anderson BS, Phillips BM, Siegler K, Voorhees, J. 2012.Initial Trends in Chemical Contamination, Toxicity and Land Use in California Watersheds: Stream Pollution Trends (SPoT) Monitoring Program. Second Technical Report - Field Years 2009-2010. California State Water Resources Control Board, Sacramento, CA. 92pp (with appendices).

BASMAA. 2012a. Creek Status Monitoring Program Quality Assurance Project Plan, Final Draft Version 1.0.Prepared for BASMAA by EOA, Inc. on behalf of the Santa Clara Urban Runoff Pollution Prevention Program and the San Mateo Countywide Water Pollution Prevention Program, Applied Marine Sciences on behalf of the Alameda Countywide Clean Water Program, and Armand Ruby Consulting on behalf of the Contra Costa Clean Water Program. 80 pp plus appendices.

BASMAA. 2012b. Creek Status Monitoring Program Standard Operating Procedures.Prepared for BASMAA by EOA, Inc. on behalf of the Santa Clara Urban Runoff Pollution Prevention Program and the San Mateo Countywide Water Pollution Prevention Program, Applied Marine Sciences on behalf of the Alameda Countywide Clean Water Program, and Armand Ruby Consulting on behalf of the Contra Costa Clean Water Program. 196 pp.

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BASMAA. 2014b. Creek Status Monitoring Program Standard Operating Procedures, Final Version 2.Prepared for BASMAA by EOA, Inc. on behalf of the Santa Clara Urban Runoff Pollution Prevention Program and the San Mateo Countywide Water Pollution Prevention Program, Applied Marine Sciences on behalf of the Alameda Countywide Clean Water Program, and Armand Ruby Consulting on behalf of the Contra Costa Clean Water Program. 203 pp.

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7 Attachments

Attachment A: Full Analytical Data for Castro Valley SSID

Metal (mg/kg dw)	204CVY090	204CVY105	204CVY110	204CVY125	204CVY135
Arsenic	3.1	3.4	3.9	6.7	20
Cadmium	0.18	0.17	0.15	0.11	0.51
Chromium	20	19	11	30	24
Copper	29	42	11	46	25
Lead	15	20	10	26	92
Mercury	0.055	0.043	0.037	0.041	0.17
Nickel	27	22	14	30	20
Zinc	160	170	99	74	140
PAH (µg/kg DW)	204CVY090	204CVY105	204CVY110	204CVY125	204CVY135
Acenaphthene	ND	ND	ND	ND	ND
Acenaphthylene	ND	ND	ND	ND	ND
Anthracene	26	6.7	14	20	ND
Benz(a)anthracene	68	83	57	160	44
Benzo(a)pyrene	59	37	26	69	130
Benzo(b)fluoranthene	110	53	73	110	36
Benzo(e)pyrene	73	27	43	54	50
Benzo(g,h,i)perylene	ND	ND	ND	64	ND
Benzo(k)fluoranthene	46	22	31	46	ND
Biphenyl	ND	ND	ND	ND	ND
Chlordene, cis-	ND	ND	ND	ND	ND
Chlordene, trans-	2.4	3.3	ND	2.7	280
Chrysene	230	90	140	200	160
Dibenz(a,h)anthracene	ND	ND	ND	ND	ND
Dibenzothiophene	9.5	ND	ND	ND	ND
Dimethylnaphthalene, 2,6-	150	150	660	ND	260
Esfenvalerate/Fenvalerate, total	ND	ND	ND	ND	ND
Fluoranthene	300	120	200	410	120
Fluorene	ND	ND	ND	ND	ND
HCH, gamma-	ND	ND	ND	ND	ND
Heptachlor epoxide	ND	ND	ND	ND	ND
Indeno(1,2,3-c,d)pyrene	ND	ND	ND	61	ND
Methylnaphthalene, 1-	8.1	ND	ND	ND	ND
Methylnaphthalene, 2-	9	ND	ND	ND	ND
Methylphenanthrene, 1-	ND	ND	ND	ND	ND
Naphthalene	7.4	ND	ND	ND	ND
Perylene	28	9.6	ND	16	ND

Phenanthrene	160	31	100	150	43
Pyrene	240	130	180	390	120
Pyrethroids (µg/kg DW)	204CVY090	204CVY105	204CVY110	204CVY125	204CVY135
Bifenthrin	5.6	7.8	2	2	1.2
Cyfluthrin, total	2.5	4.8	2	1	2.4
Cyhalothrin, lambda, total	0.52	1.1	0.31	ND	ND
Cypermethrin, total	0.67	0.41	ND	ND	ND
Permethrin, cis-	5.8	10	ND	0.93	ND
Permethrin, trans-	1.2	1.1	ND	ND	ND
Organochlorine Pesticides (µg/kg DW)	204CVY090	204CVY105	204CVY110	204CVY125	204CVY135
DDD(o,p')	5.6	ND	ND	ND	15
DDD(p,p')	3.7	4.5	ND	2.8	69
DDE(o,p')	ND	ND	ND	ND	ND
DDE(p,p')	6.4	8.6	ND	5.2	330
DDT(o,p')	ND	ND	ND	ND	ND
DDT(p,p')	ND	ND	2.2	ND	11
Dieldrin	ND	ND	ND	ND	200
Endrin	ND	ND	ND	ND	ND

ALAMEDA COUNTYWIDE CLEAN WATER PROGRAM

STRESSOR / SOURCE IDENTIFICATION PROJECT:

CROW CREEK SITE 204CRW030- LOW DISSOLVED OXYGEN

WATER YEAR 2013 PROGARESS REPORT

INTEGRATED MONITORING REPORT, PART A - APPENDIX A.4C

Alameda
Albany
Berkeley
Dublin
Emeryville
Fremont
Hayward
Livermore
Newark
Oakland
Piedmont
Pleasanton
San Leandro
Union City
County of Alameda
Alameda County Flood Control and Water Conservation District
Zone 7 Water Agency

Report prepared by

Alameda Countywide Clean Water Program

399 Elmhurst Street,
Hayward, California 94544

Submitted to:

California Regional Water Quality Control Board, San Francisco Bay Region

Protecting Alameda County Creeks, Wetlands & the Bay

List of Acronyms

Acronym	Definition
ACCWP	Alameda Countywide Clean Water Program
BASMAA	Bay Area Stormwater Management Agencies Association
BOD	Biochemical Oxygen Demand
COD	Chemical Oxygen Demand
DO	Dissolved Oxygen
DQO	Data Quality Objective
FY	Financial Year
ID	Identification
LUCMP	Local Urban Creek Monitoring Program
MRP	Municipal Regional Stormwater Permit
NPDES	National Pollutant Discharge Elimination System
QAPP	Quality Assurance Project Plan
RMC	Regional Monitoring Coalition
RMP	Regional Monitoring Program
RWQCB	Regional Water Quality Control Board
SFBRWQCB	San Francisco Bay Regional Water Quality Control Board
SSID	Stressor/Source Identification
SOP	Standard Operating Procedure
SWAMP	Surface Water Ambient Monitoring Program
TOC	Total Organic Carbon
TSS	Total Suspended Solids
USEPA	United States Environmental Protection Agency
WY	Water Year

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Executive Summary

Stressor/Source Identification (SSID) Projects are required by Provision C.8.d.i of the Municipal Regional Stormwater Permit (MRP). SSID projects are initiated as a result of triggers as indicated in MRP Table 8.1.

The Stressor Identification process may be iterative, and if the stressor cannot be adequately identified in the first attempt, the process may continue with collection of better data or testing other suspected stressors (USEPA, 2000).

This report presents the results of a site-specific Stressor Source Identification study to follow up on observations of low dissolved oxygen (DO) at the Crow Creek Site 204CRW030.

During WY2012 Creek Status monitoring this site was determined to have low DO during September with four out of seven 7-day rolling averages below the COLD beneficial use criteria of 7mg/L.

A three phase investigation was undertaken which included deployment of automated water parameter monitoring equipment and water sampling for nutrient analysis during July, August and September, 2013.

The initial results of this investigation drew the following preliminary conclusions:

1. *Is the Reservoir spillway a contributor to lower DO in the creek system?*

It was found that, during the monitoring period, there was no connectivity between Cull Reservoir and Crow Creek. Flow rates were negligible in the Cull creek system which was majority pooled and stagnant. The finding of this study, therefore, was that, during the monitoring period, no water quality impacts could be attributed to the spillway associated with the reservoir, or flows from the reservoir.

2. *Is seasonality contributing to lower DO concentrations?*

Dissolved oxygen concentrations were found to decrease between July and September suggesting the potential for increased impacts due to seasonality.

3. *Is low flow contributing to lower DO concentrations?*

Flows within Crow Creek were found to be low (generally less than 10L/sec). There was no observed decrease in flows between July and September.

4. *Is nutrient availability contributing to lower DO concentrations?*

During WY2013 water quality monitoring there was little evidence of elevated nutrient concentrations, suggesting that increased biomass and nutrient presence was not a significant cause of lower DO.

There was evidence that acute episodes of decreased DO may have occurred in the past. As reported by the public in August, 2012, this site has been impacted by discharges which have led

to fish kills. This particular event may have contributed to the lower levels of DO observed during the WY2012 monitoring.

In conclusion, this study represents an adaptive and iterative preliminary investigation into low DO in Crow Creek. Adjustments in the monitoring plan (in the form of Monitoring Phases) were implemented throughout the study as additional information was gathered. Further revising of the study questions for future phases may be necessary as part of the next steps. ACCWP will work with stakeholders to determine what additional information or data is needed to identify potential sources.

1 Introduction

The Alameda Countywide Clean Water Program (ACCWP) conducts Creek Status Monitoring as required by Provision C.8.c of the Municipal Regional Stormwater Permit (MRP, SFBRWQCB Order R2009-0074). ACCWP's 17 member agencies have joined with 56 other MRP Permittees to form the BASMAA Regional Monitoring Coalition (RMC), a regional collaborative to coordinate monitoring conducted pursuant to MRP Provision C.8. The RMC prepared a Quality Assurance Project Plan (QAPP, BASMAA 2012a and 2014a) and Standard Operating Procedures (SOPs, BASMAA 2012b and 2014b) to standardize monitoring methods and ensure comparability of monitoring data with the state's Surface Water Ambient Monitoring Program (SWAMP) see Table 1-1.

Table 1-1: Standard Operating Procedures Pertaining to BASMAA RMC Creek Status Monitoring.

SOP #	SOP Title
FS-1	BMI and Algae Bioassessments, and Physical Habitat Measurements
FS-2	Water Quality Sampling for Chemical Analysis, Pathogen Indicators, and Toxicity
FS-3	Field Measurements, Manual
FS-4	Field Measurements, Continuous General Water Quality
FS-7	Field Equipment Cleaning Procedures
FS-8	Field Equipment Decontamination Procedures
FS-9	Sample Container, Handling, and Chain of Custody Procedures
FS-10	Completion and Processing of Field Datasheets
FS-11	Site and Sample Naming Convention
FS-12	Ambient Creek Status Monitoring Site Evaluation
FS-13	QA/QC Data Review
N/A	Unified Stream Assessment: A User's Manual, v2.0

The RMC's Creek Status and Long-Term Trends Monitoring Plan (BASMAA 2011) which assigns each of the Creek Status monitoring parameters listed in MRP Table 8.1 to one of two sub-design components:

- Regional: ambient monitoring to assess the condition of aquatic life in creeks across the San Francisco Bay Area. Candidate monitoring sites were drawn from a probabilistically generated master list that included all perennial and non-perennial creeks and rivers within the applicable portions of the five participating counties. Sites from the RMC master list are identified by an alphanumeric code in which the last 6 characters are "Rnnnnn" with "R" designating the RMC probabilistic design and "nnnnn" the site's numeric sequence number generated through the RMC master draw[1]. RMC sites can also be assigned an alternative ID using the SWAMP naming procedure described in RMC SOP FS-11.
- Targeted: monitoring design and site selection address local watershed management questions. The last 6 characters of each Site ID reflect the watershed and numbering from the base of the watershed per the RMC SOP FS-11.

Creek Status Monitoring was initiated in WY2012 (October 2011 through September 2012) and reported in the Urban Creeks Monitoring Report (UCMR, BASMAA 2013) submitted to the (RWQCB) in March 2013. The UCMR evaluated all data against "trigger criteria" listed for each parameter in MRP Table 8.1, which identifies potential follow-up actions, including Stressor/Source Identification (SSID) projects as required by Provision C.8.d.i of the Municipal Regional Stormwater Permit (MRP), subject to several conditions[2]:

1. Creek Status Monitoring results meet one or more trigger criteria in MRP Table 8.1
2. When conducting monitoring through a regional collaborative, Permittees are collectively required to initiate no more than ten SSID projects during the Permit term (ACCWP's proportionate share is assumed to be three projects out of the 10).
3. If results indicate toxicity, at least 2 of the 10 SSID projects must be for toxicity
4. No need to repeat for continuing or recurring occurrences of the trigger in later results from the same receiving water limitations, unless directed to do so by the Water Board
5. No need to follow up on trigger results that are caused by Pollutants of Concern which are already being addressed by other portions of the MRP (e.g. pesticides).

[1] As recommended for SWAMP data compatibility per RMC SOP FS-11, all site ID codes begin with a 3 digit Hydrologic Unit Code.

The RMC programs developed a collaborative decision-making process for selecting sites for SSID follow-up. Program representatives reviewed the previous year's creek status monitoring results which reached "trigger" criteria, and prioritized sites for SSID follow-up based on several criteria including environmental significance of the trigger results and the feasibility of completing the project steps outlined in the MRP (see below). After consultation with affected Permittee(s), the RMC confirmed the candidate SSID project list with Water Board staff in April 2012 and individual programs planned implementation of SSID studies in their areas for Financial Year 2013-14.

The MRP lists four steps for an SSID project. ACCWP and other Countywide Programs will lead the technically oriented steps 1 and 4 and collaborate with relevant Permittees on step 2: Permittee(s) will be the lead on step 3 to the extent that effective stormwater BMPs are within their power and jurisdiction.

(1) Conduct a site specific study (or non-site specific if the problem is wide-spread) to identify and isolate the cause(s) of the trigger stressor/source. If the trigger stressor or source is already known (e.g. toxicity), proceed directly to step 2.

(2) Identify and evaluate the effectiveness of options for controlling the cause(s) of the trigger stressor/source.

(3) Implement one or more controls.

(4) Confirm the reduction of the cause(s) of trigger stressor/source.

This report documents ACCWP planning and implementation activities for a site-specific study as step 1 in development of a SSID project for the Crow Creek watershed through December 2013. Further evaluation and project planning will continue in WY2014.

The outline of this initial SSID study is based on the Stressor Identification steps identified by the Causal Analysis/Diagnosis Decision Information System (CADDIS), an Internet-based tool[3] based on USEPA guidance (USEPA 2000)[4]:

1. Define the Case;
2. List Candidate Causes;
3. Evaluate Data from the Case;

[3] http://www.epa.gov/caddis/index.html

4. Evaluate Data from Elsewhere; and

5. Identify Probable Causes.

The Stressor Identification process may be iterative, and if the stressor cannot be adequately identified in the first attempt, the process may continue with collection of better data or testing other suspected stressors (USEPA, 2000).

2 Study Area & Background

This section provides background information regarding the Crow Creek Watershed and its beneficial uses, as well as the RMC pollutant benchmarks reported from WY2013.

2.1.1 Crow Creek Watershed

Crow Creek is a tributary of San Lorenzo Creek with a watershed area of about 11.2 square miles in unincorporated Alameda County (Figure 2-1). Most of the existing development in the upper watershed is concentrated along Crow Canyon Road, which parallels the creek. Rural land uses include grazing, some single family homes and also a number of equine facilities, primarily for horse boarding. The lower watershed contains some suburban residential tracts and also receives sporadic inputs from Cull Creek, a primarily non-urban watershed whose 6.4 square mile drainage is mostly impounded in Cull Reservoir just above its confluence with Crow Creek. The East Bay Regional Parks District manages the area around the reservoir as Cull Canyon Regional Recreation Area.

2.1.2 Beneficial Uses

Beneficial uses (SFRWQCB, 2011) assigned to Crow Creek and its tributary Cull Creek are as follows:

- Cold Freshwater Habitat (COLD);
- Warm Freshwater Habitat (WARM);
- Fish Migration (MIGR) - assigned Crow Creek only,
- Preservation of Rare and Endangered Species (RARE);
- Fish Spawning (SPWN); and
- Water Contact and Non-contact Recreation (REC-1 and REC-2).

Figure 2-1. SSID study area on Crow and lower Cull Creeks, with inset showing watersheds of Cull Creek and greater Crow Creek (including tributaries).

2.1.3 Confluence of Cull Creek and Crow Creek

Cull Reservoir, fed by seasonal flows from Cull Creek, sporadically discharges into Crow Creek at a channelized confluence located in Bay Trees Park just below Cull Dam (Figure 2-1). In WY2012, low dissolved oxygen was observed during September monitoring for General Water Quality at a site (Site 204CRW030) directly below the confluence. These results met MRP benchmarks described in detail in Section 2.2.

2.2 Trigger Results from Water Year 2012 Creek Status Monitoring

Comparison of WY2012 sampling results with MRP benchmark criteria are presented in Table 2-1.

Table 2-1. Trigger Type and Significance from WY2012 Creek Status Monitoring

Trigger type	Strength/magnitude	Comment
"Triad" - bioassessment indication of alteration	Not sampled	Previous bioassessment generally good
"Triad" - sediment chemistry	chemicals Not sampled	
	Not sampled	
	Pyrethroids Not sampled	
"Triad" - sediment toxicity	Not sampled	
Chlorine in water column	Not sampled	
Toxicity in water column	Not sampled	
General Water Quality - DO	**67% <7 mg/L 7-day rolling average**	4 of 6 rolling averages were below 7mg/L – observed between 20th – 25th September, 2012
General WQ - other	Not triggered	
Temperature	Not triggered	
Pathogen Indicators	Not sampled	

2.3 Review of Available Data

This section presents a preliminary summary of the some select data available pertaining to Cull and Crow Creeks.

2.3.1 Cull Reservoir Inflow

The Cull Reservoir has a total drainage area of 5.79 mi^2 (USGS, 2013). The United States Geological Service (USGS) has an established gauging station within Cull Reservoir, located on the left bank approximately 0.9 miles upstream of Cull Creek Dam. Summary data obtained from this gauging station in 2012 are presented in Figure 2-2. Summary data for the historical discharges between 1979 and 2012 are presented in Figure 2-3. In general, discharges from the Cull Reservoir were negligible between July and October. Highest flow volumes were generally recorded between February and May.

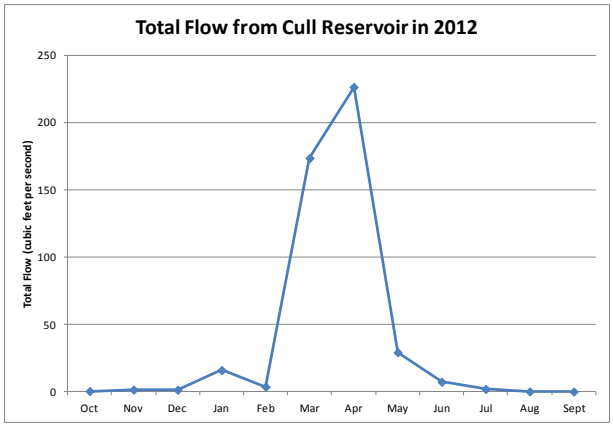


Figure 2-2. Summary Total Flow Data from Cull Reservoir in 2012

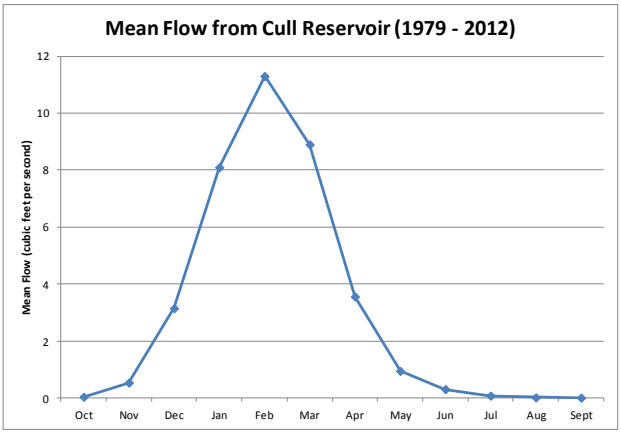


Figure 2-3. Summary Mean Flow Data from Cull Reservoir between 1979 – 2012

2.3.2 Observations of Water Quality Issues

On August 11, 2012, a local creek-side resident reported to Alameda County that there was a significant fish kill in the segment of Crow Creek extending above the vicinity of Site 204CRW020 (Internal correspondence, August-September, 2012, see synopsis in Attachment B). Extensive follow-up investigation by Alameda County illicit discharge inspection staff and staff from the Regional Water Board NPDES enforcement group could not ascertain the exact cause or stressor that produced this significant fish kill although a Sanitary Sewer Overflow had been suspected (see Attachment B).

In 2013, the same resident communicated with ACCWP staff and consultants, providing photographs of the August 11 fish kill and additional comments, previously unreported, of

observations which suggested that illicit discharges to a storm drain may have contributed to this incident and also that he observed several smaller fish kills later that summer through fall which were apparently unreported. The possibility that one of the recurring fish kills may have been concurrent to the September deployment of the YSI during WY2012 was considered in the adaptive design for Phase 2 of this SSID study

Overview of Creek Status Results from WY2012

Water quality parameters were recorded, using a YSI, at Site 204CRW030 during two ten day periods of continuous monitoring in WY2012 (box plots[5] in **Error! Reference source not found.** Figure 2-4)[6]. The data suggest that, in general, DO ranged from 7mg/L to 10mg/L. The highest DO measurement of 11.8mg/L was recorded on May 27, 2012 at Site 204CRW030. This site also recorded the lowest DO measurement of 1.86mg/L, on September 22, 2012.

The daily mean and 7-day rolling mean results are provided in Figure 2-5. These data show that all Spring daily mean DO concentrations were above 7mg/L. Fall daily mean data at Site 204CRW030 were consistently lower than 8mg/L but above 5mg/L.

[5]A box plot splits the data set into quartiles. The body of the plot consists of a "box", which goes from the first quartile to the third quartile. Within the box, a vertical line is drawn at the median of the data set. Two horizontal lines, called whiskers, extend from the front and back of the box. The front whisker goes from the first quartile to the smallest non-outlier in the data set, and the back whisker goes from the third quartile to the largest non-outlier. If the data set includes one or more outliers, they are plotted separately as points.

[6] Intermittent power failure (due to a leaking battery) for the YSI deployed in the fall at site 204CRW030 recording General Water Quality measurements prevented a complete record over the deployment period. Post-deployment calibration and drift checks passed all checks, therefore recorded data is viewed as compliant with QAPP DQOs.

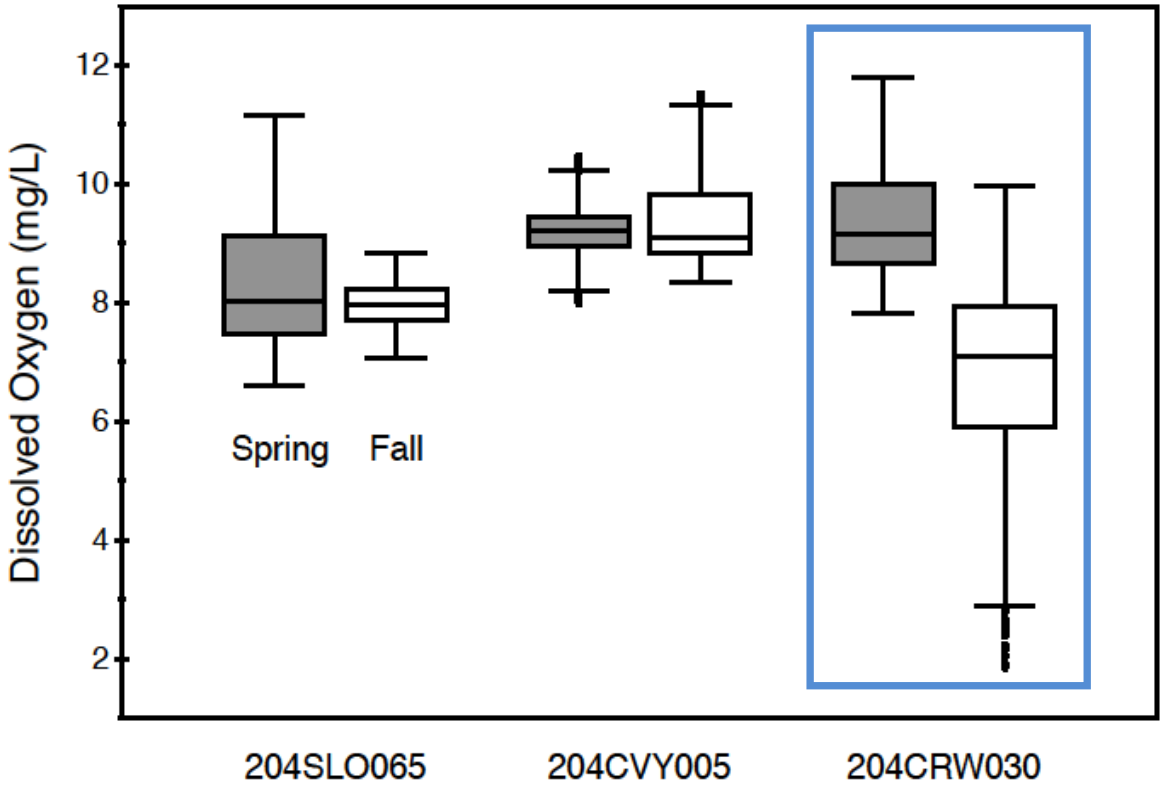


Figure 2-4. Dissolved Oxygen Box Plot for Spring (May and June) and Fall (August and September)

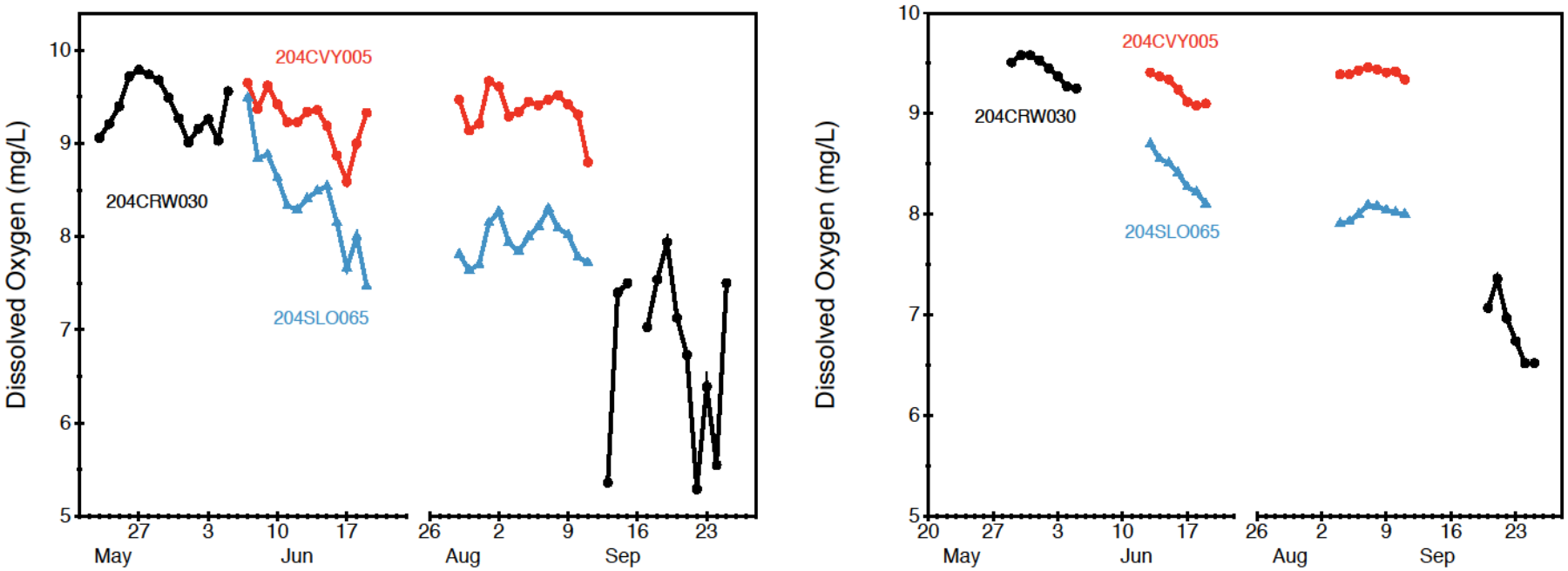


Figure 2-5. Dissolved Oxygen Line Graph of Daily Mean (left) and 7-Day Rolling Mean (right Results in Spring (May and June) and Fall (August and September).

3 Study Design and Monitoring Methods

This section presents the original conceptual model and study questions used to design the Crow Creek SSID monitoring program. The study design was iterative as information was gathered throughout the monitoring period and therefore comprised three distinct phases. Based on the results of this preliminary project, further phases may be designed to further address arising study questions.

3.1 Study Questions

Study questions were posed as a framework for the study design during initial stages of the SSID program. The study questions presented in Table 3-1 are based on the preliminary conceptual model and review of historical data relevant to the site. Most questions posed in this initial planning stage were intended to characterize the system and its processes and were added to and adjusted as the project continued.

Table 3-1. Study Questions Developed for Crow Creek SSID

Question	Study Method	Expected outcome
Is the Reservoir spillway outflow a contributor to lower DO in the creek system?	Addressed through continuous monitoring equipment deployment at five locations within Cull and Crow Creeks.	Tests the hypothesis that water from the spillway is lower in DO and higher in nutrients, leading to downstream impacts. Hypothesis tested through comparison of water quality parameters from the spillway with downstream locations.
Is seasonality contributing to lower DO concentrations?	Addressed through continuous monitoring equipment deployment and comparison to historical data.	Tests the hypothesis that warmer water temperature and increases in nutrients play a role in decreasing DO concentrations in the Cull/Crow water system. Hypothesis tested through comparison of data from WY12 (May/June and August/Sept) and WY13 (July and August) at 204CRW030.
Is low flow contributing to	Addressed through continuous	Tests the hypothesis that low

lower DO concentrations?	monitoring equipment deployment	flow is linked to decreases in DO. Hypothesis tested by comparison of water quality data from sites directly above the confluence of Cull and Crow creeks, as well as the downstream site at 204CRW030. Comparison of conductivity will also be used as a surrogate indicator of flow contribution.
Is nutrient availability contributing to lower DO concentrations?	Addressed through water sampling at five different sampling locations within creek system.	Tests the hypothesis that higher nutrient concentrations correlate with lower DO in this system. Hypothesis tested through comparison of nutrient concentrations and DO from all creek locations.
Is an illicit discharge responsible for the low DO observed in WY2012?	Addressed through review of prior investigations and interviews with resident/s and comparison against WY2013 data.	Tests the hypothesis that an acute illicit discharge was responsible for those low DO concentrations observed during WY2012 monitoring.

The monitoring program design for WY2013 was developed to address these study questions.

3.2 Conceptual Model of Sources and Processes

As part of the initial project scoping, a conceptual model was outlined for relevant processes and inputs in the watershed draining to the original creek status monitoring site. This was used to:

- generate hypotheses to be tested in the site-specific study;
- develop a preliminary list of potential follow up control measures; and
- evaluate the feasibility of all SSID project steps.

In the Crow Creek SSID project, a number of potential candidate causes were identified and presented as a geographical illustration in Figure 3-1**Error! Reference source not found.** and in

flow chart form in Figure 3-2**Error! Reference source not found.**. Under this conceptual model the most likely causes of low observed DO were proposed to be:

- Discharges from the Cull Reservoir – excess vegetation and warmer temperatures were hypothesized to reduce DO in the water;
- Inputs from Cull Creek – downstream of the reservoir, Cull Creek enters an exposed, high temperature, engineered channel, which was hypothesized to reduce DO concentrations; and
- Inputs from Crow Creek – upstream of the confluence with Cull Creek, Crow Creek is impacted by rural/suburban land uses including horse ranches. Presence of elevated nutrients was hypothesized to lead to DO concentrations.
- Illicit discharges were not originally considered, but in light of further information gathered during the course of WY2013 they were included as a potential source during Phase 2 of the study.

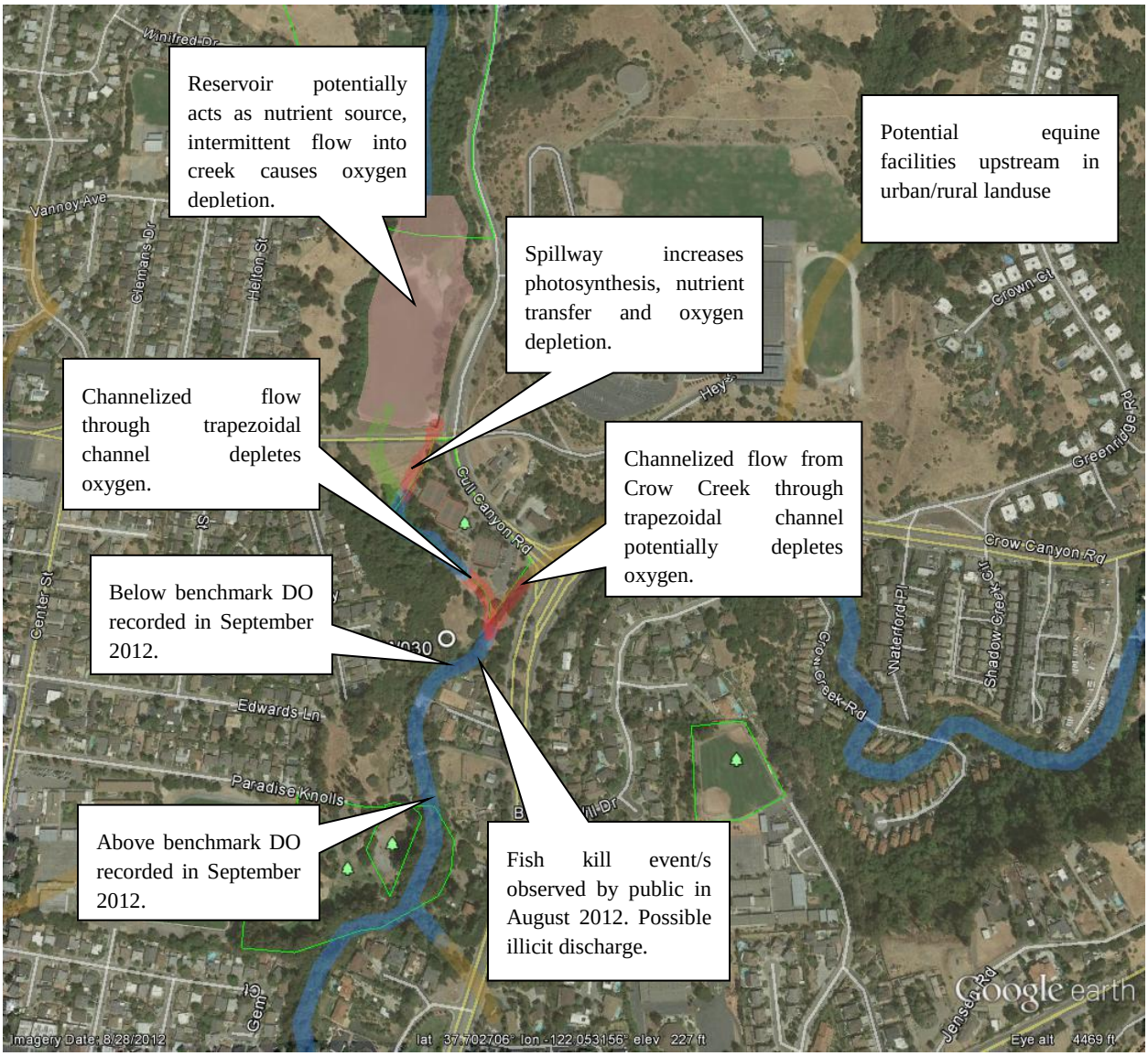


Figure 3-1. Concept Model of Candidate Causal Stressors and Observed Impacts [arrows are not pointing to appropriate places]

Figure 3-2 presents a rudimentary categorization of the aspects of the conceptual model of potential causes, process, potential impacts and observed impacts developed for the Crow Creek SSID project. The conceptual model is developed based on the overall guidance provided in CADDIS. The potential stressors identified in the watershed leading to the study area were low

flow from the Cull Creek spillway, flows from Crow Creek, seasonal influences and illicit discharges.

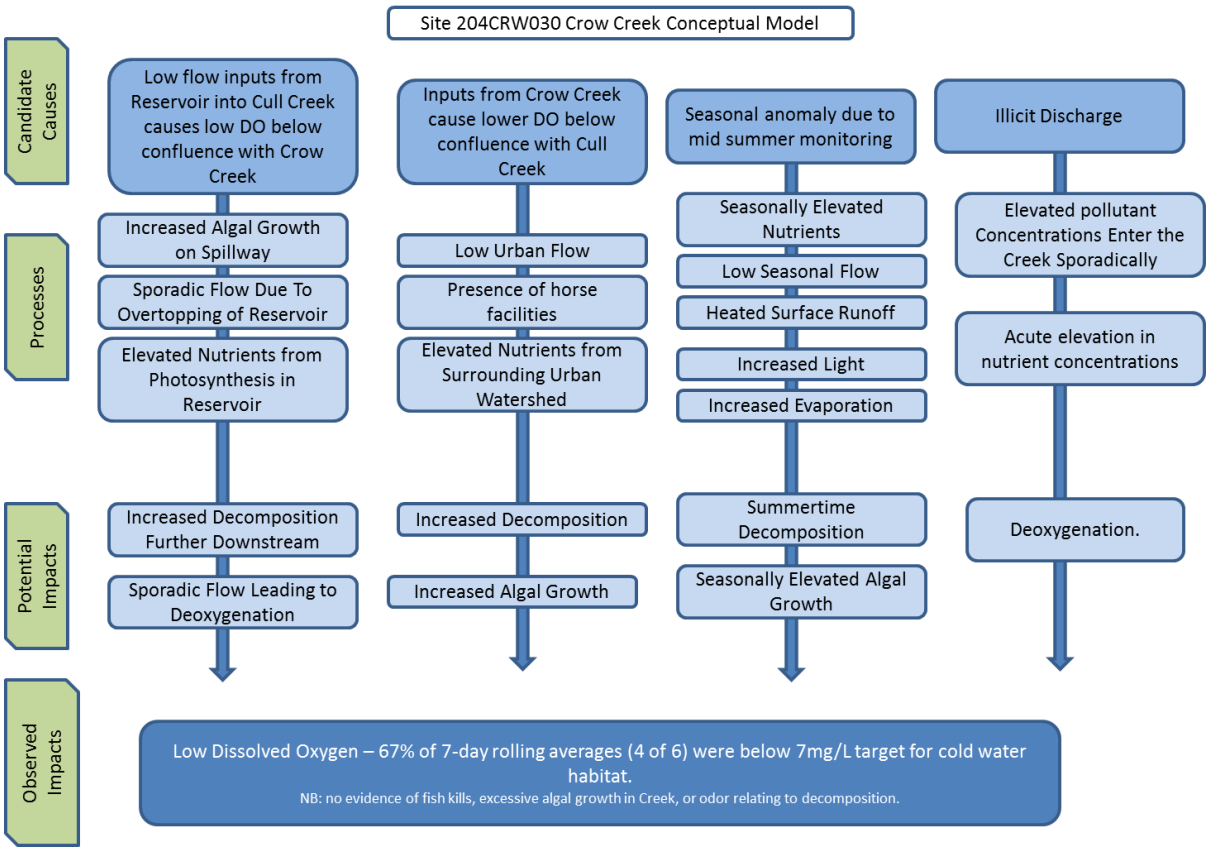


Figure 3-2. Conceptual Model and Processes for Site 204CRW030

3.3 Monitoring Locations

Monitoring design followed an adaptive process, with an initial phase performed during summer to better understand the seasonal patterns of the water quality parameters, followed by two more phases that were each informed by the results of the previous phase. Monitoring locations for WY2013, together with site codes and coordinates are presented in

Table 3-2.

Table 3-2.Monitoring Locations and Water Sampling for Crow Creek SSID.

Site Code	Description	Latitude	Longitude
204CUL015	Cull reservoir spillway settling pond, comprised of reinforced concrete approximately 12,000ft^2 volume	37.70308	-122.05587
204CUL005	Cull creek directly upstream of confluence under footbridge in natural channel, just upstream of concrete channel	37.70147	-122.05530
204CRW040	Crow creek directly upstream of confluence in concrete channel within stormdrain pipe located under Cull Canyon Road.	37.70130	-122.05468
204CRW030	Downstream of confluence in natural creek	37.70118	-122.05505
204CRW020	Downstream of 204CRW030 in natural creek	37.70018	-122.05542
OT-CRW-D1	Storm drain outlet at confluence pond below 204CRW040	37.70148	-122.05451

Figure 1-1: Cull and Crow Creek Monitoring Locations

3.4 Monitoring and Sampling

3.4.1 Phase I

Phase I of the monitoring and sampling plan (as described in Table 3-3) was implemented during the week of July 8 – 18th. YSI 6600 Sonde monitoring was conducted at 15 minute intervals. HOBO recording intervals (of temperature only) were 60 minutes.

Table 3-3. Phase I - July Monitoring Locations and Water Sampling for Crow Creek SSID.

	Continuous monitoring			Water sampling		Field measurements	
Site Code	**Equipment**	**Deployment**	**Data**	**Collection date**	**Analysis**	**Collection date**	**Analysis**
204CUL015	YSI 6600 Sonde	10 day deployment July 8 – 18, 2013	Water level* DO Temper-ature pH Conduct-ivity	July 8, 2013	COD BOD TKN Nitrate Nitrite Ammonia Total P Ortho-P TSS TDS TOC	July 8, 2013	Instant-aneous flow Temper-ature Conduct-ivity Turbidity Chlorine pH DO
204CUL005	HOBO (Onset Corp)						
204CRW040	HOBO (Onset Corp)						
204CRW030	YSI						
204CRW020	HOBO (Onset Corp)						

*at Site 204CRW030 only

3.4.2 Phase II

Based on the results of the July deployment and water quality sampling, the monitoring plan was adapted to adjust for the following considerations:

- Cull Creek was not flowing into Crow during July and August 2013, therefore no connectivity between the two streams was occurring;
- Information from a local resident suggested that the origin of the depleted oxygen in 2012 was attributable to flows from a 24" diameter storm drain entering the creek from underneath Crow Canyon Road adjacent to Site 204CRW040. Therefore sampling at this storm drain outlet was appropriate.

Phase II of the monitoring and sampling plan was implemented during the week of August 13th – 23rd, 2013 (Table 3-4). YSI 6600 Sonde monitoring was conducted at 15 minute intervals. HOBO recording intervals (of temperature only) were 60 minutes.

Table 3-4. Phase II - August Monitoring Locations and Water Sampling for Crow Creek SSID.

	Continuous monitoring			Water sampling		Field measurements	
Site Code	**Equipment**	**Deployment**	**Data**	**Collection date**	**Analysis**	**Collection date**	**Analysis**
204CRW040	YSI	10 day deployment August 13 – 23, 2013	Water level* DO Temper-ature pH Conducti vity	August 13, 2013	COD BOD TKN Nitrate Nitrite Ammonia Total P Ortho-P TSS TDS TOC	August 13, 2013	Instantaneous flow Temperature Conductivity Turbidity Chlorine pH DO
204CRW030	YSI						
204CRW020	Hobo*						
OT-CRW-D1 (Storm drain)	NA						

*at Site 204CRW030 site only

3.4.3 Phase III

Phase III of the monitoring and sampling plan was implemented during the week of September 24 – October 4, 2013 (Table 3-5).

Based on the results of the July and August deployments and water quality sampling, the monitoring plan was further adapted to adjust for the following considerations:

- Monitoring of DO at Site 204CRW030 should be continued as this was the original point of concern and had been assessed in both July and August with YSI 6600 Sonde monitoring conducted at 15 minute intervals; and
- Further water sampling (with associated analysis for chemistry) was not necessary since previous water sampling indicated no causative connection.

Table 3-5. Phase III - September Monitoring Locations for Crow Creek SSID.

	Continuous monitoring			Field measurements	
Site Code	**Equipment**	**Deployment**	**Data**	**Collection date**	**Analysis**
204CRW040	YSI	10 day deployment September 24 – October 4, 2013	Water level* DO Temperature pH Conductivity	September 24, 2013	Instantaneous flow Temperature Conductivity Turbidity Chlorine pH DO
204CRW030	YSI				

*at Site 204CRW030 only

3.5 Data Collection Methods

Field data were collected in accordance with SWAMP-comparable methods and procedures described in the BASMAA RMC Quality Assurance Project Plan (QAPP) (BASMAA 2012a) and Standard Operating Procedures (SOP) (BASMAA 2012b) (Table 1-1). All nutrient samples were processed and sent to the same laboratories as those used in the RMC program. Data were

analyzed and reported per SWAMP-comparable methods as described in the RMC QAPP (BASMAA 2012a and BASMAA 2014a). Analytical laboratory methods, reporting limits and holding times for chemical water quality parameters are also reported in the BASMAA QAPP (2012a and 2014a).

3.5.1 Quality Assurance/Quality Control

Data quality assessment and quality control procedures are described in detail in the BASMAA RMCQAPP (BASMAA 2012a). Data were collected according to the procedures described in the relevant SOPs, including appropriate documentation of data sheets and samples, and sample handling and custody. Laboratories providing analytical support to the RMC were selected based on demonstrated capability to adhere to specified protocols.

Specific to this study, the following quality control water samples were collected:

- One additional water sample was collected as a field duplicate;
- One field blank was collected for dissolved ortho-Phosphate; and
- Matrix spikes and lab blanks were conducted by the analytical laboratory.

4 Results

4.1 Statement of Data Quality

Field data sheets and laboratory reports were reviewed by ACCWP and the results evaluated against the relevant DQOs as described in the QAPP (BASMAA, 2012a, 2014a) and SOPs (BASMAA, 2012b).

4.2 Monitoring Results

This section presents monitoring results based on each program component. Results were reviewed for all parameters as a 7-day rolling average for purposes of comparison to trigger criteria in provision C.8.c and Table 8.1 of the MRP.

4.2.1 Water Quality Assessment of the Outflow From Cull Reservoir

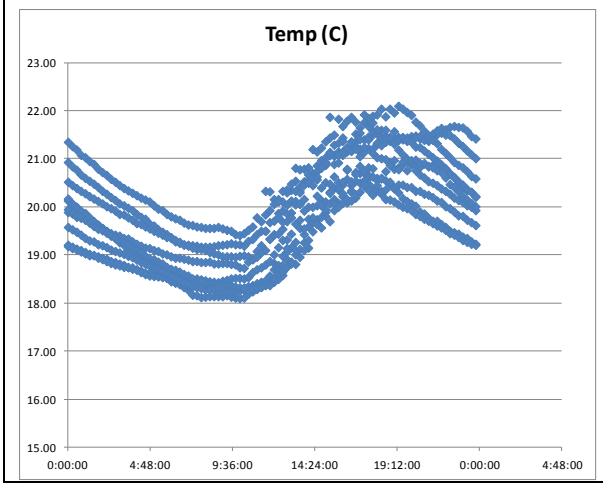
During the Phase I July deployment of YSIs, the Cull Reservoir spillway (Site 204CUL015) was monitored for a ten day period. The results of that monitoring (Table 4-1 and Figure 4-1) indicated that:

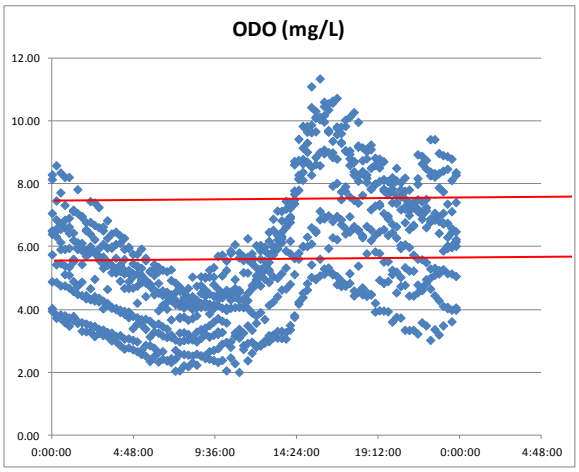
- Visual observations in the field confirmed USGS gauging data to show that Cull Reservoir had no flow entering from the Cull tributary into the Crow tributary; and did not contribute flows to Crow Creek between July 8, 2013 and October 4, 2013.
- Average daily water temperatures ranged between 18.77°C and 21.06°C, with the highest temperatures recorded in late afternoon;
- Field measurement of chlorine at this site were elevated in July (0.3mg/L)[7];
- Average daily dissolved oxygen ranged between 3.83 and 7.28mg/L with the highest DO concentrations recorded in late afternoon; and
- The 7-day rolling average for DO was below the COLD benchmark of 7mg/L for the July monitoring period but was above the WARM benchmark of 5mg/L.

[7] This observation was from an isolated grab sample and unrelated to the study questions. ACCWP staff reported this to the EBRPD Water Management Supervisor who later confirmed that he worked with staff at Cull Canyon Recreation Area to correct dechlorination practices at the swim lagoon (Hal MacLean pers. comm. To Arleen Feng, July 2013),

Table 4-1. Average Daily Water Quality Measurements at Site 204CUL015 during Phase I Deployment in July 2013

Date	Temp (°C)	pH	DO (mg/L)	Specific Conductivity (mS/cm)
7/8/13	21.06	8.05	5.73	1.691
7/9/13	20.42	7.97	3.83	1.720
7/10/13	20.71	7.92	3.60	1.753
7/11/13	20.11	7.92	4.40	1.775
7/12/13	20.01	7.97	5.86	1.794
7/13/13	19.57	8.04	6.54	1.812
7/14/13	19.69	8.07	7.28	1.830
7/15/13	19.36	8.07	6.94	1.847
7/16/13	19.14	8.04	6.19	1.865
7/17/13	19.24	8.04	5.96	1.881
7/18/13	18.77	8.02	5.28	1.891





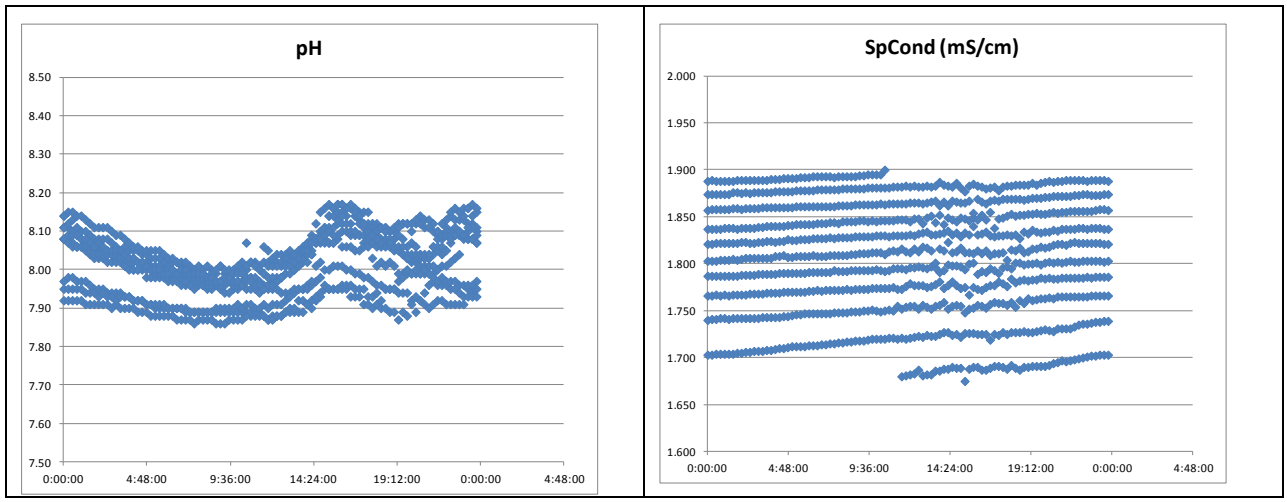


Figure 4-1. Daily Recorded Temperature, Dissolved Oxygen, pH and Conductivity at Site 204CUL015 during Phase I Deployment in July 2013. DO benchmarks are shown for COLD (7 mg/L minimum) and WARM (5 mg/L minimum) Beneficial Uses (red line).

4.2.2 Water Quality Assessment of the Crow Creek Site 204CRW030

Site 204CRW030 was originally monitored in WY2012 over two ten day periods, it was during this monitoring that low DO was observed and the site chosen for special study. Three phases of YSI deployment were scheduled at this site to assess changes in DO concentrations. Those results are presented in Figure 4-2 through Figure 4-5 and summarized in Table 4-2.

Table 4-2. Percentage of Weekly (7-day rolling) Averages Meeting Benchmarks

Parameter	Month	Temp. > 19ºC	pH < 6.5	pH > 8.5	DO < 5mg/L (WARM)	DO < 7mg/L (COLD)
% meeting Benchmark	July	0.0%	0.0%	0.0%	0.0%	100.0%
	August	0.0%	0.0%	0.0%	40.0%	100.0%
	September	0.0%	0.0%	0.0%	80.0%	100.0%

Results indicated that DO concentrations decreased from July through to early October, with increased 7-day rolling averages meeting benchmarks for WARM (5mg/L). During the same period of time water temperatures decreased from an average of 16.5ºC in July to 14.3ºC in late September.

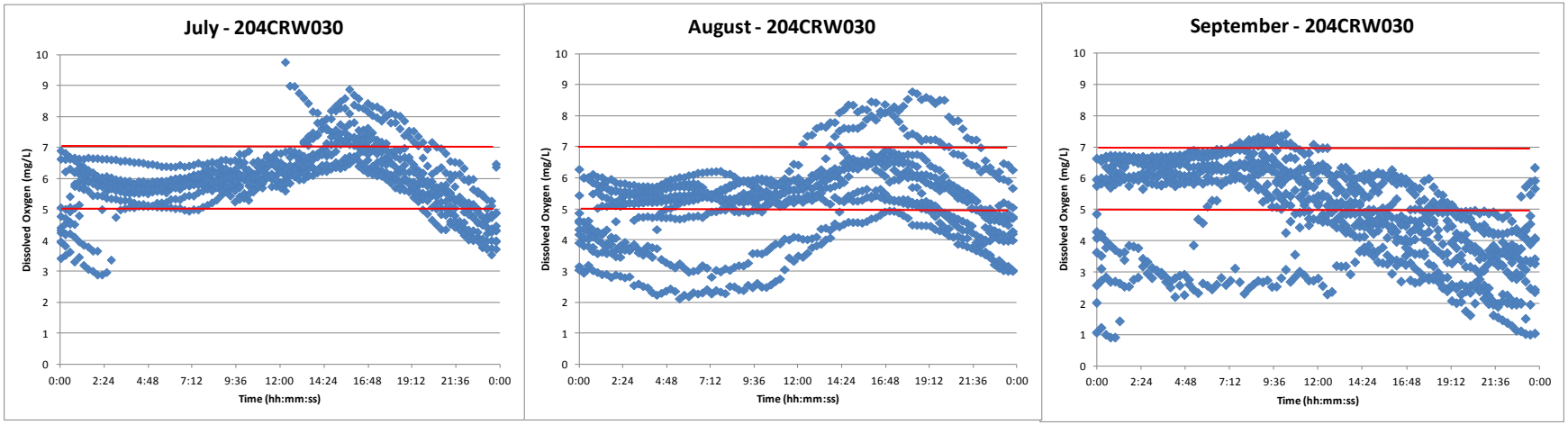


Figure 4-2. Daily Merged Dissolved Oxygen Concentrations at Site 204CRW030 during July, August and September, 2013. DO benchmarks are shown for COLD (7 mg/L minimum) and WARM (5 mg/L minimum) Beneficial Uses (red line).

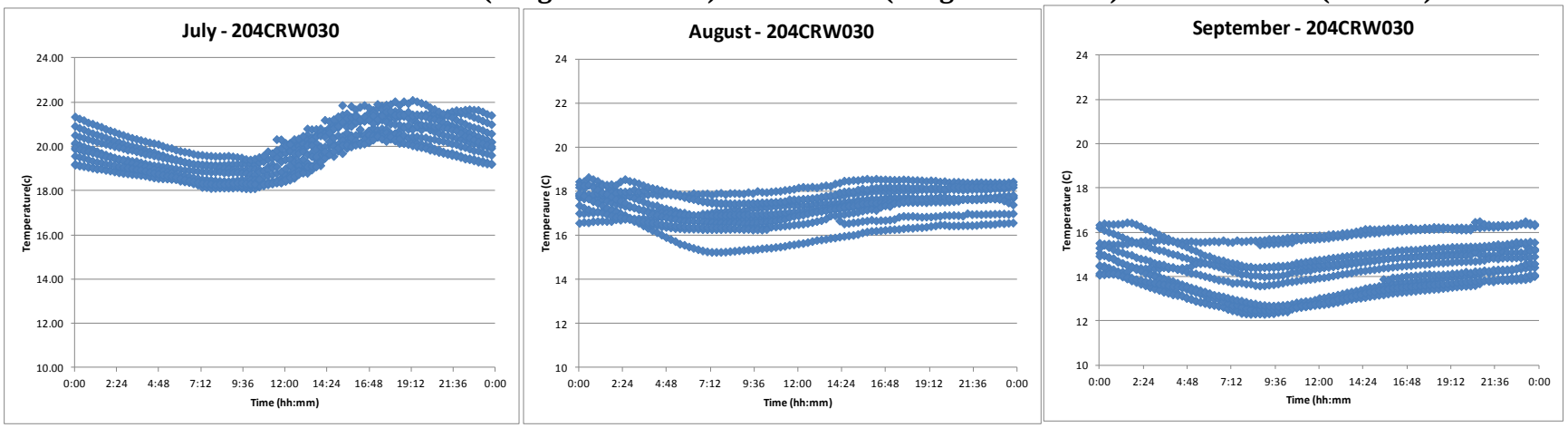


Figure 4-3. Daily Merged Temperature at Site 204CRW030 during July, August and September, 2013.

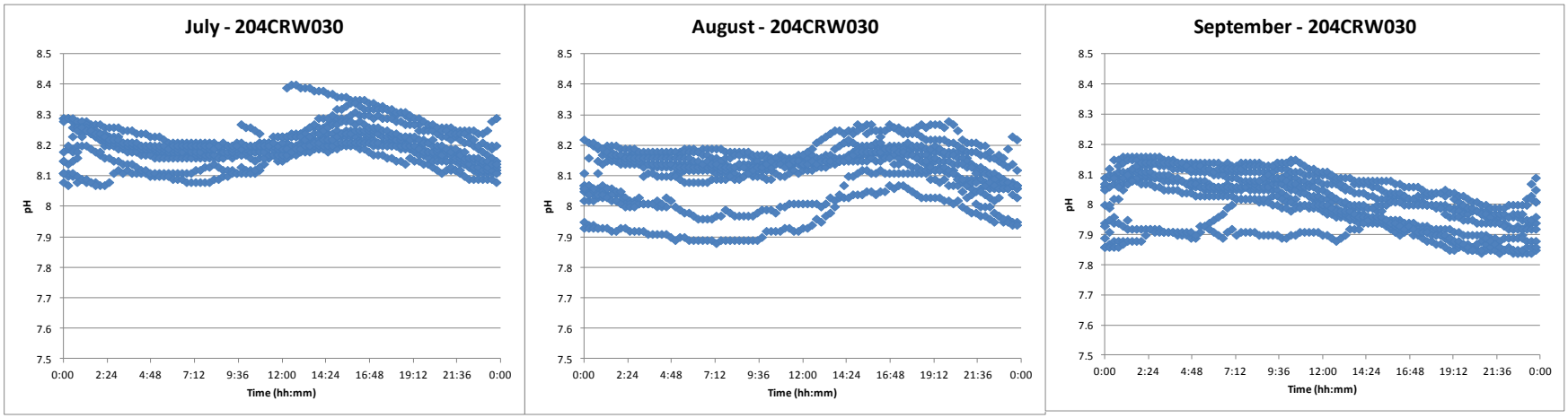


Figure 4-4. Daily Merged pH at Site 204CRW030 during July, August and September, 2013.

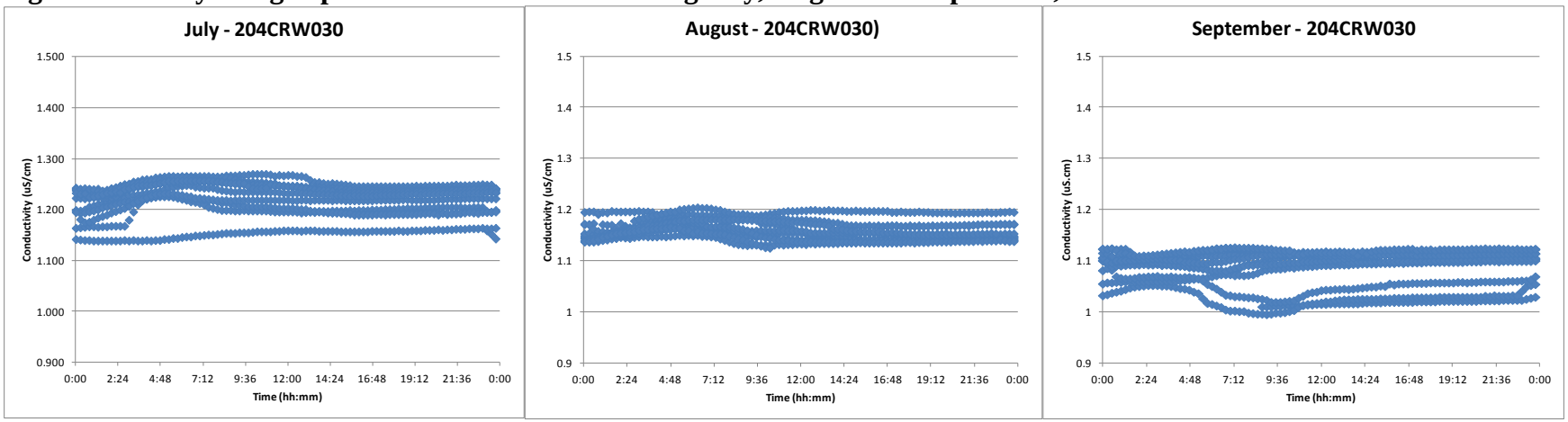


Figure 4-5. Daily Merged Conductivity at Site 204CRW030 during July, August and September, 2013.

4.2.3 Water Quality Assessment of the Crow Creek Site 204CRW040

Site 204CRW040 is located upstream of Site 204CRW030, within a ponded area in the modified channel at the confluence of Cull and Crow Creeks. This site was an important area for investigation when considering the potential impact of flows from upstream Cull and Crow sources. Continuous monitoring was conducted at this location during August, with temperature measurements collected during July together with water chemistry assessments in July and August.

Daily merged data from the August YSI deployment are shown in Figure 4-6. These results illustrate the elevated DO concentrations at this site with concentrations well above benchmarks for WARM and COLD DO concentrations, with a regular diurnal pattern. Temperatures within the pool were consistently elevated during the latter part of the day with a similar diurnal pattern.

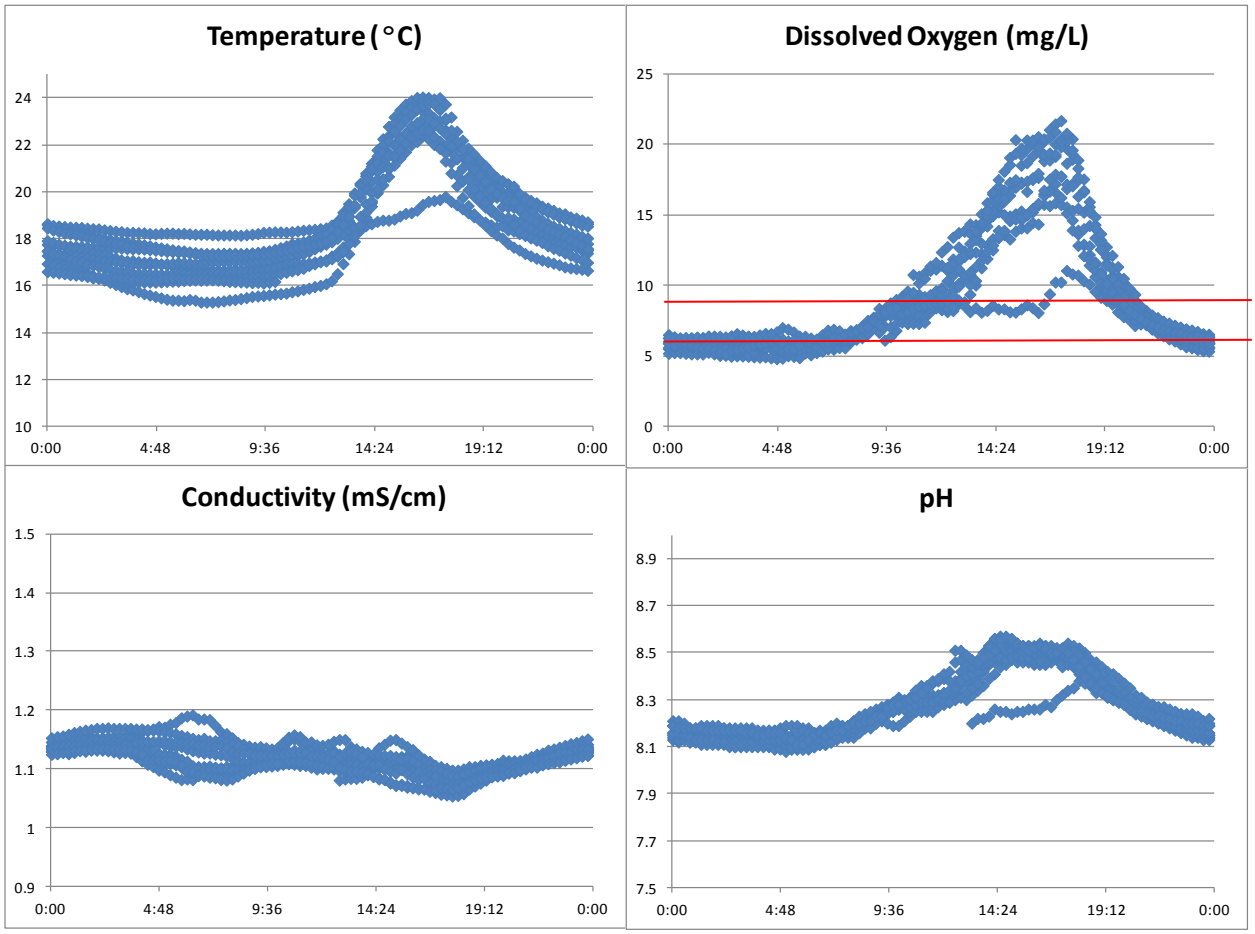


Figure 4-6. Daily Merged Water Quality Parameters at Site 204CRW040 during August, 2013. DO benchmarks are shown for COLD (7 mg/L minimum) and WARM (5 mg/L minimum) Beneficial Uses (red line).

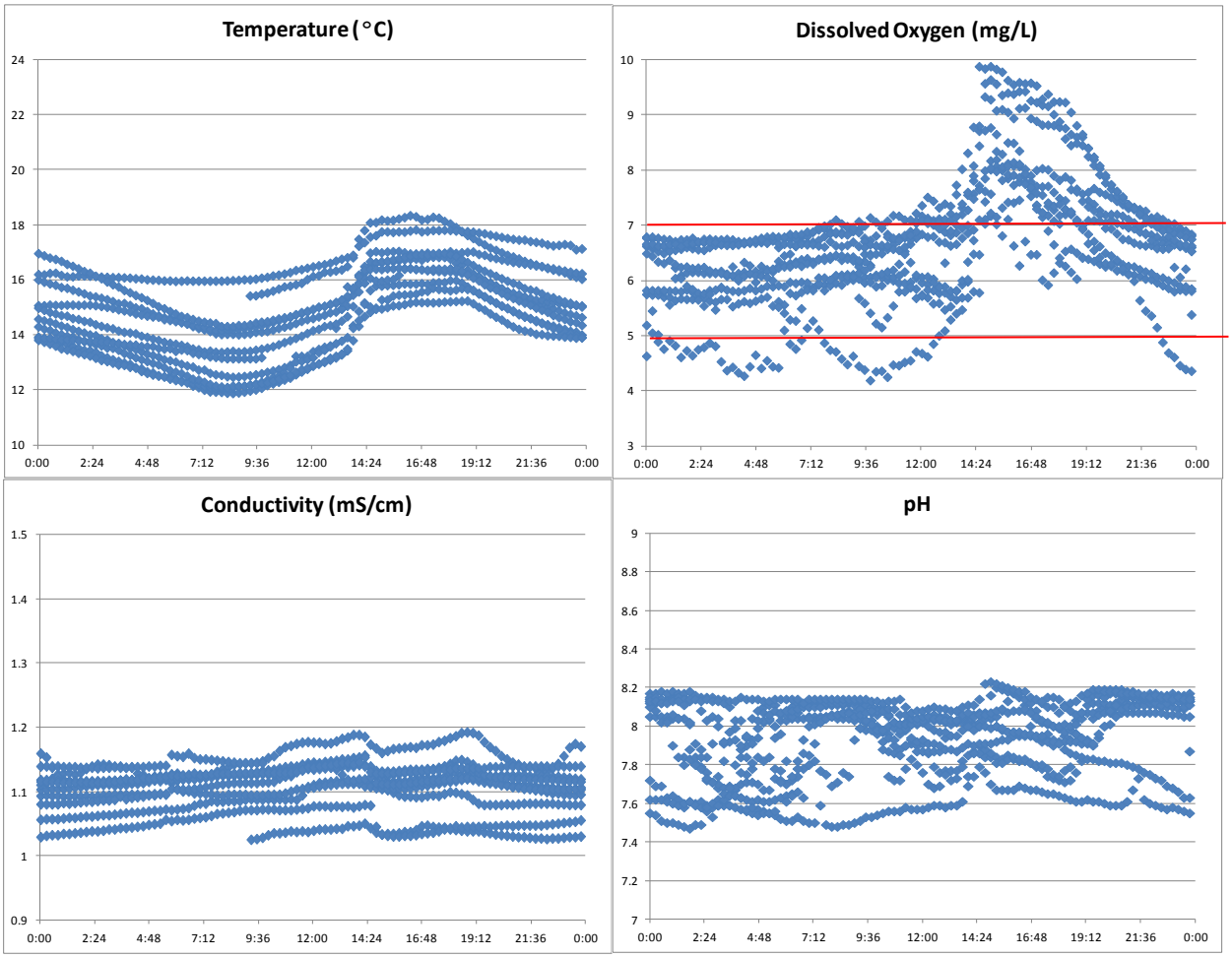


Figure 4-7. Daily Merged Water Quality Parameters at Site 204CRW040 during September/October, 2013. DO benchmarks are shown for COLD (7 mg/L minimum) and WARM (5 mg/L minimum) Beneficial Uses (red line).

4.2.4 Estimated Flow

Flow velocity at each of the monitoring sites was estimated using either a Marsh McBirney hand held flow meter or the "leaf" method, and used to estimate stream discharge.

Table 4-3. Estimated Flow at Crow Creek Sampling Locations in July and August, 2013.

Site ID	July 23, 2013	August 13, 2013
204CRW020	6 L/sec	4 L/sec
204CRW030	10 L/sec	12 L/sec
204CRW040	7 L/sec*	4 L/sec*
OT-CRW-D1	NA	0.05 L/sec**

*"Leaf" method used for flow estimate, with assumed 0.8 roughness coefficient
**Visually estimated discharge from storm drain with likely intermittent and variable flows.

Transect measurements at the confluence of Cull and Crow Creek at Site 204CRW040 indicated a total pool volume of 17.1 m^3 (or 17,100L). Flow into the pool was estimated to be approximately 5 L/sec, therefore residence time within the pool was estimated to be approximately one hour.

4.2.5 Chemistry Results

Water samples were collected during the July and August sampling periods to assess water chemistry parameters at a number of different locations within the Cull and Crow Creek systems.

The results of the July and August water chemistry analyses are presented in Table 4-4 and Table 4-5 respectively.

The results indicated the following:

- In July, the highest concentrations of COD, total phosphorus, TSS, BOD and TOC were measured at Site 204CUL015, the site of the Cull Reservoir spillway. Since this spillway has no connectivity with the downstream Crow Creek, these results are not relevant to the observed low DO; and
- Results from the August water chemistry analyses indicated no qualitative difference between parameter concentrations.

Table 4-4. Water Chemistry Results for Crow Creek Monitoring Sites, July 8, 2013

Analyte	CUL015	CUL005	CRW040	CRW030	CRW020
Chemical Oxygen Demand (mg/L)	73	J26	J18	J22	J22
Total Kjeldahl Nitrogen (mg/L)	2.3	0.79	3.9	3.5	2.9
Ammonia (as N) (mg/L)	J0.088	ND	ND	ND	ND
Nitrite (mg/L)	ND	ND	ND	J0.003	J0.002
Nitrate (as N) (mg/L)	ND	ND	0.11	J0.075	J0.046
Total Phosphorus as P (mg/L)	0.3	0.27	0.15	0.15	0.19
Dissolved Ortho Phosphate as P (mg/L)	J0.0093	0.22	0.14	0.14	0.15
Total Dissolved Solids (mg/L)	1400	3200	650	700	690
Total Suspended Solids (mg/L)	56	10	16	18	15
Biochemical Oxygen Demand (mg/L)	10	ND	ND	ND	ND
Total Organic Carbon (mg/L)	10	4.9	6.4	5.7	5.4

"J" - The reported value was obtained from a reading that was less than the CRQL (Contract Required Quantitation Limit) but greater than or equal to the MDL (Method Detection Limit).

Table 4-5. Water Chemistry Results for Crow Creek Monitoring Sites, August 13, 2013

Analyte	CRW020	CRW030	CRW040	OT-CRW-D1
Chemical Oxygen Demand (mg/L)	ND	J15	ND	J18
Total Kjeldahl Nitrogen (mg/L)	1.1	0.83	0.92	0.92
Ammonia (as N) (mg/L)	J0.099	J0.099	J0.066	J0.044
Nitrite (mg/L)	J0.002	J0.0020	ND	J0.0040
Nitrate (as N) (mg/L)	J0.023	J0.055	J0.088	0.28
Total Phosphorus as P (mg/L)	0.19	0.14	0.17	0.11
Dissolved Ortho Phosphate as P (mg/L)	0.12	0.12	0.14	0.011
Total Dissolved Solids (mg/L)	700	700	650	1200
Total Suspended Solids (mg/L)	6	6	J2	ND
Biochemical Oxygen Demand (mg/L)	ND	ND	ND	ND
Total Organic Carbon (mg/L)	3.4	3	2.9	2.5

"J" - The reported value was obtained from a reading that was less than the CRQL (Contract Required Quantitation Limit) but greater than or equal to the MDL (Method Detection Limit).

5 Discussion

5.1 Overall Findings

The following preliminary conclusions can be drawn from the data collected in this study:

- **Flows:** There was found to be no summertime connectivity between the Cull Reservoir and the Crow Creek branch. Therefore impacts to water quality within Crow Creek were not attributable to the Cull branch of the water system at the time of monitoring. Flow throughout the Crow Creek system between July and September was low and, at the times of assessment, generally less than 10L/sec.
- **Cull Reservoir spillway pond:** Water quality in this ponded area was suggestive of some problems with elevated COD, Ortho-P, TSS and TOC. If flow conditions were to increase, leading to discharge from the spillway into Cull Creek and then to Crow Creek, there could be potential for some downstream impact.
- **Storm drain discharges:** The stormdrain discharge at OTCRW-01 was characterized by high TDS and nitrates, suggesting this stormdrain may contribute sporadic discharges with elevated levels of these parameters; however the flow rate was small, and potentially sporadic, relative to the creek at the time of monitoring for this study. Anecdotal reports that this stormdrain was responsible for an acute discharge in August 2012 could not be substantiated through the WY2013 SSID investigation.
- **Water Quality Chemistry:** Water quality chemistry in Crow Creek was not indicative of problems, with samples showing low nutrient concentrations, low BOD and low TOC.
- **Dissolved oxygen concentrations:** Results indicated that DO concentrations decreased from July through to early October. All 7-day rolling daily averages met the COLD reference criteria (<7mg/L) during the sampling period. In July, all DO 7-day rolling averages met the WARM benchmark (<5mg/L), however, in August 40% of 7-day rolling averages were below 5mg/L and in September 80% of 7-day rolling averages were below the WARM benchmark of 5mg/L.

5.2 Study Questions

1) Is the Reservoir spillway a contributor to lower DO in the creek system?

It was found that there was no connectivity between Cull Reservoir and Crow Creek. Flow rates were negligible in the Cull creek system which was majority pooled and stagnant. The finding of this study, therefore, was that, at the time of monitoring, no water quality impacts could be attributed to the reservoir.

2) Is seasonality contributing to lower DO concentrations?

Dissolved oxygen concentrations were found to decrease between July and September.

3) Is low flow contributing to lower DO concentrations?

At the time of monitoring, flows within Crow Creek were found to be low (generally less than 10L/sec). There was no significant decrease in flows between July and September suggesting that low flow, in and of itself, was not the cause of lower DO concentrations.

4) Is nutrient availability contributing to lower DO concentrations?

During WY2013 water quality analyses, there was little evidence of elevated nutrient concentrations, suggesting that increased biomass and nutrient presence was not a significant cause of lower DO.

5) Is an illicit discharge responsible for the low DO observed in WY2012?

There is anecdotal evidence that an acute episode of decreased DO occurred in 2012. As reported by a creek-side resident in August 2012, this site received discharges of unknown type which were associated with recurring fish kills. This particular event or events may have contributed to the lower levels of DO observed during the WY2012 monitoring.

From the results of WY2013 monitoring, few inferences can be made regarding sources of the low DO, and these are only broadly categorical. While illicit discharges to a storm drain may have been related to a specific low DO episode in WY2012, no similar discharge was reported or observed during the monitoring in WY2013. There is no evidence that ongoing storm drain discharges are causing the observed fluctuations in DO, although it is possible that some episodic illicit discharges have had short-term influences on creek conditions.

5.3 Next Steps

ACCWP will review these initial results with affected Permittees and other watershed stakeholders to identify additional sources of data or information, and clarify needs, roles and responsibilities for further steps in the SSID project.

Further technical studies may be implemented to support this review, and to identify measures of effectiveness to confirm reduction of the stressors or sources.

6 References

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7 Attachments

Attachment A. Summary Data from Crow Creek Monitoring WY2013

Water Chemistry Data

		8-Jul-13						13-Aug-13			
Analyte	**Unit**	**204CUL015**	**204CUL005**	**204CRW040**	**204CRW040 - FD**	**204CRW030**	**204CRW025**	**204CRW020-W-01**	**204CRW030-W-01**	**204CRW040-W-01**	**OT-CROW-D1-W-01**
Ammonia (as N)	mg/L	J0.088	ND	ND	ND	ND	ND	0	0	0	0
Biochemical Oxygen Demand	mg/L	10	ND	ND	ND	ND	ND	0	0	0	0
Chemical Oxygen Demand	mg/L	73	J26	J18	23	J22	J22	0	0	0	0
Dissolved Ortho Phosphate as P	mg/L	J0.0093	0.22	0.14	0.14	0.14	0.15	0.12	0.12	0.14	0.011
Nitrogen, Nitrate (as N)	mg/L	ND	ND	0.11	0.11	J0.075	J0.046	0	0	0	0.28
Nitrogen, Nitrite	mg/L	ND	ND	ND	ND	J0.003	J0.002	0	0	0	0
Total Dissolved Solids	mg/L	1400	3200	650	660	700	690	700	700	650	1200
Total Kjeldahl Nitrogen	mg/L	2.3	0.79	3.9	4.2	3.5	2.9	1.1	0.83	0.92	0.92
Total Organic Carbon	mg/L	10	4.9	6.4	6.1	5.7	5.4	3.4	3	2.9	2.5
Total Phosphorus as P	mg/L	0.3	0.27	0.15	0.16	0.15	0.19	0.19	0.14	0.17	0.011
Total Suspended Solids	mg/L	56	10	16	9	18	15	6	6	0	0

Continuous Monitoring Data

204CUL015		Daily Averages			
Day	Date	mean Temp (C)	mean pH	mean ODO (mg/L)	mean SpCond (mS/cm)
1	7/8/13	21.06	8.05	5.73	1.691
2	7/9/13	20.42	7.97	3.83	1.720
3	7/10/13	20.71	7.92	3.60	1.753
4	7/11/13	20.11	7.92	4.40	1.775
5	7/12/13	20.01	7.97	5.86	1.794
6	7/13/13	19.57	8.04	6.54	1.812
7	7/14/13	19.69	8.07	7.28	1.830
8	7/15/13	19.36	8.07	6.94	1.847
9	7/16/13	19.14	8.04	6.19	1.865
10	7/17/13	19.24	8.04	5.96	1.881
11	7/18/13	18.77	8.02	5.28	1.891

204CRW030		Daily Averages			
Day	Date	mean Temp (C)	mean pH	mean ODO (mg/L)	mean SpCond (mS/cm)
1	7/8/13	17.72	8.31	6.20	1.198
2	7/9/13	16.55	8.20	6.00	1.153
3	7/10/13	17.12	8.13	5.20	1.196
4	7/11/13	16.79	8.16	5.94	1.247
5	7/12/13	16.55	8.19	6.08	1.203
6	7/13/13	15.64	8.20	6.00	1.217
7	7/14/13	16.09	8.19	5.89	1.243
8	7/15/13	16.15	8.22	6.39	1.244
9	7/16/13	16.28	8.24	6.53	1.245
10	7/17/13	16.45	8.21	5.94	1.237
11	7/18/13	16.19	8.22	5.78	1.246

204CRW040		Daily Averages			
Day	Date	mean Temp (C)	mean pH	mean ODO (mg/L)	mean SpCond (mS/cm)
1	8/13/13	19.86	8.27	8.19	1.115
2	8/14/13	17.59	8.28	8.71	1.114
3	8/15/13	19.05	8.26	8.64	1.129
4	8/16/13	19.46	8.27	8.74	1.112
5	8/17/13	17.82	8.29	9.25	1.114
6	8/18/13	18.80	8.29	9.58	1.121
7	8/19/13	19.29	8.28	9.41	1.119
8	8/20/13	18.99	8.26	9.16	1.127
9	8/21/13	18.16	8.28	9.84	1.106
10	8/22/13	17.67	8.28	9.79	1.113
11	8/23/13	16.30	8.18	6.51	1.112

204CRW030		Daily Averages			
Day	Date	mean Temp (C)	mean pH	mean ODO (mg/L)	mean SpCond (mS/cm)
1	8/13/13	16.82	8.16	5.75	1.169
2	8/14/13	16.09	8.16	5.78	1.152
3	8/15/13	17.27	8.01	3.90	1.179
4	8/16/13	18.14	7.98	3.51	1.166
5	8/17/13	17.37	8.13	5.59	1.143
6	8/18/13	17.34	8.15	5.62	1.150
7	8/19/13	17.84	8.11	4.92	1.158
8	8/20/13	17.96	8.10	5.00	1.177
9	8/21/13	17.24	8.17	6.30	1.149
10	8/22/13	16.96	8.18	6.46	1.163
11	8/23/13	16.58	8.16	5.59	1.150

204CRW020		Daily Averages			
Day	Date	mean Temp (C)	mean pH	mean ODO (mg/L)	mean SpCond (mS/cm)
1	9/24/13	16.95	7.91	6.05	1.036
2	9/25/13	15.30	7.88	6.23	1.052
3	9/26/13	14.16	7.92	6.50	1.094
4	9/27/13	13.73	8.02	7.01	1.094
5	9/28/13	14.17	8.07	6.96	1.107
6	9/29/13	15.60	7.87	6.71	1.123
7	9/30/13	16.77	7.59	5.46	1.152
8	10/1/13	15.67	8.01	7.16	1.124
9	10/2/13	14.75	8.05	7.32	1.126
10	10/3/13	13.73	8.14	7.53	1.130
11	10/4/13	13.55	7.87	6.06	1.143

204CRW030		Daily Averages			
Day	Date	mean Temp (C)	mean pH	mean ODO (mg/L)	mean SpCond (mS/cm)
1	9/24/13	15.99	7.93	3.71	1.018
2	9/25/13	14.86	7.99	5.11	1.026
3	9/26/13	13.65	7.98	5.06	1.093
4	9/27/13	13.46	8.02	5.90	1.052
5	9/28/13	13.21	8.04	5.99	1.090
6	9/29/13	14.65	7.94	3.90	1.104
7	9/30/13	15.90	7.90	2.55	1.114
8	10/1/13	15.24	8.05	4.92	1.104
9	10/2/13	14.38	8.04	5.30	1.112
10	10/3/13	13.46	8.09	5.95	1.113
11	10/4/13	13.38	8.12	6.53	1.119

Attachment B. Summary of August 2012 Reported Fish Kill in Crow Creek, and Agencies Follow-Up

Summary:

On August 13, 2012, a local creek-side resident reported to Alameda County that there was a significant fish kill in the segment of Crow Creek extending above the vicinity of Site 204CRW020. The following timeline describes subsequent activities and communications as documented in email records from Scott Seery of the Alameda County Environmental Health Department, who at the time was the Illicit Discharge stormwater inspector for Unincorporated Alameda County. Extensive follow-up by Mr. Seery and staff from the Regional Water Board NPDES enforcement group could not ascertain the exact cause or stressor that produced this significant fish kill although a Sanitary Sewer Overflow had been suspected. More recent contacts with ACCWP staff and contractors revealed additional observations with potential relevance to the Crow Creek SSID study of low Dissolved Oxygen data recorded in September 2012.

Timeline of events:

August 13, 2012 – A phone call was referred to Scott Seery from a resident on Crow Canyon Road (near SSID site) reporting a fish kill observed the morning of 8/11/12. Mr. Seery reported it to the wardens for the CA Dept of Fish and Game (CDFG, now CA Dept of Fish & Wildlife) and to ACPWA personnel representing the Unincorporated Alameda County stormwater program, with initial information on the incident:

"The complainant said the water exhibited no foam or suds. He said it had a sweet odor, like a perfume smell, with a hint of ammonia. He collected a water sample and several pounds of dead fish. The fish are in his freezer, but the water sample has not been refrigerated nor apparently sampled following standard SOP. But he did retain the water sample.

He also did a little sleuthing on his own and determined the discharge did not come from Cull Creek Reservoir, located just upstream. He said the spillway was dry. He suspects it came from a storm channel/drain that meets the stream from the neighborhoods, above."

Scott Seery conducted a field visit starting at Bay Trees Park located at the confluence of Cull and Crow Creeks, where he confirmed there was no water in the Cull Creek channel but there was flow in Crow, and observed masses of dead fish caught among rocks just downstream of the engineered channel at the confluence. On further reconnaissance Mr. Seery identified odors in the upstream Crow Creek culvert beneath Crow Canyon Road that he associated with possible sanitary sewer spills, but could not see well enough in the tunnel to tell if dead fish were present

[although he did note the presence of extensive graffiti and numerous discarded spray paint cans]. Some ~300 yards upstream in the daylighted portion of the creek there were no odors no observed dead fish. He then drove farther upstream (east-northeast) on Crow Canyon Rd. and noticed a Castro Valley Sanitary District (CVSD) truck and crew working in the landscaping of a housing development at the corner of Crow Canyon and Crow Creek Roads. The CVSD crew informed Mr. Seery that there had been a sewer blockage on Friday night 8/10 but they did not get to the location to remedy the blockage until Monday due the weekend. However they had not found evidence that the blockage and resulting Sanitary Sewer Overflow (SSO) produced any discharge of sewage to the creek. Mr. Seery then met a CDFG warden who confirmed some of his observations and they walked the creek in the vicinity of the housing development and further upstream, where the water and fish communities appeared unimpacted.

August 14, 2012 – Scott Seery referred this issue to RWQCB staff as a suspected SSO, for regulatory follow-up.

August 21 – 22, 2012 – RWQCB staff conducted inspections of the CVSD records and collection system (staff attempted to invite Mr. Seery to participate in the field inspection but the message was not delivered due to an incorrect email address).

September 10, 2012 – RWQCB staff informed Mr. Seery that they found no evidence to tie the SSO from the CVSD to the August fish kill, although they did plan to issue a Notice of Violation for an unrelated SSO in another watershed.

June 22, 2013 - The same resident called Arleen Feng, ACCWP monitoring manager, in response to an outreach letter about ACCWP stream surveys in Crow Creek and recounted his observations from August 2012, adding that he noticed additional fish kills on several more occasions after the first one (possibly up to 4 more); these generally diminished in intensity with each re-occurrence and generally happened overnight between Friday and Saturday which discouraged him from making additional reports to the county about these recurrences.

June 29, 2013 - ACCWP contractor working on SSID study visited the resident, who does not use email, to obtain copies of digital photographs taken of Crow Creek during the 2012 fish kills and listened to the resident's statements (detailed below) which included:

a) He identified a "soapy smell" and turbid water in the creek several days before he saw the fish kill on 8/11/12; and

b) On 8/11 he walked up the creek and saw no turbidity or evidence of fish kill upstream of the Crow/Cull confluence, contrasting with conditions below. He noted that the initial turbidity and odor had dissipated by the time of Mr. Seery's visit on 8/14 and

suspected that the source of the problem was discharge originating from the 24 inch diameter storm drain outfall immediately below the confluence and located approximately 15 feet above the bed of the concrete engineered channel on the eastern wall.

c) He had not observed any recurring fish kills after fall 2012

Figure B1: Diagram of investigation synopsis provided by Alameda County Environmental Health Department.

Resident's Interview with Azimuth Partners, LLC (Contractor to ACCWP) – July 29, 2013

During preliminary assessments of available data for the Crow Creek SSID, it was established that a local resident had informed ACCWP in August 2012 of a potential fish kill within the creek. In follow-up discussions with the resident, further information was gathered and assessed and is summarized here.

Historical photos of the Crow Creek area were provided, showing a rural landuse with low density farm housing (Figure B2). The current area of interest is shown in Figure B3.

Figure B2: Photo shows Crow Creek Rd with surrounding farm land and Crow Canyon creek.

The resident was first alerted to the fish kill event on August 8th 2012 at 9:30am, when he noticed soapy water in the creek, with a sweet perfumed odor (Figure B4). On August 11, 2013 at 3:09pm he noticed dead fish within the creek directly below his house (located at footbridge adjacent to Earl Warren Park at 4672 Crow Canyon Rd) (Figure B5). Water was noticeably turbid, retained the perfumed smell but did not seem to smell of sewage.

The resident walked up the creek and determined that the there was no turbidity or evidence of fish kill upstream of the Crow/Cull confluence.

He assumed the pollutant was originating from the stormdrain directly below the confluence which is situated approximately 15 feet above the creek bed where the two creeks converge (Figure B6).

The resident remembered speaking with an Alameda County official on August 14, 2013 about the creek. The creek water was not turbid or soapy - it was assumed the pollutant had washed through.

August 18 at 4:43pm – The resident noted another stormdrain (at a culvert directly below his property adjacent to the footbridge at Earl Warren Park) was discharging turbid water.

The creek directly downstream of this culvert was turbid, with the same smell of perfume and also ammonia.

As of 2013, small fish have returned to the creek but it took a number of months and no large fish are present.

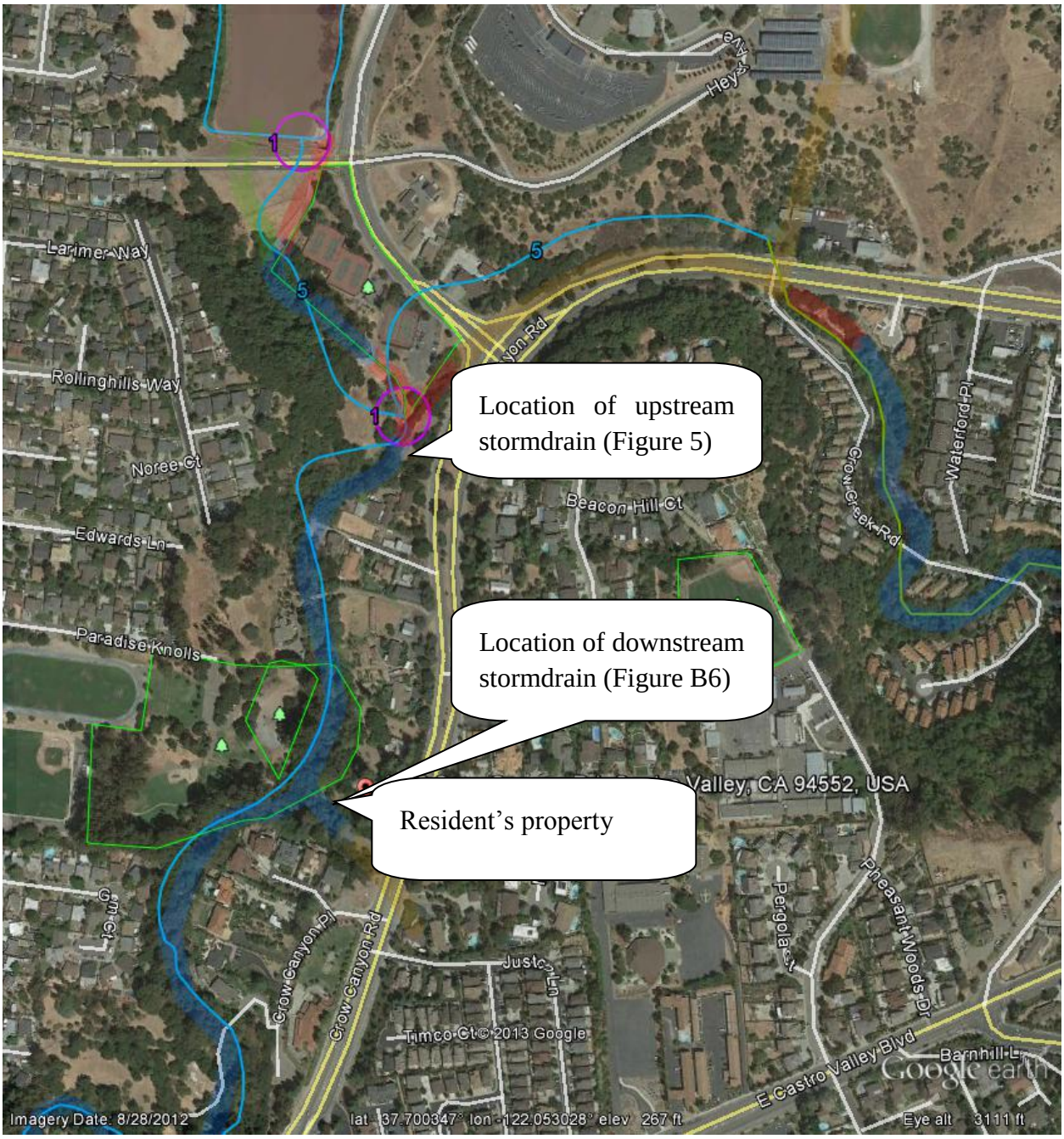

Figure B3: Aerial View of Crow and Cull Creeks.

Figure B4: August 8, 9:30am. Soapy discharge noted at base of Resident's property

Figure B5: August 11, 3:09pm. Fish kill noted at base of Resident's property

Figure B6: August 11, around 3:30pm. Upstream stormdrain suspected of pollutant discharge

Pollutants of concern (POC) loads monitoring data progress report, water years (WYs) 2012 and 2013

Prepared by

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San Francisco Estuary Institute, Richmond, California

On

February 21, 2014

For

Bay Area Stormwater Management Agencies Association (BASMAA)

And

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

Acknowledgements

We were glad for the support and guidance of the Sources, Pathways and Loadings Workgroup of the Regional Monitoring Program for Water Quality in San Francisco Bay. The detailed work plan behind this work was developed through the Small Tributaries Loading Strategy (STLS) during a series of meetings in the summer of 2011. Local members on the STLS are Arleen Feng, Lucy Buchan, Khalil Abusaba and Chris Sommers (for BASMAA) and Richard Looker, Jan O'Hara, and Tom Mumley (for the Water Board). Khalil Abusaba, AMEC Environment and Infrastructure and Chris Sommers, EOA INC. provided helpful written reviews on the draft report that we incorporated to improve this final report. This project was completed with funding provided by the Bay Area Stormwater Management Agencies Association (BASMAA) and the Regional Monitoring Program for Water Quality in San Francisco Bay (RMP).

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1. Introduction

The San Francisco Regional Water Quality Control Board (Water Board) has determined that San Francisco Bay is impaired by mercury and PCBs due to threats to wildlife and human consumers of fish from the Bay. These contaminants persist in the environment and accumulate in aquatic food webs (SFRWRCB 2006; SFRWRCB, 2008). The Water Board has identified urban runoff from local watersheds as a pathway for pollutants of concern into the Bay, including mercury and PCBs. The Municipal Regional Stormwater Permit (MRP; SFRWRCB, 2009) contains several provisions requiring studies to measure local watershed loads of suspended sediment (SS), total organic carbon (TOC), polychlorinated biphenyl (PCB), total mercury (HgT), total methylmercury (MeHgT), nitrate-N (NO3), phosphate-P (PO4), and total phosphorus (TP) (provision C.8.e), as well as other pollutants covered under provision C.14. (e.g., legacy pesticides, PBDEs, and selenium).

Bay Area Stormwater Programs, represented by the Bay Area Stormwater Management Agencies Association (BASMAA), collaborated with the San Francisco Bay Regional Monitoring Program (RMP) to develop an alternative strategy allowed by Provision C.8.e of the MRP, known as the Small Tributaries Loading Strategy (STLS) (SFEI, 2009). An early version of the STLS provided an initial outline of the general strategy and activities to address four key management questions (MQs) that are found in MRP provision C.8.e:

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

Since then, a Multi-Year-Plan (MYP) has been written (BASMAA, 2011) and updated twice (BASMAA, 2012; BASMAA, 2013). The MYP provides a comprehensive description of activities that will be implemented over the next 5-10 years to provide information and comply with the MRP. The MYP provides rationale for the methods and locations of proposed activities to answer the four MQs listed above. Activities include modeling using the regional watershed spreadsheet model (RWSM) to estimate regional scale loads (Lent and McKee, 2011; Lent et al., 2012; SFEI in preparation), and pollutant characterization and loads monitoring in local tributaries beginning Water Year (WY) 2011 (McKee et al., 2012), that continued in WY 2012 (McKee et al., 2013), WY 2013 (this report), and is underway again for WY 2014.

The purpose of this report is to describe data collected during WYs 2012 and 2013 in compliance with MRP provision C.8.e., following the standard report content described in provision C.8.g.vi. The study

design (selected watersheds and sampling locations, analytes, sampling methodologies and frequencies) as outlined in the MYP was developed to assess concentrations and loads in watersheds that are considered to likely be important watersheds in relation to sensitive areas of the Bay margin (MQ1):

- Lower Marsh Creek (Hg);
- North Richmond Pump Station;
- San Leandro Creek (Hg);
- Guadalupe River (Hg and PCBs);
- Sunnyvale East Channel (PCBs); and
- Pulgas Creek Pump Station.

Loads monitoring provides calibration data for the RWSM (MQ2), and is intended to provide baseline data to assess long term loading trends (MQ3) in relation to management actions (MQ4). This report is structured to allow annual updates after each subsequent winter season of data collection. It should be noted that the sampling design described in this report (and modeling design: Lent and McKee, 2011; Lent et al., 2012; SFEI in preparation) was focused mainly on addressing MQ2. Recent discussions between BASMAA and the Region 2 Regional Water Quality Control Board (and discussion at the October 2013 SPLWG meeting) have highlighted the increasing focus towards finding watersheds and land areas within watersheds for management focus (MQ4). The monitoring design described in this report is not intended to address this increasing management focus.

2. Field methods

2.1. Watershed physiography, sampling locations, and sampling methods

The San Francisco Bay estuary is surrounded by nine highly urbanized counties with a total population greater than seven million people (US Census Bureau, 2010). Although urban runoff from upwards of 300 small tributaries (note the number is dependent upon how the areas are lumped or split) flowing from the adjacent landscape represents only about 6% of the total freshwater input to the San Francisco Bay, this input has broadly been identified as a significant source of pollutants of concern (POCs) to the estuary (Davis et al., 2007; Oram et al., 2008; Davis et al., 2012; Gilbreath et al., 2012). Four watershed sites were sampled in WY 2012 and two additional watershed sites were added in WY 2013 (Figure 1; Table 1). The sites were distributed throughout the counties where loads monitoring are required by the MRP. The selected watersheds include urban and industrial land uses, watersheds where stormwater programs are planning enhanced management actions to reduce PCB and mercury discharges, and watersheds with historic mercury or PCB occurrences or related management concerns.

The monitoring design focused on winter season storms between October 1 and April 30 of each water year; the period when the majority of pollutant transport occurs in the Bay Area (McKee et al., 2003; McKee et al., 2006; Gilbreath et al, 2012). At all six sampling locations, measurement of continuous stage and turbidity at time intervals of 15 min or less was the basis of monitoring design (Table 1). At free flowing sites, stage was used along with a collection of discrete velocity measurements to generate a rating curve between stage and instantaneous discharge. Subsequently this rating curve was used to estimate a continuous discharge record over the wet season by either the STLS team or USGS depending

on the sampling location (Table 1). At Richmond pump station, an optical proximity sensor (Omron, model E3F2) was used along with stage measurements and a pump efficiency curve based on the pump specifications to estimate flow. ISCO flow meters were deployed at the Pulgas Street Pump Station (Table 1). Turbidity is a measure of the "cloudiness" in water caused by suspension of particles, most of which are less than 62.5 µm in size and, for most creeks in the Bay Area, virtually always less than 250 µm (USGS data). In natural flowing rivers and urban creeks or storm drains, turbidity usually correlates with the concentrations of suspended sediments and hydrophobic pollutants. Turbidity probes were mounted in the thalweg of each sampling location on an articulated boom that allowed turbidity sampling at approximately mid-depth under most flow conditions (McKee et al., 2004).

Composite and discrete samples were collected for multiple analytes from the water column over the rising, peak, and falling stages of the hydrograph. The sampling design was developed to support the use of turbidity surrogate regression during loads computations. This method is deemed one of the most accurate methods for the computation of loads of pollutants transported dominantly in particulate phase such as suspended sediments, mercury, PCBs and other pollutants (Walling and Webb, 1985; Quémerais et al., 1999; Wall et al., 2005; Gilbreath et al., 2012). The method involves logging a continuous turbidity record in a short time interval (15 min or less during the study) and collecting a number of discrete samples to support the development of pollutants specific regressions. In this study, although not always achievable (see discussion later in the report), field crews aimed to collect 16 samples per water year during an early storm, several mid-season storms (ideally including one of the largest storms of the season) and later season storm. The use of turbidity surrogate regression and the other components of this sampling design was recommended over a range of alternative designs (Melwani et al 2010), and was adopted by the STLS (BASMAA, 2011).

Discrete samples except mercury, methylmercury and a simultaneously collected suspended sediment concentration (SSC) sample were collected using the ISCO as a pump at all the sites besides Guadalupe. Discrete mercury and methylmercury samples (including a simultaneously collected SSC sample) were collected with the D-95 at Guadalupe, Sunnyvale East Channel, North Richmond Pump Station, and San Leandro Creek (WY 2012 only), using a pole sampler at Pulgas Creek Pump Station, and by manually dipping an opened bottle from the side of the channel at San Leandro (in WY 2013 only) and Lower Marsh Creek (both WYs) (Table 1). Tubing for the ISCOs was installed using the clean hands technique, as was the 1 L Teflon bottle when used in the D-95. Composite samples, with the intent of representing average concentrations of storm runoff over each storm event sampled, were collected using the ISCO autosampler at all of the sites except Guadalupe River. At the Guadalupe site, a FISP D-95 depth integrating water quality sampler was used to collect multiple discrete samples over the hydrograph which were manually composited on-site in preparation for shipment to the laboratories.

2.2. Loads computational methods

It has been recognized since the 1980s that different sampling designs and corresponding loads computation techniques generate computed loads of differing magnitude and of varying accuracy and precision. Therefore, how can we know which methodology generates the most accurate load? In all environmental situations, techniques that maintain high resolution variability in concentration and flow data during the field collection and subsequent computation process result in high-resolution loads

estimates that are more accurate no matter which loads computation technique is applied. Less accurate loads are generated by sampling designs that do not account for (or adequately describe) the concentration variability (e.g. a daily or weekly sampling protocol would not work for a semi-arid environment like the Bay Area) or that use some kind of mathematical average concentration (e.g. simple mean; geometric mean; flow weighted mean) combined with monthly annual time interval flows (again would not work in the semi-arid environment since 95% of flow occurs during storms).

Since the objective of any type of environmental data interpretation exercise is to neither over nor under interpret the available data, any loads computation technique that employs extra effort to stratify the data as part of the computation protocol will generate the most accurate loading information. Stratification can be done in relation to environmental processes such as seasonality, flow regime, or data quality. In a general sense, the more resolved the data are in relation to the processes of concentration or flow variation, the more likely it is that computations will result in loads with high accuracy and precision. The data collection protocol implemented through the Small Tributaries Loading Strategy (STLS) was designed to allow for data stratification in the following manner:

1. Early-season ("1st storm") storm flow sampled for pollutants
2. Mid-season ("largest flood") storm flow sampled for pollutants
3. Later-season storm flow sampled for pollutants
4. Early-, mid-, and later-season storm flow when no pollutant sampling took place
5. Dry weather flow

Loads computation techniques differ for each of these strata in relation to pollutants that are primarily transported in dissolved or particulate phase. As subsequent samples are collected each year at the STLS monitoring sites, knowledge will improve about how concentrations vary with season and flow (improvements of the definition of the strata) and thus about how to apply loads computation techniques. Therefore, with each additional annual reporting year, a revision of loads is expected for the previous water year(s). This will occur in relation to improved flow information as well as an improved understanding of concentration variation in relation to seasonal characteristics and flow.

During the study, concentrations either measured or estimated were multiplied with the continuous estimates of flow (2-15 minute interval) to compute the load on a 2 to 15 minute basis and summed to monthly and wet season loads. Laboratory measured data was retained in the calculations and assumed real for that moment in time. The techniques for estimating concentrations were applied in the following order of preference (and resulting accuracy and loads):

Linear interpolation: Linear interpolation is the primary technique used for interpolating concentrations between measured data points when storms are well sampled (Note, this method was not yet applied but will be applied when the final report for the data collection during WYs 2012, 2013, and 2014 is written – likely late 2014).

Linear Interpolation using particle ratios: Linear interpolation using particle ratios can be thought of as locally derived regression in three-dimensional space. It is superior to linear interpolation using water concentrations for pollutants which occur mainly in particulate form because it ensures that the

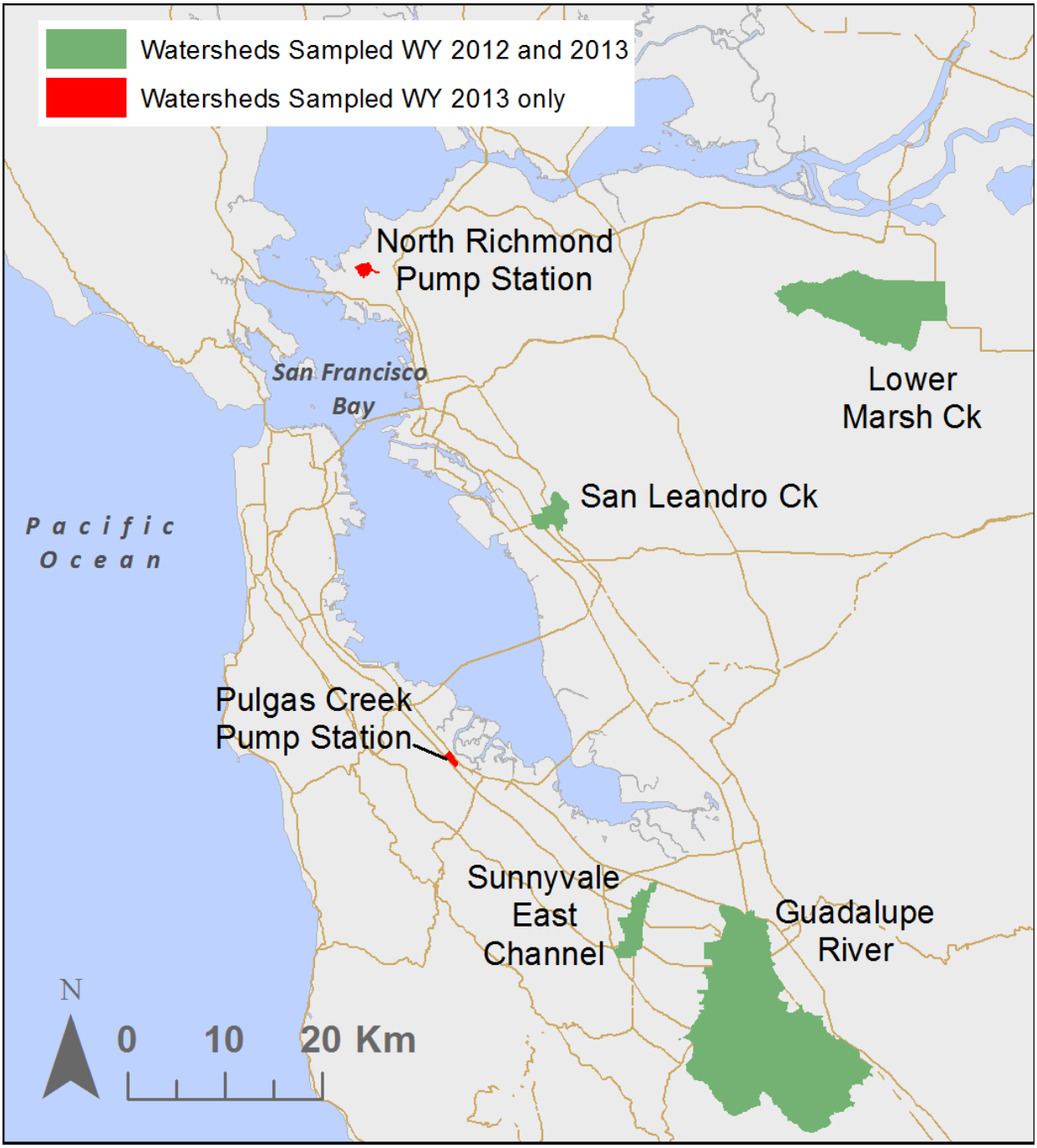

Figure 1. Water year 2012 and 2013 sampling watersheds.

Table 1. Sampling locations in relation to County programs and sampling methods at each site.

County program	Watershed name	Water years sampled	Watershed area (km^2)[1]	Sampling location			Operator	Discharge monitoring method	Turbidity	Water sampling for pollutant analysis		
				City	Latitude (WGS1984)	Longitude (WGS1984)				Hg/MeHg collection	Discrete samples excluding Hg species	Composite samples
Contra Costa	Marsh Creek	2012 and 2013	99	Brentwood	37.990723	-122.16265	ADH	USGS Gauge Number: 11337600[2]	OBS-500[4]	Manual grab	ISCO auto pump sampler[8]	ISCO auto pump sampler[8]
Contra Costa	North Richmond Pump Station	2013	2.0	Richmond	37.953945	-122.37398	SFEI	Measurement of pump rotations/ interpolation of pump curve	OBS-500[4]	FISP US D95[7]	ISCO auto pump sampler[8]	ISCO auto pump sampler[8]
Alameda	San Leandro Creek	2012 and 2013	8.9	San Leandro	37.726073	-122.16265	SFEI WY2012 ADH WY2013	STLS creek stage/ velocity/ discharge rating	OBS-500[4]	FISP US D95[7] WY 2012 Manual grab WY 2013	ISCO auto pump sampler[8]	ISCO auto pump sampler[8]
Santa Clara	Guadalupe River	2012 and 2013	236	San Jose	37.373543	-121.69612	SFEI WY2012 Balance WY 2013	USGS Gauge Number: 11169025[3]	DTS-12[5]	FISP US D95[7]	FISP US D95[7]	FISP US D95[7]
Santa Clara	Sunnyvale East Channel	2012 and 2013	14.8	Sunnyvale	37.394487	-122.01047	SFEI	STLS creek stage/ velocity/ discharge rating	OBS-500*[4] WY 2012 DTS-12[5] WY 2013	FISP US D95[7]	ISCO auto pump sampler[8]	ISCO auto pump sampler[8]
San Mateo	Pulgas Creek Pump Station	2013	0.6	San Carlos	37.504583	-122.24901	KLI	ISCO area velocity flow meter with an ISCO 2150 flow module	DTS-12[5]	Pole sampler	ISCO auto pump sampler[8]	ISCO auto pump sampler[8]

[1]Area downstream from reservoirs.
[2]USGS 11337600 MARSH C A BRENTWOOD CA
[3]USGS 11169025 GUADALUPE R ABV HWY 101 A SAN JOSE CA
[4]Campbell Scientific OBS-500 Turbidity Probe
[5]Forest Technology Systems DTS-12 Turbidity Sensor
[6]FISP US DH-81 Depth integrating suspended hand line sampler
[7]FISP US D-95 Depth integrating suspended hand line sampler
[8]Teledyne ISCO 6712 Full Size Portable Sampler
*OBS-500 malfunctioned during WY 2012 due to low flow water depth. A DTS-12 was installed during WY 2013.

relationship between the derived concentration and varying turbidity that occurs between the two laboratory pollutant measurements results in particle ratios that at all time intervals are reasonable.

Linear Interpolation using water concentrations: Linear interpolation using water concentrations is the process by which the interpreter varies the concentrations between observed measurements using a linear time step. It is appropriately used for pollutants which occur mainly in dissolved phase because it does not incorporate any regard for varying turbidity or SSC.

Interpolation using a turbidity based regression equation with each POC: Turbidity surrogate regression can be considered the default standard for pollutants of concern that are primarily transported in a particulate form. These types of contaminants (for example PCBs and mercury) form strong linear relationships with either turbidity or SSC. Turbidity surrogate regression was applied to all unsampled flood flow conditions observed at each monitoring site.

Interpolation using a regression equation derived from two chemical species (e.g. TP:PO4): For pollutants primarily transported in dissolved phase, the turbidity regression estimator was not be appropriate. In this instance it may be possible to use an alternative surrogate such as electrical conductivity or a parent pollutant. A "chemical surrogate regression" estimator of this nature can be considered the default standard for pollutants of concern that are primarily transported in a dissolved form. This method was applied to unsampled flood flow conditions if a reliable regression was found.

Interpolation assuming a representative concentration (e.g. "dry weather lab measured" or "lowest measured"): To apply this method, an estimate of average of concentrations under certain flow conditions is combined with discharge. This is in effect a simple average estimator and is the least accurate and precise of all the loads calculation methods.

3. Continuous data quality assurance

3.1. Continuous data quality assurance methods

In 2013, a better documented method for quality assurance was developed and applied to continuous data (turbidity, stage, and rainfall) collected at the POC loads monitoring stations. These protocols were established towards the end of the season and therefore some field checks now required in the QA protocol will not be implemented until WY 2014, specifically including precision checks on the instrumentation through replicate testing of equipment at high and low reference values. Throughout the season, field staff were responsible for data verification checks after data were downloaded during site visits. The field staff reviewed the data and completed the data transmission record. During the data validation process, individual records were flagged if they didn't meet the criteria developed in the continuous QA protocol. Datasets were evaluated in relation to the validation criteria, including: accuracy through calibration, accuracy in relation to comparison with manual measurements, dataset representativeness relative to logging interval, and finally on completeness of the dataset (Table 2 and Table 3). For more information on the quality assurance procedures developed and applied for continuous data, the reader is referred to the current version of the draft "*Quality Assurance Methods for Continuous Rainfall, Run-off, and Turbidity Data"* (McKee et al., 2013).

Table 2. Continuous data quality assurance summary for accuracy and precision for each monitoring location. "NR" indicates that the QA procedure was not completed and "NA" indicates that the QA procedure was not applicable.

	Accuracy at Calibration			Accuracy of Comparison		
	Rainfall	**Stage**	**Turbidity**	**Rainfall**	**Stage**	**Turbidity**
Sunnyvale	NR	NR	Excellent	Excellent	Excellent	Excellent
Pulgas	NR	NR	New instrument	Excellent	NR	Poor[1]
Richmond	NR	NR	Excellent	Poor	NR	Good
Guadalupe	NA	USGS maintained	USGS maintained	NA	USGS maintained	Excellent
San Leandro	NR	NR	Within Tolerance	Excellent	Excellent	NR
Lower Marsh	NR	USGS maintained	Excellent	Excellent	USGS maintained	NR

Table 3. Continuous data quality assurance summary for representativeness and completeness for each monitoring location.

	Representativeness of the population			Completeness (Confidence in corrections)		
	Rainfall	**Stage**	**Turbidity**	**Rainfall**	**Stage**	**Turbidity**
Sunnyvale	Excellent	Good[2]	Excellent	Excellent	Excellent	Poor[6]
Pulgas	Excellent	Excellent	Good[3]	Excellent	Poor[7]	Excellent/Poor[8]
Richmond	Excellent	Excellent	Poor[4]	Poor	Excellent	Excellent
Guadalupe	NA	USGS maintained	Excellent	NA	USGS maintained	Excellent
San Leandro	Excellent	Excellent	Excellent	Good[5]	Excellent	Poor[9]
Lower Marsh	Excellent	USGS maintained	Excellent	Excellent	USGS maintained	Excellent

[1] Manual turbidity measurements against sensor measurements had a coefficient of determination of 0.25.
[2] 4.7% of records at Sunnyvale showed a >15% change between consecutive readings, and manual stage measurements were only made in the 4th quartile.
[3] 1.9% of the population (483 records) had greater than 20 NTU absolute value change and ≥15% relative change from the preceding record; 1.3% (328 records) had greater than 20 NTU absolute value change and >50% relative change from the preceding record. Recommended action for improvement is to shorten the recording interval from 5 minutes to 1 minute.
[4] 4.2% of the population (251 records) had greater than 20 NTU absolute value change and ≥15% relative change from the preceding record; 2.9% (171 records) had greater than 20 NTU absolute value change and >50% relative change from the preceding record. Data intervals already set to minimum of 1 minute interval. Recommended action for improvement is to collect as many manual turbidity measurements as possible in order to better understand whether variability in the record is real or anomalous.
[5] Rainfall data at San Leandro Creek missing from 10/1/2012-11/6/2012, 12/6/2012-12/12/2012, and 1/4/2013-1/9/2013. Missing 10.6% of records.
[6] 31% of the period of record was missing turbidity due to the minimum stage criterion for turbidity measurement to be 0.4 ft and this amount of the record being during stages below 0.4 ft. An additional 8.3% of the turbidity record was rejected due to fouling.
[7] A large portion of the data record was on intervals greater than 15minutes.
[8] Completeness of the turbidity record was excellent during the period in which turbidity was measured, but a large portion of the wet season was missing data.
[9] 23% of records for stages > 1 ft have no corresponding turbidity record.

3.2. Continuous data quality assurance summary

Overall the continuous rainfall data were acceptable. Rain data were collected at all the sites except for Guadalupe (Note, SCVWD collects high quality rainfall data throughout the Guadalupe River watershed), and the data were collected on the same time interval as stage and turbidity. Rain gauges were cleaned before and periodically during the season, but not calibrated. All sites except for the North Richmond Pump Station compared well to nearby rain gauges. Discrepancies between the rain gauge at North Richmond Pump Station and nearby gauges during December and January resulted in the accuracy of this data set to be labeled as "poor". All sites had rainfall totals during 5-, 10- and 60-minute intervals that aligned with 1-, 2- and 5-year rainfall returns in their respective regions.

Overall the continuous stage data were acceptable. Manual stage measurements made at Sunnyvale and San Leandro compared well with the corresponding record from the pressure transducer (R^2=0.99 at both sites). The entire stage dataset at Lower Marsh was compared to the USGS gauge on Marsh creek, and showed a regression with R^2=0.98. Percent differences between consecutive records were reasonable at all sites and the datasets were complete for the period where the equipment was installed. Manual stage measurements were not collected at either of the pump station sampling locations and could not be used to verify the accuracy or precision of those stage records, an improvement to be implemented in WY 2014.

Continuous turbidity data were rated excellent at Lower Marsh Creek and Guadalupe River. San Leandro Creek, Sunnyvale East Channel and Pulgas Creek Pump Station (qualified) all received poor quality ratings on completeness: the San Leandro Creek dataset was relatively free from spikes requiring censorship or correction but had a large portion of missing records; Sunnyvale East Channel had a full record but a large portion of data censored due to spikes; and Pulgas Creek Pump Station recorded turbidity during only three of the seven wet season months in large part due to instrumentation failures. The pump station sites both received poor ratings for representativeness given how records could fluctuate multiple times from one reading to the next. Both of these sites experience very rapidly changing conditions and may warrant unique rating criterion in the QA protocol; a topic for continued discussion and potential revision for future reporting. Pulgas Creek Pump Station also had poor repeatability between manual and sensor collected data and improvements to the monitoring set-up should be considered for next wet season.

4. Laboratory analysis and quality assurance

4.1. Sample preservation and laboratory analysis methods

All samples were labeled, placed on ice, transferred back to the respective site operator's headquarters, and refrigerated at 4 °C until transport to the laboratory for analysis. Laboratory methods were chosen to ensure the highest practical ratio between method detection limits, accuracy and precision, and costs (BASMAA, 2011; 2012) (Table 4). In water year 2013, laboratory changes were made for the following chemical analyses:

- Total Mercury and total methylmercury from Moss Landing Marine Laboratory to Caltest
- Nutrients and SSC from East Bay MUD to Caltest

- Pyrethroids from AXYS Analytical Laboratory to Caltest
- Selenium, copper, and hardness from Brooks Rand Laboratory to Caltest

An inter-comparison study was designed to assess any impacts of laboratory change during the study. A subset of samples were collected in replicate in the field and sent to the previous laboratory and replacement laboratory. Acceptance limits for precision and recovery in QC samples (e.g., for matrix spikes or reference materials) in published methods provide practical guides for the expected

Table 4. Laboratory analysis methods

Analyte	Method	Field Filtration	Field Acidification	Laboratory
Carbaryl	EPA 632M	no	no	DFG WPCL
Fipronil	EPA 619M	no	no	DFG WPCL
Suspended Sediment Concentration	ASTM D3977-97B	no	no	Caltest Analytical Laboratory
Total Phosphorus	SM20 4500-P E	no	yes (bottle pre-preserved)	Caltest Analytical Laboratory
Nitrate	EPA 353.2 / SM20 4500-NO3 F	yes	yes (bottle pre-preserved)	Caltest Analytical Laboratory
Dissolved OrthoPhosphate	SM20 4500-P E	yes	no	Caltest Analytical Laboratory
PAHs	AXYS MLA-021 Rev 10	no	no	AXYS Analytical Services Ltd.
PBDEs	AXYS MLA-033 Rev 06	no	no	AXYS Analytical Services Ltd.
PCBs	AXYS MLA-010 Rev 11	no	no	AXYS Analytical Services Ltd.
Pyrethroids	EPA 8270Mod (NCI-SIM)	no	no	Caltest Analytical Laboratory
Total Methylmercury	EPA 1630M Rev 8	no	yes (bottle pre-preserved)	Caltest Analytical Laboratory
Total Mercury	EPA 1631EM Rev 11	no	yes (bottle pre-preserved)	Caltest Analytical Laboratory
Copper[1]	EPA 1638M	no	no	Caltest Analytical Laboratory
Selenium[1]	EPA 1638M	no	no	Caltest Analytical Laboratory
Total Hardness[1]	SM 2340	no	no	Caltest Analytical Laboratory
Total Organic Carbon	SM20 5310B	no	yes (bottle pre-preserved)	Caltest Analytical Laboratory
Toxicity[3]	See 2 below	no	no	Pacific Eco-Risk Labs

[1] Dissolved selenium and dissolved copper were field filtered at the Lower Marsh Creek and San Leandro Creek stations in water year 2013. Dissolved selenium and dissolved copper field filtered for Lower Marsh Creek only in water year 2012. Field filtered samples are also field preserved.
[2] Hardness is a calculated property of water based on magnesium and calcium concentrations. The formula is: Hardness (mg/L) = (2.497 [Ca, mg/L] + 4.118 [Mg, mg/L])
[3] Toxicity testing includes: chronic algal growth test with *Selenastrum capricornutum (*EPA 821/R-02-013)chronic survival & reproduction test with *Ceriodaphnia dubia* (EPA 821/R-02-013)*,* chronic survival and growth test with fathead minnows (EPA 821/R-02-013), and10-day survival test with *Hyalella Azteca (*EPA 600/R-99-064M)

agreement between samples analyzed by different labs; differences between labs will reflect the aggregate of uncertainty for each measurement (the propagated error would be the square root of the sum of the squared errors), and thus may often be larger than the accepted limits of intra- (single) lab variation. Differences among locations or over time, that were smaller than these propagated errors, could not be distinguished from measurement variability, so results (e.g., calculated loads) should be interpreted with awareness of these uncertainties.

Mercury and methylmercury samples were analyzed during the inter-comparison study. Comparability for total mercury samples was good, averaging 26% RPD (similar to the expected 25% RPD for within lab replicates) and ranging from 2 to 42% RPD for individual pairs, with the previous laboratory reporting higher concentrations for all inter-compared sample pairs. Methylmercury comparability was even better, averaging 11% RPD (10.7 and 11.1% RPD on individual sample pairs), again with the previous laboratory reporting slightly higher concentrations.

Comparability of nutrient and conventional water quality parameters was usually good except for SSC. RPDs between nitrate results from the labs ranged 2 to 6% (average 4%), and orthophosphate results were identical within rounding error (reported to the nearest 0.01 mg/L). Total phosphorous was slightly more variable but averaged only 6% RPD (4 to 7% range). Only SSC showed a wide degree of variation, with RPDs ranging 0 to 60% (average 25%), illustrating some of the challenges of consistently representatively sampling particulate matter in stormwater flows.

For pyrethroids, the results were fairly similar for the most abundant compound, bifenthrin (17% RPD), with somewhat poorer agreement for the next most abundant compound, permethrin with 40% RPD. For two independent measurements each with up to 35% error, the propagated error would be the square root of the sum of the squared errors (i.e., SQRT[$0.35^2 + 0.35^2$]), approximately 49%, so 40% RPD was within this range of expected error. Comparability could not be assessed quantitatively (i.e., no RPDs were calculated) for the remaining pyrethroids. MDLs from the previous laboratory were mostly in the range 0.25-5 ng/L, with most samples reported as non-detect or as estimated results near MDL/below RL. Therefore RPDs (even if calculated) could not be quantitative.

Hardness, copper, and selenium were also analyzed. Although hardness reported by the current laboratory was censored due to poor matrix spike recovery (error 4 times over the 5% target; the error tolerance on hardness measurements are tighter due to the usual ease of good precision and accuracy on those measurements), raw results were compared to see if the bias reported in QC samples was also reflected in comparability between laboratories. The RPD for hardness was 16%, with the current laboratory reporting lower concentrations; a similar low bias is seen in their matrix spike samples, which reported 21% lower than their expected values. The concurrence between these IC results and the current laboratory's MS results suggests a consistent low bias for hardness, so any use of the currently censored data should be made with full awareness and acknowledgement of this likely bias. Comparability on copper was much better, averaging 7% RPD (5 and 12% respectively for the total and dissolved samples compared), and similarly the comparability on selenium was quite good, averaging 6% (0.5 and 11% for the total and dissolved fractions of compared samples).

Where differences being sought are similar in magnitude to the uncertainty in precision around individual measurements, a large number of measurements may be needed to verify the significance of possible differences (or lack thereof) seen. When the uncertainty arises from bias, comparison to other laboratories' results (either through inter-comparison exercises or certified reference materials[1]) can provide an indication of the possible bias. The inter-comparability data provide greater confidence in individual measurements where there is better agreement; the results are less likely to reflect an artifact of any particular laboratory's sample handling and quantitation methods. Thus for this study, there is generally better confidence in the measurement of inorganic pollutants and water quality parameters (other than SSC). Overall, the results from the IC study (from a relatively small sub-set of samples) did not provide evidence to indicate non-comparability between the new laboratories for most analytes. Due to sample concentrations near MDL for pyrethriods, evidence is weaker and there was some concern with the SSC comparability; SSC inter-comparisons are likely most influenced among all the analytes by grain size and field sub-sampling techniques in addition to laboratory sample treatment. At this time, the results from the IC study have not been factored into loads computations; this will occur during the completion of the final report estimated to occur in late 2014.

4.2. Quality assurance methods for pollutants of concern concentration data

4.3.1. Sensitivity

The sensitivity review evaluated the percentage of field samples that were non-detects as a way to evaluate if the analytical methods employed were sensitive enough to detect expected environmental concentrations of the targeted parameters. In general, if more than 50% of the samples were ND then the method may not be sensitive enough to detect ambient concentrations. However, review of historical data from the same project/matrix/region (or a similar one) helped to put this evaluation into perspective; in most cases the lab was already using a method that is as sensitive as is possible.

4.3.2. Blank Contamination

Blank contamination review was performed to quantify the amount of targeted analyte in a sample from external contamination in the lab or field. This metric was performed on a lab-batch basis. Lab blanks within a batch were averaged. When the average blank concentration was greater than the method detection limit (MDL), the field samples, within this batch, were qualified as blank contaminated. If the field sample result was less than 3 times the average blank concentration (including those reported as ND) those results were "censored" and not reported or used for any data analyses.

4.3.3. Precision

Rather than evaluation by lab batch, precision review was performed on a project or dataset level (e.g., a year or season's data) so that the review took into account variation across batches. Only results that were greater than 3 times the MDL were evaluated, as results near MDL were expected to be highly

[1] Although certified reference materials provide one indicator of possible bias, they in themselves provide no absolute guarantee of a particular measurement's accuracy; the certified values are consensus values that often have very wide confidence bands. This may depend on the particular labs participating in the certification and the methods used by those labs. Furthermore, concentrations of analytes and interfering matrices may differ from those in samples from a particular study.

variable. The overarching goal was to review precision using sample results that were most similar in characteristics and concentrations to field sample results. Therefore the priority of sample types used in this review was as follows: lab-replicates from field samples, or field replicates (but only if the field replicates are fairly homogeneous - unlikely for wet-season runoff event samples unless collected simultaneously from a location). Replicates from CRMs, matrix spikes, or spiked blank samples were reviewed next with preference to select the samples that most resembled the targeted ambient samples in matrix characteristics and concentrations. Results outside of the project management quality objective (MQO) but less than 2 times the MQO (e.g., ≤50% if the MQO RPD is ≤25%) were qualified; those outside of 2 times the MQO were censored.

4.3.4. Accuracy

Accuracy review was also performed on a project or dataset level (rather than a batch basis) so that the review takes into account variation across batches. Only results that were greater than 3 times the MDL were evaluated. Again, the preference was for samples most similar in characteristics and concentrations to field samples. Thus the priority of sample types used in this review was as follows: Certified Reference Materials (CRMs), then Matrix Spikes (MS), then Blank Spikes. If CRMs and MS were both reported in the same concentration range, CRMs were preferred because of external validation/certification of expected concentrations, as well as better integration into the sample matrix (MS samples were often spiked just before extraction). If both MS and blank spike samples were reported for an analyte, the MS was preferred due to its more similar and complex matrix. Blank spikes were used only when preferred recovery sample types were not available (e.g., no CRMs, and insufficient or unsplittable material for creating an MS). Results outside the MQO were flagged, and those outside 2 times the MQO (e.g., >50% deviation from the target concentration, when the MQO is ≤25% deviation) were censored for poor recovery.

4.3.5. Comparison of dissolved and total phases

This review was only conducted on water samples that reported dissolved and particulate fractions. In most cases the dissolved fraction was less than the particulate or total fraction. Some allowance is granted for variation in individual measurements, e.g. with an MQO of RPD<25%, a dissolved sample result might easily be higher than a total result by that amount.

4.3.6. Average and range of field sample versus previous years

Comparing the average range of the field sample results to comparable data from previous years (either from the same program or other projects) provided confidence that the reported data do not contain egregious errors in calculation or reporting (errors in correction factors and/or reporting units). Comparing the average, standard deviation, minimum and maximum concentrations from the past several years of data aided in exploring data, for example if a higher average was driven largely by a single higher maximum concentration.

4.3.7. Fingerprinting summary

The fingerprinting review evaluated the ratios or relative concentrations of analytes within an analysis. For this review, we looked at the reported compounds to find out if there are unusual ratios for individual samples compared to expected patterns from historic datasets or within the given dataset.

Since analyses of organic contaminants at trace levels are often susceptible to biases that may not be detected by conventional QA measures, additional QA review is necessary to ensure the integrity of the reported data. Based on knowledge of the chemical characteristics and typical relative concentrations of organic contaminants in environmental samples, concentrations of the target contaminants are compared to results for related compounds to identify potentially erroneous data. Compounds that are more abundant in the original technical mixtures and are more stable and recalcitrant in the environment are expected to exist in higher concentrations than the less abundant or less stable isomers. For example, PCB congener concentrations follow general patterns of distribution based on the original concentrations in Aroclor mixtures. If an individual congener occurs at concentrations much higher than usual relative to more abundant congeners, the result warrants further investigation.

Furthermore, several contaminants chemically transform into other toxic compounds and are usually measured within predicted ranges of concentrations compared to their metabolites (e.g. heptachlor epoxide/heptachlor), so deviations from such expectations are also further investigated. However, great care should be exercised in using information on congener ratios of common Aroclor mixtures and other such heuristic methods, for some of the same reasons that interpreting environmental PCBs only as mixtures of Aroclors has limitations. Over-reliance on such patterns in data interpretation may lead to inadvertent censoring of data, e.g., for contributions from unknown or unaccounted sources.

When results are reported outside the range of expected relative concentrations, and the laboratory cannot identify the source of variability, values are qualified to indicate uncertainty in the results. If the reported values do not deviate much from the expected range, they are generally allowed to stand and are included in calculations of “sums” for their respective compound classes. However, if the reported concentrations deviate greatly from the expected range and are clearly higher than observed in past analyses or current sample splits, it can be reasonably concluded that the results are erroneous.

5. Results

The following sections present synthetic results from the six monitored tributaries. In this section, a summary of data quality is initially presented. This is then followed by sub-sections that synthesize climate and flow across the six locations, concentrations of POCs across the six locations, loads across six locations, and a graphical summary of particle concentrations across the six locations.

5.1. Project Quality Assurance Summary

The section below reports on WY 2013 data; for the WY 2012 quality assurance summary, refer to section 4.1 in McKee et al., 2013. Attachment 1 provides a detailed QAQC summary for WY 2013 data.

The PCB data were acceptable. MDLs were sufficient for the majority of PCBs with 22% (16 out of 71 congeners) having some non-detects (ND), but none were extensive. A number of PCB congeners were found in laboratory blanks. About 27% (19 out of 71) of the congeners had some contamination in at least one method blank. PCB congeners 18, 28, 31, 44, 49, 52, 66, 70, 87, 95, 118, and 153 had 3% of grab sample results flagged with the censoring contamination qualifier of “VRIP” (results with reported concentrations <3x the blank results (by batch) being censored for contamination). Precision and accuracy metrics were within MQOs.

Overall the total mercury and total methylmercury results were acceptable. MDLs were sufficient with only one ND for methylmercury. Total mercury and methylmercury were not detected in lab blanks, although total mercury was found in one field blank at .004 µg/L, about 20 times above the MDL, but still ~5 times lower than the average concentration for field samples in this data set. Precision and accuracy metrics were within MQOs. Methylmercury concentrations were generally in the range of 1% of total mercury concentrations which is fairly typical. No additional qualifiers were needed on the data set.

The nutrient data were generally acceptable. MDLs were sufficient to get quantitative results for most analytes at all stations. Nitrate had 7% non-detects and suspended sediment concentration had 3% non-detects. No blank contamination was found in either the method blanks or equipment blanks (3 batches). Field blanks were analyzed for 21 batches with blank contamination found for nitrate and phosphorus as in one batch each. Precision and accuracy metrics were within MQOs.

The carbaryl and fipronil data were acceptable. MDLs were sufficient with carbaryl having ≥50% NDs. Blank contamination was not found in either the method blanks or the field blanks. Precision and accuracy metrics were within MQOs.

The PAH dataset was acceptable with some minor QA issues. MDLs were sufficient for most of the PAHs, with <50% non-detects for 76% of the target PAHs; Acenaphthene, Acenaphthylene, Benz(a)anthracene, Dibenz(a,h)anthracene , Dibenzothiophene, and Fluorene had >50% NDs. Thirteen PAHs were found in at least one of the three lab blanks; subsequently Benz(a)anthracene, Benz(a)anthracenes/Chrysenes, C4- , Biphenyl, Dibenzothiophene, Fluorene, Methylnaphthalene, 1-, Naphthalene, and Trimethylnaphthalene, 2,3,5- had results flagged with the censoring qualifier VRIP for being <3x the average blank concentration. Precision was good with <35% RSD on lab or blank spike replicates for all analytes. Accuracy was evaluated using recoveries for the 43 PAHs in the laboratory control samples and were generally good, with only Tetramethylnaphthalene, 1,4,6,7- (40%) having a recovery averaging >35%.

Overall the PBDE data were acceptable. MDLs were sufficient with 29 of the 49 reported PBDE congeners having some level of non-detect, and 27% having ≥50% NDs. PBDE congeners 17, 28, 47, 49, 85, 99, 100, 138, 153, 154, 183 and 209 had some contamination in at least one method blank, but only PBDE 183 had 6% of its samples censored. Replicates on field samples were used to evaluate precision and were generally good, less than the target 35% average RSD, except for PBDE 8 and 12, which were flagged with the non-censoring qualifier. Accuracy metrics were within MQOs.

Overall the pyrethroids data were acceptable. MDLs were sufficient with 12 of the 13 pyrethroids reported having some level of non-detect (ranging from 5 to 95% non-detects) and 50% of the pyrethroids reported having ≥50% NDs (Allethrin, Deltamethrin/Tralomethrin, Diazinon, Fenpropathrin, Tetramethrin and T-Fluvalinate). Blank contamination was not found in any of the method blanks. Field blanks were examined, but not used in the evaluation, with blank contamination found in one of the field blanks for Chlorpyrifos and Diazon at a concentration equal to the MDL. Matrix spikes were used to assess accuracy with recovery errors less than the target 35% for all reported analytes, except Allethrin,

Deltamethrin/Tralomethrin, and Tetramethrin, which were flagged with a non-censoring qualifier. Replicates on matrix spikes were used to evaluate precision and were generally good, less than the target 35% average RSD, except Allethrin and Cyhalothrin, lambda total, which were flagged with a non-censoring qualifier.

Overall the other trace elements dataset was acceptable. MDLs were sufficient with only dissolved selenium having non-detects (1 out of 21 samples; 5% ND). No blank contamination was observed except in two of the equipment blanks for total copper; one at a concentration equal to the MDL (0.08 µg/L), the other at less than two times the method blank (0.125 µg/L). Precision and accuracy metrics were within MQOs except for the metric accuracy for Hardness (recovery error 21%), which was flagged with a censoring qualifier. The ratio of dissolved to total concentrations can help characterize the sources and environmental processes of contaminants, and ratios >100% (i.e., dissolved concentrations greater than totals) may indicate some analytical problems with one or both fractions. Dissolved copper results ranged from 4% to 69% of the total results, with the majority being less than 50%. Dissolved selenium results ranged from 57% to 102% of the total results; dissolved and total selenium results for San Leandro Creek on 11/21/2012 were both 0.19 µg/L. Lower Marsh Creek selenium dissolved and total results from 4/5/2013 were 0.51 and 0.5 µg/L, respectively.

5.2. Climate and flow at the sampling locations during water years 2012 and 2013

The climatic conditions under which observations are made of pollutant concentrations in flowing river systems have a large bearing on concentrations and loads observed. It has been argued that a 30 year period is needed in California to capture the majority of climate related variability of a single site (McKee et al., 2003). Given monitoring programs for concentrations or loads do not normally continue for such a long period, the objective of sampling is usually to try to capture sufficient components of the full spectrum of variability to make inferences from a smaller dataset. In general, high magnitude (high intensity or long duration) events occur infrequently and thus are usually poorly represented in datasets yet for most pollutants, these types of events usually transport the majority of a decadal scale load. This occurs because the discharge-load relation is described by a power function and therefore storms and wet years with larger discharge have a profound influence on the estimate of mean annual load for a given site and will likely confound any comparisons of loads between sites unless adequately characterized. However, if it is assumed that this is consistently true for all sites, comparisons across sites will be more valid.

Conceptually, watersheds that are more impervious, or smaller in area, or have lower pollutant production variability (or sources) should exhibit lower inter-annual variability (lower slope of the power function) and therefore require less sampling to adequately quantify pollutant source-release-transport processes (the exemplary example in this group is Marsh Creek in relation to PCBs). In contrast, a longer sampling period spanning a wider climatic variability will be required to adequately describe pollutant source-release-transport processes in watersheds that are larger, or less impervious, or have large and known pollutant sources. The quintessential example of this category within this study is Guadalupe River in relation to Hg sources, release mechanisms, and loads but San Leandro Creek (both Hg and PCBs) and Sunnyvale East channel and Pulgas Creek (PCBs) may also fall into this category.

Unfortunately, during the study to date, winter seasons have been very dry relative to average annual conditions with all observations to-date made during years of <89% mean annual precipitation or flow (Table 5). For example, Lower Marsh Creek experienced just 22% of mean annual runoff in WY 2012 and 73% of mean annual run-off in WY 2013. However, there have been some notable storms, particularly those occurring during late November and December of WY 2013. For example, approximately 65% of the total wet season rainfall fell on Sunnyvale East Channel in the span of less than one month. Loads of pollutants were disproportionately transported during such events; at Sunnyvale East Channel, 88%, 92% and 83% of the total wet season sediment, PCBs and mercury loads were transported during those larger November and December storms. However, despite these larger individual storm events, at this time, any effort to estimate long-term averages for each site will likely result in estimates that are biased low due to observations during relatively dry and therefore benign flow production, sediment erosion and transport conditions.

Table 5. Climate and flow during sampling years to-date at each sampling location.

		Marsh Creek[2]	North Richmond Pump Station[3]	San Leandro Creek[4]	Guadalupe River[5]	Sunnyvale East Channel[6]	Pulgas Creek Pump Station[7]
Rainfall (mm) (% mean annual)	WY 2012	321 (70%)	No data	486 (75%)	179 (47%)	224 (58%)	No data
	WY 2013	278 (61%)	508 (89%)	342* (52%)	223 (59%)	259* (67%)	378* (78%)
	Mean Annual	457	570	652	378	387	488
Runoff (Mm^3) (% mean annual)	WY 2012	1.87 (22%)	No data	5.47	38.0 (68%)	1.07	No data
	WY 2013	6.23 (73%)	0.76	8.81	45.45 (82%)	1.79	0.21
	Mean Annual	8.51	No data	No data	55.6	No data	No data

[1] Unless otherwise stated, averages are for the period Climate Year (CY) (Jul-Jun) (rainfall) or Water Year (WY) (Oct-Sep) (runoff) 1971-2010.
[2] Rainfall gauge: Concord Wastewater treatment plant (NOAA gauge number 041967) (CY 1991-2013); Runoff gauge: Marsh Creek at Brentwood (gauge number 11337600) (WY 2001-2013).
[3] Rainfall gauge: This study with mean annual from modeled PRISM data; Runoff gauge: This study.
[4] Rainfall gauge: Upper San Leandro Filter (gauge number 049185); Runoff gauge: This study.
[5] Rainfall gauge: San Jose (NOAA gauge number 047821); Runoff gauge: Guadalupe River at San Jose (gauge number 11169000) and at Hwy 101 (gauge number 11169025).
[6] Rainfall gauge: Palo Alto (NOAA gauge number 046646); Runoff gauge: This study
[7] Rainfall gauge: Redwood City NCDC (gauge number 047339-4); Runoff gauge: This study.
* indicates data missing for the latter few months of the season

5.3. Concentrations of pollutants of concern during sampling to-date

Understanding the concentrations of pollutants in the watersheds is important to both directly answering one of the Small Tributary Loading Strategy management questions (MQ2) as well as forming the basis from which to answer all of the other key management questions identified by the Strategy. Sampling to-date has provided data that, in some cases, indicate surprisingly high concentrations (e.g. Hg in San Leandro Creek; PCBs in Sunnyvale East Channel; PBDEs in North Richmond Pump Station); other cases indicate surprisingly low concentrations (Hg in Marsh Creek). In some cases non-detects and quality assurance issues continue to confound robust interpretations. This section explores those issues

through synthesis of data collected across all six sampling locations to date to provide support for rationale for continued sampling in relation to answering management questions.

Concentrations of pollutants typically vary over the course of a storm, between storms of varying magnitudes, and are dependent on related discharge, sediment and source-related transport processes. Thus, it is important to sample at a wide range flow conditions both within a storm and over a wide range of storm magnitudes to adequately characterize concentrations of pollutants in a watershed. The monitoring design for this project aims to collect pollutant concentration data from 12 storms over the span of three years, with priority pollutants sampled at an average of four samples per storm for a total of 48 samples collected during the monitoring term. Sampling at the six locations to date has included sampling between one and six storm events at each location. Given the small sample size and varying sample sizes between sites, the following synthesis should be considered qualitative at this time; data collection during WY 2014 will likely provide further insights into pollutant characteristics at single sites and between sites.

Overall, detections of concentrations in the priority pollutants (suspended sediment, total PCBs, total mercury, total methylmercury, total organic carbon, total phosphorous, nitrate, and phosphate) were all 94% or better, as were detections of several of the "tier II" pollutants (total and dissolved copper and selenium, PAHs and PBDEs) (Table 6). Numerous pyrethroids were not detected at any of the sites, whereas Delta/Tralomethrin, Cypermethrin, Cyhalothrin lambda, Permethrin, Bifenthrin as well as Carbaryl and Fipronil were all detected in one or more samples at each sampling location (except Pulgas Creek Pump Station where Fipronil was not detected in the one sample to-date).

The two sampling locations added this year (North Richmond and Pulgas Creek pump stations), have the lowest mean SSC; whereas pollutant concentrations are relatively high for these watersheds (e.g. PCBs at Pulgas Creek Pump Station). As a result, the particle ratio (turbidity or SSC to pollutant; discussed further in section 5.5) was higher relative to other watersheds with similar pollutant concentrations but greater SSC. Given the high imperviousness and small size of these watersheds, although few storms have been sampled at these locations, it is unlikely great variation in SSC will be observed in future sampling efforts.

The maximum PCB concentration of the dataset to date (176 ng/L) was collected in Sunnyvale East Channel, which also has the greatest mean PCB concentration of the six locations; consistent with the high ranking assigned to Sunnyvale East Channel based on the WY 2011 reconnaissance study of 17 watersheds distributed across four Bay Area counties (McKee et al., 2012). However, sampling at Pulgas Creek Pump Station has so far captured only one relatively small storm event; future monitoring at this location will likely indicate higher PCB concentrations until management actions take effect. Guadalupe River has mercury mines in the upper watershed and is a known mercury source to the San Francisco Bay, explaining the high mercury and, possibly, methylmercury concentrations in this watershed. Less well understood is San Leandro Creek, which has mercury and methylmercury concentrations nearly as high as Guadalupe River. Continued sampling under more variable storm and climatic conditions in San Leandro Creek may improve our understanding of source-release-transport processes of mercury in this watershed. It is also worth noting (with regard to the tier I priority analytes) that phosphorus

Table 6. Synthesis of concentrations of pollutants of concern based on all samples collected to-date at each sampling location.

		Marsh Creek		North Richmond Pump Station		San Leandro Creek		Guadalupe River		Sunnyvale East Channel		Pulgas Creek Pump Station	
Analyte Name	**Unit**	**Number (% detect)**	**Mean (std. error)**	**Number (% detect)**	**Mean (std. error)**	**Number (% detect)**	**Mean (std. error)**	**Number (% detect)**	**Mean (std. error)**	**Number (% detect)**	**Mean (std. error)**	**Number (% detect)**	**Mean (std. error)**
SSC	mg/L	81 (99%)	243 (27.5)	41 (95%)	45.7 (8.48)	81 (94%)	145 (18.5)	82 (100%)	161 (18.3)	62 (97%)	302 (66.1)	15 (100%)	33.3 (8.54)
∑PCB	ng/L	22 (100%)	1.25 (0.258)	12 (100%)	12.0 (2.05)	28 (100%)	9.45 (1.50)	23 (100%)	14.0 (3.63)	18 (100%)	51.3 (12.9)	4 (100%)	34.7 (10.1)
Total Hg	ng/L	25 (100%)	45.8 (11.5)	12 (100%)	27.7 (7.10)	28 (100%)	145 (35.7)	24 (100%)	210 (50.1)	18 (100%)	52.8 (12.9)	6 (100%)	10.5 (2.82)
Total MeHg	ng/L	19 (95%)	0.306 (0.076)	6 (100%)	0.118 (0.029)	18 (100%)	0.438 (0.099)	17 (100%)	0.438 (0.082)	12 (92%)	0.251 (0.061)	6 (100%)	0.178 (0.041)
TOC	mg/L	24 (100%)	7.13 (0.416)	12 (100%)	7.46 (0.970)	28 (100%)	7.13 (0.453)	24 (100%)	7.55 (0.657)	18 (100%)	6.10 (0.369)	4 (100%)	10.3 (2.26)
NO3	mg/L	24 (96%)	0.579 (0.045)	12 (100%)	1.13 (0.245)	29 (100%)	0.429 (0.094)	24 (83%)	0.919 (0.150)	18 (100%)	0.287 (0.022)	4 (100%)	0.358 (0.051)
Total P	mg/L	20 (100%)	0.438 (0.054)	12 (100%)	0.276 (0.013)	25 (100%)	0.34 (0.035)	20 (100%)	0.434 (0.044)	19 (100%)	0.422 (0.078)	4 (100%)	0.15 (0.035)
PO4	mg/L	24 (100%)	0.098 (0.008)	11 (100%)	0.168 (0.013)	29 (100%)	0.09 (0.005)	24 (100%)	0.105 (0.007)	18 (100%)	0.102 (0.005)	4 (100%)	0.066 (0.010)
Hardness	mg/L	4 (100%)	189 (8.86)	-	-	7 (100%)	46.0 (6.55)	4 (100%)	136 (9.31)	2 (100%)	56.3 (4.90)	-	-
Total Cu	µg/L	6 (100%)	16.7 (4.10)	3 (100%)	15.3 (2.94)	7 (100%)	19.6 (4.36)	6 (100%)	19.8 (3.74)	4 (100%)	20.0 (4.16)	1 (100%)	30.0 (-)
Dissolved Cu	µg/L	6 (100%)	2.868 (0.792)	3 (100%)	6.367 (1.819)	7 (100%)	6.459 (0.981)	6 (100%)	4.52 (0.852)	4 (100%)	6.79 (2.70)	1 (100%)	20.0 (-)
Total Se	µg/L	6 (100%)	0.783 (0.128)	3 (100%)	0.397 (0.098)	7 (100%)	0.213 (0.027)	6 (100%)	1.46 (0.392)	4 (100%)	0.450 (0.041)	1 (100%)	0.180 (-)
Dissolved Se	µg/L	6 (100%)	0.694 (0.111)	3 (100%)	0.363 (0.098)	7 (100%)	0.149 (0.018)	6 (100%)	1.21 (0.42)	4 (100%)	0.343 (0.018)	1 (100%)	0.17 (-)
Carbaryl	ng/L	6 (33%)	4.83 (3.08)	3 (100%)	23.7 (8.41)	7 (29%)	3.43 (2.26)	6 (83%)	27.1 (9.50)	4 (75%)	12.8 (4.77)	1 (100%)	204 (-)
Fipronil	ng/L	6 (100%)	11.6 (1.52)	3 (33%)	1.33 (1.33)	7 (86%)	6.14 (1.42)	6 (100%)	10.1 (2.34)	4 (75%)	6.00 (2.45)	1 (0)	-
∑PAH	ng/L	3 (100%)	267 (120)	3 (100%)	952 (397)	3 (100%)	3327 (1142)	4 (100%)	614 (194)	2 (100%)	1322 (32.8)	4 (100%)	614 (194)

		Marsh Creek		North Richmond Pump Station		San Leandro Creek		Guadalupe River		Sunnyvale East Channel		Pulgas Creek Pump Station	
Analyte Name	**Unit**	**Number (% detect)**	**Mean (std. error)**	**Number (% detect)**	**Mean (std. error)**	**Number (% detect)**	**Mean (std. error)**	**Number (% detect)**	**Mean (std. error)**	**Number (% detect)**	**Mean (std. error)**	**Number (% detect)**	**Mean (std. error)**
∑PBDE	ng/L	3 (100%)	29.2 (13.9)	3 (100%)	2340 (2340)	4 (100%)	44.6 (18.0)	3 (100%)	39.1 (16.5)	2 (100%)	19.8 (15.0)	4 (100%)	45.8 (24.9)
Delta/ Tralo-methrin	ng/L	6 (83%)	1.70 (0.820)	3 (100%)	2.52 (0769)	6 (67%)	0.652 (0.308)	6 (50%)	0.737 (0.372)	3 (67%)	2.47 (1.23)	1 (0%)	-
Cypermethrin	ng/L	6 (83%)	14.6 (10.9)	3 (100%)	3.18 (0.651)	7 (29%)	0.214 (0.159)	6 (50%)	0.917 (0.547)	4 (50%)	2.10 (1.28)	1 (100%)	0.900 (-)
Cyhalothrin lambda	ng/L	6 (83%)	1.37 (0.551)	3 (100%)	0.767 (0.273)	6 (33%)	0.693 (0.635)	6 (67%)	0.483 (0.227)	3 (67%)	1.23 (0.722)	1 (0%)	-
Permethrin	ng/L	6 (83%)	7.70 (2.75)	3 (100%)	12.0 (2.88)	7 (71%)	4.86 (1.73)	6 (67%)	10.4 (3.95)	4 (100%)	24.1 (8.78)	1 (100%)	2.90 (-)
Bifenthrin	ng/L	6 (100%)	91.5 (38.1)	3 (100%)	5.98 (1.23)	7 (86%)	10.3 (4.07)	6 (83%)	5.64 (1.97)	4 (75%)	8.68 (3.68)	1 (100%)	1.30 (-)

Analyzed but not detected: Fenpropathrin, Esfenvalerate/ Fenvalerate, Cyfluthrin, Allethrin, Prallethrin, Phenothrin, and Resmethrin
All Hardness results in WY 2013 were censored.

concentrations in most of the six watersheds appear greater than elsewhere in the world under similar land use scenarios, perhaps attributable to geological sources (McKee and Krottje, 2005).

Selenium and PBDE concentrations, two analytes being collected at a lesser frequency in this study (intended only for characterization) are particularly notable. In the Guadalupe River, mean selenium concentrations were 2-8 fold greater than the other five locations; elevated groundwater concentrations have been observed in Santa Clara County previously (Anderson, 1998). Maximum PBDE concentrations in North Richmond Pump Station were 37- to 96-fold greater than the PBDE maxima observed in the five other locations of this current study. These are the highest PBDE concentrations measured in Bay area stormwater to-date (see section 8.2 for details).

Concentration sampling to date at the six locations have in part confirmed previously known or suspected pollutant sources (e.g. mercury in Guadalupe, PCBs in Sunnyvale East Channel). Concentration results to date have also raised some questions about certain pollutants in certain watersheds (e.g. upper versus lower watershed Hg concentrations in San Leandro Creek, PBDE concentrations in North Richmond Pump Station). More sampling under a broader range of storm events is necessary to more confidently characterize pollutants in those watersheds. With a more targeted sampling approach in future water years based on storm variability and data that are still lacking to answer management questions adequately (see section 6), it is expected that this monitoring study will produce a robust characterization of pollutants in these watersheds.

5.4. Loads of pollutants of concern computed for each sampling location

One of the primary goals of this project and key management questions of the Small Tributary Loading Strategy was to estimate the annual loads of POCs from tributaries to the Bay (MQ2). In particular, large loads of POCs entering sensitive Bay margins are likely to have a disproportionate impact on beneficial uses (Greenfield and Allen, 2013). As described in the climatic section (5.2), given the relationship between climate (manifested as either rainfall and resulting discharge) and watershed loads follows a power function, estimates of long-term average loads for a given watershed are highly influenced by samples collected during wetter than average conditions and rare high magnitude storm events. Comparing loads estimates between the sites is currently confounded by small sample datasets during climatically dry years. At this time, comparison should therefore be considered qualitative; with subsequent years of sampling an attempt at computing long-term average loads for each sampling location will likely be made. Accepting these caveats, the following observations are made on the total wet season loads estimates at the six locations.

Comparison of total loads between watersheds is largely driven by drainage area of each watershed. In terms of total wet season loads from each of the six watersheds, the largest watershed sampled is the Guadalupe River, which also has the largest load for every pollutant estimated in this study. Conversely, Pulgas Creek Pump Station is the smallest watershed in the study and has the lowest total wet season load (except for TOC in which the load is similar to North Richmond Pump Station) (Table 7). As another example, methylmercury in San Leandro Creek (8.9 km2) and Guadalupe River (236 km2) have similar concentrations but Guadalupe River discharges 10x the total mass of methylmercury given the much greater overall discharge of runoff volume and sediments.

Table 7. Loads of pollutants of concern during the sampling years to-date at each sampling location.

Site	Water Year	Discharge (Mm^3)	SS (t)	TOC (kg)	PCBs (g)	HgT (g)	MeHgT (g)	NO3 (kg)	PO4 (kg)	Total P (kg)	Mean annual loads confidence	Main issues
Marsh Creek	2012	1.39	226	9,467	1.21	44.4	0.454	833	155	480	Moderate (PCBs) Low (Hg)	Lack of data on storms that cause run-off through the upper watershed reservoir.
	2013	5.82	2,600	39,682	16.2	594	1.90	3,491	652	4,020		
North Richmond Pump Station	2012	-	-	-	-	-	-	-	-	-	Moderate	Limited data on first flush conditions and generally during more intense storms. Surprisingly elevated PDBE concentrations.
	2013	0.763	34.4	5,709	7.90	16.1	0.113	863	130	211		
San Leandro Creek	2012	3.99	114	26,560	11.7	137	0.772	1,515	367	843	Low	Lack of a robust discharge rating curve; lack of sampling during reservoir release and during more intense storms.
	2013	8.81	218	58,674	22.6	280	1.52	3,348	811	1,671		
Guadalupe River	2012	25.8	2,116	146,483	113	2,033	8.20	16,347	2,243	7,042	High (PCBs) Low (Hg)	Lack of high intensity storms samples for Hg.
	2013	35.5	4,352	237,227	334	5,603	15.2	22,482	3,440	12,099		
Sunnyvale East Channel	2012	1.07	36.7	6192	14.6	18.4	0.181	263	114	241	Low	Few storms sampled.
	2013	1.79	672.5	10352	73.1	109	0.538	440	190	865		
Pulgas Creek Pump Station	2012	-	-	-	-	-	-	-	-	-	Low	Few storms sampled.
	2013	0.206	11.2	5967	9.3	3.2	0.050	75.6	32.4	34.3		

[a] Marsh Creek wet season loads are reported for the period of record 12/01/11 – 4/26/12 and 10/19/12 – 4/18/13.

[b] North Richmond Pump Station (WY 2013 only) and Guadalupe River (WY 2012 and 2013) wet season loads are reported for the full period of record each water year (10/01/11 – 4/30/12 for WY 2012 and 10/01/12 – 4/30/13 for WY 2013).

[c] San Leandro Creek wet season loads are reported for the period of record 12/01/11 – 4/30/12 and 11/01/12 – 4/18/13.

[d] Sunnyvale East Channel wet season loads are reported for the period of record 12/01/11 – 4/30/12 and 10/01/12 – 4/30/13.

[e] Pulgas Creek Pump Station South WY 2013 wet season loads are estimates provided for the entire wet season (10/01/12 – 4/30/13) however monitoring only occurred during the period 12/17/2012 – 3/15/2012. Monthly loads for the non-monitored period were extrapolated using regression equations developed for the monthly rainfall and corresponding monthly (or partial month) contaminant load.

Comparison of total wet season loads between water years at the sites with two years of data highlighted how loads estimates can be highly variable even during two drier than average years. Additionally, the size and intensity of the storm events in the different regions where the sampling sites are located greatly impacted the load variation from year to year and between sampling locations. For example PCBs and mercury in San Leandro Creek and Guadalupe River were approximately 2x greater in WY 2013 than WY 2012, whereas loads of those same pollutants were 5 – 20x larger in WY 2013 in Lower Marsh Creek and Sunnyvale East Channel, where the late November and December 2012 storms were moderately large events. Even when normalized to total discharge (in other words, the flow-weighted mean concentration [FWMC]), Sunnyvale East Channel transported 11x as much sediment in WY 2013 than WY 2012, whereas the FWMC of suspended sediment in San Leandro Creek was the same in both water years. This observation suggests that any attempt at this time to estimate long-term loads for Sunnyvale East channel will be biased low. In this manner, the relationship between FWMC and discharge (either at the annual or individual flood scale) can be used as an indicator of when enough data has been collected to characterize the site adequately to answer our management questions.

In light of these climatic considerations as well as the known data quality considerations and challenges at each of the sampling locations, the two far-right columns in Table 7 note our current level of confidence in the mean annual loads estimates as well as the main issues at each site which warrant the confidence level rating. Future sampling at each of these locations should seek to alleviate these issues and to raise the quality of the data in relation to answering management questions.

5.5. Comparison of regression slopes and normalized loads estimates between watersheds

One of our key activities in relation to the small tributary loading strategy is improving our understanding of which Bay tributaries (including stormwater conveyances) contribute most to Bay impairment from pollutants of concern (MQ1) and therefore potentially represent watersheds where management actions should be implemented to have the greatest beneficial impact (MQ4). Unfortunately, the comparison of loading estimates between watersheds in relation to these key management needs is confounded by variations in climate and how well samples collected to date represent source-release-transport processes for each watershed and pollutant (see section 5.2). With these caveats accepted, a preliminary comparison based on data collected during water year 2012 and 2013 was provided in this section. It is anticipated that these comparisons will change as additional data are collected in WY 2014, and, should data be sufficient, the best comparisons will be made in next year's report update based on (where/if possible) climatically averaged data.

Multiple factors influence the treatability of pollutant loads in relation to impacts to San Francisco Bay. Conceptually a large load of pollutant transported on a relatively small mass of sediment is more treatable than less polluted sediment. Therefore, the graphical function between either sediment concentration or turbidity provides a first order mechanism for ranking relative treatability of watersheds (Figure 2A). This method is valid for pollutants that are dominantly transported in a particulate form (total mercury and the sum of PCBs are examples) and when there is relatively little variation in the particle ratios between water years or storms (note data presented at the October 2013

SPLWG meeting demonstrated that this assumption is sometimes violated and influences our perception of relative ranking).

These issues accepted, based on the ratios between turbidity and Hg, runoff derived from less urbanized portions of San Leandro Creek watershed and run-off from the Guadalupe River watershed exhibit the greatest particle ratios for total mercury (Figure 2). Sunnyvale East Channel, Marsh Creek and Pulgas Creek Pump Station appear to have relatively low particle ratios for total mercury, although, Marsh Creek has not been observed under wet conditions when the possibility of mercury release from historic mining sources exists and an insufficient number of samples have yet been collected from Pulgas Creek Pump Station to be confident that the mercury transport processes are adequately characterized. With the exception of the addition of two more sampling stations (North Richmond Pump Station and Pulgas Creek Pump Station), the relative nature of these rankings has not changed in relation to the previous report (McKee et al., 2013).

In contrast, for the sum of PCBs, Pulgas Creek Pump Station and Sunnyvale East Channel exhibit the highest particle ratios among these six watersheds, with urban sourced run-off from Guadalupe River and North Richmond Pump Station ranked 3rd and 4th as indicated by the turbidity-PCB graphical relation

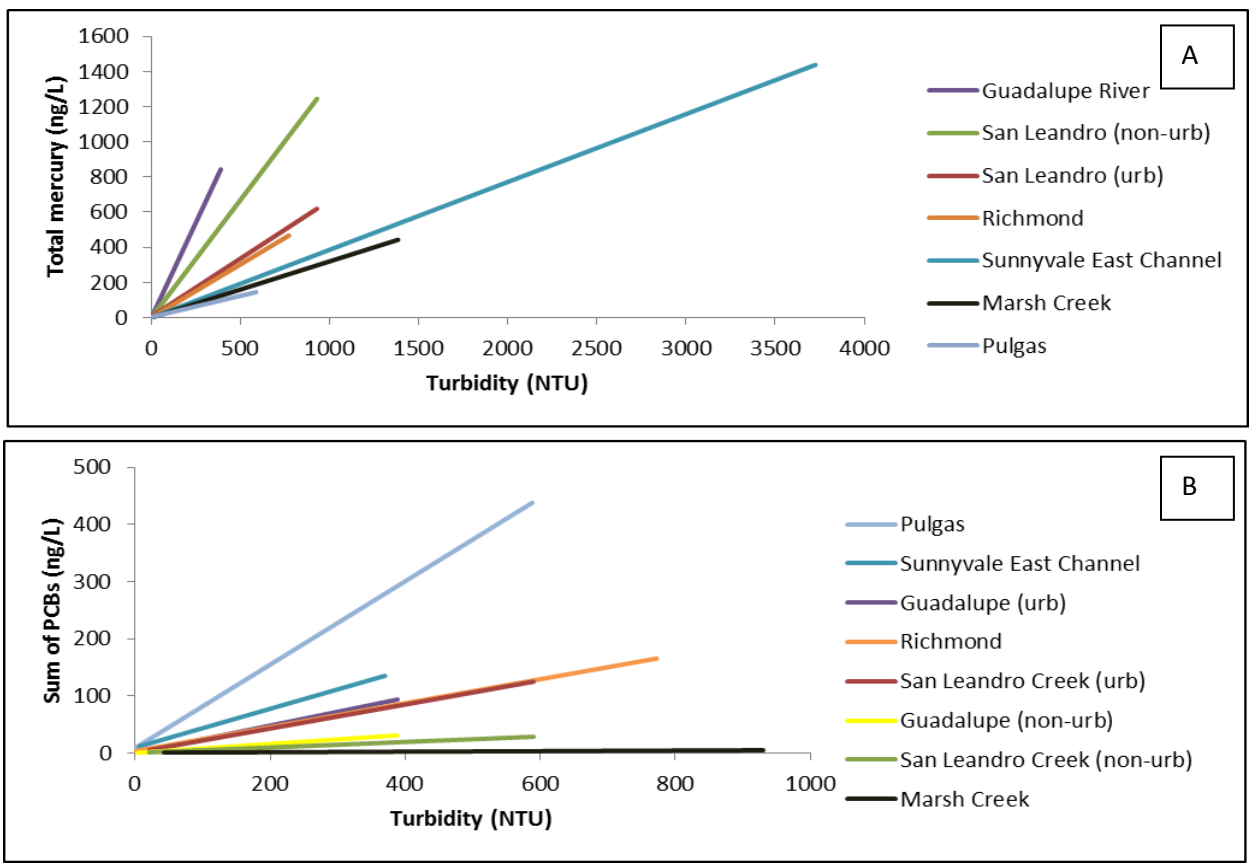

Figure 2. Comparison of regression slopes between watersheds based on data collected during sampling to-date A) total Mercury and B) PCBs (Note Sunnyvale, Richmond and Pulgas includes data for water year 2013 only; Pulgas turbidity maximum is storm maximum not record maximum). Note these comparisons will likely change once additional data are collected in subsequent water years.

(Figure 2). Marsh Creek exhibits very low particle ratios for PCBs, an observation that is unlikely to change with additional samples given the likelihood of relatively low pollutant sources and relatively low variability of release-transport processes. Unlike Hg, new data collected during WY 2013 did alter the relative PCB rankings based on this graphical analysis providing an example of the influence of either low sample numbers or the random nature of sample capture on the resulting interpretation of particle ratios (as discussed in the October 2013 SPLWG meeting). Given the relatively large confidence intervals (not shown) and the relatively low numbers of samples collected to-date during relatively dry years, the relative nature of these regression equations may change in the future as more samples are collected.

Another influence on potential treatability is the size of the watershed. Conceptually, a large load that is transported from a relatively small watershed and therefore in association with a relatively small volume of water is more manageable (efforts to manage flows from the North Richmond Pump Station watershed exemplify this type of opportunity). Thus, area normalized loads (yields) provide another useful mechanism for first order ranking of watersheds (Table 8) in relation to ease of management. This method is much more highly subject to climatic variation than the turbidity function/particle ratio method for ranking and would ideally be done on climatically averaged loads (not yet done). Despite quite large differences in unit runoff between the watersheds during water year 2012 and 2013, in a general sense, the relative rankings for PCBs exhibit a similar ranking to the particle ratio method; Pulgas Creek Pump Station watershed ranked highest and Marsh Creek watershed ranked lowest. However the relative ranking of the other watersheds is not similar. In the case of mercury, Guadalupe River, San Leandro Creek, and Richmond pump station exhibit the highest currently estimated yields corroborating the evidence from the particle ratio method. However, it is anticipated that the relative nature of the area-normalized loads will be subject to greater change in the event that sampling during WY 2014 captures rainstorms of greater magnitude and less frequent recurrence interval. In particular, the relative rankings for suspended sediment loads normalized by unit area could change substantially with the addition of data from a water year that is closer to or exceeds the climatic normal for each watershed; total phosphorus unit loads would also respond in a similar manner. For pollutants such as PCBs and total Hg that are found in specific source areas such as industrial and mining areas (Hg only) of these watersheds, release processes will likely be influenced by both climatic factors and sediment transport off impervious surfaces; also factors that are not likely well captured by the sampling to date that has occurred under relatively dry conditions.

6. Conclusions and next steps

6.1. Current and future uses of the data

The monitoring program implemented during the study was designed primarily to improve estimates of watershed-specific and regional loads to the Bay (MQ2) and secondly, to provide baseline data to support evaluation of trends towards concentration or loads reductions in the future (conceptually one or two decades hence) (MQ3) (see introduction section) in compliance with MRP provision C.8.e. (SFRWRCB, 2009). Multiple metrics have been developed and presented in this report to support these management questions:

- Pollutant loads: Pollutant loading estimates can help measure relative delivery of pollutants to sensitive Bay margin habitats and support calibration and verification of the Regional Watershed Spreadsheet Model and resulting regional scale loading estimates.
- Flow Weighted Mean Concentrations: FWMC can help to identify when sufficient data has been collected to adequately characterize watershed processes in relation to a specific pollutant in the context of management questions.
- Sediment-pollutant particle ratios: Particle ratios can help identify relative watershed pollution levels on a particle basis and relates to treatment potential.
- Pollutant area yields: Pollutant yields can help identify pollutant sources and relates to treatment potential.
- Correlation of pollutants: Finding co-related pollutants helps identify those watersheds with multiple sources and provides additional cost/benefit for management actions.

As discussed briefly in the introduction (section 1), as management effort focuses more and more on locating high leverage watersheds and patches within watersheds, the monitoring (and modeling) design will need to evolve.

Table 8. Area normalized loads (yields) ranked in relation to PCBs based on free flowing areas downstream from reservoirs (See Table 1 for areas used in the computations). Note these yield estimates are based on the average of data from water year 2012 and 2013. Quantitative comparison between watersheds is confounded by dry climatic conditions and differing unit runoff. With additional years of sampling, climatically-averaged area-normalized loads may be generated.

	Unit runoff (m)	SS (t/km^2)	TOC (mg/m^2)	PCBs ($\mu g/m^2$)	HgT ($\mu g/m^2$)	MeHgT ($\mu g/m^2$)	NO3 (mg/m^2)	PO4 (mg/m^2)	Total P (mg/m^2)
Pulgas Creek Pump Station [e]	*0.35*	*19.1*	*10218*	*15.9*	*5.53*	*0.0858*	*130*	*55.6*	*58.8*
North Richmond Pump Station [b]	0.39	17.6	2913	4.03	8.22	0.0575	440	66.2	107
Sunnyvale East Channel [d]	0.10	24.0	559	2.96	4.31	0.0243	23.7	10.3	37.4
San Leandro Creek [c]	0.72	18.7	4788	1.93	23.4	0.129	273	66.1	141
Guadalupe River [b]	0.13	13.7	813	0.947	16.2	0.0496	82.3	12.0	40.6
Marsh Creek [a]	0.04	16.9	294	0.104	3.82	0.0141	25.9	4.83	26.9

[a] Marsh Creek wet season loads are reported for the period of record 12/01/11 – 4/26/12 and 10/19/12 – 4/18/13.
[b] North Richmond Pump Station (WY 2013 only) and Guadalupe River (WY 2012 and 2013) wet season loads are reported for the full period of record each water year (10/01/11 – 4/30/12 for WY 2012 and 10/01/12 – 4/30/13 for WY 2013).
[c] San Leandro Creek wet season loads are reported for the period of record 12/01/11 – 4/30/12 and 11/01/12 – 4/18/13.
[d] Sunnyvale East Channel wet season loads are reported for the period of record 12/01/11 – 4/30/12 and 10/01/12 – 4/30/13.
[e] Pulgas Creek Pump Station South WY 2013 wet season loads are estimates provided for the entire wet season (10/01/12 – 4/30/13) however monitoring only occurred during the period 12/17/2012 – 3/15/2012. Monthly loads for the non-monitored period were extrapolated using regression equations developed for the monthly rainfall and corresponding monthly (or partial month) contaminant load.

6.2. What data gaps remain at current loads stations?

With regard to addressing the main management endpoints (single and regional watershed loads and baseline data for trends) that caused the monitoring design described by the MYP (BASMAA, 2011) and updated twice [BASMAA, 2012; BASMAA, 2013], an important question that managers are asking is how to determine when sufficient data have been collected. Several sub-questions are important when trying to make this determination. Are the data representative of climatic variability; have storms and years been sampled well enough relative to expected climatic variation? Is the data representative of the source-release-transport processes of the pollutant of interest? In reality, these two factors tend to juxtapose and after two years of monitoring, some data gaps remain for each of the monitoring locations.

- Guadalupe River watershed has been sampled at the Hwy 101 location during eight water years (WY 2003-2006, 2010-2013) to-date, but data are still lacking to adequately describe high intensity upper watershed rain events when mercury may still be released from sources in relation to historic mining activities. This type of information could help estimate the upper range of mercury loads from the mercury mining district and continue to help focus management attention. Further data collection in Guadalupe River watershed should focus on high intensity storms only; further sampling of relatively frequent smaller runoff events is unnecessary. The current sampling design is not cost-effective for gathering improved information to support management decisions in this watershed.
- San Leandro Creek watershed has been sampled for two WYs to-date. San Leandro Creek, received poor quality ratings on the quality of discharge information and completeness of turbidity data. The largest weakness is the lack of velocity measurements to adequately describe the stage-discharge rating curve and generate a continuous flow record. Additional velocity measurements are necessary to increase the accuracy and precision of discharge data for the site and support the computation of loads. There is currently no information on pollutant concentrations during reservoir releases yet volumetrically, reservoir release during WYs 2012 and 2013 has been proportionally large. Sample collection during release would help elucidate pollutant load contributions from the reservoir. Data collection during more intense rainstorms are also desirable for this site given the complex sources of PCBs and mercury in the watershed and the existence of areas of less intense land use and open space lending to likely relatively high inter-annual variability of water and sediment production.
- Marsh Creek watershed has been sampled for two WYs to-date. Continuous turbidity data were rated excellent at Lower Marsh Creek; no changes to monitor design for turbidity are necessary. Ample lower watershed stormwater runoff data are available at Lower Marsh Creek, but this site is lacking information on high intensity upper watershed rain events where sediment mobilization from the historic mercury mining area could occur. Sampling during WY 2014 would ideally be focused on storms of greater intensity preferably when spillage is occurring from the upstream reservoir. Beyond WY 2014, the sampling design should be revisited with the objective of increased cost efficiency for data gathering to support management questions.
- North Richmond Pump Station watershed has been sampled for just one year (although data exists from a previous study [Hunt et al., 2012]). Although some data exist, further data in

relation to early season (seasonal 1st flush or early season storms) would help estimate loads averted from diversion of early season storms to wastewater treatment. Further data collection in relation to high concentrations of PBDEs is necessary to verify the existence of PBDEs source in this watershed. Providing these types of data can be collected during WY 2014, an alternative sampling design could be considered.

- At Pulgas Creek Pump Station and Sunnyvale East Channel (two locations with much below average rainfall during sampling to date), more storm event water quality monitoring is needed for establishing confidence in particle ratios, pollutant loads, FWMCs, and yields. Sunnyvale East Channel and Pulgas Creek Pump Station received poor quality ratings on completeness of turbidity data: Sunnyvale East Channel had a full record but a large portion of data censored due to spikes and Pulgas Creek Pump Station recorded turbidity during only three of the seven wet season months in large part due to instrumentation failures. The Pulgas Creek sampling location also received a low rating on representativeness given how turbidity records could fluctuate multiple times from one reading to the next. Pulgas Creek Pump Station also had poor repeatability between manual and sensor collected data and improvements to the monitoring set-up should be considered for next wet season. Improvements have been recommended for the WY 2014 winter season for both sampling sites. The existing sampling design (with ongoing annual improvements as lessons are learned) may be warranted for these two watersheds for additional years.

6.3. Next Steps

Recent discussions between BASMAA and the Region 2 Regional Water Quality Control Board (and discussion at the October 2013 SPLWG meeting) have highlighted the increasing focus towards finding watersheds and land areas within watersheds for management focus (MQ4). The monitoring design described in this report is likely not appropriate for this increasing management focus. During the first quarter of 2014, the STLS will be reviewing lessons learned to-date and will be developing recommendations for alternative monitoring designs and sampling locations (in concert with the RWSM modeling design). Based on recent findings, there is evidence to support effort reduction at Lower Marsh Creek and Guadalupe River as well as development of monitoring decision points for determining when sufficient data has been collected to address MQ2 (single watershed and regional pollutant loads), and to provide baseline data to support MQ3 (future trends in relation to management actions). Additional information is needed for Pulgas Creek Pump Station, Sunnyvale East Channel, North Richmond Pump Station and San Leandro Creek, especially during early season/high-intensity rain events. If the right climatic conditions and field work focus occurs during WY 2014, these data gaps may be addressed sufficiently. A revised monitoring design will need to be robust enough to continue to support MQ 1, 2, and 3 for PCBs and Hg and emerging pollutants of interest as well as increasing information to support MQ4.

There are various alternative monitoring designs that are more cost-effective for the addressing the increasing focus in the second MRP permit term towards finding watersheds and land areas within watersheds for management attention while still supporting the other STLS management questions. The

challenge for the STLS and SPWLG is finding the right balance between the different alternatives within budget constraints. Options include:

- Loads monitoring
    - Changing to a rotating site approach (e.g. all six monitoring locations are maintained for stage and turbidity but each monitored fewer years for pollutants)
    - Changing monitoring frequency (e.g. opportunistic sampling for specific events with overall reduction in effort but increased informational outcomes)
    - Reducing the number of sites (currently six)
    - Adding new sites of specific interest (e.g. to determine load magnitude in relation to upstream pollution or downstream beneficial use impact)
    - Dropping loads monitoring completely
- Reconnaissance monitoring design
    - Make improvements to the WY 2011 design:
        - Increase the number of samples from 4-7 to 8-14 per site
        - Selectively add measurements of stage and possibly velocity
    - Focus on sampling a subset of feasible pump stations downstream from industrial land use (73 possible locations identified). Pump stations have the advantage of forcing unidirectional flow very near the Bay margin but have disadvantages in terms of complex flow patterns, confined space, permission or limited access during work hours. Lessons learned at the North Richmond and Pulgas Creek Pump Stations during the current study will be valuable.
    - Rotate in single land use/ source area "high opportunity" sites.

It is likely that a sampling design that simultaneously addresses all four STLS management questions will require a compromise between the different monitoring options (i.e. some loads monitoring effort retained). However, the advantage of the reconnaissance sampling design is flexibility and given recent advances on the development of the RWSM (SFEI in preparation) have indicated the value of the data collected previously using the reconnaissance design (McKee et al., 2012), it seems likely that the reconnaissance design may end up being the most cost-effective. Data and information gathered over the last 10+ years guided by the SPLWG and STLS will continue to help guide the development of a cost effective monitoring design to adapt to changing management needs.

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8. Detailed information for each sampling location

8.1. Marsh Creek

8.1.1. Marsh Creek flow

The US geological survey has maintained a flow record on Marsh Creek (gauge number 11337600) since October 1, 2000 (13 WYs). Peak annual flows for the previous 13 years have ranged between 168 cfs (1/22/2009) and 1770 cfs (1/2/2006). For the same period, annual runoff has ranged between 3.03 Mm3 (WY 2009) and 26.8 Mm3 (WY 2006). In the Bay Area, at least 30 years of observations are needed at a particular site to get a reasonable understanding of climatic variability (McKee et al., 2003). Since, at this time, Marsh Creek has a relatively short history of gauging, flow record on Marsh Creek were compared with a reasonably long record as an adjacent monitoring station near San Ramon. Based on this comparison, WY 2006 may be considered representative of very rare wet conditions (upper 10th percentile) and WY 2009 is perhaps representative of moderately rare dry conditions (lower 20th percentile) based on records that began in WY 1953 at San Ramon Creek near San Ramon (USGS gauge number 11182500).

A number of relatively minor storms occurred during WY 2012 and 2013 (Figure 3). In WY 2012, flow peaked at 174 cfs on 1/21/2012 at 1:30 am and then again 51 ½ hours later at 143 cfs on 1/23/2012 at 5:00 am. Total runoff during the whole of WY 2012 (October 1st to September 30th) was 1.87 Mm^3. During water year 2013, flow peaked at 1300 cfs at 10:00 am on 11/30/2012; total run-off for the water year was 6.26 Mm^3 based on preliminary USGS data and was much greater relative to the first year of monitoring. Although the peak discharge for WY 2013 was the second highest since records began in WY 2001, total annual flow ranked eighth in the last 13 years. Thus, discharge of these magnitudes for both water years of observations to-date are likely exceeded most years in this watershed. Rainfall data corroborates this assertion; rainfall during WY 2012 and 2013 respectively was 70% and 71% of mean annual precipitation (MAP) based on a long-term record at Concord Wastewater treatment plant (NOAA gauge number 041967) for the period Climate Year (CY) 1992-2013. Marsh Creek has a history of mercury mining in the upper part of the watershed. The Marsh Creek Reservoir is downstream from the historic mining area but upstream of the current gauging location. During water years 2012 and 2013, discharge through the reservoir occurred on March, November, and December 2012.

8.1.2. Marsh Creek turbidity and suspended sediment concentration

Turbidity generally responded to rainfall events in a similar manner to runoff. During WY 2012, turbidity peaked at 532 NTU during a late season storm on 4/13/12 at 7 pm. Relative to flow magnitude, turbidity remained elevated during all storms and was the greatest during the last storm despite lower flow. During WY 2013, turbidity peaked at 1384 NTU during the December storm series on 12/02/12 at 7:05 pm. These observations, and observations made previously during the RMP reconnaissance study (maximum 3211 NTU; McKee et al., 2012), provide evidence that during larger storms and wetter years, the Marsh Creek watershed is capable of much greater sediment erosion and transport than occurred during observations in WY 2012 and 2013, resulting in greater turbidity and concentrations of suspended sediment. The OBS-500 instrument utilized at this sampling location with a range of 0-4000 NTU will likely be exceeded during medium or larger storms.

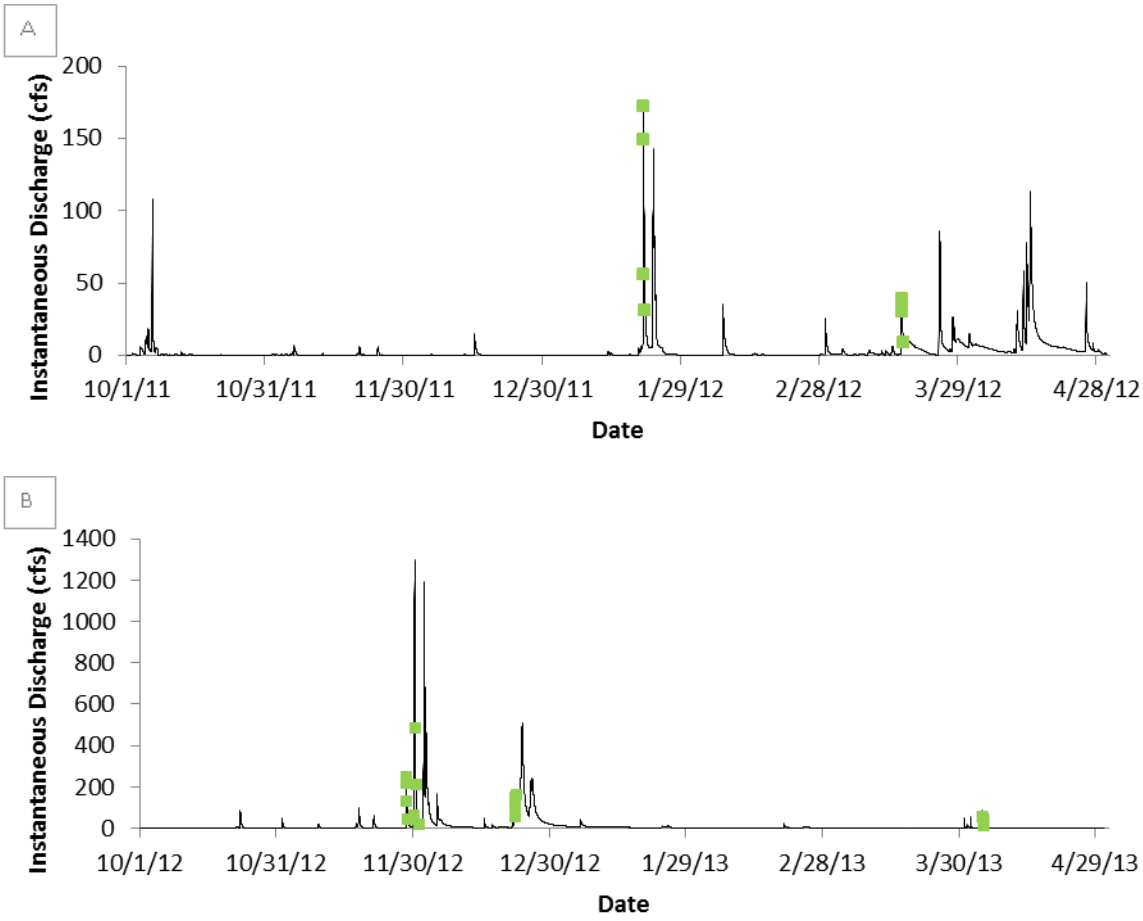

Figure 3. Flow characteristics in Marsh Creek during water year 2012 (A) based on published data and for the water year 2013 (B) based on preliminary 15 minute data provided by the United States Geological Survey, gauge number 11337600) with sampling events plotted in green. Note, USGS normally publishes finalized data for the permanent record in the spring following the end of each water year.

Suspended sediment concentration, since it was computed from the continuous turbidity data, follows the same patterns as turbidity in relation to discharge. SSC peaked at 1312 mg/L during the 4/13/12 late season storm and at 1849 mg/L on 12/02/12 at the same time as the peaks in turbidity. During WY 2012, relative to flow magnitude, SSC remained elevated during all storms and was the greatest during the last storm despite lower flow. A similar pattern was also observed during WY 2013. Turbidity and computed SSC peaked during a smaller storm in December rather than the largest storm which occurred in late November. Turbidity remained relatively elevated from an even smaller storm that occurred on December 24th. These observations of increased sediment transport as the season progresses relative to flow in addition to the maximum SSC observed during the RMP reconnaissance study of 4139 mg/L (McKee et al., 2012), suggest that in wetter years, greater SSC can be expected.

8.1.3. Marsh Creek POC concentrations summary (summary statistics)

In relation to the other five monitoring locations, Marsh Creek is representative of a relatively rural watershed with lower levels of urbanization but potentially impacted by mercury residues from historic

mining upstream. Summary statistics (Table 9) were used to provide useful information to compare Marsh Creek water quality to other Bay Area streams. The comparison of summary statistics to knowledge from other watersheds and conceptual models of pollutant sources and transport processes provided a further check on data quality. The maximum PCB concentration (4.32 ng/L) was similar to background concentrations normally found in relatively nonurban areas while maximum mercury concentrations (252 ng/L) were similar to concentrations found in mixed land use watersheds (Lent and McKee, 2011). Maximum MeHg concentrations (0.407 ng/L during WY 2012 and 1.2 ng/L during WY 2013 were greater than the proposed implementation goal of 0.06 ng/l for methylmercury in ambient water for watersheds tributary to the Central Delta (Wood et al., 2010: Table 4.1, page 40). Nutrient concentrations appear to be reasonably typical of other Bay Area watersheds (McKee and Krottje, 2005). As is typical in the Bay Area, phosphorus concentrations appear greater than elsewhere in the world under similar land use scenarios, an observation perhaps attributable to geological sources (McKee and Krottje, 2005). For pollutants sampled at a sufficient frequency for loads analysis (suspended sediments, PCBs, mercury, organic carbon, and nutrients), concentrations exhibited the typical pattern of median < mean with the exception of organic carbon during both years.

A similar style of first order quality assurance is also possible for analytes measured at a lower frequency. Pollutants sampled at a lesser frequency using composite sampling design (see methods section) and appropriate for characterization only (copper, selenium, PAHs, carbaryl, fipronil, and PBDEs) were quite low and similar to concentrations found in watersheds with limited or no urban influences. It was surprising to see PBDE concentrations so much greater in the second year of sampling relative to the first year, possibly just an artifact of the randomness sample capture and small sample numbers. Carbaryl and fipronil (not measured previously by RMP studies) were on the lower side of the range of peak concentrations reported in studies across the US and California (fipronil: 70 – 1300 ng/L, Moran, 2007) (Carbaryl: DL - 700 ng/L, Ensiminger et al., 2012). Pyrethroid concentrations of Delta/ Tralo-methrin were similar to those observed in Zone 4 Line A, a small 100% urban tributary in Hayward, whereas concentrations of Permethrin and Cyhalothrin lambda were about 10-fold and 2-fold lower and concentrations of Bifenthrin were about 5-fold higher; cypermethrin was not detected in Z4LA (Gilbreath et al., 2012). It was a little surprising to see cypermethrin concentrations more than 4-fold lower in WY 2013 relative to WY 2012. Again, this may just be an artifact of the randomness of sample capture. In summary, the statistics indicate pollutant concentrations typical of a Bay Area non-urban stream and there is no reason to suspect data quality issues.

8.1.2. Marsh Creek toxicity

Composite water samples were collected at the Marsh Creek station during two storm events in Water Year 2012 and four storm events in Water Year 2013. No significant reductions in the survival, reproduction and growth of three of four test species were observed during WY 2012. Significant reductions in the survival of the amphipod *Hyalella azteca* was observed during both WY 2012 storm events. Water Year 2013 had complete mortality of *Hyalella Azteca* between 5 and 10 days of exposure to storm water (0% survival compared to a 100% laboratory survival rate) during all four storm events. Although limited use of this species has occurred for the evaluation of toxicity in water, it has consistently been used by scientists to assess the toxicity of sediments in receiving waters. Additionally,

Table 9. Summary of laboratory measured pollutant concentrations in Marsh Creek during WY 2012 and 2013.

		Water Year 2012							Water Year 2013						
Analyte Name	Unit	Samples taken (n)	Proportion detected (%)	Min	Max	Median	Mean	Standard Deviation	Samples taken (n)	Proportion detected (%)	Min	Max	Median	Mean	Standard Deviation
SSC	mg/L	27	96%	ND	930	180	297	276	54	100%	3.3	1040	167	217	230
∑PCB	ng/L	7	100%	0.354	4.32	1.27	1.95	1.61	15	100%	0.240	3.46	0.676	0.927	0.856
Total Hg	ng/L	8	100%	8.31	252	34.6	74.3	85.2	17	100%	1.90	120	19.0	32.5	33.9
Total MeHg	ng/L	5	100%	0.085	0.407	0.185	0.218	0.120	14	94%	ND	1.20	0.185	0.337	0.381
TOC	mg/L	8	100%	4.6	12.4	8.55	8.34	2.37	16	100%	4.30	9.50	6.55	6.52	1.60
NO3	mg/L	8	100%	0.470	1.10	0.635	0.676	0.202	16	94%	ND	1.0	0.53	0.53	0.22
Total P	mg/L	8	100%	0.295	1.10	0.545	0.576	0.285	12	100%	0.140	0.670	0.305	0.346	0.166
PO4	mg/L	8	100%	0.022	0.120	0.056	0.065	0.030	16	100%	0.046	0.180	0.110	0.114	0.036
Hardness	mg/L	2	100%	200	203	189	202	2.12	-	-	-	-	-	-	-
Total Cu	µg/L	2	100%	13.8	27.5	20.6	20.6	9.70	4	100%	3.80	30.0	12.5	14.7	11.0
Dissolved Cu	µg/L	2	100%	4.99	5.62	5.31	5.31	0.445	4	100%	1.30	2.40	1.45	1.65	0.520
Total Se	µg/L	2	100%	0.647	0.784	0.716	0.716	0.097	4	100%	0.525	1.40	0.670	0.816	0.395
Dissolved Se	µg/L	2	100%	0.483	0.802	0.643	0.643	0.226	4	100%	0.510	1.20	0.585	0.720	0.323
Carbaryl	ng/L	2	50%	-	-	-	16.0	-	4	25%	ND	13.0	0	3.25	6.50
Fipronil	ng/L	2	100%	7.00	18.0	12.5	12.5	7.78	4	100%	10.0	13.0	10.8	11.1	1.44
∑PAH	ng/L	1	100%	-	-	-	494	-	2	100%	85.7	222	154	154	96
∑PBDE	ng/L	1	100%	-	-	-	20.0	-	2	100%	11.2	56.4	33.8	33.8	32.0
Delta/ Tralo-methrin	ng/L	2	100%	0.954	5.52	3.23	3.23	3.23	4	75%	ND	2.20	0.750	0.925	0.943
Cypermethrin	ng/L	2	50%	-	-	-	68.5	-	4	100%	1.80	13.0	2.15	4.78	5.49
Cyhalothrin lambda	ng/L	2	50%	-	-	-	2.92	-	4	100%	0.500	3.20	0.800	1.33	1.27
Permethrin	ng/L	2	100%	3.81	17.3	10.6	10.6	9.54	4	75%	ND	12.0	6.55	6.28	6.11
Bifenthrin	ng/L	2	100%	25.3	257	141	141	163	4	100%	27.0	150	45.0	66.8	56.2

Analyzed but not detected: Fenpropathrin, Esfenvalerate/ Fenvalerate, Cyfluthrin, Allethrin, Prallethrin, Phenothrin, and Resmethrin
Zeroes were used in the place of non-detects when calculating means, medians, and standard deviations.
The minimum number of samples used to calculate standard deviation at Marsh Creek was two.
All Hardness results in WY 2013 were censored.

one Water Year 2013 sample showed a significant reduction in fathead minnow survival (57.5% compared to a 90% laboratory survival). No significant effects were observed for the crustacean *Ceriodaphnia dubia* or the algae *Selenastrum capricornutum* during these storms.

8.1.3. Marsh Creek preliminary loading estimates

Site-specific methods were developed for computed loads (Table 10). Preliminary loads estimates generated for WY 2012 and reported by McKee et al. (2013) have now been revised based on additional data collected in WY 2013 and an improving understanding of pollutant transport processes for the site. Preliminary monthly loading estimates correlate well with monthly discharge (Table 11). There are no data available for October and November 2011 because monitoring equipment was not installed until the end of November. Monthly discharge was greatest in December 2012 as were the monthly loads for each of the pollutants regardless of transport mode (dominantly particulate or dissolved). The discharge was relatively high for December given the rainfall, an indicator that the watershed was reasonably saturated by this time. The sediment loads are well-aligned with the total discharge and the very high December 2012 sediment load appears real; the watershed became saturated after late November rains such that early December and Christmas time storms transported a lot of sediment. Monthly loads of total Hg appear to correlate with discharge for all months; this would not be the case if there was variable release of mercury from historic mining sources upstream associated with climatic and reservoir discharge conditions. At this time, all load estimates should be considered preliminary. Additionally (and, in this case, more importantly), if data collected during WY 2014 is able to capture periods when saturated and high rainfall conditions occur along with reservoir releases, new information may emerge about the influence, if any, of Hg pollution associated with historic mining. In any case, WY 2014 data will be used to improve our understanding of rainfall-runoff-pollutant transport processes for all the pollutants and used to recalculate and finalize loads for WYs 2012 and 2013. Regardless of these improvements however, given the very dry flow conditions of WY 2012 and 2013 (see discussion on flow above), preliminary loads presented here may be considered representative of dry conditions.

Table 10. Regression equations used for loads computations for Marsh Creek during water years 2012 and 2013. Note that regression equations will be reformulated with each future wet season of storm sampling.

Analyte	Slope	Intercept	Correlation coefficient (r^2)	Notes
Suspended Sediment (mg/NTU)	1.3	33	0.45	Regression with turbidity
Total PCBs (ng/NTU)	0.0089		0.84	Regression with turbidity
Total Mercury (ng/NTU)	0.32		0.65	Regression with turbidity
Total Methylmercury (ng/L)	0.327			Flow weighted mean concentration
Total Organic Carbon (mg/L)	6.82			Flow weighted mean concentration

Analyte	Slope	Intercept	Correlation coefficient (r^2)	Notes
Total Phosphorous (mg/NTU)	0.0016	0.19	0.57	Regression with turbidity
Nitrate (mg/L)	0.6			Flow weighted mean concentration
Phosphate (mg/L)	0.112			Flow weighted mean concentration

Table 11. Preliminary monthly loads for Marsh Creek during water years 2012 and 2013.

Water Year	Month	Rainfall (mm)	Discharge (Mm^3)	SS (t)	TOC (kg)	PCBs (g)	HgT (g)	MeHgT (g)	NO3 (kg)	PO4 (kg)	Total P (kg)
2012	11-Oct	33	-	-	-	-	-	-	-	-	-
	11-Nov	26	-	-	-	-	-	-	-	-	-
	11-Dec	6	0.0252	1.57	172	0.00493	0.180	0.00823	15.1	2.82	5.63
	12-Jan	51	0.318	68.3	2,169	0.389	14.2	0.104	191	35.6	130
	12-Feb	22	0.0780	6.59	532	0.0269	0.983	0.0255	46.8	8.74	19.5
	12-Mar	60	0.361	31.8	2,458	0.133	4.87	0.118	216	40.4	91.9
	12-Apr[a]	59	0.606	118	4,136	0.658	24.1	0.198	364	67.9	233
	Wet season total	198	1.39	226	9,467	1.21	44.4	0.454	833	155	480
2013	12-Oct[b]	23	0.0875	10.0	596	0.0474	1.73	0.0286	52.5	9.79	25.0
	12-Nov	96	0.989	248	6,745	1.45	53.1	0.323	593	111	448
	12-Dec	75	4.00	2,297	27,291	14.6	534	1.31	2,401	448	3,384
	13-Jan	15	0.428	24.1	2,920	0.0660	2.41	0.140	257	48.0	92.5
	13-Feb	6	0.142	5.98	970	0.00825	0.302	0.0465	85.3	15.9	28.3
	13-Mar	9	0.0721	3.79	492	0.00932	0.341	0.0236	43.2	8.07	15.2
	13-Apr[c]	19	0.098	10.8	667	0.0506	1.85	0.0320	58.7	11.0	27.5
	Wet season total	243	5.82	2,600	39,682	16.2	594	1.90	3,491	652	4,020

[a] April 2012 monthly loads are reported for only the period April 01-26. In the 4 days missing from the record, <0.03 inches of rain fell in the lower watershed.

[b] October 2012 monthly loads are reported for only the period October 19-31. In the 18 days missing from the record, <0.05 inches of rain fell in the lower watershed.

[c] April 2013 monthly loads are reported for only the period April 01-18. In the 12 days missing from the record, no rain fell in the lower watershed.

8.2. North Richmond Pump Station

8.2.1. North Richmond Pump Station flow

Richmond flow and discharge estimates were calculated during periods of active pumping at the station from October 1, 2012 to April 30, 2013. Flow and discharge estimates include all data collected when where the pump rate was operating at is greater than 330 RPM. This rate is generally reached 30 seconds after pump ignition. For the purposes of this study, flows at less than 330 RPM were considered negligible due to limitations of the pump efficiency curve. This assumption would have resulted in slight underestimation of active flow from the station particularly during shorter duration pump outs but this under estimate was minor relative to storm and annual flows. The annual estimated discharge from the station was 0.76 Mm^3 for WY 2013 (Table 14). A discharge estimate at the station for WY 2011 was 1.1 Mm^3 (Hunt et al., 2012). The rainfall to run-off ratios between the two studies was similar supporting the hypothesis that the flows and resulting load estimates from the previous study remain valid. October 2012 exhibited a lower discharge per unit rainfall, perhaps caused by a dry watershed. Water quality samples were collected during three storm events (Figure 4). Most pump-outs had one operating pump except for a few storm events where two pumps were in operation.

A number of relatively minor storms occurred during WY 2013 except during the period late November to mid-December when 15 inches of rain fell in North Richmond (74% of October-April rainfall). During water year 2013, peak flow of 210 cfs occurred on December 2, 2013 after approximately 3.8 inches of rain fell over a 63 hour period. Approximately 20 inches of rain fell during Water Year 2013. Rainfall during 2013 was 89% mean annual precipitation (MAP) based on a long-term record PRISM data record (modeled PRISM data) for the period Climate Year (CY) 1970-2000. Thus it appears WY 2013 was slightly drier than average.

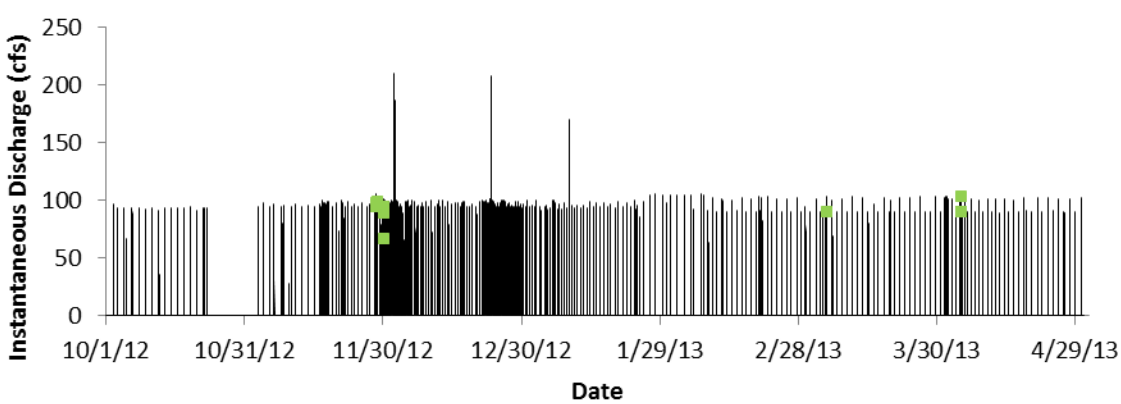

Figure 4. Preliminary flow characteristics at North Richmond Pump Station during Water Year 2013 with sampling events plotted in green. Note, flow information may be updated in the future as we continue to refine how we interpret the well depth, pump RMP, pump efficiency curves, and well geometry information.

8.2.2. North Richmond Pump Station turbidity and suspended sediment concentration

Maximum turbidity during Water Year 2013 was measured at 772 NTU which occurred during a dry flow pump out on January 24, 2013 following a low magnitude storm event of 0.22 inches on January 23. Maximum turbidity during other storm events ranged up to 428 NTU. The pattern of turbidity variation over the wet season was remarkably similar to that observed during WY 2011 in the previous study (Hunt et al., 2012). The turbidity dataset collected by Hunt et al. (2012) was noisy and contained unexplainable turbidity spikes that were censored. The similarities between the WY 2011 and 2013 datasets suggest that the WY 2011 data set was not over censored and therefore that pollutant loads based on both flow and turbidity computed by Hunt et al. (2012) remain valid.

8.2.3. North Richmond Pump Station POC concentrations summary (summary statistics)

The North Richmond pump station is a 1.6 km watershed primarily comprised of industrial, transportation, and residential land uses. The land-use configuration results in a watershed that is approximately 62% covered by impervious surface. Summary statistics (Table 12) were used to provide useful information to compare Richmond pump station water quality to other Bay Area monitoring locations. The comparison of summary statistics to knowledge from other watersheds and conceptual models of pollutant sources and transport processes provided a further check on data quality. The maximum PCB concentration measured in WY 2013 was 31.6 ng/L. In WY2011, the maximum concentration measured was 82 ng/L. PCB concentrations were in the range of other findings for urban locations (range 0.1-1120 ng/L) (Lent and McKee, 2011). Maximum mercury concentrations (98 ng/L) were approximately half the maximum observed concentrations during previous monitoring efforts (200 ng/L) (Hunt et al., 2012). Mercury concentrations were in the range of Zone 4 Line-A findings, another small urban impervious watershed (Gilbreath et al., 2012). Maximum MeHg concentrations in WY 2013 were 0.19 ng/L compared with WY 2011 concentrations of 0.6 ng/L (Hunt et al., 2012). For pollutants sampled at a sufficient frequency for loads analysis (suspended sediments, PCBs, mercury, organic carbon, and nutrients), concentrations exhibited the typical pattern of median < mean; unlike Marsh Creek and San Leandro Creek, TOC also exhibited this pattern.

Copper, selenium, PAHs, carbaryl, fipronil, and PBDEs were sampled at a lesser frequency using a composite sampling design (see methods section) and were used to characterize pollutant concentrations to help support management questions possible causes of toxicity (in the case of the pesticides). Maximum PBDE concentrations were 50-fold greater than the greatest average observed in the five other locations of this current study and previously reported for Zone 4 Line (Gilbreath et al., 2012). These are the highest PBDE concentrations measured in Bay area stormwater to-date of any study. BDE 209 usually contributes at least 50% of the sum of BDE congeners to stormwater samples in the Bay Area. Richmond appears to be the exception to this rule. The highest concentration samples had approximately 45% BDE 209, and relatively larger amounts of 206-208 than normally observed in Bay Area stormwater samples. Although the relative contributions of 206-208 are a bit unusual, summing to approximately the 209 amount, that it occurred in two samples (albeit in the same event) in similar proportions makes it less likely that it is purely an analytical anomaly. Blanks were fairly low in 206-208 so it is unlikely that the high contribution in the Richmond samples was from blank contamination, as

Table 12. Summary of laboratory measured pollutant concentrations in North Richmond Pump Station during water year 2013.

		Water Year 2012	Water Year 2013						
Analyte Name	**Unit**	**Samples taken (n)**	**Samples taken (n)**	**Proportion detected (%)**	**Min**	**Max**	**Median**	**Mean**	**Standard Deviation**
SSC	mg/L	0	41	95%	ND	213	26.5	45.7	54.3
∑PCB	ng/L	0	12	100%	4.85	31.6	10.1	12.0	7.09
Total Hg	ng/L	0	12	100%	13.0	98.0	18.5	27.7	24.6
Total MeHg	ng/L	0	6	100%	0.030	0.190	0.145	0.118	0.071
TOC	mg/L	0	12	100%	3.50	13.5	6.60	7.46	3.36
NO3	mg/L	0	12	100%	0.210	3.10	0.855	1.13	0.848
Total P	mg/L	0	12	100%	0.180	0.350	0.270	0.276	0.045
PO4	mg/L	0	11	100%	0.110	0.240	0.160	0.168	0.042
Hardness	mg/L	0	-	-	-	-	-	-	-
Total Cu	µg/L	0	3	100%	9.90	20.0	16.0	15.3	5.09
Dissolved Cu	µg/L	0	3	100%	4.40	10.0	4.70	6.37	3.15
Total Se	µg/L	0	3	100%	0.270	0.590	0.330	0.397	0.170
Dissolved Se	µg/L	0	3	100%	0.260	0.560	0.270	0.363	0.170
Carbaryl	ng/L	0	3	100%	12.0	40.0	19.0	23.7	14.6
Fipronil	ng/L	0	3	33%	ND	4.00	0	1.33	2.31
∑PAH	ng/L	0	2	100%	160	1349	754	754	840
∑PBDE	ng/L	0	2	100%	153	3362	1611	1757	2269
Delta/ Tralo-methrin	ng/L	0	3	100%	1.00	3.50	3.05	2.52	1.33
Cypermethrin	ng/L	0	3	100%	2.10	4.35	3.10	3.18	1.13
Cyhalothrin lambda	ng/L	0	3	100%	0.400	1.30	0.600	0.767	0.473
Permethrin	ng/L	0	3	100%	6.40	16.0	13.5	12.0	4.98
Bifenthrin	ng/L	0	3	100%	3.80	8.05	6.10	5.98	2.13

Zeroes were used in the place of non-detects when calculating means, medians, and standard deviations.
The minimum number of samples used to calculate standard deviation at the North Richmond Pump Station was two.
All Hardness results in WY 2013 were censored.

those were also the samples with the highest total PBDEs of all those measured. The North Richmond watershed currently contains an auto dismantling yard and a junk/wrecking yard; possible source areas. At this time we are unwilling to sensor the data but anticipate data collected during WY 2014 helping to support or reject the magnitude of concentrations.

Similar to the other sites, carbaryl and fipronil were on the lower side of the range of peak concentrations reported in studies across the US and California (fipronil: 70 – 1300 ng/L, Moran, 2007) (Carbaryl: DL - 700 ng/L, Ensiminger et al., 2012). Pyrethroid concentrations of Delta/ Tralo-methrin were similar to those observed in Zone 4 Line A, whereas concentrations of Cyhalothrin lambda and Permethrin were about 6-fold and 7-fold lower respectively and concentrations of Bifenthrin were about 3-fold higher (Gilbreath et al., 2012). In summary, the statistics indicate pollutant concentrations typical of a Bay Area urban stream and there is no reason to suspect data quality issues (except PBDE has been flagged for further investigation).

8.2.4. North Richmond Pump Station toxicity

Composite water samples were collected at North Richmond Pump Station during three storms between Nov 28, 2012 and March 6, 2013. Two of these samples showed a significant decrease in *Hyalella Azteca* survival. One sample showed an 88% survival rate compared to a 98% lab survival rate. The other sample showed a 12% survival rate compared to a 100% lab survival rate. No significant effects were observed for the crustacean *Ceriodaphnia dubia*, the algae *Selenastrum capricornutum* or fathead minnows during these storms.

8.2.5. North Richmond Pump Station preliminary loading estimates

The following methods were applied for calculating preliminary loading estimates (Table 13). During active pumpout conditions, regression equations between PCBs, total mercury, methylmercury, SSC and turbidity were used to estimate loads (Table 12). Load estimates for total phosphorous, nitrate, and phosphate utilized flow weighted mean concentration derivations. Preliminary monthly loading estimates correlate very well with monthly discharge (Table 14). Monthly discharge was greatest in December as were the monthly loads for suspended sediment and pollutants. Although there were slight climatic differences that have not been adjusted for, WY 2013 suspended sediment (34.4 t) and PCB (7.90 g) load estimates were comparable to the Water Year 2011 estimates (29 t and 8.0 g, respectively) even thought it was a wetter year (134% MAP) (Hunt., 2012) helping to give us 1st order confidence that the computed loads are reasonable. Due to lessons learned from the previous study, there is much higher confidence in the Water Year 2013 loads estimates due to improvements in both the measurements of turbidity and flow rate using optical sensor equipment.

Given the below average rainfall conditions experienced during WY 2013, loads from the present study may be considered representative of somewhat dry conditions.

Table 13. Regression equations used for loads computations for North Richmond Pump Station during water year 2013. Note that regression equations will be reformulated with each future wet season of storm sampling.

Analyte	Origin of runoff	Slope	Intercept	Correlation coefficient (r^2)	Notes
Suspended Sediment (mg/NTU)	Mainly urban	1.293		0.78	Regression with turbidity
Total PCBs (ng/NTU)	Mainly urban	0.21	3.1	0.71	Regression with turbidity
Total Mercury (ng/NTU)	Mainly urban	0.605		0.92	Regression with turbidity
Total Methylmercury (ng/NTU)	Mainly urban	0.0028	0.05	0.88	Regression with turbidity
Total Organic Carbon (mg/L)	Mainly urban	7.48			Flow weighted mean concentration
Total Phosphorous (mg/L)	Mainly urban	0.276			Flow weighted mean concentration
Nitrate (mg/L)	Mainly urban	1.13			Flow weighted mean concentration
Phosphate (mg/L)	Mainly urban	0.17			Flow weighted mean concentration

Table 14. Preliminary monthly loads for North Richmond Pump Station.

Water Year	Month	Rainfall (mm)	Discharge (Mm^3)	SS (t)	TOC (kg)	PCBs (g)	HgT (g)	MeHgT (g)	NO3 (kg)	PO4 (kg)	Total P (kg)
2013	12-Oct	54	0.0278	1.44	208	0.318	0.674	0.00451	31.4	4.72	7.67
	12-Nov	156	0.152	7.78	1138	1.72	3.64	0.0245	172	25.9	42.0
	12-Dec	232	0.374	20.5	2795	4.46	9.61	0.0632	422	63.5	103
	13-Jan	18	0.0641	1.29	479	0.406	0.605	0.00602	72.4	10.9	17.7
	13-Feb	18	0.0438	1.26	328	0.338	0.590	0.00493	49.5	7.45	12.1
	13-Mar	19	0.0418	0.409	312	0.195	0.191	0.00299	47.2	7.10	11.5
	13-Apr	26	0.0602	1.70	450	0.460	0.796	0.00670	68.0	10.2	16.6
	Wet season total	523	0.763	34.4	5,709	7.90	16.1	0.113	863	130	211

8.3. San Leandro Creek

8.3.1. San Leandro Creek flow

There is no historic flow record on San Leandro Creek. For the previous report that presented WY 2012 results only (McKee et al., 2013), a preliminary rating curve was developed based on discharge sampling during WY 2012 augmented by the Manning's formula. This rating was improved this year by adding

known reservoir release rates associated with consistent stage readings. However, the resulting discharge estimates are still challenged by the lack of velocity measurements at flow stages greater than 3.5 feet and therefore are deemed of poor accuracy and precision. Based on this latest version of a still preliminary rating curve, total runoff during WY 2012 for the period 11/7/11 to 4/30/12 was revised from the 4.13 Mm^3 reported previously (McKee et al., 2013) to a new estimate of 5.47 Mm^3. This total discharge was mostly a result of a series of relatively minor storms that occurred during WY 2012 (Figure 5). During WY 2012, flow peaked at 244 cfs on 1/20/12 22:50. During WY 2013, flow peaked at 338 cfs on 12/23/12 14:20 and total wet season flow was 8.81 Mm^3. San Lorenzo Creek to the south has been gauged by the USGS in the town of San Lorenzo (gauge number 11181040) from WY 1968-78 and again from WY 1988-present. Based on these records, annual peak flow has ranged between 300 cfs (1971) and 10300 cfs (1998). During WY 2012, flow peaked on San Lorenzo Creek at San Lorenzo at 1600 cfs on 1/20/2012 at 23:00; a flow that has been exceeded 68% of the years on record. During, WY 2013, flow in San Lorenzo peaked at 2970 cfs on 12/2/2012 at 11:15 am; a flow of this magnitude has been exceeded 38% of the years on record. Annual flow for San Lorenzo Creek at San Lorenzo (gauge number 11181040) for WY 2012 and 2013 respectively was 95 and 99 Mm^3 both well below the long term average for the site of 169 Mm^3. Based on this evidence alone, we suggest flow in San Leandro Creek flow was likely much lower than average for both water years.

In addition to the flow response from rainfall, East Bay Municipal Utility District (EBMUD) made releases from Chabot Reservoir in the first half of the WY 2012 season indicated by the square and sustained nature of the hydrograph at the sampling location. This also occurred in December and January of WY 2013 also indicated by the square nature of the hydrograph. Despite this augmentation, it seems likely that annual flow in San Leandro Creek during both years of observation was below average and would be exceeded in 60-70% of years. Rainfall data corroborates this assertion; rainfall during WY 2012 was 19.02 inches, or 74% of mean annual precipitation (MAP = 25.55 in) based on a long-term record at Upper San Leandro Filter (gauge number 049185) for the period 1971-2010 [Climate Year (CY]). CY 2012 was ranked 17th driest in the available 57-year record (1949-present [Note 7-year data-gap during CY 1952-58]). Data for CY 2013 is not yet available.

8.3.1. San Leandro Creek turbidity and suspended sediment concentration

Turbidity generally responded to rainfall events in a similar manner to runoff. During the reservoir release period in the early part of WY 2012, turbidity remained relatively low indicating very little sediment was eroded from within San Leandro Creek at this magnitude and consistency of stream power. A similar phenomenon occurred in January of WY 2013 when again little rainfall occurred and relatively clean run-off devoid of sediment and pollutants was associated with the reservoir release. With each of the storms that occurred beginning 1/20/2012 in WY 2012, maximum storm turbidity increased in magnitude. Turbidity peaked at 929 NTU during a late season storm on 4/13/12 at 5:15 am. In contrast, during WY 2013, saturated watershed conditions began to occur in late November and sediment began to be released from the upper watershed much earlier in the season. A peak turbidity of 495 NTU occurred on 11/30/12 at 9:45 am. The post new year period was relatively dry and the latter season storm in April was relatively minor. These observations provide evidence that during larger

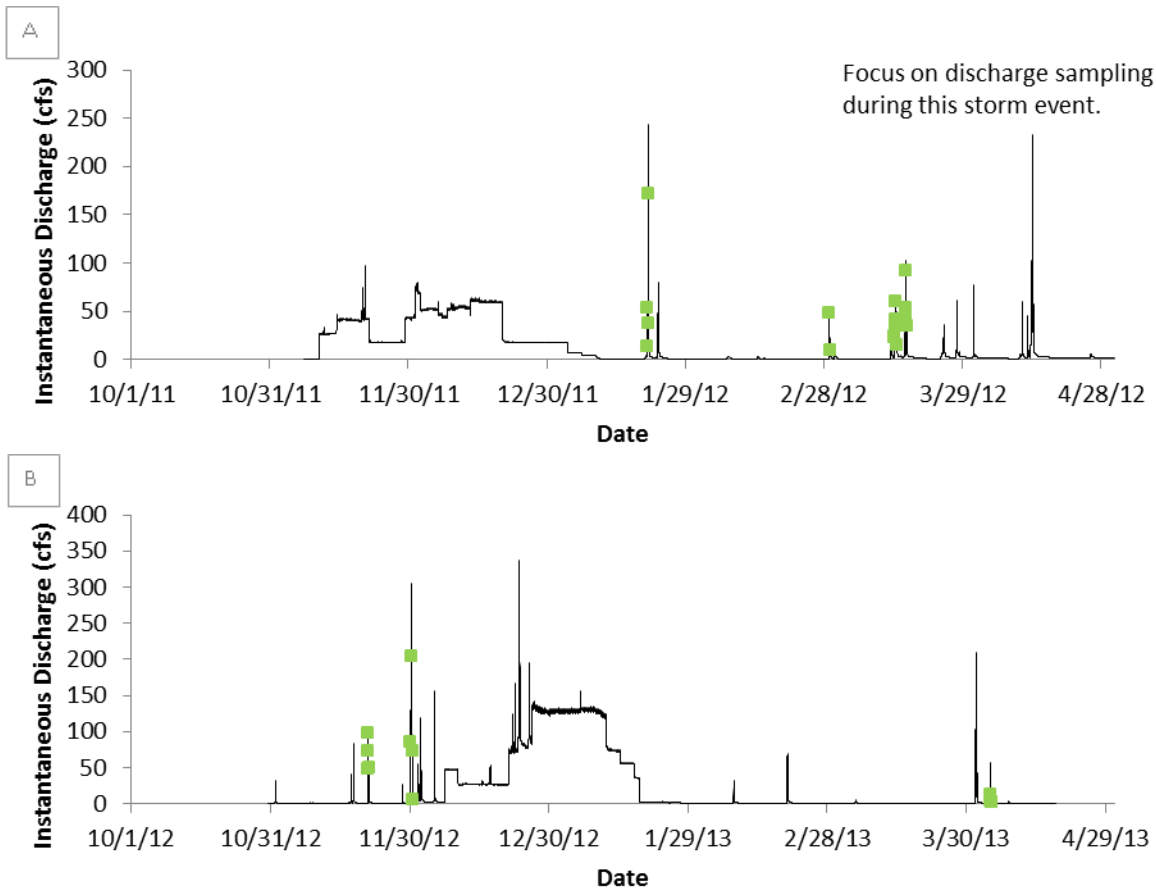

Figure 5. Preliminary flow characteristics (primary y axis) in San Leandro Creek at San Leandro Boulevard during Water Year 2012 (A) and WY 2013 (B) with sampling events plotted in green. Note, flow information will be updated in the future when additional data.

storms and wetter years, the San Leandro Creek watershed is likely capable of much greater sediment erosion and transport resulting in greater turbidity and concentrations of suspended sediment. At this time, we have no evidence to suggest that the OBS-500 instrument utilized at this sampling location (with a range of 0-4000 NTU) will not be sufficient to handle most future storms.

Suspended sediment concentration, since it was computed from the continuous turbidity data, follows the same patterns as turbidity in relation to discharge. Suspended sediment concentration during WY 2012 peaked at 1141 mg/L during the late season storm on 4/13/12 at 5:15 am; a peak SSC of 608 mg/L occurred on 11/30/12 at 9:45 am for WY 2013; although it should be noted that there was considerable scatter around the upper end of the turbidity-SSC regression relation thus it is possible that this will be reinterpreted with a subsequent year of data collection. The maximum concentration observed during the RMP reconnaissance study (McKee et al., 2012) was 965 mg/L but at this time we have not evaluated the relative storm magnitude between WY 2011 and WY 2012 to determine if the relative concentrations are logical.

8.3.2. San Leandro Creek POC concentrations summary (summary statistics)

Summary statistics of pollutant concentrations measured in San Leandro Creek during WY 2012 and 2013 provide a basic understanding of general water quality and also allow a first order judgment of quality assurance (Table 15). For pollutants sampled at a sufficient frequency for loads analysis (suspended sediments, PCBs, mercury, organic carbon, and nutrients), concentrations followed the typical pattern of median < mean with the exception of organic carbon. The range of PCB concentrations were typical of mixed urban land use watersheds (Lent and McKee, 2011). Maximum mercury concentrations (590 ng/L) were greater than observed in Zone 4 Line A in Hayward (Gilbreath et al., 2012) and of a similar magnitude to those observed in the San Pedro stormdrain draining an older urban residential area of San Jose (SFEI, unpublished). Nutrient concentrations were in the same range as measured in in Z4LA (Gilbreath et al., 2012), and as is typical in the Bay Area, phosphorus concentrations appear to be greater than reported elsewhere in the world under similar land use scenarios, an observation perhaps attributable to geological sources (McKee and Krottje, 2005). We find no reason to suspect data quality issues since the concentration ranges appear reasonable in relation to our conceptual models of water quality for these analytes.

A similar style of first order quality assurance is also possible for analytes measured at a lesser frequency using composite sampling design (see methods section) (copper, selenium, PAHs, carbaryl, fipronil, and PBDEs) and appropriate for water quality characterization only. During WY 2013, maximum concentrations of PAHs, PBDEs, and the pyrethroid pesticides were all considerably lower (around 5-fold) than observed during WY 2012. This is possibly due to differences in the randomness of the representativeness of sub samples of the composites or due to dilution from cleaner water and sediment loads from upstream, hypotheses to explore further with additional data collection in WY 2014. Concentrations of many of these analytes were generally similar to concentrations observed in Z4LA (Gilbreath et al., 2012). Carbaryl and fipronil have not been measured previously by RMP studies but were on the lower side of the range of peak concentrations reported in studies across the US and California (Fipronil: 70 – 1300 ng/L, Moran, 2007) (Carbaryl: DL - 700 ng/L, Ensiminger et al., 2012). The total selenium concentrations in San Leandro Creek appear to be about double those observed in Z4LA (Gilbreath et al., 2012) but still not remarkable compared to other previous observations made in the Bay Area (e.g. North Richmond Pump station [Hunt et al., 2012] and Walnut and Marsh Creeks [McKee et al., 2012]). Pyrethroid concentrations of Delta/ Tralo-methrin, Cyhalothrin lambda, and Bifenthrin were similar to those observed in Z4LA whereas concentrations of Permethrin were about 10x lower (Gilbreath et al., 2012). In summary, mercury concentrations in San Leandro are on the high end of typical Bay Area urban watersheds, whereas concentrations of other POCs are either within the range of or below those measured in other typical Bay Area urban watersheds. There does not appear to be any data quality issues.

8.3.1. San Leandro Creek toxicity

Composite water samples were collected at the San Leandro Creek station during four storm events in Water Year 2012 and three storm events during Water Year 2013. The survival of the freshwater fish species *Pimephales promelas* was significantly reduced during one of the four Water Year 2012 and one of the three Water Year 2013 events. Similar to the results for other POC monitoring stations, significant

Table 15. Summary of laboratory measured pollutant concentrations in San Leandro Creek during water years 2012 and 2013.

		Water Year 2012							Water Year 2013						
Analyte Name	Unit	Samples taken (n)	Proportion detected (%)	Min	Max	Median	Mean	Standard Deviation	Samples taken (n)	Proportion detected (%)	Min	Max	Median	Mean	Standard Deviation
SSC	mg/L	53	98%	ND	590	100	162	100	28	86%	ND	904	48.0	114	202
∑PCB	ng/L	16	100%	2.91	29.4	10.5	12.3	41.5	12	100%	0.730	15.7	4.15	5.59	4.65
Total Hg	ng/L	16	100%	11.9	577	89.4	184	21.7	12	100%	7.50	590	44.0	93	162
Total MeHg	ng/L	9	100%	0.164	1.48	0.220	0.499	0.220	9	100%	0.150	1.40	0.200	0.377	0.397
TOC	mg/L	16	100%	4.50	12.7	7.95	7.79	1.40	12	100%	4.00	14.0	5.65	6.25	2.55
NO3	mg/L	16	100%	0.140	0.830	0.340	0.356	0.119	13	100%	0.130	2.80	0.230	0.520	0.732
Total P	mg/L	16	100%	0.200	0.760	0.355	0.393	0.098	9	100%	0.100	0.610	0.210	0.247	0.144
PO4	mg/L	16	100%	0.057	0.16	0.073	0.087	0.019	13	100%	0.069	0.130	0.093	0.094	0.019
Hardness	mg/L	4	100%	33.8	72.5	45.5	54.8	6.93	-	-	-	-	-	-	-
Total Cu	µg/L	4	100%	12.3	39.5	20.1	23.0	5.79	3	100%	5.90	28.0	11.0	15.0	11.6
Dissolved Cu	µg/L	4	100%	6.04	10.0	8.34	8.18	7.38	3	100%	3.50	4.90	4.10	4.17	0.702
Total Se	µg/L	4	100%	0.104	0.292	0.216	0.207	0.118	3	100%	0.180	0.290	0.190	0.220	0.061
Dissolved Se	µg/L	4	100%	0.068	0.195	0.131	0.131	0.012	3	100%	0.160	0.190	0.170	0.173	0.015
Carbaryl	ng/L	4	50%	ND	14.0	5.00	6.00	7.07	3	0%	ND	-	-	-	-
Fipronil	ng/L	4	100%	6.00	10.0	8.00	8.00	4.24	3	33%	ND	9.00	2.00	3.67	4.73
∑PAH	ng/L	2	100	3230	5352	4291	4291	1501	1	100%	1399	1399	1399	1399	-
∑PBDE	ng/L	2	100	64.9	82.0	73.5	73.5	12.1	2	100%	1.61	29.7	15.7	15.7	19.9
Delta/ Tralo-methrin	ng/L	3	100%	0.163	1.74	1.41	1.10	0.832	3	33%	ND	0.600	0	0.200	0.346
Cypermethrin	ng/L	4	0%	ND	-	-	-	-	3	67%	ND	0.800	0.700	0.500	0.436
Cyhalothrin lambda	ng/L	3	25%	ND	3.86	0	1.29	2.23	3	33%	ND	0.300	0	0.100	0.173
Permethrin	ng/L	4	100%	3.35	13.1	5.77	7.00	10.8	3	33%	ND	6.00	0	2.00	3.46
Bifenthrin	ng/L	4	75%	ND	32.4	12.1	14.1	5.66	3	100%	2.80	7.10	5.50	5.13	2.17

Zeroes were used in the place of non-detects when calculating means, medians, and standard deviations.
The minimum number of samples used to calculate standard deviation at San Leandro Creek was two.
All Hardness results in WY 2013 were censored.

reductions in the survival of the amphipod *Hyalella azteca* were observed, in this case in three of the four Water Year 2012 storm events sampled. Although limited use of this species has occurred for the evaluation of toxicity in water, it has consistently been used by scientists to assess the toxicity of sediments in receiving waters. No significant reductions in the survival, reproduction and growth of the crustacean *Ceriodaphnia dubia* or the algae *Selenastrum capricornutum* were observed during any of these storms.

8.3.2. San Leandro Creek preliminary loading estimates

Site specific methods were developed for computed loads (Table 16). Preliminary loads estimates generated for WY 2012 and reported by McKee et al. (2013) have now been revised based on revisions to the discharge estimates, additional pollutant concentration data collected in WY 2013 and an improving understanding of pollutant transport processes for the site. Preliminary monthly loading estimates correlate well with monthly discharge (Table 17). There are no data available for October of each water year because monitoring equipment was not installed. Discharge and rainfall are not aligned due to reservoir release. Monthly discharge was greatest in January 2013 when large releases were occurring from the upstream reservoir. The greatest monthly loads for each of the pollutants regardless of transport mode (dominantly particulate or dissolved) occurred in December 2012 when rainfall induced run-off caused high turbidity and elevated concentrations of suspended sediments and pollutants. The sediment and pollutant loads were less well correlated with the total discharge than for other sampling sites due to reservoir releases and complex sources. When discharge was dominated by upstream flows induced by rainfall, relatively high loads of mercury occurred; conversely, PCB loads were greater relative to rainfall during smaller rainfall events when less run-off occurred from the upper watershed. At this time, all loads estimate should be considered preliminary. Additional data collected during WY 2014 will be used to improve our understanding of rainfall-runoff-pollutant transport processes and used to recalculate and finalize loads for WYs 2012 and 2013. Regardless of these improvements however, given the very dry flow conditions of WY 2012 and 2013 (see discussion on flow above), preliminary loads presented here may be considered representative of dry conditions.

8.3. Guadalupe River

8.3.1. Guadalupe River flow

The US Geological Survey has maintained a flow record on lower Guadalupe River (gauge number 11169000; 11169025) since October 1, 1930 (83 WYs; note 1931 is missing). Peak annual flows for the period have ranged between 125 cfs (WY 1960) and 11000 cfs (WY 1995). Annual runoff from Guadalupe River has ranged between 0.422 (WY 1933) and 241 Mm^3 (WY 1983).

During WY 2012, a series of relatively minor storms[2] occurred (Figure 6). A storm that caused flow to escape the low flow channel and inundate the in-channel bars did not occur until 1/21/12, very late in

[2] A storm was defined as rainfall that resulted in flow that exceeds bankfull, which, at this location, is 200 cfs, and is separated by non-storm flow for a minimum of two days.

Table 16. Regression equations used for loads computations for San Leandro Creek during water year 2012 and 2013. Note that regression equations will be reformulated with future wet season storm sampling.

Analyte	Origin of runoff	Slope	Intercept	Correlation coefficient (r^2)	Notes
Suspended Sediment (mg/NTU)	Mixed	1.2286		0.81	Regression with turbidity
Total PCBs (ng/NTU)	Mainly urban	0.0871	4.097	0.58	Regression with turbidity
Total PCBs (ng/NTU)	Mainly non-urban	0.031	1.567	0.81	Regression with turbidity
Total Mercury urban (ng/NTU)	Mainly urban	0.66	6.17	0.83	Regression with turbidity
Total Mercury non-urban (ng/NTU)	Mainly non-urban	1.34		0.86	Regression with turbidity
Total Methylmercury (ng/NTU)	Mixed	0.0026	0.12	0.92	Regression with turbidity
TOC	Mixed	6.66			Flow weighted mean concentration
Total Phosphorous (mg/NTU)	Mixed	0.0012	0.18	0.64	Regression with turbidity
Nitrate (mg/L)	Mixed	0.38			Flow weighted mean concentration
Phosphate (mg/L)	Mixed	0.092			Flow weighted mean concentration

Table 17. Preliminary monthly loads for San Leandro Creek for water year 2012 and 2013.

Water Year	Month	Rainfall (mm)	Discharge (Mm^3)	SS (t)	TOC (kg)	PCBs (g)	HgT (g)	MeHgT (g)	NO3 (kg)	PO4 (kg)	Total P (kg)
2012	11-Oct	-	-	-	-	-	-	-	-	-	-
	11-Nov	-	-	-	-	-	-	-	-	-	-
	11-Dec	0	3.14	23.9	20,909	5.66	32.1	0.438	1,193	289	587
	12-Jan	73	0.316	17.3	2,106	1.87	15.5	0.0827	120	29.1	76.7
	12-Feb	22	0.0206	0.591	137	0.0931	0.569	0.00329	7.81	1.89	3.32
	12-Mar	151	0.245	22.3	1,634	1.48	27.6	0.0863	93.2	22.6	69.0
	12-Apr	85	0.266	50.2	1,773	2.59	61.4	0.162	101	24.5	107
	Wet season total	332	5.47	120	36,423	14.2	145	0.965	2,078	503	1,113
2013	12-Oct	-	-	-	-	-	-	-	-	-	-
	12-Nov	121	0.238	32.9	1,587	1.93	40.6	0.113	90.5	21.9	80.5
	12-Dec	127	4.07	122	27,128	11.3	155	0.699	1,548	375	715
	13-Jan	7	4.37	54.6	29,111	8.54	73.1	0.665	1,661	402	842
	13-Feb	19	0.0359	1.46	239	0.155	1.61	0.00802	13.6	3.30	8.04
	13-Mar	11	0.0104	0.879	69.0	0.110	0.642	0.00347	3.94	0.954	2.82
	13-Apr[a]	41	0.0811	6.99	540	0.558	8.03	0.0277	30.8	7.46	22.6
	Wet season total	326	8.81	218	58,674	22.6	280	1.52	3,348	811	1,671

[a] April 2013 monthly loads are reported for only the period April 01-18. In the 12 days missing from the record, no rain fell in the San Leandro Creek watershed.

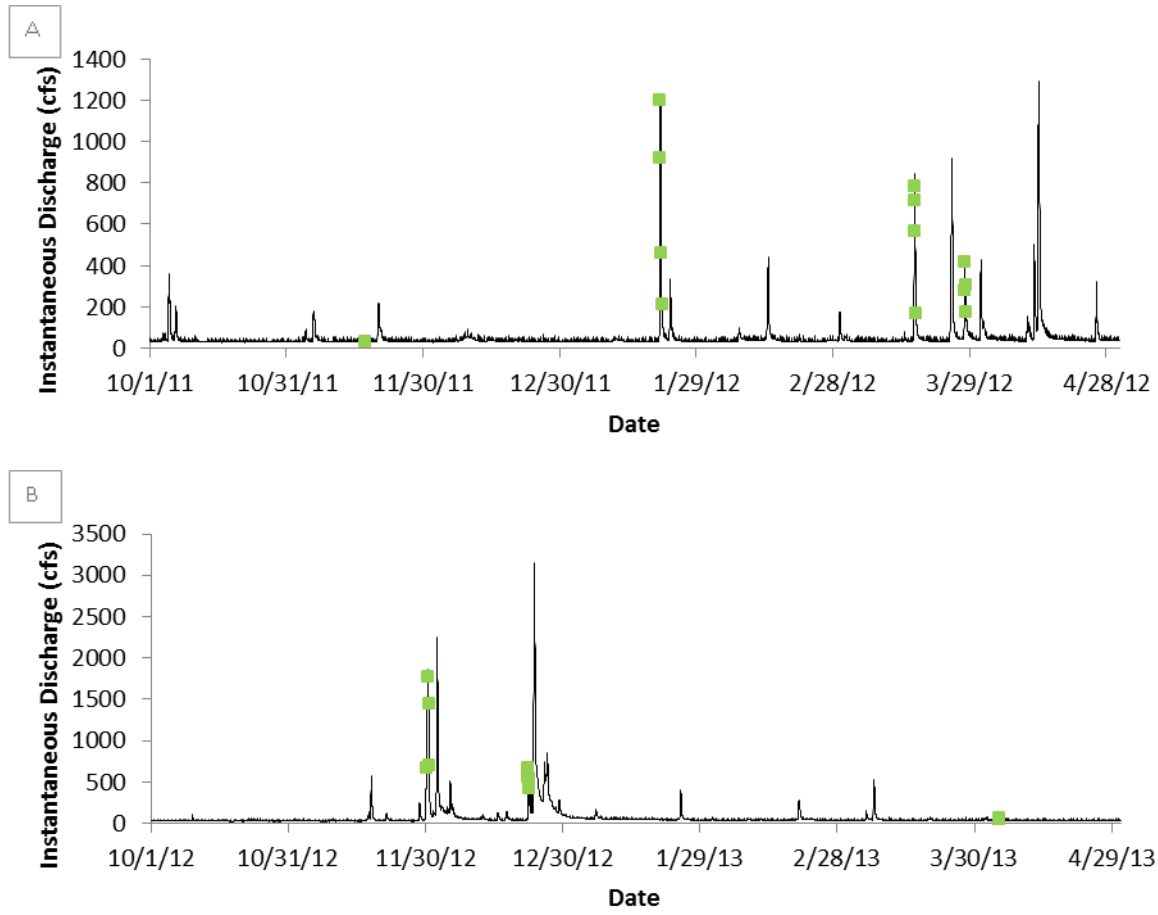

Figure 6. Flow characteristics in Guadalupe River during water year 2012 (A) based on published data and preliminary 15 minute data for water year 2013 (B) provided by the USGS (gauge number 11169025), with sampling events plotted in green. The fuzzy nature of the low flow data are caused by baseflow discharge fluctuations likely caused by pump station discharges near the gauge.

the season compared to what has generally occurred over the past years of sampling and analysis for this system (McKee et al., 2004; McKee et al., 2005; McKee et al., 2006; McKee et al., 2010; Owens et al., 2011). The flow during this January storm was 1220 cfs; flows of this magnitude are common in most years. Flow peaked in WY 2012 at 1290 cfs on 4/13/2012 at 7:15 am and total runoff during WY 2012 based on USGS data was 38.0 Mm^3; discharge of this magnitude is about 85% mean annual runoff (MAR) based on 83 years of record and 68% MAR if we consider the period WY1971-2010 (perhaps more representative of current climatic conditions given climate change). Rainfall data corroborates this assertion; rainfall during WY 2012 was 7.05 inches, or 47% of mean annual precipitation (MAP = 15.07 in) based on a long-term record at San Jose (NOAA gauge number 047821) for the period 1971-2010 (CY). CY 2012 was the driest year in the past 42 years and the 7th driest for the record beginning CY 1875 (138 years).

Water year 2013 was only slightly wetter, raining 8.78 inches as the San Jose gauge (58% MAP for the period 1971-2010 [CY]). Three moderate sized storms occurred in late November and December which

led to three peak flows above 1500 cfs within a span of one month (Figure 6). Flow peaked on the third of these storms at 3160 cfs on 12/23/12 at 18:45, a peak flow which has been exceeded in half of all years monitored (83 years). Total runoff during WY 2013 based on preliminary USGS data was 45.5 Mm^3; discharge of this magnitude is about 82% mean annual runoff (MAR) based on 83 years of record and equivalent to the MAR for the period WY1971-2010. Flow data and resulting loads calculations for WY 2013 will be updated once USGS publishes the official record. The USGS normally publishes finalized data for the permanent record in the spring following the end of each Water Year.

8.3.2. Guadalupe River turbidity and suspended sediment concentration

Turbidity generally responded to rainfall events in a similar manner to runoff. In WY 2012, Guadalupe River exhibited a pronounced first flush during a very minor early season storm when, relative to flow, turbidity was elevated and reached 260 FNU. In contrast, the storm that produced the greatest flow for the season that occurred on 4/13/2012 had lower peak turbidity (185 FNU). A similar pattern occurred in WY 2013, except that the third large storm event on 12/23/12 raised turbidity to its peak for the season (551 FNU). Peak turbidity for WY 2012 was 388 FNU during a storm on 1/21/12 at 3:15 am. Based on past years of record, turbidity can exceed 1000 FNU at the sampling location (e.g. McKee et al., 2004); the FTS DTS-12 turbidity probe used at this study location is quite capable of sampling most if not all future sediment transport conditions for the site.

A continuous record of SSC was computed by SFEI using the POC monitoring SSC data, the preliminary USGS turbidity record, and a linear regression model between instantaneous turbidity and SSC for each water year. Based on USGS sampling in Guadalupe River in past years, >90% of particles in this system are <62.5 µm in size (e.g. McKee et al., 2004). Because of these consistently fine particle sizes, turbidity correlates well with the concentrations of suspended sediments and hydrophobic pollutants (e.g. McKee et al., 2004). Suspended sediment concentration, since it was computed from the continuous turbidity data, follows the same patterns as turbidity in relation to discharge. It is estimated that SSC peaked in WY 2012 at 844 mg/L during the 1/21/12 storm event at 3:15, and in WY 2013 at 933 mg/L on 12/23/12 at 19:00. The maximum SSC observed during previous monitoring years was 1180 mg/L in 2002. Rainfall intensity was much greater during WY 2003 than any other year since, leading to the hypothesis that concentrations of this magnitude will likely occur in the future during wetter years with greater and more intense rainfall (McKee et al., 2006).

8.3.3. Guadalupe River POC concentrations summary (summary statistics)

A summary of concentrations is useful for providing comparisons to other systems and also for doing a first order quality assurance check. Concentrations measured in Guadalupe River during WYs 2012 and 2013 are summarized (Table 18). The range of PCB concentrations are typical of mixed urban land use watersheds (Lent and McKee, 2011) and mean concentrations in this watershed were the 3rd highest measured of the six locations (Sunnyvale Channel > Pulgas Creek PS > Guadalupe River >North Richmond PS > San Leandro Creek >Lower Marsh Creek). Maximum mercury concentrations (1000 ng/L measured in WY 2012) are greater than observed in Z4LA (Gilbreath et al., 2012) and the San Pedro stormdrain (SFEI unpublished data), which drains an older urban residential area of San Jose. This maximum concentration was higher than the average mercury concentration (690 ng/L) over the period of record at this location (2002-2010). Nutrient concentrations were in the same range as measured in in Z4LA

Table 18. Summary of laboratory measured pollutant concentrations in Guadalupe River for water years 2012 and 2013.

		Water Year 2012							Water Year 2013						
Analyte Name	Unit	Samples taken (n)	Proportion detected (%)	Min	Max	Median	Mean	Standard Deviation	Samples taken (n)	Proportion detected (%)	Min	Max	Median	Mean	Standard Deviation
SSC	mg/L	41	100%	8.6	730	82.0	198	205	41	100%	5.9	342	128	124	104
∑PCB	ng/L	11	100%	2.70	59.1	6.96	17.7	21.5	12	100%	2.04	47.4	6.29	10.6	12.7
Total Hg	ng/L	12	100%	36.6	1000	125	268	324	12	100%	14.5	360	155	153	119
Total MeHg	ng/L	10	100%	0.086	1.15	0.381	0.445	0.352	7	100%	0.040	0.940	0.490	0.428	0.340
TOC	mg/L	12	100%	4.90	18.0	7.45	8.73	4.03	12	100%	5.30	11.0	6.05	6.36	1.55
NO3	mg/L	12	100%	0.560	1.90	0.815	0.918	0.380	12	67%	ND	2.30	0.520	0.921	0.992
Total P	mg/L	12	100%	0.190	0.810	0.315	0.453	0.247	8	100%	0.300	0.610	0.390	0.405	0.092
PO4	mg/L	12	100%	0.060	0.160	0.101	0.101	0.032	12	100%	0.061	0.180	0.120	0.109	0.034
Hardness	mg/L	3	100%	133	157	126	143	12.3	-	-	-	-	-	-	-
Total Cu	µg/L	3	100%	10.7	26.3	24.7	20.6	8.58	3	100%	5.90	28.0	23.0	19.0	11.6
Dissolved Cu	µg/L	3	100%	5.07	7.91	5.51	6.16	1.53	3	100%	2.50	3.60	2.50	2.87	0.635
Total Se	µg/L	3	100%	1.16	1.63	1.21	1.33	0.258	3	100%	0.700	3.30	0.780	1.59	1.48
Dissolved Se	µg/L	3	100%	0.772	1.32	1.04	1.04	0.274	3	100%	0.400	3.20	0.540	1.38	1.58
Carbaryl	ng/L	3	100%	13.0	57.0	57.0	41.4	24.7	3	67%	ND	21.0	17.0	12.7	11.2
Fipronil	ng/L	3	100%	6.50	20.0	11.0	12.5	6.87	3	100%	3.00	11.0	9.00	7.67	4.16
∑PAH	ng/L	1	100%	-	-	-	2186	-	8	100%	40.7	736	174	251	245
∑PBDE	ng/L	1	100%	-	-	-	34.5	-	2	100%	13.1	69.8	41.4	41.4	40.1
Delta/ Tralo-methrin	ng/L	3	100%	0.704	1.90	1.82	1.47	0.667	3	0%	ND	-	-	-	-
Cypermethrin	ng/L	3	0%	ND	-	-	-	-	3	100%	0.500	3.30	1.70	1.83	1.40
Cyhalothrin lambda	ng/L	3	33%	ND	-	-	1.20	-	3	100%	0.300	1.50	0.500	0.767	0.643
Permethrin	ng/L	3	100%	16.8	20.5	19.5	18.9	1.91	3	33%	ND	5.40	0	1.80	3.12
Bifenthrin	ng/L	3	67%	ND	13.3	6.16	6.47	6.63	3	100%	0.900	7.60	5.90	4.80	3.48

Zeroes were used in the place of non-detects when calculating means, medians, and standard deviations.
The minimum number of samples used to calculate standard deviation at Guadalupe River was two.
All Hardness results in WY 2013 were censored.

(Gilbreath et al., 2012), and typical for the Bay Area, phosphorus concentrations appear greater than elsewhere in the world under similar land use scenarios, perhaps attributable to geological sources (McKee and Krottje, 2005). Based on previous sampling experience in the system (McKee et al., 2004; McKee et al., 2005; McKee et al., 2006; McKee et al., 2010; Owens et al., 2011) and these simple comparisons to other studies, there are no reasons to suspect any data quality issues.

In a similar manner, summary statistics and comparisons were developed for the lower sample frequency analytes collected using composite sampling design (see the methods section). Copper, which was sampled at a lesser frequency for characterization only, was similar to concentrations previously observed (McKee et al., 2004; McKee et al., 2005; McKee et al., 2006) and similar to those observed in Z4LA (Gilbreath et al., 2012). Maximum selenium concentrations were generally 2-8 fold greater than the other five locations; elevated groundwater concentrations have been observed in Santa Clara County previously (Anderson, 1998). Carbaryl and fipronil were on the lower side of the range of peak concentrations reported in studies across the US and California (Fipronil: 70 – 1300 ng/L, Moran, 2007) (Carbaryl: DL - 700 ng/L, Ensiminger et al., 2012). Pyrethroid concentrations of Cyhalothrin lambda were similar to those observed in Z4LA whereas concentrations of Permethrin and Bifenthrin were on the lower end (Gilbreath et al., 2012). No quality issues appear from the comparisons.

8.3.4. Guadalupe River toxicity

Composite water samples were collected at the Guadalupe River station during three storm events in WY 2012 and three storm events in Water Year 2013. Similar to the results for other POC monitoring stations, no significant reductions in the survival, reproduction and growth of three of four test species were observed during storms. Significant reductions in the survival of the amphipod *Hyalella azteca* was observed during two of the three storm Water Year 2012 events sampled. There were no significant effects observed for any samples collected during Water Year 2013. Although limited use of this species has occurred for the evaluation of toxicity in water, it has consistently been used by scientists to assess the toxicity of receiving water sediments.

8.3.5. Guadalupe River preliminary loading estimates

The following methods were applied to estimate loads for the Guadalupe River in WYs 2012 and 2013. Suspended sediment loads for WY 2012 were downloaded from USGS. Since the WY 2013 suspended sediment record has not yet been published, concentrations were estimated from the turbidity record using a linear relation (Table 19). Once the official USGS flow and SSC record is published for WY 2013, the suspended sediment load will be updated. Concentrations were estimated using regression equations between the contaminant and turbidity, except for nitrate in which a flow weighted mean concentration was used (Table 19). As found during other drier years (McKee et al., 2006), a separation of the data for PCBs and total mercury to form regression relations based on origin of flow was not possible with WY 2012 data, in which the majority of runoff was of urban origin. This separation was, however, possible for PCBs during WY 2013 flows.

Preliminary monthly loading estimates correlate fairly well with monthly discharge (Table 20). Monthly discharge was greatest in December 2012 as were loads of most pollutants. This single wet month transported approximately 50% of the PCB and mercury load of the two wet seasons combined. WY

Table 19. Regression equations used for loads computations for Guadalupe River during water year 2012 and 2013. Note that regression equations will be reformulated upon future wet season storm sampling.

Analyte	Origin of runoff	Slope	Intercept	Correlation coefficient (r^2)	Notes
Suspended Sediment WY 2013 (mg/NTU)[a]	Mixed	1.69		0.92	Regression with turbidity
Total PCBs urban (ng/NTU)	Mainly urban	0.23898		0.76	Regression with turbidity
Total PCBs non-urban (ng/NTU)	Mainly non-urban	0.079123		0.84	Regression with turbidity
Total Mercury (ng/NTU)	Mixed	2.17		0.81	Regression with turbidity
Total Methylmercury (ng/NTU)	Mixed	0.0031	0.21	0.48	Regression with turbidity
Total Organic Carbon (mg/NTU)	Mixed	0.028	4.7	0.62	Regression with turbidity
Total Phosphorous (mg/NTU)	Mixed	0.0019	0.2	0.71	Regression with turbidity
Nitrate (mg/L)	Mixed	0.633			Flow weighted mean concentration
Phosphate (mg/NTU)	Mixed	0.00028	0.077	0.59	Regression with turbidity

[a]Suspended sediment loads in WY 2012 were downloaded from the USGS for this site.

2013 loads were approximately 3x higher than WY 2012. However, compared to previous sampling years (McKee et al., 2004; McKee et al., 2005; McKee et al., 2006; McKee et al., 2010; Owens et al., 2011 [Hg only]), loads of total mercury and PCBs were several times lower. At this time, all loads estimates for WY 2013 should be considered preliminary. Once available, USGS official records for flow, turbidity, and SSC can be substituted for the preliminary data presented here. In addition pollutant data collected in future sampling years will be used to improve our understanding of rainfall-runoff-pollutant transport processes and used to recalculate these loads. Regardless of these improvements, overall, WY 2012 and 2013 loads may be considered representative of loads during dry conditions in this watershed.

8.3. Sunnyvale East Channel

8.3.1. Sunnyvale East Channel flow

Santa Clara Valley Water District (SCVWD) has maintained a flow gauge on Sunnyvale East Channel from WY 1983 to present. Unfortunately, the record is known to be poor quality (pers. comm., Ken Stumpf, SCVWD), which was apparent when the record was regressed against rainfall (R^2 = 0.58) (Lent et al., 2012). The gauge is presently scheduled for improvement by SCVWD. Due to the knowledge of the poor quality runoff data for this channel, in WY 2012 discharge was estimated based on the continuous stage record and application of the Manning's formula. However, in WY 2013 additional velocity discharge measurements were collected in the field and corroborated the SCVWD rating curve up to stages of 2.9

Table 20. Preliminary monthly loads for Guadalupe River for water year 2012 and 2013.

Water Year	Month	Rainfall (mm)	Discharge (Mm^3)	SS (t)	TOC (kg)	PCBs (g)	HgT (g)	MeHgT (g)	NO3 (kg)	PO4 (kg)	Total P (kg)
2012	11-Oct	19	2.91	167	15966	9.08	188	0.865	1840	247	757
	11-Nov	15	2.88	104	14844	5.68	110	0.750	1823	235	685
	11-Dec	1	2.73	76.4	13244	1.38	38.0	0.619	1730	215	593
	12-Jan	18	3.85	565	25069	29.2	555	1.58	2439	367	1268
	12-Feb	14	3.15	315	17766	10.0	240	0.989	1995	273	852
	12-Mar	50	5.08	404	29516	29.6	456	1.69	3213	448	1433
	12-Apr	44	5.23	485	30078	28.2	446	1.71	3307	458	1454
	Wet season total	161	25.8	2116	146483	113	2033	8.20	16347	2243	7042
2013	12-Oct	8	2.26	52.5	11406	3.44	67.5	0.56	1430	182	521
	12-Nov	48	5.23	913	39385	85.0	1175	2.73	3309	551	2082
	12-Dec	92	14.8	3100	119995	224	3991	8.67	9373	1643	6468
	13-Jan	15	4.14	98.4	20924	7.95	127	1.03	2618	334	957
	13-Feb	11	3.05	58.2	15186	4.45	75.0	0.74	1929	244	689
	13-Mar	21	3.47	93.6	17733	6.93	120	0.89	2196	282	815
	13-Apr	5	2.57	36.6	12598	2.12	47.2	0.60	1626	204	567
	Wet season total	201	35.5	4352	237227	334	5603	15.2	22482	3440	12099

feet (corresponding to flows of 190 cfs). Therefore, WY 2013 discharge was estimated based on continuous stage and application of the SCVWD rating curve, and WY 2012 discharge was recalculated using the same method. Efforts will be made in subsequent sampling years to evaluate the accuracy of the SCVWD rating curve at stages greater than 3 feet.

Both WY 2012 and 2013 were relatively dry years and discharge was likely lower than average. Rainfall during WY 2012 and 2013 was 8.82 and 10.2 inches, respectively, at Palo Alto (NOAA gauge number 046646). Relative to mean annual precipitation (MAP = 15.25 in) based on a long-term record for the period 1971-2010 (CY), WY 2012 was only 58% MAP and WY 2013 67% MAP. A series of relatively minor storms occurred during WY 2012 (Figure 7). Flow peaked at 492 cfs overnight on 4/12/12- 4/13/12 at midnight. Total runoff during WY 2012 for the period 12/1/11 to 4/30/12 was 1.07 Mm^3 based on our stage record and the SCVWD rating curve. Total annual runoff for the period between 10/01/12 and 4/30/13 was 1.79 Mm^3 and likely below average based on below average rainfall. However, unlike WY 2012 in which the rainfall was spread over several smaller events, the majority of WY 2013 rainfall occurred during three large storm events in late November and December, each of which was of 1-2

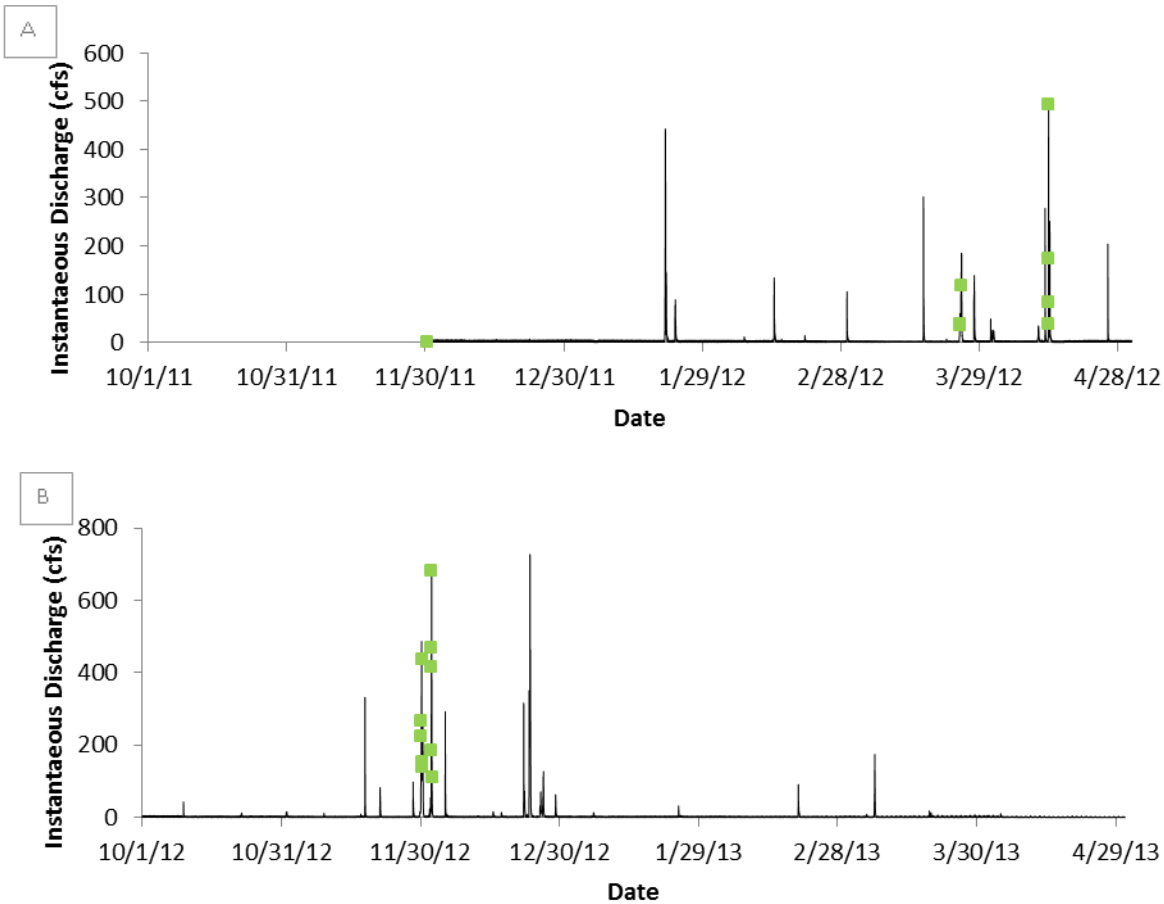

Figure 7. Preliminary flow characteristics in Sunnyvale East Channel at East Ahwanee Avenue during WY 2012 (A) and WY 2013 (B) with sampling events marked in green. The flow record is based on the District rating curve for this station as verified by velocity sampling completed to-date. The rating relationship may be improved in subsequent years as more velocity sampling is completed.

year recurrence based on NOAA Atlas 14 partial duration series data for the area. Flow peaked during the third event of this series at 727 cfs on 12/23/12 at 15:15. Given that SCVWD maintains the channel to support a peak discharge of 800 cfs, the December 2012 storms resulted in significant flows for the system. Field observations during sampling of the early December storms corroborate this assertion; stages neared the top of bank and the banks of the channel for the observable reach at and upstream from the sampling location showed evidence of erosion. This is yet another vivid example of why peak discharge often correlates with total wet season load better than total wet season flow (Lewicki and McKee, 2009).

8.3.2. Sunnyvale East Channel turbidity and suspended sediment concentration

The entire turbidity record for WY 2012 was censored due to problems with the installation design and the OBS-500 instrument reading the bottom of the channel. Suspended sediment concentration in WY 2012 could not be computed from the continuous turbidity data, and was alternatively computed as a

function of flow (with much lower confidence due to the loss of hysteresis in the computational scheme). In WY 2013, the OBS-500 instrument was replaced with an FTS DTS-12 turbidity probe (0-1,600 NTU range). This instrument performed well through to the first large storm on 11/30/12 and then the turbidity record experienced numerous spikes through the rest of the season. Our observations during maintenance suggested that the three large storm events in late November and December uprooted and dislodged a lot of vegetation and some trash, which slowly passed through the system throughout the season and caught on the boom structure where turbidity was monitored. After field visits to download data and perform maintenance on site including removing the vegetation from the boom, the turbidity record cleared until the next elevated flow. Consequently, 8.3% of the turbidity record was censored due to fouling. During the period of record in which the turbidity sensor was functioning correctly, SSC was estimated based on regression with turbidity. During the period of record in which turbidity was censored, SSC was computed as a function of flow in a similar manner to estimates made in WY 2012.

Turbidity in Sunnyvale East Channel in WY 2013 remained low (<40 NTU) during base flows and increased to between 500 and 1000 NTU during storms. Turbidity peaked at 1014 NTU early in the season on 10/9/12 in response to a small but intense rainfall in which 0.19 inches fell in 20 minutes. The three large events in November and December resulted in turbidities in the 600-900 NTU range, providing evidence to suggest that the DTS-12 instrument now utilized at this sampling location will be sufficient to handle future storms.

Suspended sediment concentration in WY 2012 peaked at 352 mg/L on 4/13/12 just after midnight and at 3726 mg/L on 10/9/12 in response to the early season small but intense rainfall. Although these concentrations are an order of magnitude different, lab measured samples from storm monitoring events in each WY corroborated these results; the maximum sampled lab measured SSC in WY 2012 was 370 mg/L (collected on 4/13/12) and in WY 2013 was 3120 mg/L (collected on 12/2/12; the 10/9/12 estimated peak SSC occurred during a non-sampled storm event). Note that the estimated SSC (estimated from the continuous turbidity record) for the 10/9/12 peak had a ratio to turbidity of 3.7:1. This ratio is higher than typical for urban creeks and resulted because the WY 2013 sampling occurred during two of the three largest storm events, at which time bank erosional processes led to mixed grain fractions in the samples and higher SSC per unit of turbidity. This observation suggests that as the Sunnyvale East Channel dataset grows in future sampling years, the data should be stratified between storms that do and do not exhibit bank erosional processes. The maximum concentration measured during the WY 2011 RMP reconnaissance study (McKee et al., 2012) was 1050 mg/L and was collected during a relatively small but intense rain event, but at this time we have not evaluated the relative storm magnitude between WY 2011, 2012 and 2013 to determine if the relative concentrations are logical.

8.3.3. Sunnyvale East Channel POC concentrations summary (summary statistics)

A wide range of pollutants were measured in Sunnyvale East Channel during WY 2012 and 2013 (Table 21). Concentrations for pollutants sampled at a sufficient frequency for loads analysis (suspended sediments, PCBs, mercury, organic carbon, and nutrients) exhibited the typical pattern of median < mean except for organic carbon, nitrate and phosphate in WY 2013 in which the mean and median were similar. The range of PCB concentrations were typical of mixed urban land use watersheds

Table 21. Summary of laboratory measured pollutant concentrations in Sunnyvale East Channel during water years 2012 and 2013.

		Water Year 2012							Water Year 2013						
Analyte Name	Unit	Samples taken (n)	Proportion detected (%)	Min	Max	Median	Mean	Standard Deviation	Samples taken (n)	Proportion detected (%)	Min	Max	Median	Mean	Standard Deviation
SSC	mg/L	28	97%	ND	370	49.0	81.6	100	34	97%	ND	3120	312	485	645
∑PCB	ng/L	8	100%	3.27	119	33.6	41.3	41.5	10	100%	9.16	176	31.3	59.3	64.3
Total Hg	ng/L	8	100%	6.30	64.1	21.7	27.7	21.7	10	100%	13	220	55.5	72.9	65.2
Total MeHg	ng/L	6	86%	ND	0.558	0.184	0.250	0.220	6	100%	0.020	0.540	0.290	0.252	0.220
TOC	mg/L	8	100%	4.91	8.60	5.94	6.41	1.40	10	100%	4.10	10.0	5.85	5.85	1.71
NO3	mg/L	8	100%	0.200	0.560	0.280	0.309	0.119	10	100%	0.150	0.370	0.280	0.269	0.069
Total P	mg/L	8	100%	0.190	0.500	0.250	0.278	0.098	11	100%	0.230	1.70	0.390	0.527	0.412
PO4	mg/L	8	100%	0.067	0.110	0.079	0.085	0.019	10	100%	0.094	0.130	0.120	0.115	0.010
Hardness	mg/L	2	100%	51.4	61.2	56.3	56.3	6.93	-	-	-	-	-	-	-
Total Cu	µg/L	2	100%	10.8	19.0	14.9	14.9	5.79	2	100%	19.0	31.0	25.0	25.0	8.49
Dissolved Cu	µg/L	2	100%	4.36	14.8	9.58	9.58	7.38	2	100%	3.10	4.90	4.00	4.00	1.27
Total Se	µg/L	2	100%	0.327	0.494	0.411	0.411	0.118	2	100%	0.490	0.490	0.490	0.490	0
Dissolved Se	µg/L	2	100%	0.308	0.325	0.317	0.317	0.012	2	100%	0.35	0.39	0.370	0.370	0.028
Carbaryl	ng/L	2	100%	11.0	21.0	16.0	16.0	7.07	2	50%	ND	19.0	9.50	9.5	13.4
Fipronil	ng/L	2	100%	6.00	12.0	9.00	9.00	4.24	2	50%	ND	6.00	3.00	3.00	4.24
∑PAH	ng/L	1	100%	-	-	-	1289	-	1	100%	-	-	-	1355	-
∑PBDE	ng/L	1	100%	-	-	-	4.77	-	1	100%	-	-	-	34.9	-
Delta/ Tralo-methrin	ng/L	1	0%	ND	-	-	-	-	2	100%	3.60	3.80	3.70	3.70	0.141
Cypermethrin	ng/L	2	0%	ND	-	-	-	-	2	100%	3.20	5.20	4.20	4.20	1.41
Cyhalothrin lambda	ng/L	1	0%	ND	-	-	-	-	2	100%	1.20	2.50	1.85	1.85	0.919
Permethrin	ng/L	2	100%	5.70	20.9	13.3	13.3	10.8	2	100%	22.0	48.0	35.0	35.0	18.4
Bifenthrin	ng/L	2	50%	ND	8	4	4.0	5.7	2	100%	8.70	18.0	13.4	13.4	6.58

Zeroes were used in the place of non-detects when calculating means, medians, and standard deviations.
The minimum number of samples used to calculate standard deviation at Sunnyvale East Channel was two.
All Hardness results in WY 2013 were censored.

(Lent and McKee, 2011) and maximum PCB concentrations (176 ng/L) exceeded the maximum observed in Z4LA (110 ng/L) (Gilbreath et al., 2012). Similarly, the range of mercury concentrations were comparable to those observed in Z4LA while the maximum total mercury concentration in Sunnyvale East Channel (220 ng/L) was greater than sampled in Z4LA (150 ng/L). Nutrient concentrations were also in the same range as measured in in Z4LA (Gilbreath et al., 2012) and like the other watersheds reported from the current study, phosphorus concentrations appear to be greater than elsewhere in the world under similar land use scenarios.

Of the pollutants sampled at a lesser frequency using a composite sampling design (see methods section) appropriate for characterization only, copper and selenium were similar to concentrations observed in Z4LA (Gilbreath et al., 2012) while PAHs and PBDEs were on the lower end of the range observed in Z4LA. Carbaryl and Fipronil (not measured previously by RMP studies) were lower or on the low end relative to peak concentrations reported in studies across the US and California (Fipronil: 70 – 1300 ng/L, Moran, 2007) (Carbaryl: DL - 700 ng/L, Ensiminger et al., 2012). Concentrations of Bifenthrin, Cyhalothrin lambda, and Permethrin were within but on the low end of the range observed in Z4LA. Based on these first order comparisons, we see no quality issues with the data.

8.3.1. Sunnyvale East Channel toxicity

Composite water samples were collected in the Sunnyvale East Channel during two storm events in WY 2012 and two storm events in WY 2013. No significant reductions in the survival, reproduction and growth of three of four test species were observed during storms. Significant reductions in the survival of the amphipod *Hyalella azteca* was observed during both WY 2012 and WY 2013 storm events[3]. Although limited use of this species has occurred for the evaluation of toxicity in water, it has consistently been used for assessments of receiving water sediment toxicity. No significant effects were observed for the crustacean *Ceriodaphnia dubia*, the algae *Selenastrum capricornutum* or the fathead minnow during these storms.

8.3.2. Sunnyvale East Channel preliminary loading estimates

Given that the turbidity record in WY 2012 was unreliable due to optical interference from bottom substrate (problem now rectified), and gaps existed in the WY 2013 record due to vegetation interference throughout the season, continuous suspended sediment concentration was estimated from the discharge record using a linear relation for the period of record in which turbidity was censored, and otherwise using the power relation with turbidity during the period in which the turbidity record was acceptable (Table 22). Concentrations of other POCs were estimated using regression equations between the contaminant and either flow or estimated SSC, whichever relation was stronger. Total organic carbon and the dissolved nutrients did not have a strong relation with either suspended sediment or flow and therefore a flow weighted mean concentration was applied.

Preliminary monthly loading estimates for Sunnyvale East Channel are presented in Table 23. This table highlights how monthly loads can be dominated by a few large storm events. Relative to discharge,

[3] In one of the two samples where significant toxicity was observed, a holding time violation occurred and therefore the results should be considered in the context of this exceedance of measurement quality objectives.

Table 22. Regression equations used for loads computations for Sunnyvale East Channel during water year 2012 and 2013. Note that regression equations will be reformulated upon future wet season storm sampling.

Analyte	Origin of runoff	Slope	Intercept	Correlation coefficient (r^2)	Notes
Suspended Sediment (WY2012) (mg/CFS)	Mainly urban	0.7145		0.97	Regression with flow
Suspended Sediment (WY2013) (mg/CFS)	Mainly urban	1.4421		0.67	Regression with flow
Suspended Sediment (WY2013) (mg/NTU)	Mainly urban	0.4913x1.2907		0.75	Regression with turbidity
Total PCBs (ng/CFS)	Mainly urban	0.23	2.7	0.62	Regression with flow
Total Mercury (ng/mg)	Mainly urban	0.13	13	0.93	Regression with estimated SSC
Total Methylmercury (ng/CFS)	Mainly urban	0.0011	0.12	0.77	Regression with flow
Total Organic Carbon (mg/L)	Mainly urban	5.77			Flow weighted mean concentration
Total Phosphorous (mg/mg)	Mainly urban	0.00076	0.2	0.86	Regression with estimated SSC
Nitrate (mg/L)	Mainly urban	0.245			Flow weighted mean concentration
Phosphate (mg/L)	Mainly urban	0.106			Flow weighted mean concentration

suspended sediment load exerted quite high variability relative to some of the other sampling locations in the study. Although December 2012 only discharged 27% of the total volume for WYs 2012 and 2013 combined, 73% of the suspended sediment load was transported during this month as well as approximately 60% of the PCB and mercury loads. Normalized to total annual discharge, WY 2013 transported 11-fold more sediment than WY 2012, 3-fold the amount of PCBs and almost 4-fold the amount of Hg. Provided the context that both WY 2012 and 2013 were relatively dry years, we may be likely to see an even broader range of rainfall-runoff-pollutant transport processes in Sunnyvale East Channel if wetter seasons are sampled.

8.6. Pulgas Creek Pump Station

8.6.1. Pulgas Creek Pump Station flow

Flow into the Pulgas Creek Pump Station from the southern catchment has not historically been monitored. An ISCO area velocity flow meter situated directly in the incoming pipe was used to measure stage and flow in WY 2013. Total runoff during WY 2013 for the period of record 12/17/12 to 3/15/13 was 0.09 Mm^3. A monthly (or partial monthly for December 2012 and March 2013) rainfall to runoff regression was applied to the missing period of the wet season. Based on this regression estimator method, a coarse estimate total runoff during WY 2013 for the period 10/01/12 to 4/30/13 was 0.21

Table 23. Preliminary monthly loads for Sunnyvale East Channel during water years 2012 and 2013.

Water Year	Month	Rainfall (mm)	Discharge (Mm^3)	SS (t)	TOC (kg)	PCBs (g)	HgT (g)	MeHgT (g)	NO3 (kg)	PO4 (kg)	Total P (kg)
2012	11-Oct	-	-	-	-	-	-	-	-	-	-
	11-Nov	-	-	-	-	-	-	-	-	-	-
	11-Dec	2	0.148	0.282	852	0.492	1.92	0.0175	36.2	15.7	29.6
	12-Jan	37	0.254	13.4	1468	4.98	4.96	0.0502	62.3	27.0	60.7
	12-Feb	22	0.151	1.36	872	0.846	2.10	0.0196	37.0	16.0	31.1
	12-Mar	69	0.260	8.29	1501	3.36	4.38	0.0429	63.7	27.6	58.0
	12-Apr	39	0.260	13.3	1498	4.95	5.01	0.0506	63.6	27.5	61.7
	Wet season total	169	1.07	36.7	6192	14.6	18.4	0.181	263	114	241
2013	12-Oct	13	0.125	7.33	722	0.445	2.53	0.0150	30.7	13.3	30.4
	12-Nov	61	0.456	130	2634	19.1	22.5	0.139	112	48.4	189
	12-Dec	101	0.786	516	4535	50.9	76.1	0.327	193	83.3	546
	13-Jan	8	0.115	2.78	664	0.407	1.82	0.0138	28.2	12.2	25.0
	13-Feb	10	0.102	7.15	591	0.536	2.22	0.0131	25.1	10.9	25.8
	13-Mar	20	0.150	8.80	867	1.51	3.04	0.0227	36.8	15.9	36.5
	13-Apr	6	0.059	0.238	339	0.187	0.780	0.007	14.4	6.24	11.9
	Wet season total	219	1.79	673	10352	73.1	109	0.538	440	190	865

Mm^3. This estimate will be improved as the monthly rainfall to runoff regression improves in future years with a larger dataset. Since runoff from this watershed is likely to highly correlate with rainfall due to its small drainage area and high imperviousness, but since MAP for the nearby Redwood City NCDC meteorologic gauge (gauge number 047339-4) was 78% of normal, total runoff for WY 2013 at Pulgas Creek was likely below average.

During the very short and incomplete period of record at Pulgas Creek pump station, a large storm series occurred towards the end of December 2012, followed by few and relatively minor storms for the remainder of the record. Flow peaked at 50 cfs on 12/23/12 at 17:04 (Figure 8). San Francisquito Creek to the south has been gauged by the USGS at the campus of Stanford University (gauge number 11164500) from WY 1930-41 and again from 1950-present. Annual peak flows in San Francisquito over the long term record have ranged between 12 cfs (WY 1961) and 7200 cfs (WY1998). During WY 2013, flow at San Francisquito Creek peaked at 5400 cfs on 12/23/12 at 18:45, a flow that has been exceeded in only two previous years on record. However large the peak flows were for nearby creek systems such as San Francisquito Creek, flows in Pulgas Creek Pump Station south may respond differently again due to its very small size and high imperviousness. Pulgas Creek Pump Station south would be less affected by antecedent saturation conditions than San Francisquito Creek and more by hourly and sub-hourly

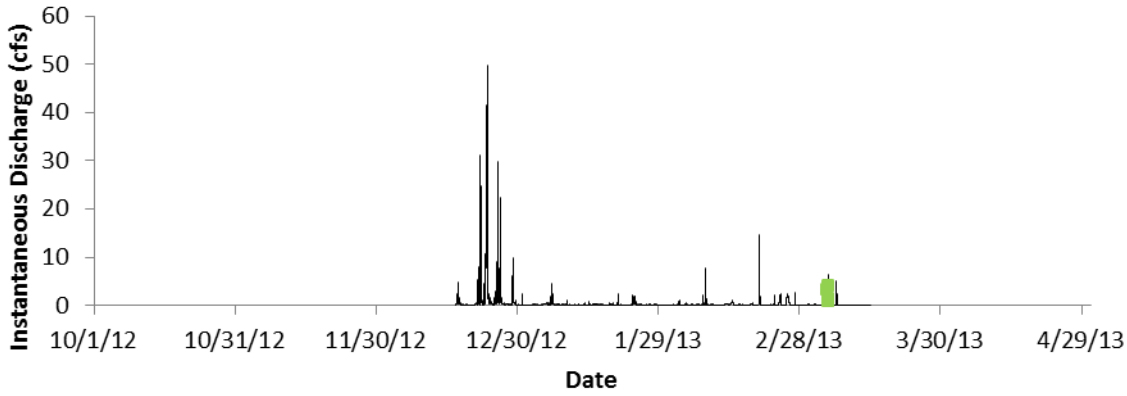

Figure 8. Preliminary flow characteristics at Pulgas Creek Pump Station South during Water Year 2013 with sampling events plotted in green. Pulgas Creek Pump Station turbidity and suspended sediment concentration

rainfall intensities. The maximum 1-hour rainfall intensity at Pulgas Creek was 0.43 inches per hour and occurred on 12/23/12 at 17:10, concurrent with the peak flow. Relative to the Redwood City NCDC meteorologic gauge and based on the partial duration series, the maximum 1-hour rainfall intensity at Pulgas has approximately a 1-year recurrence interval. Based on this rainfall intensity recurrence, we suggest peak flows in Pulgas Creek Pump Station South watershed were approximately average.

8.6.2. Pulgas Creek Pump Station turbidity and suspended sediment concentration

Turbidity in Pulgas Creek Pump Station south watershed generally responded to rainfall events in a similar manner to runoff. During non-storm periods, turbidity fluctuated between 2 and 20 NTU, whereas during storms, maximum turbidity for each event reached between 100 and 600 NTU. Near midnight on 12/30/12, during flow conditions slightly elevated above base flows but not associated with rainfall, turbidity spiked above the sensor maximum[4] and did not return to readings below 20 NTU for 18 hours. Storm-associated turbidity peaked at 588 NTU on 1/6/13 during the first storm following the 12/30/12 spike. During all storm events after the 12/30/12 spike, storm maximum turbidities were all greater than maximum turbidities in the large storm series around 12/23/12. Two hypotheses are suggested to explain these observations: a) during larger storm events such as the 12/23/12 storm, turbidity becomes diluted, or b) that the signal of particles released into the watershed and measured on 12/30/12 continued to present at lower magnitudes through the remainder of the season. Future monitoring at Pulgas Creek will help elucidate which of these current hypotheses are more likely and what the typical range of turbidity is for this watershed sampling location as water passes through to the Bay. Despite the turbidity measurements being out of the sensor range during the 12/30/12 spike, at this time we have no evidence to suggest that the DTS-12 instrument utilized at this sampling location (with a range of 0-1600 NTU) will not be sufficient to handle most future storms.

[4] Note the reported DTS-12 turbidity sensor maximum is 1600 NTU. Maximum sensor reading during this spike was 2440 NTU. Given this is beyond the accurate range of the sensor, we do not suggest this reading is accurate but rather reflects that a significant spike in turbidity occurred in the system at this time.

Suspended sediment concentration was computed from the continuous turbidity data and therefore follows the same patterns as turbidity in relation to discharge and the non-storm associated spike on 12/20/12. Suspended sediment concentration peaked at 2693 mg/L during the spike on 12/30/12 at 23:00. Storm-associated suspended sediment concentration peaked at 647 mg/L and occurred in the first subsequent storm event on 1/6/13 at 6:15. These concentration estimates based on the continuous turbidity record are much greater than observed during collection events. The maximum SSC concentration was 110 mg/L measured on 3/6/13 L while the maximum concentration measured during the RMP reconnaissance study (McKee et al., in review) was 60 mg/L. At this time we have chosen to censor the data minimally, however future sampling may indicate that further censorship or reinterpretation is necessary.

8.6.3. Pulgas Creek Pump Station POC concentrations summary (summary statistics)

Summary statistics of pollutant concentrations measured in Pulgas Creek Pump Station South in WY 2013 are presented in Table 24. Except for total methylmercury, in which two dry flow samples were additionally collected, these samples were collected during a single small storm event. Due to the small size of this dataset and relatively low SSC during sample collection, it is likely that samples collected in future years will yield higher concentrations for many pollutants of concern. Therefore, the following statements provide a first order judgment of quality assurance, but are heavily caveated by the currently unrepresentative sample dataset.

For all pollutants sampled with the exception of total methylmercury and total phosphorous, concentrations followed the typical pattern of median < mean. The range of PCB concentrations were typical of mixed urban land use watersheds previously monitored in the San Francisco Bay Area (i.e. Guadalupe River, Zone 4 Line A, Coyote Creek, reported in Lent and McKee, 2011). Mean total mercury concentrations (10.5 ng/L) were lower than observed in any of the other watersheds in this study and on the very low end of concentrations sampled in Z4LA (Gilbreath et al., 2012). Nutrient concentrations were in the same range as measured in in Z4LA, but generally lower than the other watersheds in this study. Although the dataset is possibly unrepresentative of the broader range of concentrations we might see in subsequent years as the dataset grows, we find no reason to suspect data quality issues since the concentration ranges appear reasonable in relation to our conceptual models of water quality for these analytes.

Pollutants sampled at a lesser frequency using a composite sampling design (see methods section) and appropriate for water quality characterization only (copper, selenium, PAHs, carbaryl, fipronil, and PBDEs) were similar to concentrations observed in Z4LA (Gilbreath et al., 2012). Carbaryl and fipronil were on the lower side of the range of peak concentrations reported in studies across the US and California (Fipronil: 70 – 1300 ng/L, Moran, 2007) (Carbaryl: DL - 700 ng/L, Ensiminger et al., 2012). Concentrations of Cypermethrin were similar to those observed in Z4LA whereas concentrations of Permethrin and Bifenthrin were about 20x and 10x lower, respectively (Gilbreath et al., 2012). In summary, concentrations measured at Pulgas Creek Pump Station South during WY 2013 are in a the typical range of Bay Area urban watersheds, however the dataset is currently very small and is probably unrepresentative of the full range of concentrations for this site.

Table 24. Summary of laboratory measured pollutant concentrations in Pulgas Creek Pump Station during water year 2013.

		Water Year 2012	Water Year 2013						
Analyte Name	**Unit**	**Samples taken (n)**	**Samples taken (n)**	**Proportion detected (%)**	**Min**	**Max**	**Median**	**Mean**	**Standard Deviation**
SSC	mg/L	0	15	100%	4.3	110	24.0	33.3	33.1
∑PCB	ng/L	0	4	100%	15.1	62.7	30.5	34.7	20.1
Total Hg	ng/L	0	6	100%	4.20	23.0	7.45	10.53	6.90
Total MeHg	ng/L	0	6	100%	0.040	0.280	0.215	0.178	0.100
TOC	mg/L	0	4	100%	7.30	17.0	8.35	10.3	4.53
NO3	mg/L	0	4	100%	0.240	0.490	0.350	0.358	0.102
Total P	mg/L	0	4	100%	0.100	0.250	0.125	0.150	0.071
PO4	mg/L	0	4	100%	0.051	0.094	0.059	0.066	0.020
Hardness	mg/L	0	-	-	-	-	-	-	-
Total Cu	µg/L	0	1	100%	-	-	-	30.0	-
Dissolved Cu	µg/L	0	1	100%	-	-	-	20.0	-
Total Se	µg/L	0	1	100%	-	-	-	0.180	-
Dissolved Se	µg/L	0	1	100%	-	-	-	0.170	-
Carbaryl	ng/L	0	1	100%	-	-	-	204	-
Fipronil	ng/L	0	1	0%	ND	-	-	-	-
∑PAH	ng/L	0	4	100%	211	1138	552	614	389
∑PBDE	ng/L	0	4	100%	5.18	89.8	32.5	40.0	39.7
Delta/ Tralo-methrin	ng/L	0	1	0%	ND	-	-	-	-
Cypermethrin	ng/L	0	1	100%	-	-	-	0.9	-
Cyhalothrin lambda	ng/L	0	1	0%	ND	-	-	-	-
Permethrin	ng/L	0	1	100%	-	-	-	2.9	-
Bifenthrin	ng/L	0	1	100%	-	-	-	1.3	-

Zeroes were used in the place of non-detects when calculating means, medians, and standard deviations.
The minimum number of samples used to calculate standard deviation Pulgas Creek Pump Station was four.
All Hardness results in WY 2013 were censored.

8.6.4. Pulgas Creek Pump Station toxicity

A composite water sample was collected at Pulgas Creek on March 6, 2013. No significant effects were observed on any of the four test organisms.

8.6.5. Pulgas Creek Pump Station preliminary loading estimates

Continuous concentrations of suspended sediment, PCBs, total mercury and methylmercury, and total phosphorous were computed using regression equations of each contaminant with turbidity (Table 25). Similarly, continuous concentrations of TOC and phosphate were computed using regression equations with instantaneous flow. A flow weighted mean concentration (FWMC) was computed for nitrate and the static concentration was applied to the entire record. These equations and FWMC were applied during both storm and baseflow conditions as there was no data to support using a different method for base flow conditions. The monthly (or partial monthly for December 2012 and March 2013) load for each POC was regressed with monthly (or partial monthly) rainfall. The resulting equation was used to estimate the monthly POC load for the non-monitored period of record. This is considered a coarse method of estimation and the resulting loads are shown for uses of preliminary comparison between the six monitored watersheds and should not be considered accurate at this time. As the dataset for this site grows in future monitoring years, these estimates will be recalculated.

Preliminary monthly loading estimates are dominated by the two wet months of WY 2013 (November and December) (Table 26), during which time 65% of the total discharge volume occurred and 67 – 83% of the total load for each POC passed through the system. At this time, all loads estimates should be considered preliminary and data collected in subsequent water years will be used to improve our understanding of rainfall-runoff-pollutant transport processes and used to recalculate and finalize loads for WY 2013.

Table 25. Regression equations used for loads computations for Pulgas Creek Pump Station during water year 2013. Note that regression equations will be reformulated upon future wet season storm sampling.

Analyte	Origin of runoff	Slope	Intercept	Correlation coefficient (r^2)	Notes
Suspended Sediment (mg/NTU)	Mainly urban	1.102		0.84	Regression with turbidity
Total PCBs (ng/NTU)	Mainly urban	0.73	8.6	0.77	Regression with turbidity
Total Mercury (ng/NTU)	Mainly urban	0.24	3.4	0.94	Regression with turbidity
Total Methylmercury (ng/NTU)	Mainly urban	0.00094	0.2	0.53	Regression with turbidity
Total Organic Carbon (mg/CFS)	Mainly urban	1.8	5.8	0.4	Regression with flow
Total Phosphorous (mg/NTU)	Mainly urban	0.0016	0.081	0.47	Regression with turbidity
Nitrate (mg/L)	Mainly urban	0.34			Flow weighted mean concentration
Phosphate (mg/CFS)	Mainly urban	0.0086	0.045	0.41	Regression with flow

Table 26. Preliminary monthly loads for Pulgas Creek Pump Station during water year 2013.

Water Year	Month	Rainfall (mm)	Discharge (Mm^3)	SS (t)	TOC (kg)	PCBs (g)	HgT (g)	MeHgT (g)	NO3 (kg)	PO4 (kg)	Total P (kg)
2013	12-Oct[a]	25	*0.0165*	*0.779*	*339*	*0.667*	*0.233*	*0.00394*	*6.00*	*1.93*	*2.56*
	12-Nov[a]	121	*0.0548*	*3.28*	*1947*	*2.69*	*0.932*	*0.0135*	*20.5*	*10.4*	*9.67*
	12-Dec[a]	183	*0.0797*	*4.90*	*2992*	*4.00*	*1.39*	*0.0197*	*29.9*	*15.9*	*14.3*
	13-Jan	8	0.0103	0.253	68.8	0.256	0.0908	0.00230	3.49	0.503	1.20
	13-Feb	10	0.0168	0.735	159	0.631	0.220	0.00403	5.70	1.05	2.43
	13-Mar[a]	20	*0.0143*	*0.640*	*249*	*0.555*	*0.194*	*0.00341*	*5.19*	*1.46*	*2.17*
	13-Apr[a]	18	*0.0134*	*0.580*	*211*	*0.506*	*0.177*	*0.00318*	*4.84*	*1.25*	*2.00*
	Wet season total	386	*0.206*	*11.2*	*5967*	*9.30*	*3.23*	*0.0501*	*75.6*	*32.4*	*34.3*

[a] As described in the text, discharge and loads for these months (data italicized) were computed based on monthly or partial monthly regressions between rainfall and discharge/load. These loads are considered coarse estimates and will be updated in future sampling years.

Attachment 1. Quality Assurance information

Table A1: Summary of QA data at all sites. This table includes the top eight PAHs found commonly at all sites , the PBDE congeners that account for 75% of the sum of all PBDE congeners, the top nine PCB congeners found at all sites, and the pyrethroids that were detected at any site.

Analyte	Unit	Average Lab Blank	Detection Limit (MDL) (range; mean)	Average Reporting Limit (RL)	RSD of Lab Duplicates (% range; % mean)	RSD of Field Duplicates (% range; % mean)	Percent Recovery of CRM (% range; % mean)	Percent Recovery of Matrix Spike (% range; % mean)
Carbaryl	ug/L	0	0.01-0.01; 0.01	0.02	75.71-75.71; 75.71	1.39-83.55; 42.47	NA	90-116; 102.3
Fipronil	ug/L	0	0-0.01; 0	0.0064	NA	0-141.42; 37.68	NA	45-112.5; 74.4
NH4	mg/L	0.0018	0.01-0.02; 0.01	0	0-9.87; 1.89	0-9.87; 2.43	NA	NA
NO3	mg/L	0	0-0.02; 0.01	0.046	NA	0-4.47; 0.35	NA	105-105; 105
NO2	mg/L	0	0-0; 0	0.013	0-0.73; 0.29	0-4.04; 0.56	NA	89-103.5; 96.5
TKN	mg/L	0	0.07-0.4; 0.23	0.1	0-47.88; 13.65	0-36.35; 14.94	NA	NA
PO4	mg/L	0	0-0.06; 0.01	0.011	0-1.61; 0.9	0-5.29; 1.16	NA	83.5-107; 97.8
Total P	mg/L	0	0.01-0.1; 0.03	0.01	0-2.4; 0.79	0-14.24; 3.86	NA	86-86; 86
SSC	mg/L	470	0.23-6.8; 2.55	3	NA	0-50.63; 13.23	99.8-99.8; 99.8	NA
Benz(a)anthracenes /Chrysenes, C1-	pg/L	102	99-75500; 3661.22	NA	1.01-6.77; 3.96	1.01-27.92; 8.64	NA	NA
Benz(a)anthracenes /Chrysenes, C2-	pg/L	164	118-43100; 2374.97	NA	2.59-16.42; 9.24	0.64-25.76; 9.46	NA	NA
Fluoranthene	pg/L	106	57.9-2580; 481.01	NA	1.26-15.98; 6.48	2.21-33.15; 17.99	NA	NA
Fluoranthene/Pyrenes, C1-	pg/L	430	138-25400; 2277.5	NA	2.63-4.4; 3.3	2.63-24.68; 13.55	NA	NA
Fluorenes, C3-	pg/L	1588	45.1-29400; 1888.57	NA	0.13-5.43; 2.09	0.69-15.99; 8.69	NA	NA
Naphthalenes, C4-	pg/L	2864	95.5-3540; 918.73	NA	2.44-10.96; 6.45	2.44-78.83; 18.97	NA	NA
Phenanthrene/Anthracene, C4-	pg/L	1565	208-27100; 3350.34	NA	0-6.39; 2.27	0.43-23.46; 8.75	NA	NA
Pyrene	pg/L	77.4	57.4-5960; 662.16	NA	0.99-14.38; 5.71	1.59-31.82; 16.25	NA	NA
PBDE 047	pg/L	40.9	0.37-0.87; 0.41	NA	0.39-18.19; 6.09	1.2-13.82; 6.86	NA	NA
PBDE 099	pg/L	43.4	0.47-12.4; 3.19	NA	1.99-9.88; 5.14	1.81-15.1; 7.31	NA	NA
PBDE 209	pg/L	76	12.7-146; 49.83	NA	2.21-42.31; 17.67	1.39-45.22; 19.57	NA	NA
PCB 087	pg/L	0.834	0.18-5.42; 0.87	NA	0-31.19; 13.75	0-31.19; 12.29	NA	NA
PCB 095	pg/L	1.31	0.18-6.23; 1	NA	3.89-37.99; 16.43	0.59-37.99; 14.24	NA	NA
PCB 110	pg/L	1.27	0.18-4.58; 0.74	NA	0.27-25.61; 12.31	0.27-27.4; 12.04	NA	NA
PCB 138	pg/L	2.36	0.25-19.8; 2.26	NA	3.01-25.44; 11.74	0.34-25.44; 9.04	NA	NA
PCB 149	pg/L	1.3	0.26-21.3; 2.45	NA	1.97-31.09; 11.26	1.97-28.66; 10.39	NA	NA
PCB 151	pg/L	0.56	0.18-8.38; 0.75	NA	0.26-29.2; 8.97	0.26-39.81; 10.25	NA	NA
PCB 153	pg/L	2.44	0.22-17.4; 2	NA	1.21-24.37; 10.36	0.59-23.88; 9.57	NA	NA
PCB 174	pg/L	0.039	0.2-4; 0.78	NA	0.25-36.32; 6.22	0.25-37.01; 7.79	NA	NA
PCB 180	pg/L	0.91	0.18-4.52; 0.68	NA	0.43-29.54; 6.15	0.43-23.7; 8.7	NA	NA
Bifenthrin	pg/L	274	1500-5520; 2830	NA	NA	4.8-34.98; 16.11	NA	NA
Cypermethrin	pg/L	0	968-5290; 2694.53	NA	NA	27.58-27.58; 27.58	NA	NA
Delta/Tralomethrin	pg/L	243	185-862; 353.6	NA	NA	22.99-32.44; 27.71	NA	NA
Total Cu	ug/L	0	0.04-0.42; 0.16	0.55	0.2-2.68; 0.88	0.2-10.56; 3.31	104.2-104.2; 104.2	100-100.6; 100.3
Dissolved Cu	ug/L	0	0.04-0.42; 0.12	0.5	NA	3.01-27.52;	104.2-104.2;	100-100.6; 100.3

Analyte	Unit	Average Lab Blank	Detection Limit (MDL) (range; mean)	Average Reporting Limit (RL)	RSD of Lab Duplicates (% range; % mean)	RSD of Field Duplicates (% range; % mean)	Percent Recovery of CRM (% range; % mean)	Percent Recovery of Matrix Spike (% range; % mean)
						10.41	104.2	
Total Hg	ug/L	0	0-0; 0	0.0005	2.12-2.12; 2.12	1.07-31.06; 8.59	98.5-98.5; 98.5	100-100.8; 100.4
Total MeHg	ng/L	0.006	0.01-0.02; 0.02	0.033	0.97-5.87; 3.35	0-37.52; 6.34	NA	74.2-90.4; 85.4
Total Se	ug/L	0.006	0.02-0.06; 0.04	0.086	0-2.4; 0.79	0-14.24; 3.86	103.4-103.4; 103.4	86.5-90.3; 88.4
Dissolved Se	ug/L	0	0.02-0.06; 0.04	0.15	6.18-6.18; 6.18	0-8.59; 4.72	103.4-103.4; 103.4	86.5-90.3; 88.4
TOC	ug/L	0	0.3-0.35; 0.32	462	NA	NA	NA	NA

Table A2: Field blank data from all sites.

AnalyteName	Unit	Average MDL	RL	Minimum Field Blank	Maximum Field Blank	Average Field Blank
Carbaryl	ug/L	0.01	0.02	ND	ND	ND
Fipronil	ug/L	0.000875	0.004	ND	ND	ND
Fipronil Desulfinyl	ug/L	0.000625	0.0028	ND	ND	ND
Fipronil Sulfide	ug/L	0.000625	0.0028	ND	ND	ND
Fipronil Sulfone	ug/L	0.000875	0.004	ND	ND	ND
NH4	mg/L	0.01	-	0.01	0.01	0.01
NO3	mg/L	0.0164	0.041	ND	0.039	0.0078
NO2	mg/L	0.001142	0.01	ND	0.025	0.005
TKN	mg/L	0.18	0.1	ND	ND	ND
PO4	mg/L	0.006	0.01	ND	ND	ND
Total P	mg/L	0.0076	0.01	ND	0.018	0.0052
SSC	pg/L	653	-	ND	ND	ND
Acenaphthene	pg/L	147	-	ND	ND	ND
Acenaphthylene	pg/L	119.5	-	ND	ND	ND
Anthracene	pg/L	230	-	ND	ND	ND
Benz(a)anthracene	pg/L	68.5	-	ND	ND	ND
Benz(a)anthracenes/Chrysenes, C1-	pg/L	31	-	69.5	109	89.25
Benz(a)anthracenes/Chrysenes, C2-	pg/L	63.05	-	171	393	282
Benz(a)anthracenes/Chrysenes, C3-	pg/L	64.9	-	149	389	269
Benz(a)anthracenes/Chrysenes, C4-	pg/L	66.35	-	449	1030	739.5
Benzo(a)pyrene	pg/L	199	-	ND	ND	ND
Benzo(b)fluoranthene	pg/L	82.05	-	ND	ND	ND
Benzo(e)pyrene	pg/L	182.5	-	ND	ND	ND
Benzo(g,h,i)perylene	pg/L	123.9	-	ND	ND	ND
Benzo(k)fluoranthene	pg/L	110	-	ND	ND	ND
Chrysene	pg/L	72.3	-	ND	86.5	43.25
Dibenz(a,h)anthracene	pg/L	119	-	ND	ND	ND
Dibenzothiophene	pg/L	78.6	-	ND	ND	ND
Dibenzothiophenes, C1-	pg/L	63.85	-	ND	ND	ND

AnalyteName	Unit	Average MDL	RL	Minimum Field Blank	Maximum Field Blank	Average Field Blank
Dibenzothiophenes, C2-	pg/L	62.9	-	278	582	430
Dibenzothiophenes, C3-	pg/L	48.95	-	576	771	673.5
Dimethylnaphthalene, 2,6-	pg/L	422	-	ND	ND	ND
Fluoranthene	pg/L	45.15	-	238	343	290.5
Fluoranthene/Pyrenes, C1-	pg/L	90.05	-	82.8	716	399.4
Fluorene	pg/L	207.5	-	ND	ND	ND
Fluorenes, C2-	pg/L	139.15	-	2080	2730	2405
Fluorenes, C3-	pg/L	133.5	-	2950	4130	3540
Indeno(1,2,3-c,d)pyrene	pg/L	43.1	-	ND	ND	ND
Methylnaphthalene, 2-	pg/L	479.5	-	ND	677	338.5
Methylphenanthrene, 1-	pg/L	210.7	-	ND	89.5	44.75
Naphthalene	pg/L	207	-	2330	21200	11765
Naphthalenes, C1-	pg/L	129	-	ND	1120	560
Naphthalenes, C3-	pg/L	298.5	-	941	3940	2440.5
Perylene	pg/L	213.5	-	ND	ND	ND
Phenanthrene	pg/L	101.6	-	469	608	538.5
Phenanthrene/Anthracene, C1-	pg/L	210.7	-	ND	335	167.5
Phenanthrene/Anthracene, C2-	pg/L	82.95	-	423	843	633
Pyrene	pg/L	43.25	-	179	229	204
Trimethylnaphthalene, 2,3,5-	pg/L	154.5	-	ND	189	94.5
PBDE 007	pg/L	0.3775	-	ND	1.64	0.82
PBDE 008	pg/L	0.3775	-	ND	1.3	0.65
PBDE 010	pg/L	0.527	-	ND	ND	ND
PBDE 011	pg/L	-	-	-	-	-
PBDE 012	pg/L	0.3775	-	ND	0.793	0.3965
PBDE 013	pg/L	-	-	-	-	-
PBDE 015	pg/L	0.3775	-	ND	4.16	2.08
PBDE 017	pg/L	0.3905	-	ND	23.6	11.8
PBDE 025	pg/L	-	-	-	-	-
PBDE 028	pg/L	0.3775	-	0.811	29	14.9055
PBDE 030	pg/L	0.4105	-	ND	ND	ND
PBDE 032	pg/L	0.3775	-	ND	ND	ND
PBDE 033	pg/L	-	-	-	-	-
PBDE 035	pg/L	1.7285	-	ND	ND	ND
PBDE 047	pg/L	0.3775	-	26.4	1040	533.2
PBDE 049	pg/L	0.3775	-	0.845	86.3	43.5725
PBDE 051	pg/L	0.3775	-	ND	8.65	4.325
PBDE 066	pg/L	0.3775	-	ND	49.4	24.7
PBDE 071	pg/L	0.3775	-	ND	14.3	7.15
PBDE 075	pg/L	1.6885	-	ND	ND	ND
PBDE 077	pg/L	0.529	-	ND	ND	ND

AnalyteName	Unit	Average MDL	RL	Minimum Field Blank	Maximum Field Blank	Average Field Blank
PBDE 079	pg/L	0.3775	-	ND	ND	ND
PBDE 085	pg/L	0.8735	-	1.49	57.8	29.645
PBDE 099	pg/L	0.6535	-	29.9	1200	614.95
PBDE 100	pg/L	0.505	-	6.47	281	143.735
PBDE 105	pg/L	1.0985	-	ND	ND	ND
PBDE 116	pg/L	1.557	-	ND	11.3	5.65
PBDE 119	pg/L	0.9635	-	ND	6.86	3.43
PBDE 120	pg/L	-	-	-	-	-
PBDE 126	pg/L	0.619	-	ND	1.21	0.605
PBDE 128	pg/L	9.519	-	ND	ND	ND
PBDE 140	pg/L	0.5205	-	ND	6.77	3.385
PBDE 153	pg/L	0.4765	-	3.34	135	69.17
PBDE 155	pg/L	0.382	-	ND	9.43	4.715
PBDE 166	pg/L	-	-	-	-	-
PBDE 181	pg/L	2.3685	-	ND	ND	ND
PBDE 183	pg/L	1.715	-	ND	43.7	21.85
PBDE 190	pg/L	6.1835	-	ND	ND	ND
PBDE 197	pg/L	4.52	-	2.36	97.3	49.83
PBDE 203	pg/L	4.9135	-	5.08	123	64.04
PBDE 204	pg/L	-	-	-	-	-
PBDE 205	pg/L	8.683	-	ND	ND	ND
PBDE 206	pg/L	24.92	-	ND	1400	700
PBDE 207	pg/L	2.2935	-	75.6	2330	1202.8
PBDE 208	pg/L	25.115	-	ND	1690	845
PBDE 209	pg/L	9.99	-	1240	22900	12070
PCB 008	pg/L	1.4536	-	ND	1.33	0.4176
PCB 018	pg/L	0.5882	-	ND	1.37	0.748
PCB 020	pg/L	-	-	-	-	-
PCB 021	pg/L	-	-	-	-	-
PCB 028	pg/L	0.2558	-	1.58	2.43	2.05
PCB 030	pg/L	-	-	-	-	-
PCB 031	pg/L	0.4338	-	ND	1.61	1.082
PCB 033	pg/L	0.2446	-	0.617	0.915	0.7782
PCB 044	pg/L	0.7	-	ND	2.94	1.85
PCB 047	pg/L	-	-	-	-	-
PCB 049	pg/L	0.2668	-	0.782	2.07	1.1386
PCB 052	pg/L	0.734	-	ND	2.65	2.06
PCB 056	pg/L	0.3356	-	0.408	0.909	0.6332
PCB 060	pg/L	0.3888	-	ND	1.3	0.3304
PCB 061	pg/L	-	-	-	-	-
PCB 065	pg/L	-	-	-	-	-

AnalyteName	Unit	Average MDL	RL	Minimum Field Blank	Maximum Field Blank	Average Field Blank
PCB 066	pg/L	0.4328	-	ND	4.87	1.5982
PCB 069	pg/L	-	-	-	-	-
PCB 070	pg/L	0.317	-	2.33	5.91	3.478
PCB 074	pg/L	-	-	-	-	-
PCB 076	pg/L	-	-	-	-	-
PCB 083	pg/L	-	-	-	-	-
PCB 086	pg/L	-	-	-	-	-
PCB 087	pg/L	0.3138	-	2.53	3.74	2.962
PCB 090	pg/L	-	-	-	-	-
PCB 093	pg/L	-	-	-	-	-
PCB 095	pg/L	0.354	-	2.76	4.39	3.568
PCB 097	pg/L	-	-	-	-	-
PCB 098	pg/L	-	-	-	-	-
PCB 099	pg/L	0.3666	-	1.39	2.4	1.952
PCB 100	pg/L	-	-	-	-	-
PCB 101	pg/L	0.3208	-	3.14	3.92	3.422
PCB 102	pg/L	-	-	-	-	-
PCB 105	pg/L	0.7304	-	ND	2.16	1.048
PCB 108	pg/L	-	-	-	-	-
PCB 110	pg/L	0.2704	-	3.43	6.53	4.968
PCB 113	pg/L	-	-	-	-	-
PCB 115	pg/L	-	-	-	-	-
PCB 118	pg/L	0.355	-	1.72	3.74	2.778
PCB 119	pg/L	-	-	-	-	-
PCB 125	pg/L	-	-	-	-	-
PCB 128	pg/L	0.401	-	0.28	1.27	0.7448
PCB 129	pg/L	-	-	-	-	-
PCB 132	pg/L	0.4912	-	0.846	2.72	1.6392
PCB 135	pg/L	-	-	-	-	-
PCB 138	pg/L	0.3996	-	1.76	5.37	3.33
PCB 141	pg/L	0.4506	-	ND	0.78	0.2378
PCB 147	pg/L	-	-	-	-	-
PCB 149	pg/L	0.4212	-	1.63	3.64	2.39
PCB 151	pg/L	0.3766	-	ND	1.65	0.978
PCB 153	pg/L	0.355	-	1.19	3.08	1.826
PCB 154	pg/L	-	-	-	-	-
PCB 156	pg/L	0.409	-	ND	0.581	0.2076
PCB 157	pg/L	-	-	-	-	-
PCB 158	pg/L	0.3134	-	ND	0.602	0.1204
PCB 160	pg/L	-	-	-	-	-
PCB 163	pg/L	-	-	-	-	-

AnalyteName	Unit	Average MDL	RL	Minimum Field Blank	Maximum Field Blank	Average Field Blank
PCB 166	pg/L	-	-	-	-	-
PCB 168	pg/L	-	-	-	-	-
PCB 170	pg/L	0.3922	-	ND	1.09	0.5358
PCB 174	pg/L	0.4822	-	ND	0.58	0.2824
PCB 177	pg/L	0.3628	-	ND	0.645	0.1854
PCB 180	pg/L	0.6086	-	ND	1.66	0.4408
PCB 183	pg/L	0.4356	-	ND	0.24	0.048
PCB 185	pg/L	-	-	-	-	-
PCB 187	pg/L	0.3644	-	ND	1.31	0.3662
PCB 193	pg/L	-	-	-	-	-
PCB 194	pg/L	0.3704	-	ND	ND	ND
PCB 195	pg/L	0.3968	-	ND	ND	ND
PCB 201	pg/L	0.295	-	ND	ND	ND
PCB 203	pg/L	0.3798	-	ND	ND	ND
Allethrin	pg/L	2790	-	ND	ND	ND
Bifenthrin	pg/L	949	-	ND	ND	ND
Cyfluthrin, total	pg/L	7020	-	ND	ND	ND
Cyhalothrin,lambda, total	pg/L	748	-	ND	ND	ND
Cypermethrin, total	pg/L	997	-	ND	ND	ND
Delta/Tralomethrin	pg/L	539	-	ND	ND	ND
Esfenvalerate/Fenvalerate, total	pg/L	845	-	ND	ND	ND
Fenpropathrin	pg/L	1770	-	ND	ND	ND
Permethrin, total	pg/L	287	-	ND	ND	ND
Phenothrin	pg/L	525	-	ND	ND	ND
Prallethrin	pg/L	7020	-	ND	ND	ND
Resmethrin	pg/L	653	-	ND	ND	ND
Calcium	ug/L	6.32	31.6	ND	ND	ND
Total Cu	ug/L	0.063	0.4013	ND	1.13	0.365
Dissolved Cu	ug/L	0.063	0.4013	ND	0.681	0.17025
Magnesium	pg/L	43.1	-	ND	ND	ND
Total Hg	ug/L	0.000198	0.0004	ND	0.0044	0.00092
Total MeHg	ng/L	0.018571429	0.0314	ND	0.021	0.003
Dissolved Se	ug/L	0.051	0.093	ND	ND	ND
Total Se	ug/L	0.051	0.093	ND	ND	ND
Total Hardness (calc)	mg/L	0.02	0.09	ND	ND	ND
TOC	mg/L	-	-	-	-	-

Table A3: Average RSD of field and lab duplicates at each site.

Analyte	San Leandro		Sunnyvale Channel		Lower Marsh Creek		Guadalupe River		Richmond Pump Station		Pulgas Creek Pump Station	
	Avg Field RSD	Avg Lab RSD	Avg Field RSD	Avg Lab RSD	Avg Field RSD	Avg Lab RSD	Avg Field RSD	Avg Lab RSD	Avg Field RSD	Avg Lab RSD	Avg Field RSD	Avg Lab RSD
Carbaryl	-	-	-	-	-	-	83.5%	75.7%	-	-	1.4%	-
Fipronil	79.5%	-	-	-	9.2%	-	10.9%	-	-	-	-	-
Fipronil Desulfinyl	10.9%	-	0.0%	-	15.5%	-	-	-	-	-	-	-
Fipronil Sulfide	0.0%	-	-	-	-	-	-	-	-	-	-	-
Fipronil Sulfone	0.0%	-	-	-	4.9%	-	-	-	-	-	-	-
NH4	3.1%	0.0%	1.8%	1.5%	4.0%	4.9%	0.0%	0.0%	3.3%	-	-	-
NO3	0.0%	0.0%	0.0%	0.0%	1.1%	-	0.0%	0.0%	0.0%	-	0.0%	-
NO2	1.0%	0.7%	0.0%	0.0%	1.0%	-	0.0%	0.0%	0.0%	-	0.0%	-
TKN	10.2%	3.4%	-	-	14.5%	23.9%	12.0%	-	31.4%	-	-	-
PO4	0.3%	0.8%	0.9%	0.9%	0.3%	-	1.5%	1.1%	0.0%	-	4.7%	-
Total P	7.1%	0.0%	0.0%	0.0%	3.0%	2.4%	0.0%	0.0%	2.9%	-	-	-
SSC	12.3%	-	11.9%	-	11.5%	-	8.6%	-	19.6%	-	19.9%	-
Acenaphthene	20.1%	-	-	-	-	-	10.0%	0.4%	1.5%	1.5%	-	-
Acenaphthylene	10.7%	-	-	-	-	-	31.8%	18.1%	5.5%	5.5%	-	-
Anthracene	14.2%	-	24.6%	9.4%	43.4%	-	39.1%	23.4%	5.7%	5.7%	-	-
Benz(a)anthracene	15.3%	-	-	-	-	-	-	-	-	-	-	-
Benz(a)anthracenes/Chrysenes, C1-	5.7%	-	6.9%	4.1%	2.9%	-	17.3%	6.8%	1.0%	1.0%	-	-
Benz(a)anthracenes/Chrysenes, C2-	4.3%	-	7.5%	8.7%	6.0%	-	19.0%	16.4%	2.6%	2.6%	-	-
Benz(a)anthracenes/Chrysenes, C3-	23.6%	-	6.3%	6.9%	11.1%	-	40.2%	8.9%	0.7%	0.7%	-	-
Benz(a)anthracenes/Chrysenes, C4-	5.9%	-	25.2%	20.6%	10.6%	-	16.7%	7.0%	0.3%	0.3%	-	-
Benzo(a)pyrene	16.7%	-	19.5%	7.0%	20.8%	-	23.6%	6.5%	1.1%	1.1%	-	-
Benzo(b)fluoranthene	9.3%	-	10.2%	2.7%	26.6%	-	17.5%	5.2%	4.7%	4.7%	-	-
Benzo(e)pyrene	13.5%	-	7.0%	4.4%	9.9%	-	28.4%	5.9%	0.9%	0.9%	-	-
Benzo(g,h,i)perylene	16.6%	-	8.8%	0.0%	4.6%	-	14.2%	5.3%	4.5%	4.5%	-	-
Benzo(k)fluoranthene	36.4%	-	20.6%	1.8%	-	-	33.0%	2.8%	2.0%	2.0%	-	-
Chrysene	8.4%	-	11.6%	1.3%	9.5%	-	19.0%	7.5%	2.2%	2.2%	-	-

Analyte	San Leandro		Sunnyvale Channel		Lower Marsh Creek		Guadalupe River		Richmond Pump Station		Pulgas Creek Pump Station	
	Avg Field RSD	Avg Lab RSD	Avg Field RSD	Avg Lab RSD	Avg Field RSD	Avg Lab RSD	Avg Field RSD	Avg Lab RSD	Avg Field RSD	Avg Lab RSD	Avg Field RSD	Avg Lab RSD
Dibenz(a,h)anthracene	39.9%	-	31.9%	9.9%	-	-	-	-	2.1%	2.1%	-	-
Dibenzothiophene	-	-	8.5%	2.1%	-	-	15.9%	13.0%	-	-	-	-
Dibenzothiophenes, C1-	8.9%	-	6.3%	1.7%	5.1%	-	24.6%	2.9%	2.5%	2.5%	-	-
Dibenzothiophenes, C2-	4.5%	-	3.8%	0.7%	10.2%	-	12.2%	2.9%	6.1%	6.1%	-	-
Dibenzothiophenes, C3-	4.8%	-	7.3%	2.1%	8.0%	-	14.7%	0.8%	0.5%	0.5%	-	-
Dimethylnaphthalene, 2,6-	22.2%	-	4.7%	1.6%	0.4%	-	12.2%	13.8%	7.1%	7.1%	-	-
Fluoranthene	16.0%	-	16.3%	1.3%	33.2%	-	17.2%	16.0%	2.2%	2.2%	-	-
Fluoranthene/Pyrenes, C1-	16.3%	-	10.5%	4.4%	8.7%	-	17.4%	2.9%	2.6%	2.6%	-	-
Fluorene	15.3%	-	-	-	-	-	15.8%	9.1%	3.7%	3.7%	-	-
Fluorenes, C2-	14.0%	-	7.3%	8.9%	0.8%	-	9.4%	1.2%	1.8%	1.8%	-	-
Fluorenes, C3-	7.0%	-	8.6%	5.4%	9.0%	-	12.3%	0.1%	0.7%	0.7%	-	-
Indeno(1,2,3-c,d)pyrene	21.9%	-	14.5%	0.4%	14.9%	-	18.1%	5.3%	8.9%	8.9%	-	-
Methylnaphthalene, 2-	9.3%	-	3.3%	1.1%	2.1%	-	10.6%	6.3%	3.4%	3.4%	-	-
Methylphenanthrene, 1-	16.7%	-	12.7%	13.6%	11.6%	-	14.6%	10.7%	0.0%	0.0%	-	-
Naphthalene	10.3%	-	7.6%	1.5%	3.2%	-	2.1%	3.8%	0.5%	0.5%	-	-
Naphthalenes, C1-	14.5%	-	-	-	0.5%	-	7.5%	5.7%	3.4%	3.4%	-	-
Naphthalenes, C3-	17.2%	-	1.3%	1.9%	0.6%	-	8.9%	11.2%	8.5%	8.5%	-	-
Perylene	17.6%	-	20.8%	4.2%	5.0%	-	25.6%	8.6%	-	-	-	-
Phenanthrene	5.8%	-	33.9%	6.1%	29.0%	-	21.3%	26.5%	1.6%	1.6%	-	-
Phenanthrene/Anthracene, C1-	28.7%	-	12.0%	2.1%	13.7%	-	13.0%	0.2%	2.5%	2.5%	-	-
Phenanthrene/Anthracene, C2-	15.6%	-	6.0%	8.4%	7.1%	-	12.9%	8.1%	3.9%	3.9%	-	-
Pyrene	16.7%	-	13.4%	1.0%	19.5%	-	19.2%	14.4%	1.7%	1.7%	-	-
Trimethylnaphthalene, 2,3,5-	22.1%	-	3.6%	0.3%	2.3%	-	17.6%	9.0%	-	-	-	-
PBDE 007	-	-	-	-	-	-	-	11.2%	15.4%	15.6%	2.0%	2.0%
PBDE 008	8.3%	4.7%	-	-	-	-	-	-	56.9%	65.0%	6.5%	6.5%
PBDE 010	-	-	-	-	-	-	-	-	-	-	-	-
PBDE 011	-	-	-	-	-	-	-	-	-	-	-	-

Analyte	San Leandro		Sunnyvale Channel		Lower Marsh Creek		Guadalupe River		Richmond Pump Station		Pulgas Creek Pump Station	
	Avg Field RSD	Avg Lab RSD	Avg Field RSD	Avg Lab RSD	Avg Field RSD	Avg Lab RSD	Avg Field RSD	Avg Lab RSD	Avg Field RSD	Avg Lab RSD	Avg Field RSD	Avg Lab RSD
PBDE 012	-	-	-	-	-	-	-	11.7%	68.7%	73.4%	9.5%	9.5%
PBDE 013	-	-	-	-	-	-	-	-	-	-	-	-
PBDE 015	11.7%	9.5%	-	-	-	-	3.2%	4.3%	13.8%	15.4%	7.5%	7.5%
PBDE 017	5.9%	12.7%	7.6%	-	-	-	-	-	9.1%	5.0%	12.9%	12.9%
PBDE 025	-	-	-	-	-	-	-	-	-	-	-	-
PBDE 028	4.5%	7.0%	0.9%	-	-	-	15.6%	20.7%	5.8%	2.0%	14.9%	14.9%
PBDE 030	-	-	-	-	-	-	-	-	-	-	-	-
PBDE 032	-	-	-	-	-	-	-	-	-	-	-	-
PBDE 033	-	-	-	-	-	-	-	-	-	-	-	-
PBDE 035	-	-	-	-	-	-	-	-	-	-	-	-
PBDE 047	2.9%	1.2%	5.9%	-	-	-	13.8%	18.2%	12.0%	0.4%	4.6%	4.6%
PBDE 049	5.0%	0.7%	1.7%	-	-	-	10.2%	8.6%	5.7%	0.7%	12.4%	12.4%
PBDE 051	5.7%	5.7%	-	-	-	-	-	-	16.2%	7.8%	15.3%	15.3%
PBDE 066	2.3%	0.5%	1.0%	-	-	-	13.8%	14.1%	6.2%	1.7%	8.4%	8.4%
PBDE 071	1.9%	1.9%	-	-	-	-	-	-	-	-	32.7%	32.7%
PBDE 075	0.7%	0.7%	9.8%	-	-	-	-	-	-	-	22.0%	22.0%
PBDE 077	15.8%	15.8%	-	-	-	-	-	-	-	-	-	-
PBDE 079	16.4%	16.4%	-	-	-	-	-	-	11.3%	13.2%	-	-
PBDE 085	6.3%	5.2%	5.7%	-	-	-	4.6%	5.7%	19.6%	2.4%	2.9%	2.9%
PBDE 099	4.8%	3.9%	6.2%	-	-	-	8.1%	9.9%	15.1%	2.0%	4.8%	4.8%
PBDE 100	2.8%	0.3%	6.5%	-	-	-	9.2%	11.7%	14.6%	0.0%	6.0%	6.0%
PBDE 105	-	-	-	-	-	-	-	-	-	-	-	-
PBDE 116	-	-	-	-	-	-	-	-	-	-	-	-
PBDE 119	6.8%	6.3%	-	-	-	-	-	21.0%	34.7%	13.6%	-	-
PBDE 120	-	-	-	-	-	-	-	-	-	-	-	-
PBDE 126	-	-	-	-	-	-	-	-	-	-	-	-
PBDE 128	-	-	-	-	-	-	-	-	-	-	-	-

Analyte	San Leandro		Sunnyvale Channel		Lower Marsh Creek		Guadalupe River		Richmond Pump Station		Pulgas Creek Pump Station	
	Avg Field RSD	Avg Lab RSD	Avg Field RSD	Avg Lab RSD	Avg Field RSD	Avg Lab RSD	Avg Field RSD	Avg Lab RSD	Avg Field RSD	Avg Lab RSD	Avg Field RSD	Avg Lab RSD
PBDE 140	-	-	-	-	-	-	12.1%	12.5%	10.0%	1.6%	9.8%	9.8%
PBDE 153	6.9%	6.6%	5.5%	-	-	-	6.2%	7.1%	12.5%	1.4%	3.5%	3.5%
PBDE 155	8.1%	12.5%	-	-	-	-	6.4%	7.8%	15.2%	1.0%	6.0%	6.0%
PBDE 166	-	-	-	-	-	-	-	-	-	-	-	-
PBDE 181	-	-	-	-	-	-	-	-	-	-	-	-
PBDE 183	21.3%	1.5%	-	-	-	-	27.4%	32.6%	17.6%	11.2%	11.0%	11.0%
PBDE 190	-	-	-	-	-	-	-	-	-	-	1.7%	1.7%
PBDE 197	42.2%	12.3%	15.8%	-	-	-	-	-	-	-	1.7%	1.7%
PBDE 203	26.6%	17.6%	-	-	-	-	-	3.3%	33.4%	21.4%	4.6%	4.6%
PBDE 204	-	-	-	-	-	-	-	-	-	-	-	-
PBDE 205	-	-	-	-	-	-	-	-	-	-	-	-
PBDE 206	9.0%	23.9%	8.8%	-	-	-	6.1%	7.6%	34.1%	17.3%	37.3%	37.3%
PBDE 207	12.8%	25.5%	5.8%	-	-	-	2.0%	2.1%	34.9%	24.4%	28.2%	28.2%
PBDE 208	17.6%	23.7%	13.0%	-	-	-	3.5%	4.1%	36.6%	25.3%	30.5%	30.5%
PBDE 209	22.5%	19.4%	2.2%	-	-	-	2.1%	2.2%	35.6%	6.7%	42.3%	42.3%
PCB 008	15.5%	10.4%	13.6%	13.6%	20.0%	-	5.0%	0.3%	6.8%	3.1%	10.4%	11.9%
PCB 018	13.9%	4.1%	10.0%	10.0%	15.9%	-	4.2%	0.7%	12.3%	5.2%	6.5%	6.5%
PCB 020	-	-	-	-	-	-	-	-	-	-	-	-
PCB 021	-	-	-	-	-	-	-	-	-	-	-	-
PCB 028	10.8%	12.5%	5.9%	7.5%	4.7%	-	3.8%	1.2%	10.9%	3.6%	8.8%	5.4%
PCB 030	-	-	-	-	-	-	-	-	-	-	-	-
PCB 031	11.1%	9.1%	5.1%	7.5%	8.5%	-	4.7%	0.7%	11.3%	2.7%	7.1%	0.8%
PCB 033	13.8%	7.2%	6.4%	8.2%	13.2%	-	3.1%	0.4%	11.3%	7.0%	10.4%	0.4%
PCB 044	4.9%	9.9%	6.6%	10.0%	2.9%	-	6.5%	13.3%	13.0%	8.6%	9.0%	0.2%
PCB 047	-	-	-	-	-	-	-	-	-	-	-	-
PCB 049	6.6%	9.6%	5.6%	8.5%	5.5%	-	5.1%	13.6%	14.3%	12.8%	10.0%	2.0%
PCB 052	8.0%	13.8%	7.6%	10.4%	9.9%	-	7.0%	14.4%	19.2%	22.6%	11.9%	6.6%

Analyte	San Leandro		Sunnyvale Channel		Lower Marsh Creek		Guadalupe River		Richmond Pump Station		Pulgas Creek Pump Station	
	Avg Field RSD	Avg Lab RSD	Avg Field RSD	Avg Lab RSD	Avg Field RSD	Avg Lab RSD	Avg Field RSD	Avg Lab RSD	Avg Field RSD	Avg Lab RSD	Avg Field RSD	Avg Lab RSD
PCB 056	6.4%	5.1%	13.7%	7.3%	2.2%	-	5.5%	12.0%	7.2%	1.6%	11.9%	3.8%
PCB 060	6.1%	4.3%	16.9%	7.8%	2.0%	-	6.1%	13.6%	3.1%	3.1%	11.8%	3.2%
PCB 061	-	-	-	-	-	-	-	-	-	-	-	-
PCB 065	-	-	-	-	-	-	-	-	-	-	-	-
PCB 066	7.0%	8.0%	7.5%	8.9%	1.5%	-	8.2%	15.0%	2.3%	1.9%	11.5%	1.6%
PCB 069	-	-	-	-	-	-	-	-	-	-	-	-
PCB 070	8.9%	11.1%	7.8%	10.7%	2.2%	-	6.4%	15.5%	5.2%	9.9%	12.8%	5.5%
PCB 074	-	-	-	-	-	-	-	-	-	-	-	-
PCB 076	-	-	-	-	-	-	-	-	-	-	-	-
PCB 083	-	-	-	-	-	-	-	-	-	-	-	-
PCB 086	-	-	-	-	-	-	-	-	-	-	-	-
PCB 087	11.3%	10.2%	8.7%	9.9%	16.3%	-	6.3%	17.6%	17.3%	22.4%	16.7%	23.2%
PCB 090	-	-	-	-	-	-	-	-	-	-	-	-
PCB 093	-	-	-	-	-	-	-	-	-	-	-	-
PCB 095	13.9%	14.3%	6.2%	7.5%	18.2%	-	11.5%	18.8%	19.8%	29.8%	16.8%	27.1%
PCB 097	-	-	-	-	-	-	-	-	-	-	-	-
PCB 098	-	-	-	-	-	-	-	-	-	-	-	-
PCB 099	11.9%	10.9%	7.6%	7.4%	15.0%	-	8.1%	18.7%	19.6%	24.7%	18.5%	28.6%
PCB 100	-	-	-	-	-	-	-	-	-	-	-	-
PCB 101	10.8%	9.0%	7.6%	8.4%	19.9%	-	13.0%	18.6%	18.0%	23.9%	16.8%	33.0%
PCB 102	-	-	-	-	-	-	-	-	-	-	-	-
PCB 105	7.7%	7.9%	8.5%	11.0%	13.4%	-	7.7%	19.2%	8.1%	17.8%	18.6%	22.5%
PCB 108	-	-	-	-	-	-	-	-	-	-	-	-
PCB 110	10.7%	9.1%	6.9%	6.1%	16.3%	-	8.4%	18.2%	15.9%	20.9%	17.2%	23.3%
PCB 113	-	-	-	-	-	-	-	-	-	-	-	-
PCB 115	-	-	-	-	-	-	-	-	-	-	-	-
PCB 118	8.5%	8.6%	8.6%	8.7%	15.0%	-	8.1%	20.8%	9.2%	21.2%	17.2%	27.9%

Analyte	San Leandro		Sunnyvale Channel		Lower Marsh Creek		Guadalupe River		Richmond Pump Station		Pulgas Creek Pump Station	
	Avg Field RSD	Avg Lab RSD	Avg Field RSD	Avg Lab RSD	Avg Field RSD	Avg Lab RSD	Avg Field RSD	Avg Lab RSD	Avg Field RSD	Avg Lab RSD	Avg Field RSD	Avg Lab RSD
PCB 119	-	-	-	-	-	-	-	-	-	-	-	-
PCB 125	-	-	-	-	-	-	-	-	-	-	-	-
PCB 128	7.6%	8.3%	5.5%	4.2%	29.2%	-	10.0%	26.9%	9.6%	15.0%	7.9%	7.7%
PCB 129	-	-	-	-	-	-	-	-	-	-	-	-
PCB 132	10.5%	9.2%	8.2%	4.7%	18.5%	-	11.8%	25.8%	6.5%	14.2%	7.4%	11.4%
PCB 135	-	-	-	-	-	-	-	-	-	-	-	-
PCB 138	8.5%	11.0%	7.6%	4.5%	12.4%	-	12.1%	25.2%	4.2%	10.8%	10.7%	16.8%
PCB 141	10.3%	10.3%	8.4%	3.5%	14.8%	-	14.0%	22.9%	4.6%	6.7%	12.8%	15.9%
PCB 147	-	-	-	-	-	-	-	-	-	-	-	-
PCB 149	10.2%	7.6%	8.7%	5.0%	13.5%	-	15.7%	31.1%	4.8%	10.4%	9.6%	19.3%
PCB 151	9.1%	4.9%	8.4%	5.2%	9.0%	-	25.9%	29.2%	2.8%	5.9%	7.3%	15.6%
PCB 153	8.3%	8.3%	9.7%	4.2%	12.6%	-	14.4%	24.4%	5.1%	7.6%	9.2%	19.8%
PCB 154	-	-	-	-	-	-	-	-	-	-	-	-
PCB 156	9.1%	9.9%	6.3%	3.1%	16.1%	-	10.0%	25.1%	11.2%	18.6%	8.0%	13.2%
PCB 157	-	-	-	-	-	-	-	-	-	-	-	-
PCB 158	9.9%	11.0%	6.5%	3.8%	16.7%	-	11.1%	24.8%	6.9%	13.8%	11.5%	16.7%
PCB 160	-	-	-	-	-	-	-	-	-	-	-	-
PCB 163	-	-	-	-	-	-	-	-	-	-	-	-
PCB 166	-	-	-	-	-	-	-	-	-	-	-	-
PCB 168	-	-	-	-	-	-	-	-	-	-	-	-
PCB 170	6.9%	4.7%	5.4%	1.4%	11.3%	-	13.2%	24.7%	8.5%	1.0%	6.8%	7.7%
PCB 174	4.9%	1.7%	5.6%	2.2%	11.5%	-	21.8%	36.3%	1.4%	1.3%	5.1%	7.2%
PCB 177	4.2%	3.7%	6.1%	3.4%	18.9%	-	22.1%	-	4.6%	4.6%	4.8%	6.0%
PCB 180	9.2%	1.7%	6.2%	3.0%	5.0%	-	15.4%	29.5%	8.1%	4.4%	7.0%	8.9%
PCB 183	3.6%	3.3%	6.6%	4.6%	16.7%	-	20.0%	31.6%	2.5%	5.5%	6.2%	11.3%
PCB 185	-	-	-	-	-	-	-	-	-	-	-	-
PCB 187	3.0%	3.8%	6.2%	3.9%	6.4%	-	23.8%	34.9%	3.1%	2.7%	6.0%	10.5%

Analyte	San Leandro		Sunnyvale Channel		Lower Marsh Creek		Guadalupe River		Richmond Pump Station		Pulgas Creek Pump Station	
	Avg Field RSD	Avg Lab RSD	Avg Field RSD	Avg Lab RSD	Avg Field RSD	Avg Lab RSD	Avg Field RSD	Avg Lab RSD	Avg Field RSD	Avg Lab RSD	Avg Field RSD	Avg Lab RSD
PCB 193	-	-	-	-	-	-	-	-	-	-	-	-
PCB 194	7.9%	3.3%	6.1%	5.6%	14.4%	-	16.1%	38.7%	12.4%	13.5%	5.9%	8.2%
PCB 195	4.7%	2.0%	7.1%	3.4%	29.7%	-	15.3%	26.9%	14.8%	14.1%	4.4%	3.8%
PCB 201	11.0%	2.4%	4.0%	1.1%	10.1%	-	24.4%	-	10.3%	5.6%	4.9%	8.2%
PCB 203	9.2%	6.7%	6.7%	5.4%	14.3%	-	18.2%	44.1%	10.7%	14.4%	6.0%	12.9%
Allethrin	-	-	-	-	-	-	-	-	-	-	-	-
Bifenthrin	35.0%	-	-	-	8.5%	-	4.8%	-	9.7%	-	-	-
Cyfluthrin, total	-	-	-	-	-	-	-	-	4.3%	-	-	-
Cyhalothrin,lambda, total	-	-	-	-	-	-	-	-	-	-	-	-
Cypermethrin, total	-	-	-	-	27.6%	-	-	-	1.6%	-	-	-
Delta/Tralomethrin	-	-	-	-	32.4%	-	23.0%	-	1.6%	-	-	-
Esfenvalerate/Fenvalerate, total	-	-	-	-	-	-	-	-	24.4%	-	-	-
Fenpropathrin	-	-	-	-	-	-	-	-	-	-	-	-
Permethrin, total	12.9%	-	2.4%	-	10.6%	-	2.1%	-	5.2%	-	-	-
Phenothrin	-	-	-	-	-	-	-	-	0.4%	0.4%	-	-
Prallethrin	-	-	-	-	-	-	-	-	0.0%	-	-	-
Resmethrin	-	-	-	-	-	-	-	-	1.7%	1.7%	-	-
Calcium	0.5%	0.4%	-	-	0.5%	0.5%	1.0%	1.0%	1.3%	1.3%	-	-
Total Cu	1.5%	1.1%	0.2%	0.2%	7.3%	0.8%	-	-	-	-	-	-
Dissolved Cu	9.8%	-	-	-	27.5%	-	-	-	3.0%	-	-	-
Magnesium	0.8%	0.6%	0.3%	0.3%	0.5%	0.5%	1.3%	1.3%	8.9%	8.9%	-	-
Total Hg	13.8%	2.1%	11.5%	-	5.7%	-	5.8%	-	-	-	10.1%	-
Total MeHg	14.4%	4.1%	3.1%	-	3.3%	-	6.1%	2.6%	-	-	0.0%	-
Dissolved Se	3.7%	6.2%	-	-	8.6%	-	-	-	5.2%	-	-	-
Total Se	14.0%	10.1%	-	-	6.4%	1.5%	1.4%	1.4%	-	-	-	-
Total Hardness (calc)	0.4%	-	-	-	-	-	-	-	-	-	-	-
TOC	1.3%	-	-	-	3.8%	-	-	-	15.7%	-	-	-

ALAMEDA COUNTYWIDE CLEAN WATER PROGRAM

REVIEW OF QUALITY ASSURANCE AND QUALITY CONTROL RESULTS FOR CREEK STATUS MONITORING

WATER YEARS 2012 AND 2013

MEMBER AGENCIES:

Alameda
Albany
Berkeley
Dublin
Emeryville
Fremont
Hayward
Livermore
Newark
Oakland
Piedmont
Pleasanton
San Leandro
Union City
County of Alameda
Alameda County Flood Control and Water Conservation District
Zone 7 Water Agency

Report prepared by

Alameda Countywide Clean Water Program
399 Elmhurst Street,
Hayward, California 94544

Submitted to:

California Regional Water Quality Control Board, San Francisco Bay Region)

FINAL

March 12, 2014

Protecting Alameda County Creeks, Wetlands & the Bay

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ACCWP appreciates the preparation of this report mainly through the contributions of Armand Ruby, as ACCWP's Local Quality Assurance Officer, and Gretel Silyn Roberts of Azimuth Partners, LLC.

Executive Summary

In early 2010, several members of the Bay Area Stormwater Agencies Association (BASMAA) joined 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 (MRP; SFBRWQCB, 2009)[1]. The RMC includes the following participants:

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

This overview of Quality Assurance and Quality Control (QA/QC) is presented as an appendix to ACCWP's Integrated Monitoring Report (IMR)

This report addresses QA/QC for Creek Status monitoring required per Provision C.8.c of the MRP, in particular for the parameters specified in MRP Table 8.1 using a monitoring design conforming with the RMC Monitoring Plan (BASMAA, 2011). Except where otherwise noted, QA/QC procedures were implemented as specified in the RMC QAPP (BASMAA, 2012a), and monitoring was performed according to protocols specified in the RMC SOPs (BASMAA, 2012b) and updates agreed upon by the RMC.

All findings and data reported during Water Years (WY) 2012 and 2013 were reviewed by ACCWP's designated Local Quality Assurance Officer (LQAO) for the RMC Creek Status monitoring to determine whether data quality objectives were met.

The key recommendations from the WY2012 QA/QC review were:

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

- Representatives of ACCWP and the other RMC participating programs should meet with Caltest representatives to coordinate activities and protocols prior to the WY2013 RMC monitoring.
    - Corrective Action – this meeting was held as part of mobilization activities for WY2013 monitoring.
- Resolve with RMC collaborators and BioVir Laboratory the issues regarding deficiencies in bacteria QA/QC analyses, in accordance with RMC QAPP requirements.
    - Corrective Action – Paul Salop (AMS) coordinated with BioVir in resolution of issues required to support compliance with RMC QAPP. RMC Quality Assurance Project Plan (QAPP) was modified in 2014 (BASMAA 2014) to adopt revised SWAMP quality assurance criteria associated with Fecal Indicator Bacteria monitoring.
- Investigate alternative approaches for field measurement of chlorine to mitigate the possibility of attaining measurements of free chlorine greater than total chlorine.
    - Corrective Action – None taken. WY2013 results identified three additional locations where free chlorine > total chlorine measurements.

Several of the data quality concerns identified following implementation of WY2012 monitoring activities were addressed, eliminating them as issues for WY2013 implementation. However, new issues did arise. These issues were mainly related to initial data deliverables provided by Caltest, which raised multiple QA concerns, and required development of multiple revisions for various data deliverables. After review of data deliverables provided by Caltest and coordination with RMC collaborators, it appears the major concern with the Caltest products lies in differences in rounding enacted by the Caltest Laboratory Information Management System (LIMS) used in development of the spreadsheet EDD versus the laboratory narrative.

The following recommendations are made based on the 2013 QA/QC review and summary:

- Representatives of ACCWP and the other RMC participating programs should again meet with Caltest representatives to discuss the rounding issues and other data quality concerns carrying over from WY2013 monitoring.

List of Acronyms

Acronym	Definition
ABL	Aquatic Bioassessment Laboratory
AMS	Applied Marine Sciences, Inc.
ACCWP	Alameda Countywide Clean Water Program
AFDW	Ash Free Dry Weight
BAS	BioAssessment Services
BASMAA	Bay Area Stormwater Management Agencies Association
CDFG	California Department of Fish and Game
CDFW	California Department of Fish and Wildlife
CEDEN	California Environmental Data Exchange Network
DOC	Dissolved Organic Carbon
E. coli	*Escherichia coli*
EDD	Electronic Data Delivery
LIMS	Laboratory Information Management System
LQOA	Local Quality Assurance Officer
MPN	Most Probable Number
MQO	Measurement Quality Objective
MRP	Municipal Regional Permit
MS	Matrix Spike
MSD	Matrix Spike Duplicate
NPDES	National Pollutant Discharge Elimination System
PAH	Polyaromatic Hydrocarbon
PER	Pacific Eco-Risk
PHAB	Bioassessment, Physical Habitat Assessment
PRM	Pathogen Related Mortality
QAPP	Quality Assurance Project Plan
QA/QC	Quality Assurance/Quality Control
QAO	Quality Assurance Officer
RL	Reporting Limit
RMC	Regional Monitoring Coalition
RMP	Regional Monitoring Program
RPD	Relative Percent Difference
RWQCB	Regional Water Quality Control Board
SFBRWQCB	San Francisco Bay Regional Water Quality Control Board
SOP	Standard Operating Procedure
SSD	Suspended Sediment Concentration
SSID	Stressor/Source Identification
SWAMP	Surface Water Ambient Monitoring Program
TKN	Total Kjeldahl Nitrogen
TOC	Total Organic Carbon
USA	Unified Stream Assessment
WY	Water Year

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Attachment A: Quality Control Check List Template

Attachment B: Bioassessment Audit Reports, WY2012 and WY2013

Attachment C BMI Taxonomy Audit Reports , WY2012 and WY2013

1 Introduction

In 2010, the seventeen member agencies of the Alameda Countywide Clean Water Program (ACCWP) joined other members of the Bay Area Stormwater Agencies Association (BASMAA) to form the BASMAA Regional Monitoring Coalition (RMC), as a collaborative effort to coordinate and oversee water quality monitoring required by Provision C.8 of the Municipal Regional National Pollutant Discharge Elimination System (NPDES) Stormwater Permit. This report presents the Quality Assurance and Quality Control (QA/QC) review of Creek Status Monitoring data collected by ACCWP during the two initial years of monitoring: Water Year (WY) 2012 extending from October 1, 2011 through September 30, 2012 and WY 2013 extending from October 1, 2012 through September 30, 2013[2].

A comprehensive QA/QC program was implemented by ACCWP for the RMC Creek Status Monitoring. This program addresses the monitoring required per Provision C.8.c of the Municipal Regional Stormwater NPDES Permit (MRP), in particular as specified in MRP Table 8.1 (SFBRWQCB, 2009), and conforms with the RMC Monitoring Plan (BASMAA, 2011). In general, QA/QC procedures were implemented as specified in the RMC Quality Assurance Project Plan (QAPP) (BASMAA, 2012a), and monitoring was performed according to protocols specified in the RMC Standard Operating Procedures (SOPs) (BASMAA, 2012b), and in updates identified through discussions of the RMC Work Group and compiled in 2014 versions of the QAPP and SOPs (BASMAA, 2014a-2014b).

All findings and data reported during WY2012 were reviewed by ACCWP's designated Local Quality Assurance Officer (LQAO) for the RMC Creek Status monitoring to determine whether data quality objectives were met. In WY2013, data were reviewed by ACCWP's Local Monitoring Coordinator and Azimuth Partners, LLC (Attachment A), and the product reviewed and validated by the LQAO.

Laboratories are responsible for conducting a set of internal QA/QC procedures as well as adhering to the protocols specified in the RMC QAPP, and for reporting any quality assurance issues that arose during testing.

[2] Similar methods and QA/QC procedures are being implemented for Stressor-Source Identification (SSID) studies to investigate certain sites where WY2012 monitoring results indicated potential need for follow-up monitoring projects according to trigger criteria described in the MRP.

2 Quality Assurance and Quality Control Review Summary

2.1 Field Crew Training

All field crews received training in sampling procedures prior to participating in any field sampling activities. In some cases the training was provided by field crew leaders upon mobilization in the field.

Prior to participation in bioassessment monitoring activities, all field personnel had completed training in conduct of bioassessments from the California Department of Fish and Game (CDFG, now Department of Fish and Wildlife, CDFW). In addition, Jim Harrington of CDFW conducted on-site refresher training for RMC participating field crew members in Bioassessment, Physical Habitat (PHAB), and water quality collection and measurement procedures during a two-day field training, March 19-20, 2012. In 2013, the RMC organized a one-day field training refresher course on March 5, 2013, and Kevin Lunde of the SFBRWQCB oversaw an intercalibration exercise for RMC and SWAMP bioassessment field personnel on March 15, 2013.

As required, RMC SOP documents were brought into the field during sampling events as a protocol reference guide.

2.2 Field Measurements and Sample Collection

Field crews completed a series of field forms and performed various QA/QC activities according to protocols detailed in the RMC QAPP (especially section 9.1), the RMC SOPs (especially FS-9), and SWAMP SOP documents. The following field-generated documents were reviewed by the LQAO and ACCWP:

- Field Logs;
- Chain of Custody forms; and
- Equipment Calibration logs.

In WY2012, the LQAO interviewed field crews regarding all field procedures, and concluded that sampling and field procedures conformed to RMC protocols. Similarly, the field audits of bioassessment activities conducted by CDFW and Water Board personnel concluded that the ACCWP field crew adequately performed the field activities according to SWAMP Bioassessment protocols for all activities conducted under RMC monitoring.

Completeness: Sample collection, field measurements, analysis, and recordkeeping were completed for all sites and monitoring types as specified for ACCWP by MRP Table 8.1.

2.3 Bioassessment

Per the MRP, bioassessment is required at 20 probabilistic sites each year for ACCWP.

2.3.1 Field Activities

2.3.1.1 Water Year 2012

In WY2012, samples were collected from 11 transects at each site along a 150m reach. The full set of 20 sites was monitored as planned, and field activities generally proceeded smoothly, with the following issues noted:

- The length of reach was shortened to 120m by construction at Site 204R00391, a large culvert at Site 204R00319 and a debris dam causing headwater at Site 204R00367;
- Stream characterization was not fully completed at Site 204R00191 due to dense vegetation and inaccessible depths at several transects;
- Photos taken of Site 204R00047 failed to save on the field crew's camera; and
- Slope was less than 0.5% at four sites resulting in no slope readings on the field data sheets.

A detailed field audit of the bioassessment and physical habitat monitoring procedures was performed by Jim Harrington of CDFW during field monitoring activities at Chabot Creek in Alameda County on June 14, 2012. The audit report concluded that the field team adequately performed all requirements of the field audit for the SWAMP bioassessment procedure.

2.3.1.1 Water Year 2013

In WY2013, samples were collected as described for WY2012. The full set of 20 sites was monitored as planned, and field activities generally proceeded smoothly, with the following issues noted:

- The length of reach was shortened to 120m at Site 204R00063 due to presence of a culvert downstream and lack of permissions from upstream property owners that would allow the reach to be slid upstream;
- At Site 204R00334, the reach was found to be extremely densely vegetated, which precluded safe access to the full extent of the target reach. The reach was therefore shortened to 100m, and measurements of slope were unable to be obtained;

- At Site 204R00623, sampling personnel shortened the reach to 120m in order to fit it within a consistent channel type between residences and a freeway overpass;
- At Site 204R00623, sampling personnel shortened the reach to 120m in order to fit it between two large outfalls (>24") at the upper and lower extents of the reach;
- At Site 205R00174, the reach was found to be extremely densely vegetated, which precluded safe access to the full extent of the target reach. The reach was therefore shortened to 120m, and measurements of slope were unable to be obtained;
- At Site 205R01134, sampling personnel shortened the reach to 100m in order to fit it between two vehicle overpasses;
- During reconnaissance at Site 204R00983, sampling personnel found the target reach to be flowing but intermittent wet. After review of relevant protocols and discussion with the Project Coordinator, it was decided that when dry transects and inter-transects were encountered by the field crew, physical habitat measurements would be evaluated across the unvegetated portion of the channel and that dry reaches would not be sampled for macroinvertebrates or algae, consistent with RMC "What If" documentation and Table 4-4: from *Modifications For Support Reaches With Interrupted Flow,* of the *Western Pilot Study: Field Operations Manual for Wadeable Streams* (USEPA 2006). During sampling, sampling personnel encountered eight wetted transects and three dry within the reach. When the bio team encountered dry transects they collected make-up BMI samples at wetted replacement locations within the 150 reach, at the recommendation of Water Board staff, as close to the dry transect as possible;
- At Site 204R00590, the stream was able to be assessed over the full 150m length, but dense vegetation limited line of sight, and precluded ability to capture slope measurements; and
- Slope was less than 0.5% at six sites resulting in no slope readings on the field data sheets.

A detailed field audit of the bioassessment and physical habitat monitoring procedures was performed by Kevin Lunde during field monitoring activities conducted at a bioassessment site being monitored for the City of Vallejo[3] under the MRP on May 30, 2013 (Attachment B). The audit report concluded that the field team adequately performed all requirements of the field audit for the SWAMP Bioassessment procedure (BASMAA, 2014).

[3] Using same field personnel as performed ACCWP bioassessment monitoring activities.

2.3.2 BMI Taxonomy

2.3.2.1 Water Year 2012

During the BMI taxonomic analysis, some minor counting discrepancies were noted between the original BioAssessment Services (BAS) results and the QA recount conducted by CDFG Aquatic Bioassessment Laboratory (ABL). ABL reported that one *Corisellade color* was misidentified as *Sigara*, two *Orthocladiinae* larvae were found in the *Chironomini* vial, and a *Culicidae* pupa was misidentified as *Tanypodinae*. All sorting counts met QA/QC criteria for sorting accuracy of >95% following recount.

2.3.2.2 Water Year 2013

On October 25, 2013, ABL completed a QA recount with findings from two samples submitted from the ACCWP WY2013 project (Attachment C). Some minor discrepancies were found in the QC assessment:

- There was one instance of a tagalong organism due to probable sorting error;
- In one sample, the *Crangonyx* vial contained mainly *Gammarus*;
- Three *Trichocorixa* specimens were misidentified as *Corisella*; and
- Tanytarsini larvae were found in each of the Chironomini vials due to sorting error.

All sorting counts met QA/QC criteria for sorting accuracy of >95% following recount.

2.3.3 Algae Taxonomy

Algal taxonomy was completed by EcoAnalysts in both 2012 and 2013.

2.3.3.1 Water Year 2012

Collection of algae samples was difficult at 10 sites due to varying levels of algal growth making it hard to collect a distinguishable clump for analysis and no sample was taken at two locations due to absence of algae. EcoAnalysts reported low sample counts for soft algae in some cases, which required alternative procedures of analysis in order to ensure complete and quality data. Additional algae analysis was a time-consuming process, leading to a projected increase in processing costs.

2.3.3.2 Water Year 2013

Narrative from EcoAnalysts, regarding algal taxonomy processing, was not available at the time of report preparation. This information will be provided in WY2014.

2.4 Water Chemistry

Caltest Labs analyzed all water chemistry samples for the RMC in 2012 and 2013. Caltest performed all internal QA/QC requirements as specified in the QAPP and reported their findings to ACCWP. An initial screening of water chemistry data reports found that Ash Free Dry Weight (AFDW) was not included in certain lab reports or Electronic data deliveries (EDD); revised lab reports and EDDs were provided with AFDW results included. Other QA/QC issues are covered below. Key water chemistry Measurement quality objectives (MQOs) are listed in RMC QAPP Tables 26-1, 26-2, 26-5, and 26-7.

2.4.1 Field Blanks (Contamination):

Field blank samples are collected collaboratively and shared between copermittees in the RMC in cases where field teams overlap. As such, the requirement for 5% of samples to be collected as field duplicates is often not met by individual members but is satisfied within the overall program requirements.

2.4.1.1 Water Year 2012

Water chemistry field blanks were collected by ACCWP at Site 204R00068, submitted blind to the laboratory, and analyzed for dissolved orthophosphate (orth-P) and dissolved organic carbon (DOC) by Caltest. In both cases, reported results of the water chemistry field blanks were below reporting limits.

2.4.1.2 Water Year 2013

Water chemistry field blanks were collected by ACCWP at Site 204R00447, submitted blind to the laboratory, and analyzed for orthophosphate and dissolved organic carbon by Caltest. For each analyte, results were reported slightly above laboratory reporting limits (0.011 mg/L result vs. 0.01 mg/L reporting limit (RL) for dissolved ortho-P; and 0.6 mg/L field sample result vs. 0.5 mg/L RL for DOC). The mean result for all ortho-P samples analyzed for ACCWP was approximately an order of magnitude higher (0.11 mg/L), and the mean for all DOC samples (4.1 mg/L) was similarly higher than the field blank result as well. All DOC and ortho-P samples were therefore qualified with a QA code of VIPRL, signifying "*Analyte detected in field or lab generated blank, >RL, flagged by QAO*."

A second set of field blanks were collected for Vallejo (by field personnel performing ACCWP bioassessments) and submitted blind for analysis using the same collection techniques and laboratory. These were, however, collected later in the year using a different batch of filters for both DOC and ortho-P filtering operations. Results from these blank analyses were reported as non-detects, and therefore no qualification of Vallejo data was required. These results suggest that contamination was likely more due to field filters being used at the time of sample collection as opposed to contamination introduced through sampling techniques.

2.4.2 Spikes (Accuracy)

2.4.2.1 Water Year 2012

A limited number of internal QA/QC tests failed to meet data quality requirements for spike percent recovery; these results are reported as qualified in EDDs and Lab Reports by Caltest. Percent Recovery for the Matrix Spike/Matrix Spike Duplicate (MS/MSD) analysis performed on the wet season sample from ACCWP Site 204R00068 exceeded MQOs for chloride and silica. In the results for lab control sample spikes, analytes failing to meet MQOs include chloride, chlorophyll, DOC, nitrite as N, and silica.

2.4.2.2 Water Year 2013

As in WY2012, a limited number of internal QA/QC tests failed to meet data quality requirements for spike percent recovery. These included some analyses of Total Kjeldahl Nitrogen (TKN), silica, chloride, and nitrate as N. Associated data were qualified within the RMC database with either “GB” if qualified by lab, or “VGB”, if qualified by LQAO.

2.4.3 Field Duplicates (Precision)

Field duplicates incorporate additional variation beyond lab duplicates (e.g., field exposure, elapsed time between collections), but are held to the same control limits per the SWAMP QAPP. The results of the following analyses should therefore be viewed within that context.

2.4.3.1 Water Year 2012

Duplicate water samples were collected and analyzed for ACCWP Sites 204R00319 and 204R00535. Relative Percent Difference (RPD) was outside control limits for two analytes at each site. Chlorophyll and TKN failed to meet MQO for samples collected at Site 204R000319, and ammonia and Suspended Sediment Concentration (SSC) were outside control limits for Site 204R000535. For the affected constituents at each site, program data managers were asked to add a qualifier code of "VFDP" to the data files, to signify "Field duplicate RPD above QC limit; flagged by QAO". Because each RMC participating program provided a representative set of

field duplicate water samples for analysis, the qualifier codes resulting from the field duplicate results apply only to the other samples from ACCWP.

2.4.3.2 Water Year 2013

Duplicate water samples were collected and analyzed for ACCWP Sites 204R00473 and 204R00751. RPD was outside of MQO control limits for the following analyses:

- TKN results at Site 204R00751; and
- SSC results at Site 204R00751

Lab results of water chemistry field duplicate results are shown in Tables AC-2 and AC-3. For the affected constituents at each site, program data managers added a qualifier code of "VFDP" to the data files, to signify "Field duplicate RPD above QC limit; flagged by QAO".

2.5 Continuous General Water Quality

ACCWP conducted continuous monitoring of general water quality parameters at three sampling locations during both the wet and dry seasons in WY2012 and WY2013. General water quality was monitored using YSI Model 6600 data sondes for approximately two weeks, recording data at 15-minute time intervals. Methods for calibration and deployment, as specified in the RMC QAPP and SOP FS-4, were done appropriately and documented by ACCWP field crews.

2.5.1 Water Year 2012

In WY2012, the YSI deployed at Site 204CRW030 on September 13th began experiencing intermittent power failures beginning on September 15th, which lasted for the remainder of deployment and precluded recording of data for all 15-minute intervals. Missing data were qualified with a QA code of “FIF” to indicate instrument failure. A post-deployment inspection of the YSI suggested that a leaking battery was to blame, and the manufacturer was contacted and their protocols followed to clean and prep the YSI for future deployment.

2.5.2 Water Year 2013

For the continuous water quality measurements, there were no major QA concerns. Monitoring locations did, however, differ between spring and fall deployments, due to a lack of wetted channel at Site 204AVJ130, which precluded deployment at the location. The planned deployment at this site was substituted with a deployment location at site 204LIO050, on Chimes Creek. This location coincided with the location of a continuous temperature monitor used for WY2013.

2.6 Chlorine (Free and Total)

Chlorine field testing was performed at 20 sites at the time of bioassessment and toxicity sampling site visits, using Chemetrics ® Low Range Chlorine test kits.

2.6.1 Water Year 2012

In one case, on May 30, 2012 at Site 204R00100, there was no shade available so chlorine test results from that date may be less reliable. In multiple instances, results for analyses of free chlorine exceeded total chlorine; these counterintuitive results were also encountered by other RMC field teams.

2.6.2 Water Year 2013

Similar to WY2012, there were three sites where free chlorine results exceeded total chlorine.

2.7 Continuous Temperature

ACCWP conducted continuous monitoring of temperature at eight sampling locations. Continuous temperature was monitored and recorded hourly for eight sampling locations using Onset HOBO ® Water Temp Pro V2 digital temperature loggers. All loggers were installed within the time frame identified within the MRP.

2.7.1 Water Year 2012

In WY2012, one unit, deployed at Site 204SAU090, was removed from the creek at some point prior to mid-term inspections. A replacement unit was installed on July 16th, and data are only available from that point through the end of deployments.

2.7.2 Water Year 2013

Continuous temperature monitors were deployed at a total of nine locations, one more than the MRP requirement of eight locations, to account for potential loss or failure. At time of retrieval, one unit deployed at Site 204AVJ080 was unable to be located after multiple attempts at retrieval. At this site, an early season storm event had mobilized a large volume of silt and sand, which had covered the deployment location and restricted visibility when trying to locate it. Additionally, due to the bedrock substrate present, the monitor was secured to a large cobble rather than earth anchor, which may have led to its being mobilized downstream. Data was retrieved from this site at time of mid-season maintenance conducted in mid-July.

Additionally, one unit deployed at Site 204AVJ110 was found by sampling personnel at time of retrieval to be very close to the surface. Field staff was unsure exactly how close to the surface equipment was since the creek was very turbid and the earth anchor setup was disturbed during

the process of locating the unit. Temperatures at this location do exhibit questionable results, with temperature spikes above 35°C.

2.8 Toxicity – Water Column

Water toxicity sampling and testing was performed at three sites, once during wet weather (storm event) conditions, and once during the dry season. Water toxicity lab analysis was conducted by Pacific EcoRisk (PER).

2.8.1 Water Year 2012

All QA/QC measures listed in the QAPP were met. PER reported that the wet weather water toxicity samples collected from Sites 204R00047 and 204R00100 were affected by pathogen-related mortality (PRM), a known cause of interference in aquatic sample toxicity tests with ambient surface waters. The affected samples were re-tested using a modified approach per Geis et al. (2003), which was reported by the laboratory to have eliminated toxic response. Following further discussions with Water Board staff the RMC programs withdrew their request for approval to routinely apply the modified Geis technique to fathead minnow water toxicity tests to avoid the reoccurrence of this type of interference.

RMC data managers were asked to apply the qualifier code "PRM" for samples for which a toxic response was attributed to PRM. This is a new code that the RMC requested be added to the SWAMP “QACode Lookup List”. In WY2013 this code was added to the California Environmental Data Exchange Network (CEDEN) with the following definition: “Low survival in toxicity test resulted from test interference due to pathogen related mortality”. Data managers also were asked to add the following comment to the data files for PRM-affected samples: "Low survival resulted from test interference due to pathogen related mortality (PRM). The data should not be used for regulatory purposes. A re-test was initiated using a method to control for PRM." For the Geis method re-tests, because the tests were conducted outside of acceptable holding times, RMC data managers were asked to apply the qualifier code "VH" QA Code, indicating “Holding Time Violation flagged by QA Officer”.

2.8.2 Water Year 2013

All QA/QC measures listed in the QAPP were met. Similar to WY2012, there was one instance in the dry season monitoring where PRM was identified by the laboratory, but did not result in a finding of significant toxicity based upon fathead minnow survival. Unlike WY2012, a qualifier of “PRM” was not added to results - where identified by PER - as there was not significant mortality identified. A comment was added to affected samples, however, to indicate that the PRM issue was identified.

2.9 Toxicity – Bedded Sediment, Fine-Grained

Sediment toxicity lab analysis was conducted by PER.

2.9.1 Water Year 2012

All QA/QC measures listed in the QAPP were met. Dissolved oxygen levels fell below 2.5 mg/L during testing of samples from Site 204R00047 for *Hyalella azteca.* RMC data managers were asked to apply the qualifier code "VTW" for these samples, indicating "Water quality parameters outside recommended test method ranges, flagged by QA Officer", with a note in the comment field indicating, "Dissolved oxygen levels fell below 2.5 mg/L during testing. Aeration was initiated following this observation per USEPA protocols. Hypoxia could have had a role in the significantly reduced survival observed in this sample."

2.9.2 Water Year 2013

All QA/QC measures listed in the QAPP were met. There were no issues with dissolved oxygen concentrations reported.

2.10 Pollutants – Bedded Sediment, Fine-Grained

Caltest Laboratories performed all sediment chemistry analysis for ACCWP in WY2012 and WY2013, with the exception of the grain size distribution and total organic carbon (TOC) analyses, which were sub-contracted by Caltest to Soil Control Laboratories. Caltest conducted all QA/QC requirements as specified in the RMC QAPP and reported their findings to the RMC. Key sediment chemistry MQOs are listed in RMC QAPP Tables 26-4, 26-6, and 26-7.

2.10.1 Water Year 2012

A number of issues were noted by the laboratory in relation to the sediment chemistry analyses; none of the issues were considered to significantly impact the quality of the data. These issues included:

- Percent solids analyses on the as-received sediments were performed past regulatory holding time;
- Reporting limits (RLs) exceeded target RLs identified in the RMC QAPP for certain analytes;
- Low level contamination noted in the method blank (Arsenic, Chromium);
- Some Matrix Spike/Matrix Spike Duplicate (MS/MSD) recoveries were not calculated due to the high native concentration in the sample selected for MS/MSD versus the laboratory spike concentration (Copper, Chromium, Nickel);

- Low Matrix Spike recovery was noted due to possible matrix interference in the QC sample (Arsenic);
- High Matrix Spike recovery was noted due to possible matrix interference in the QC sample (Lead);
- Several organochlorine pesticide compounds were not included in the spike mix: 2,4'-DDD, 2,4'-DDE, 2,4'-DDT, cis-Chlordane, trans-Chlordane and Heptachlor epoxide;
- Matrix Spike recoveries were outside control limits: (Lindane, 4,4'DDT);
- LIMS 'Acodes' did not originally include 2,4 DDD, 2,4 DDT, 2,4 DDE as these were not standard compounds that reported by the laboratory under EPA method 8081, and the original analysis did not include these three compounds; the holding time violation is noted/qualified; and
- Some levels of acceptable relative percent difference (RPD) as reported by Caltest were higher than the maximum allowable RPD as specified in the RMC QAPP.

All lab QA/QC issues were properly noted as qualified in lab reports and EDDs, and Caltest notified the responsible program consultants. These issues are further discussed below.

2.10.1.1 Holding Times

Due to internal lab issues, holding times were exceeded for several organochlorine pesticides and for the percent solids analysis on as-received sediments. For WY2012 RMC sediment chemistry results for the constituents DDD(o,p'), DDE(o,p'), and DDT(o,p') (which the pdf lab reports refer to as 2,4 DDD, 2,4 DDT, 2,4 DDE), and "% Solids" (applies to re-analysis on 9/10/12, not original analysis on 8/7/12), the "VH" qualifier code was added to the data files, indicating “Holding Time Violation, flagged by QA Officer”.

2.10.1.2 Reporting Limits

Some lab reporting limits exceeded those specified in the RMC QAPP due to issues associated with the dry weight conversion, as well as target and non-target matrix interferences, which required the laboratories to concentrate less than normal. Qualifier codes were added to the EDDs for these parameters for the affected samples.

2.10.1.3 Spikes (Accuracy)

A number of matrix spike (MS) samples failed to meet the MQOs for percent recovery. Caltest reported that this issue was likely due to possible matrix interference in the QC sample batch. In some cases MS/MSD percent recoveries were not calculated due to the high native concentration in the selected MS/MSD sample compared to laboratory spike concentration. Several

organochlorine pesticide compounds were not included in the spike mix or the spike recoveries were outside of the control limits. As documented in the laboratory reports, all analytes that failed to meet MS/MSD MQOs were accepted by Caltest based on LCS and RPD QC results.

2.10.1.4 Lab Duplicates (Precision)

Some discrepancies were observed in the MQO limits Caltest applied to duplicate RPDs in lab reports versus the acceptable RPDs specified in the RMC QAPP. Caltest applied a maximum allowable RPD for metals in sediment of 30% compared to the RPD specified in the RMC QAPP of 25%. For synthetic organics in sediment Caltest applied a maximum allowable RPD of 30-40% compared to 25% specified in the QAPP. Because the laboratory calculates acceptable RPDs based on historical values, in some cases lab internal protocols specify different control limits than those specified in the QAPP. In such cases, additional qualification by the QAO may be necessary. RMC data managers were asked to apply the qualifier code "VFDP" to the results for the affected constituents to all WY2012 RMC sediment chemistry data files[4], indicating “Field duplicate RPD above QC limit, flagged by QA Officer”.

2.10.1.5 Field Duplicates (Precision)

The RMC QAPP requires collection and analysis of duplicate sediment samples at a rate of 10% of total samples collected. One sediment sample duplicate was collected and analyzed in Santa Clara County to account for the 10 sediment sites monitored by the RMC in 2012; these test results then applied to all WY2012 RMC program sediment chemistry results, including the ACCWP sediment chemistry results. RPD was in exceedance of the MQO in two of the grain size test results (% Granule and % Sand) for the sediment chemistry field duplicate sample, which is to be expected due to the typical heterogeneity of sediment samples. The qualifier code "VFDP", indicating “Field duplicate RPD above QC limit, flagged by QA Officer” was applied to all RMC sediment chemistry results for these two parameters.

2.10.2 Water Year 2013

As in WY2012, a number of issues were noted by the laboratory in relation to the sediment chemistry analyses; none of the issues were considered to significantly impact the quality of the data and all data were qualified as Acceptable (A) with Minor Deviations (MD). These issues included:

[4]Only when the RPD is outside the range specified within the QAPP, but within that used by the lab.

- Reporting limits (RLs) exceeded target RLs identified in the RMC QAPP for certain analytes (i.e., zinc, some organochlorine (OC) pesticides at some locations);
- There was minor blank contamination (between MDL and RL) identified within the lab blank for chromium;
- Due to expected matrix interferences, surrogate recoveries associated with analysis of OC pesticides were outside of control limits at stations 204R00327 and 204R00447; and
- Some MS/MSD recoveries and RPDs were outside of control limits for multiple analytes.

All lab QA/QC issues were properly noted as qualified in lab reports and EDDs, and Caltest notified the responsible Program consultants. These issues are further discussed below.

2.10.2.1 Holding Times

There were no issues with holding time violations.

2.10.2.2 Reporting Limits

Some lab reporting limits exceeded those specified in the RMC QAPP due to issues associated with the dry weight conversion, as well as target and non-target matrix interferences, which required the laboratories to concentrate less than normal. Qualifier codes of “VRE” were added to the EDDs for these parameters for the affected samples.

2.10.2.3 Spikes (Accuracy)

A number of MS samples failed to meet the MQOs for percent recovery. As documented in the laboratory reports, all analytes that failed to meet MS/MSD MQOs were accepted by Caltest based on LCS and RPD QC results.

2.10.2.4 Lab Duplicates (Precision)

Issues identified in WY2012 related to differing control limits associated with lab acceptance criteria and QAPP criteria were rectified for WY2013.

2.10.2.5 Field Duplicates (Precision)

The RMC QAPP requires collection and analysis of duplicate sediment samples at a rate of 10% of total samples collected. One sediment sample duplicate was collected and analyzed by ACCWP, on behalf of collaborating RMC Programs. RPD was in exceedance of the MQO for several of the analytes, including multiple PAHs (acenaphthene, anthracene, benz(a)anthracene, chrysene, dibenzothiophene, fluoranthene, fluorene, naphthalene, pyrene, and phenanthrene), organochlorine pesticides (DDEs), mercury, and various particle size categories. The qualifier

code "VFDP", indicating "Field duplicate RPD above QC limit, flagged by QA Officer" was applied to all RMC sediment chemistry results for these parameters.

2.11 **Pathogen Indicators**

Pathogen indicators (also known as fecal indicator bacteria (FIB)) are collected from five sites each monitoring year. Samples are analyzed for *E. coli* and fecal coliforms by BioVir Laboratory and results are submitted as EDDs.

2.11.1 Water Year 2012

Bacteria samples were to be collected for five sites, but it was necessary to sample six locations, as one sampling location lacked deep enough water to collect a subsurface sample.

Due to inadequate confirmation of deliverable specifications between BioVir lab and RMC program contractors, several lab QA/QC requirements failed to meet SWAMP standards as specified in the QAPP. Lab QA/QC measures not met include Filter Sterility Check, Filtration blank, Laboratory Blank, Laboratory Duplicate, Field Duplicate and use of Reference Material. Lab protocols were reviewed and the QAPP incorporated revisions as needed prior to WY2013 sampling to reflect requirements of laboratory method selected. These discrepancies were a result of BioVir's use of Standard Methods 9221 rather than the IDEXX Quantitray method listed in the QAPP.

2.11.2 Water Year 2013

Bacteria samples were collected from five sites.

Relative to the multiple tube fermentation (MTF) method (Standard Methods 9221), there were no failures in any of the MQOs. Media sterility checks, laboratory blanks and negative growth controls did not show any false positive reactions. Positive growth controls in the various media indicated that the media and growth conditions were not inhibiting the target bacteria. Both the on-going precision and recovery (OPR) and field duplicates were within the MTF 95% confidence interval for the target organisms.

2.12 **Data Management**

2.12.1 Water Year 2012

Upon receipt of data deliverables, AMS data management staff performed an initial check of laboratory deliverables to check for consistency between narratives and spreadsheet EDDs, completeness of data deliverables, and to identify any obvious data quality issues that would require additional laboratory review, comment, and possible revision. The QAO then manually

reviewed laboratory data, resulting in the assessments provided above and qualification of data records as required.

Field information that was converted to electronic format went through a 10% check to verify accuracy of data entry (for bioassessment data entry, coordinates were checked 100%). Any PHAB data found to be recorded in error was corrected, but a 100% manual check was not performed due to the large number of records. For all other monitoring components, any errors identified triggered a 100% check of data entry.

2.12.2 Water Year 2013

For WY2013, data management protocols were similar to those employed for WY2012. The major difference between the two years was that the RMC had developed an automated tool for reviewing laboratory data against RMC MQO. AMS then used the results of this tool to qualify analytical data as required.

3 Recommendations and Corrective Actions

The following recommendations were made to RMC collaborating Programs based upon the results of the WY2012 ACCWP QA/QC review and summary:

- Representatives of ACCWP and the other RMC participating programs should meet with Caltest representatives to coordinate activities and protocols prior to the WY2013 RMC monitoring (as was done prior to the 2012 monitoring). Issues to discuss should include any changes in sample containers, sediment chemistry reporting limits, reporting of sediment analytes as dry weight, method for reporting of sediment % solids, differences between the RMC QAPP and Caltest standards for duplicate RPDs, and proper coding of RMC sample IDs.
    - Corrective Action – this meeting was held as part of mobilization activities for WY2013 monitoring.
- Resolve with RMC collaborators and BioVir Laboratory the issues regarding deficiencies in bacteria QA/QC analyses, in accordance with RMC QAPP requirements.
    - Corrective Action – Paul Salop (AMS) coordinated with BioVir in resolution of issues required to support compliance with RMC QAPP. AMS will continue to work with BioVir to ensure data is reported to RMC collaborators in SWAMP comparable format with required QA narrative. RMC Quality Assurance Project Plan (QAPP) was modified in 2014 (BASMAA 2014) to adopt revised SWAMP quality assurance criteria associated with FIB monitoring.
- Investigate alternative approaches for field measurement of chlorine to mitigate the possibility of attaining measurements of free chlorine greater than total chlorine.
    - Corrective Action – None taken. WY2013 results identified three additional locations where free chlorine > total chlorine measurements.

Several of the data quality concerns identified following implementation of WY2012 monitoring activities were addressed, eliminating them as an issue for WY2013 implementation. However, new issues did arise. These issues were mainly related to initial data deliverables provided by Caltest, which raised multiple QA concerns, and required development of multiple revisions for various data deliverables. After review of data deliverables provided by Caltest and coordination with RMC collaborators, it appears as if the major concern with the Caltest products lies in differences in rounding enacted by the Caltest LIMS used in development of the spreadsheet EDD versus the laboratory narrative.

The following recommendations are made based on the WY2013 QA/QC review and summary:

- Representatives of ACCWP and the other RMC participating programs should again meet with Caltest representatives to discuss the rounding issues and other data quality concerns carrying over from 2013 monitoring.

4 References

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BASMAA. 2012a. Creek Status Monitoring Program Quality Assurance Project Plan, Final Draft Version 1.0. Prepared for BASMAA by EOA, Inc. on behalf of the Santa Clara Urban Runoff Pollution Prevention Program and the San Mateo Countywide Water Pollution Prevention Program, Applied Marine Sciences on behalf of the Alameda Countywide Clean Water Program, and Armand Ruby Consulting on behalf of the Contra Costa Clean Water Program. 80 pp plus appendices.

BASMAA. 2012b. Creek Status Monitoring Program Standard Operating Procedures. Prepared for BASMAA by EOA, Inc. on behalf of the Santa Clara Urban Runoff Pollution Prevention Program and the San Mateo Countywide Water Pollution Prevention Program, Applied Marine Sciences on behalf of the Alameda Countywide Clean Water Program, and Armand Ruby Consulting on behalf of the Contra Costa Clean Water Program. 196 pp.

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5 Attachments

Attachment A: Quality Control Checklist

Quality Assurance and Quality Control Checklist
Alameda Countywide Clean Water Program
Field QA/QC
March, 2013

Identifying Factors	AMS	QA Review	Comments
Training Protocol			
Field Crew members identified	Y	Y	N
Field crew received training	Y	Y	
Training date was recorded	Y	Y	
Trainer followed training protocol	Y	Y	
Proper training documentation was brought into field	Y	Y	
Training log records were prepared	Y	Y	
Bioassessment - See separate report			
Water Chemistry			
Station Name is correct on all documentation	Y	Y	
Site ID is correct on all documentation	Y	Y	
Date of Sampling	Y	Y	
Proper SWAMP Sampling Methods were used	Y	Y	
Sample containers labeled completely	Y		
Collected where stream appears comp. mixed	Y		
Sub surface samples collected 0.1m below surface	Y		
Container opened, filled, capped beneath surface (if possible)	Y		
Surface samples (if water < 0.1m deep) noted as 0m	Y		
Samples collected upstream of sampling personnel	Y		
Field filtration for Ortho-P samples within 15 minutes of collection*	Y		
Nutrient Samples preserved with acid	Y		
Field Blanks & Field Dup's submitted blind w/site labeling according to SOP	Y		
Samples stored on bagged ice in ice chest	Y		
Field Data Sheets Completed in Field	Y		
Original properly-completed COC sent with samples	Y	Y	
Holding Times Met	Y	Y	

Continuous General Water Quality - Spring			
Station Name is correct on all documentation	Y	Y	
Site ID is correct on all documentation	Y	Y	
Correct number of sampling sites for GWQ and temperature	Y	Y	
Date and time of deployment recorded	Y	Y	
Date and time of retrieval recorded	Y	Y	
Equipment used, including model	Y	Y	
Equipment calibrated prior to deployment (<24 hours)	4/15/2013 5/13/2013	Y	
Accuracy check conducted			
Readiness review conducted	4/15/13 5/13/13		
Equipment calibrated during interruptions (if any)			
Post-event calibration conducted	4/29/2013 5/29/2013		
Necessary measurements recorded at deployment			
Check field datasheets for completeness	9/27/2013	Y	
Detailed instruction on site access and sonde location recorded			
Data logged upon data sonde removal			
Data review – compare drift against SWAMP MQOs	4/26/2013 5/24/2013		Performed as part of post-run calibration check; all OK
Data review – check for outliers / out of water measurements	5/28/2013	Y	Out of water measurements removed (beginning & end of deployments); no outliers observed
Manual measurements taken twice at deployment (2 minutes apart)***			
Post-sampling event report completed	4/26/2013 5/24/2013		
Field audit conducted	NA	NA	Not conducted in 2013

Continuous General Water Quality - Fall			
Station Name is correct on all documentation	Y	Y	
Site ID is correct on all documentation	Y	Y	
Correct number of sampling sites for GWQ	Y	Y	
Date and time of deployment recorded	Y	Y	
Date and time of retrieval recorded	Y	Y	
Equipment used, including model	Y	Y	
Equipment calibrated prior to deployment (<24 hours)	8/26/13 9/9/13		

Accuracy check conducted	8/26/13 9/9/13		
Readiness review conducted	8/15/13 9/10/13		
Equipment calibrated during interruptions (if any)			
Post-event calibration conducted	9/6/13 9/20/13		
Necessary measurements recorded at deployment	Y		
Check field datasheets for completeness	9/27/2013	Y	
Detailed instruction on site access and sonde location recorded		Y	
Data logged upon data sonde removal			
Data review – compare drift against SWAMP MQOs	9/6/13 9/20/13		Performed as part of post-run calibration check; all OK
Data review – check for outliers / out of water measurements	10/22/2013		Out of water measurements removed (beginning & end of deployments); no outliers observed
Manual measurements taken twice at deployment (2 minutes apart)***			
Post-sampling event report completed	9/20/2013	Y	
Field audit conducted	NA	NA	Not conducted in 2013

Continuous Temperature - Fall

Station Name is correct on all documentation	Y	Y	
Site ID is correct on all documentation	Y	Y	Site name correction requested for CRW010
Correct number of sampling sites for GWQ	Y	Y	
Date and time of deployment recorded	Y	Y	
Date and time of retrieval recorded	Y	Y	
Equipment used, including model	Y	Y	
Equipment calibrated prior to deployment (<24 hours)	various		Calibrations initiated Feb 2013. Two units failed and returned to manufacturer for replacement. Remaining units calibrated April 2013.
Equipment calibrated during interruptions (if any)	Y		
Post-event calibration conducted	Y		
Necessary measurements recorded at deployment	Y		

Readiness review conducted	8/12/2013		
Check field datasheets for completeness	8/13/2013		
10% data entry check	NA		
Post-sampling event report completed	8/15/2013	Y	
Field audit conducted	NA		
Trim pre-deployment measurements	10/21/2013		
Data review – check for outliers / out of water measurements	10/21/2013		

Chlorine

Station Name is correct on all documentation	Y	Y	
Site ID is correct on all documentation	Y	Y	
Date of sampling recorded	Y	Y	
Proper SWAMP Sampling Methods were used	Y	Y	
Diff. sample container for each site	Y		
Collected where stream appears comp. mixed	Y		
Sub surface samples collected 0.1m below surface	Y		
Samples collected upstream of sampling personnel	Y		
Chemetrics test kit not expired	Y		
Grab sample collected in clean container	Y		
Samples tested immediately	Y		
Results recorded in duplicate	Y		

Water Toxicity - dry season

Station Name is correct on all documentation	Y	Y	
Site ID is correct on all documentation	Y	Y	
Date of sampling recorded	Y	Y	
Proper SWAMP Sampling Methods were used	Y	Y	
All sampling equipment properly pre-cleaned	Y		
Sample containers labeled completely	Y		
Collected where stream appears comp. mixed	Y		
Bottle rinsed in ambient water with cap on three times prior to filling	Y		
Sub surface samples collected 0.1m below surface	Y		
Container opened, filled, capped beneath surface (if possible)	Y		
Surface samples (if water < 0.1m deep) noted as 0m	Y		
Samples collected upstream of sampling personnel	Y		

Water samples collected prior to collecting sediment samples	Y		
Readiness review conducted	7/9/2013		
Check field datasheets for completeness	7/12/2013		
10% data entry check	11/6/2013		
Post-sampling event report completed	7/16/2013	Y	
Field audit conducted	NA		

Sediment Chemistry Toxicity

Station Name is correct on all documentation	Y	Y	
Site ID is correct on all documentation	Y	Y	
Date of sampling recorded	Y	Y	
Proper SWAMP Sampling Methods were used	Y	Y	
All sampling equipment properly pre-cleaned	Y		
Sample containers labeled completely	Y		
Collected where stream appears comp. mixed	Y		
Bottle rinsed in ambient water with cap on three times prior to filling	Y		
Sub surface samples collected 0.1m below surface	Y		
Container opened, filled, capped beneath surface (if possible)	Y		
Surface samples (if water < 0.1m deep) noted as 0m	Y		
Samples collected upstream of sampling personnel	Y		
Water samples collected prior to collecting sediment samples	Y		
Readiness review conducted	7/9/2013		
Check field datasheets for completeness	7/9/2013		

Chemistry lab (Caltest) data QA review	various		EDDs were compared against narratives with multiple discrepancies identified – main issue appears to be different use of rounding in the two products. Multiple revisions delivered. 10% consistency check between narratives and spreadsheet EDDs conducted at each delivery. Some inconsistencies identified (e.g., analyte names "chlordene" in place of "chlordane" and incorrect PSD category for finest sands). Communicated and rectified with lab, with results communicated to other Programs.
10% data entry check	11/6/2013		
Post-sampling event report completed	7/16/2013		
Field audit conducted	NA		

Water Toxicity - wet season			
Station Name is correct on all documentation	Y	Y	
Site ID is correct on all documentation	Y	Y	
Date of sampling recorded	Y	Y	
Proper SWAMP Sampling Methods were used	Y	Y	
All sampling equipment properly pre-cleaned	Y		
Sample containers labeled completely	Y		
Collected where stream appears comp. mixed	Y		
Bottle rinsed in ambient water with cap on three times prior to filling	Y		
Sub surface samples collected 0.1m below surface	Y		

Container opened, filled, capped beneath surface (if possible)	Y		
Surface samples (if water < 0.1m deep) noted as 0m	Y		
Samples collected upstream of sampling personnel	Y		
Water samples collected prior to collecting sediment samples	Y		
Readiness review conducted	2/15/2013		Note: setup for 4 sites to be monitored by two teams
Check field datasheets for completeness	3/8/2013		
10% data entry check	10/17/2013		
Post-sampling event report completed	3/8/2013		
Field audit conducted	NA		

Attachment B: Bioassessment Audit Reports, WY2012 and WY2013

STATE OF CALIFORNIA - THE RESOURCES AGENCY

DEPARTMENT OF FISH AND GAME
AQUATIC BIOASSESSMENT LABORATORY-CHICO
CALIFORNIA STATE UNIVERSITY, CHICO
CHICO, CA 95929-0555
530-898-4792

October 2, 2012

Tom King
Bioassessment Services
24988 Blue Ravine Road, Suite 108
Folsom, CA 95630

Dear Tom,

Attached are the results of my QC analysis of 2 samples submitted from the ACCWP 2012 project. The results are presented in five summary tables. This QC analysis was performed in accordance to the Southwest Association of Freshwater Invertebrate Taxonomists (SAFIT)'s Standard Taxonomic Effort Document (STE) 1 March 2011 version (Richards and Rogers, 2011) with the following exception: the Chironomidae were analyzed at the subfamily/tribe level to correspond with the original taxonomic determinations.

There was one instance of a "tagalong" organism. We define these as specimens accidentally included in a vial of organisms of another taxon. These are marked as "Probable sorting error" in the attached Listing of Taxonomic Discrepancies file.

In the *Sigara* vial, 6 adults and mature nymphs were identified correctly, but a *Corisella decolor* (Uhler) adult male was also present. *Sigara* and *Corisella* separate out based primarily on the rastrate vs. rugulose clavi of the hemelytra (Lauck, 1979). This character can be tough to discern in wetted specimens. Other useful characters include the effaced color pattern of the clavi and the presence of a fleshy pad on the male foretibia in *Corisella* and in particular the structure of the forepala in *C. decolor* males (Hungerford, 1948). I would recommend leaving the remaining immature nymphs at family. Incidentally, the stripe character that Lauck uses in the key to California corixid nymphs applies to final instar nymphs of *Sigara mckinstryi* Hungerford. I would be very careful using this character to make generic determinations.

Two Orthocladiinae larvae were found in the Chironomini vial. Since Orthocladiinae were identified correctly in this sample and 85 Chironomini were identified correctly, I suspect this was either an oversight or sorting error rather than a misidentification.

STATE OF CALIFORNIA - THE RESOURCES AGENCY

DEPARTMENT OF FISH AND WILDLIFE
AQUATIC BIOASSESSMENT LABORATORY-CHICO
CALIFORNIA STATE UNIVERSITY, CHICO
CHICO, CA 95929-0555
530-898-4792

October 25, 2013

Tom King
Bioassessment Services
24988 Blue Ravine Road, Suite 108
Folsom, CA 95630

Dear Tom,

Attached are the results of my QC analysis of 2 samples submitted from the ACCWP 2013 project. The results are presented in five summary tables. This QC analysis was performed in accordance to the Southwest Association of Freshwater Invertebrate Taxonomists (SAFIT)'s Standard Taxonomic Effort Document (STE) 1 March 2011 version, Level II (Richards and Rogers, 2011) with the following exception: the Chironomidae were analyzed at the subfamily/tribe level to correspond with the original taxonomic determinations.

There was one instance of a "tagalong" organism. These are defined as specimens accidentally included in a vial of organisms of another taxon and are marked as "Probable sorting error" in the attached Listing of Taxonomic Discrepancies file.

In sample #3273, the *Crangonyx* vial contained mainly *Gammarus*. The accessory flagellum of the second antennule for *Gammarus* has two or more distinct segments. *Crangonyx* has only one distinct segment with a much smaller second segment (Rogers, 2005). The structure of the third uropod is also useful.

Three *Trichocorixa* specimens were misidentified as *Corisella*. All three specimens were male and a series of female *Trichocorixa* were identified correctly in the same sample. The structure of the male foreleg can be similar for *Trichocorixa* and *Corisella* in that the foretibia is produced over the pala. However, the position of the nodal furrow and the position and structure of the strigil are good diagnostic characters (Lauck, 1979; Polhemus, 2008). The *Trichocorixa* in this sample were all *T. calva* (Say), which has a uniquely shaped strigil.

Tanytarsini larvae were found in each of the Chironomini vials. Since the majority of specimens for each taxon were identified correctly, I suspect these represent sorting errors rather than true misidentifications.

I welcome any questions or comments you may have concerning this report.

Sincerely,

Austin Brady Richards
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(530) 898-4792

Literature Cited

Lauck, D. R. 1979. Family Corixidae/water boatmen. [pp. 87-123]. In: A. S. Menke (editor), The semiaquatic and aquatic Hemiptera of California (Heteroptera: Hemiptera).

Polhemus, J. T. 2008. Chapter 15: Aquatic and Semiaquatic Hemiptera. [pp. 385-423]. In: R. W. Merritt, K. W. Cummins and M. B. Berg (editors), An introduction to the aquatic insects of North America, fourth edition, xvi + 1158 pp. + 39 color plates. Kendall/Hunt Publishing Company, Dubuque, Iowa.

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Rogers, D. C. 2005. Identification manual to the freshwater Crustacea of the western United States and adjacent areas encountered during bioassessment. EcoAnalysts, Inc. Technical Publication (1):1-79.

Comparative Taxonomic Listing of all Submitted Samples

Samples submitted by Bioassessment Services for Project: ACCWP 2013,

Report prepared by Brady Richards, CDFW ABL-Chico, 10/25/2013

Taxonomist	Sample no.	Vial no.	Original ID	Original Count	Stage	ABL Count	ABL ID
Tom King	BAS-3268						
		1	Astacoidea	3	X	3	Astacoidea
		2	Chironomini	1	P	1	Chironomini
		3	Chironomini	128	L	127	Chironomini
		3	Chironomini	128	L	1	Tanytarsini
		4	Crangonyx	258	X	258	Crangonyx
		5	Erpobdellidae	1	X	1	Erpobdellidae
		6	Oligochaeta	196	X	196	Oligochaeta
		7	Orthocladiinae	13	L	13	Orthocladiinae
		8	Physa	1	X	1	Physa
		9	Pisidium	1	X	1	Pisidium
		10	Tanypodinae	1	P	1	Tanypodinae
		11	Tanypodinae	5	L	5	Tanypodinae
		12	Tanytarsini	12	L	13	Tanytarsini

Taxonomist	Sample no.	Vial no.	Original ID	Original Count	Stage	ABL Count	ABL ID
Tom King	BAS-3273						
				0	x	0	
		1	Astacoidea	4	X	4	Astacoidea
		2	Bezzia/ Palpomyia	3	L	3	Bezzia/ Palpomyia
		3	Callibaetis	2	L	2	Callibaetis
		4	Chironomini	148	L	1	Tanytarsini
		4	Chironomini	148	L	148	Chironomini
		5	Corbicula	3	X	3	Corbicula
		6	Corisella	3	A	3	Trichocorixa
		7	Corixidae	72	L	72	Corixidae
		8	Crangonyx	115	X	3	Crangonyx
		8	Crangonyx	115	X	112	Gammarus
		8	Crangonyx	115	L	1	Chironomini
		9	Erpobdellidae	3	X	3	Erpobdellidae
		10	Hydroptila	18	L	18	Hydroptila
		11	Oligochaeta	51	X	51	Oligochaeta
		12	Orthocladiinae	52	L	52	Orthocladiinae
		13	Ostracoda	2	X	2	Ostracoda
		14	Physa	22	X	22	Physa
		15	Sigara	6	A	6	Sigara
		16	Tanypodinae	84	L	84	Tanypodinae
		17	Tanytarsini	19	L	19	Tanytarsini
		18	Trichocorixa	8	A	8	Trichocorixa
		19	Turbellaria	1	X	1	Turbellaria

Listing of Enumeration Discrepancies

Samples submitted by Bioassessment Services for Project: ACCWP 2013

Report prepared by Brady Richards, CDFW ABL-Chico, 10/25/2013

	Sample #	Vial #	Original ID	# Counted Original	# Counted QC	Difference (Original - QC)
Minor Counting Discrepancies						
	BAS-3268	12	Tanytarsini	12	13	-1
	BAS-3273	4	Chironomini	148	149	-1
		8	Crangonyx	115	116	-1

Listing of Taxonomic Discrepancies

Samples submitted by Bioassessment Services for Project: ACCWP 2013,

Report prepared by Brady Richards, CDFW ABL-Chico, 10/25/2013

Sample #	Vial #	Final ID Original ID	Final ID QC Final ID	Taxonomic level of dispute	# Organisms	Comments
BAS-3268						
Disputed ID						
	3	Chironomini	Tanytarsini	Tribe	1	
BAS-3273						
Disputed ID						
	4	Chironomini	Tanytarsini	Tribe	1	
	6	Corisella	Trichocorixa	Genus	3	
	8	Crangonyx	Gammarus	Family	112	
Probable sorting error						
	8	Crangonyx	Chironomini	Subphylum	1	This disputed ID also represents a difference in taxonomic precision.

Summary of Taxonomic and Enumeration Discrepancies

Samples submitted by Bioassessment Services for Project: ACCWP 2013,

Report prepared by Brady Richards, CDFW ABL-Chico, 10/25/2013

		Taxonomic Discrepancies						Counting Discrepancies			
				Taxonomic Precision Relative to QC							
Sample	**Total Taxa**	**Disputed ID**		**More precise**		**Less Precise**		Major		Minor	
		*f**	*n***	*f*	*n*	*f*	*n*	*f*	*d****	*f*	*d*
BAS-3268	10	1	1	-	-	-	-	-	-	1	1
BAS-3273	19	3	116	-	-	-	-	-	-	2	2

* = the frequency of occurence of the discrepancy, in number of samples *f*

** = the number of organisms affected (by QC Lab counts) *n*

*** = the sum total of (absolute value of) differences in counts *d*

QC Report - Disputed IDs only

Samples submitted by Bioassessment Services for Project: ACCWP 2013,

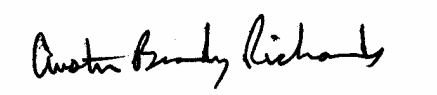
Report prepared by Brady Richards, CDFW ABL-Chico, 10/25/2013

Sample #	***Vial #.***	***Original ID***	***QC ID***	***comments***
BAS-3268	3	Chironomini	Tanytarsini	
BAS-3273	4	Chironomini	Tanytarsini	
	6	Corisella	Trichocorixa	
	8	Crangonyx	Gammarus	

A Culicidae pupa was misidentified as Tanypodinae. Among other characters, the open and distally pointed thoracic horn and the structure of the anal lobes into paddles with a midrib should serve to distinguish Culicidae from Tanypodinae (Merritt and Webb, 2008).

I welcome any questions or comments you may have concerning this report.

Sincerely,



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Literature Cited

Hungerford, H. B. 1948. The Corixidae of the Western Hemisphere (Hemiptera). University of Kansas Science Bulletin. 827 p.

Lauck, D. R. 1979. Family Corixidae/water boatmen. [pp. 87-123]. In: A. S. Menke (editor), The semiaquatic and aquatic Hemiptera of California (Heteroptera: Hemiptera).

Merritt, R. W., and D. W. Webb. 2008. Chapter 22: Part Two. Pupae and Adults of Aquatic Diptera. [pp. 723-771]. In: R. W. Merritt, K. W. Cummins and M. B. Berg (editors), An introduction to the aquatic insects of North America, fourth edition, xvi + 1158 pp. + 39 color plates. Kendall/Hunt Publishing Company, Dubuque, Iowa.

Richards, A. B., and D. C. Rogers. 2011. Southwest Association of Freshwater Invertebrate Taxonomists (SAFIT) List of Freshwater Macroinvertebrate Taxa from California and Adjacent States including Standard Taxonomic Effort Levels. Version: 1 March 2011. SAFIT. Retrieved 1 September 2011 from: http://safit.org/ste.html

Comparative Taxonomic Listing of all Submitted Samples

Samples submitted by Bioassessment Services for Project: ACCWP 2012

Report prepared by Brady Richards, CDFG ABL-Chico, 10/2/2012

Taxonomist	Sample no.	Vial no.	Original ID	Original Count	Stage	ABL Count	ABL ID
Tom King	BAS-3101						
		1	Baetis	4	L	4	Baetis
		2	Bezzia/Palpomyia	3	L	3	Bezzia/Palpomyia
		3	Callibaetis	1	L	1	Callibaetis
		4	Ceratopogonidae	2	P	2	Ceratopogonidae
		5	Chironomini	87	L	2	Orthocladiinae
		5	Chironomini	87	L	85	Chironomini
		6	Coenagrionidae	1	L	2	Coenagrionidae
		7	Dasyhelea	1	L	1	Dasyhelea
		8	Dixella	1	L	1	Dixella
		9	Ephydridae	1	L	1	Ephydridae
		10	Erpobdellidae	1	X	1	Erpobdellidae
		11	Fallceon	1	L	1	Fallceon
		12	Hyalella	252	X	252	Hyalella
		13	Oligochaeta	33	X	33	Oligochaeta
		14	Orthocladiinae	4	P	4	Orthocladiinae
		15	Orthocladiinae	85	L	85	Orthocladiinae
		16	Ostracoda	1	X	1	Ostracoda
		17	Pisidium	30	X	30	Pisidium
		18	Psychoda	4	L	4	Psychoda
		19	Sigara	25	A	1	Corisella
		19	Sigara	25	L	17	Corixidae
		19	Sigara	25	L	6	Sigara
		20	Simulium	4	L	4	Simulium
		21	Tanypodinae	8	L	7	Tanypodinae
		21	Tanypodinae	8	P	1	Culicidae
		22	Tanytarsini	1	P	1	Tanytarsini
		23	Tanytarsini	64	L	64	Tanytarsini
		24	Tricorythodes	2	L	2	Tricorythodes
		25	Tropisternus	1	L	1	Tropisternus

Taxonomist	Sample no.	Vial no.	Original ID	Original Count	Stage	ABL Count	ABL ID
Tom King	BAS-3101						
		26	Turbellaria	1	X	1	Turbellaria

Taxonomist	Sample no.	Vial no.	Original ID	Original Count	Stage	ABL Count	ABL ID
Tom King	BAS-3106						
				0	x	0	
		1	Chironomini	10	P	10	Chironomini
		2	Chironomini	319	L	319	Chironomini
		3	Crangonyx	2	X	2	Crangonyx
		4	Dolichopodidae	1	L	1	Dolichopodidae
		5	Oligochaeta	253	X	253	Oligochaeta
		6	Physa	6	X	2	Oligochaeta
		6	Physa	6	X	6	Physa
		7	Pisidium	8	X	8	Pisidium
		8	Sigara	26	L	26	Sigara
		9	Tanypodinae	3	L	3	Tanypodinae
		10	Tanytarsini	1	P	1	Tanytarsini
		11	Tanytarsini	21	L	21	Tanytarsini
		12	Turbellaria	11	X	11	Turbellaria

Listing of Enumeration Discrepancies

Samples submitted by Bioassessment Services for Project: ACCWP 2012

Report prepared by Brady Richards, CDFG ABL-Chico, 10/2/2012

	Sample #	Vial #	Original QC	# Counted Original	# Counted QC	Difference (Original - QC)
Minor Counting Discrepancies						
	BAS-3101	6	Coenagrionidae	1	2	-1
		19	Sigara	25	24	1
	BAS-3106	6	Physa	6	8	-2

Listing of Taxonomic Discrepancies

Samples submitted by Bioassessment Services for Project: ACCWP 2012

Report prepared by Brady Richards, CDFG ABL-Chico, 10/2/2012

Sample #	Vial #	Final ID Original ID	Final ID QC Final ID	Taxonomic level of dispute	# Organisms	Comments
BAS-3101						
Disputed ID						
	5	Chironomini	Orthocladiinae	Subfamily	2	This disputed ID also represents a difference in taxonomic precision.
	19	Sigara	Corisella	Genus	1	
	21	Tanypodinae	Culicidae	Family	1	This disputed ID also represents a difference in taxonomic precision.
Original ID more precise						
	19	Sigara	Corixidae		17	
BAS-3106						
Probable sorting error						
	6	Physa	Oligochaeta	Phylum	2	This disputed ID also represents a difference in taxonomic precision.

Summary of Taxonomic and Enumeration Discrepancies

Samples submitted by Bioassessment Services for Project: ACCWP 2012

Report prepared by Brady Richards, CDFG ABL-Chico, 10/2/2012

		Taxonomic Discrepancies						Counting Discrepancies			
				Taxonomic Precision Relative to QC							
Sample	**Total Taxa**	**Disputed ID**		**More precise**		**Less Precise**		Major		Minor	
		*f**	*n***	*f*	*n*	*f*	*n*	*f*	*d****	*f*	*d*
BAS-3101	27	3	4	1	17	-	-	-	-	2	2
BAS-3106	10	-	-	-	-	-	-	-	-	1	2

* = the frequency of occurence of the discrepancy, in number of samples *f*

** = the number of organisms affected (by QC Lab counts) *n*

*** = the sum total of (absolute value of) differences in counts *d*

QC Report - Disputed IDs only

Samples submitted by Bioassessment Services for Project: ACCWP 2012

Report prepared by Brady Richards, CDFG ABL-Chico, 10/2/2012

Sample #	***Vial #.***	***Original ID***	***QC ID***	***comments***
BAS-3101	5	Chironomini	Orthocladiinae	This disputed ID also represents a difference in taxonomic precision.
	19	Sigara	Corisella	
	21	Tanypodinae	Culicidae	This disputed ID also represents a difference in taxonomic precision.

STATE OF CALIFORNIA - THE RESOURCES AGENCY

DEPARTMENT OF FISH AND WILDLIFE
AQUATIC BIOASSESSMENT LABORATORY-CHICO
CALIFORNIA STATE UNIVERSITY, CHICO
CHICO, CA 95929-0555
530-898-4792

October 25, 2013

Tom King
Bioassessment Services
24988 Blue Ravine Road, Suite 108
Folsom, CA 95630

Dear Tom,

Attached are the results of my QC analysis of 2 samples submitted from the ACCWP 2013 project. The results are presented in five summary tables. This QC analysis was performed in accordance to the Southwest Association of Freshwater Invertebrate Taxonomists (SAFIT)'s Standard Taxonomic Effort Document (STE) 1 March 2011 version, Level II (Richards and Rogers, 2011) with the following exception: the Chironomidae were analyzed at the subfamily/tribe level to correspond with the original taxonomic determinations.

There was one instance of a "tagalong" organism. These are defined as specimens accidentally included in a vial of organisms of another taxon and are marked as "Probable sorting error" in the attached Listing of Taxonomic Discrepancies file.

In sample #3273, the *Crangonyx* vial contained mainly *Gammarus*. The accessory flagellum of the second antennule for *Gammarus* has two or more distinct segments. *Crangonyx* has only one distinct segment with a much smaller second segment (Rogers, 2005). The structure of the third uropod is also useful.

Three *Trichocorixa* specimens were misidentified as *Corisella*. All three specimens were male and a series of female *Trichocorixa* were identified correctly in the same sample. The structure of the male foreleg can be similar for *Trichocorixa* and *Corisella* in that the foretibia is produced over the pala. However, the position of the nodal furrow and the position and structure of the strigil are good diagnostic characters (Lauck, 1979; Polhemus, 2008). The *Trichocorixa* in this sample were all *T. calva* (Say), which has a uniquely shaped strigil.

Tanytarsini larvae were found in each of the Chironomini vials. Since the majority of specimens for each taxon were identified correctly, I suspect these represent sorting errors rather than true misidentifications.

I welcome any questions or comments you may have concerning this report.

Sincerely,

Austin Brady Richards
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California State University, Chico
Chico, CA 95929-0555
arichards@csuchico.edu
(530) 898-4792

Literature Cited

Lauck, D. R. 1979. Family Corixidae/water boatmen. [pp. 87-123]. In: A. S. Menke (editor), The semiaquatic and aquatic Hemiptera of California (Heteroptera: Hemiptera).

Polhemus, J. T. 2008. Chapter 15: Aquatic and Semiaquatic Hemiptera. [pp. 385-423]. In: R. W. Merritt, K. W. Cummins and M. B. Berg (editors), An introduction to the aquatic insects of North America, fourth edition, xvi + 1158 pp. + 39 color plates. Kendall/Hunt Publishing Company, Dubuque, Iowa.

Richards, A. B., and D. C. Rogers. 2011. Southwest Association of Freshwater Invertebrate Taxonomists (SAFIT) List of Freshwater Macroinvertebrate Taxa from California and Adjacent States including Standard Taxonomic Effort Levels. Version: 1 March 2011. SAFIT. Retrieved 1 September 2011 from: http://safit.org/ste.html

Rogers, D. C. 2005. Identification manual to the freshwater Crustacea of the western United States and adjacent areas encountered during bioassessment. EcoAnalysts, Inc. Technical Publication (1):1-79.

Comparative Taxonomic Listing of all Submitted Samples

Samples submitted by Bioassessment Services for Project: ACCWP 2013,

Report prepared by Brady Richards, CDFW ABL-Chico, 10/25/2013

Taxonomist	Sample no.	Vial no.	Original ID	Original Count	Stage	ABL Count	ABL ID
Tom King	BAS-3268						
		1	Astacoidea	3	X	3	Astacoidea
		2	Chironomini	1	P	1	Chironomini
		3	Chironomini	128	L	127	Chironomini
		3	Chironomini	128	L	1	Tanytarsini
		4	Crangonyx	258	X	258	Crangonyx
		5	Erpobdellidae	1	X	1	Erpobdellidae
		6	Oligochaeta	196	X	196	Oligochaeta
		7	Orthocladiinae	13	L	13	Orthocladiinae
		8	Physa	1	X	1	Physa
		9	Pisidium	1	X	1	Pisidium
		10	Tanypodinae	1	P	1	Tanypodinae
		11	Tanypodinae	5	L	5	Tanypodinae
		12	Tanytarsini	12	L	13	Tanytarsini

Taxonomist	Sample no.	Vial no.	Original ID	Original Count	Stage	ABL Count	ABL ID
Tom King	BAS-3273						
				0	x	0	
		1	Astacoidea	4	X	4	Astacoidea
		2	Bezzia/ Palpomyia	3	L	3	Bezzia/ Palpomyia
		3	Callibaetis	2	L	2	Callibaetis
		4	Chironomini	148	L	1	Tanytarsini
		4	Chironomini	148	L	148	Chironomini
		5	Corbicula	3	X	3	Corbicula
		6	Corisella	3	A	3	Trichocorixa
		7	Corixidae	72	L	72	Corixidae
		8	Crangonyx	115	X	3	Crangonyx
		8	Crangonyx	115	X	112	Gammarus
		8	Crangonyx	115	L	1	Chironomini
		9	Erpobdellidae	3	X	3	Erpobdellidae
		10	Hydroptila	18	L	18	Hydroptila
		11	Oligochaeta	51	X	51	Oligochaeta
		12	Orthocladiinae	52	L	52	Orthocladiinae
		13	Ostracoda	2	X	2	Ostracoda
		14	Physa	22	X	22	Physa
		15	Sigara	6	A	6	Sigara
		16	Tanypodinae	84	L	84	Tanypodinae
		17	Tanytarsini	19	L	19	Tanytarsini
		18	Trichocorixa	8	A	8	Trichocorixa
		19	Turbellaria	1	X	1	Turbellaria

Listing of Enumeration Discrepancies

Samples submitted by Bioassessment Services for Project: ACCWP 2013

Report prepared by Brady Richards, CDFW ABL-Chico, 10/25/2013

	Sample #	Vial #	Original ID	# Counted Original	# Counted QC	Difference (Original - QC)
Minor Counting Discrepancies						
	BAS-3268	12	Tanytarsini	12	13	-1
	BAS-3273	4	Chironomini	148	149	-1
		8	Crangonyx	115	116	-1

Listing of Taxonomic Discrepancies

Samples submitted by Bioassessment Services for Project: ACCWP 2013,

Report prepared by Brady Richards, CDFW ABL-Chico, 10/25/2013

Sample #	Vial #	Final ID Original ID	Final ID QC Final ID	Taxonomic level of dispute	# Organisms	Comments
BAS-3268						
Disputed ID						
	3	Chironomini	Tanytarsini	Tribe	1	
BAS-3273						
Disputed ID						
	4	Chironomini	Tanytarsini	Tribe	1	
	6	Corisella	Trichocorixa	Genus	3	
	8	Crangonyx	Gammarus	Family	112	
Probable sorting error						
	8	Crangonyx	Chironomini	Subphylum	1	This disputed ID also represents a difference in taxonomic precision.

Summary of Taxonomic and Enumeration Discrepancies

Samples submitted by Bioassessment Services for Project: ACCWP 2013,

Report prepared by Brady Richards, CDFW ABL-Chico, 10/25/2013

		Taxonomic Discrepancies						Counting Discrepancies			
				Taxonomic Precision Relative to QC							
Sample	**Total Taxa**	**Disputed ID**		**More precise**		**Less Precise**		Major		Minor	
		*f**	*n***	*f*	*n*	*f*	*n*	*f*	*d****	*f*	*d*
BAS-3268	10	1	1	-	-	-	-	-	-	1	1
BAS-3273	19	3	116	-	-	-	-	-	-	2	2

* = the frequency of occurence of the discrepancy, in number of samples *f*

** = the number of organisms affected (by QC Lab counts) *n*

*** = the sum total of (absolute value of) differences in counts *d*

QC Report - Disputed IDs only

Samples submitted by Bioassessment Services for Project: ACCWP 2013,

Report prepared by Brady Richards, CDFW ABL-Chico, 10/25/2013

Sample #	***Vial #.***	***Original ID***	***QC ID***	***comments***
BAS-3268	3	Chironomini	Tanytarsini	
BAS-3273	4	Chironomini	Tanytarsini	
	6	Corisella	Trichocorixa	
	8	Crangonyx	Gammarus	

Attachment C: BMI Taxonomy Audit Reports, WY2012 and WY2013

Revision Date: May 2012

2013 SWAMP Bioassessment Procedure
Biological and Physical Habitat Field Audit

Field Team: Paul Salop, Traci Linder, Tom King, Lucile Paquette

Field Location: 206R04080 unnamed stream in Solano County

Date of Audit: 05/30/2013

Background of Group and Audit Objectives:

The sampling crew worked for Applied Marine Sciences, Inc. 4749 Bennett Dr. Ste L, Livermore, CA 94551. This sampling was part of the BASMAA Regional Monitoring Coalition (RMC) as required under the San Francisco Bay Regional Water Quality Control Board Municipal Regional Stormwater NPDES permit. A total of three crews are sampling to fulfill requirements under the NPDES permit: Applied Marine Sciences, EOA, and Solano County RCD. The Region 2 SWAMP program is also sampling sites under the region, probabilistic sampling design. The RMC has its own QAPP and bioassessment SOP which are slightly adapted from the SWAMP versions.

Item	Y	N	N/A	Comments
Field Day and Sampling Site Preparations				
Sampling Team Briefing – did the field crew meet to discuss the project objectives, field conditions, safety procedures and any special situation associated with the site	√			
Quality Assurance Project Plan – was the field crew familiar with the project QAPP and the assigned QA Officer	√			~~Yes, Armand Ruby serves as QA officer for RMC and~~ each stormwater program has a specific QA officer. N/A PS 7/11/13
Permits – did the field crew have copies of DFG sampling MOU and LAI	√			F&W Scientific Collection Permit under Paul Salop covered the bioassessment sampling
Permits – did the field crew have a copy of the landowner permission letter	√			Flood control district permission acquired by Lance Barnett
SOP – did the field crew have a copy of the most recent SWAMP Bioassessment Protocol	√			RMC version of the SOP
SOP – did the field crew have a project specific SOP which lines out the assignments for all crew members		√		No, the crews knew their roles and written SOP for their assignments was not necessary.
SOP – did the field crew have a system for adding, updating, and retiring the SOP, as	√			Paul Salop is contracted to make updates to the SOP as necessary.

necessary				
Equipment Inspection – did the field crew ensure that all the field equipment was present and in working order	√			Inspections occur in morning at the lab.
Equipment Calibration – did the field crew ensure that all equipment was calibrated according to SOPs and/or manufacturer instructions	√			Calibrations occur in morning at the lab. YSI calibrated daily. Velocity meter (Marsh McBirney) calibrated weekly.
Field Data Sheets – did the field crew have the most recent copy of the SWAMP Bioassessment Field Forms	√			Yes, using the most recent version of the RMC field forms
Reach Documentation – did the field crew fill in this section of the field forms before starting the actual field work	√			Measured reach to 150m before starting collection.
Reach Documentation – did the field crew determine the Latitude and Longitude at the proper reach location and record the proper units and type of device use	√			
Reach Documentation – did the field crew get SWAMP site codes from the Regional SWAMP coordinator	√			Site codes using a 9 digit SWAMP compatible code for all RMC probabilistic sites. Using SWAMP codes for targeted sites.
Reach Length – did the field crew determine the average stream width, decide the reach length according to the SOP and record any discrepancies from the required reach length	√			
Notable Field Conditions – did the field crew check the appropriate boxes and if necessary obtain the information from outside the reach area	√			
Decontamination – did the field crew previously decontaminate all equipment, including boots and waders for Aquatic Invasive Species (AIS)	√			Field crews decontaminate at the lab/office first by washing gear then using industrial drier then freezing overnight (approx. 12 hrs), A second set of gear is available if sampling two sites in a day

Describe the Field Team Coordination (number of field personnel, how data is recorded, how the data collection is split among field personnel, how disputes or uncertainties in the data collection are dealt with, etc.):

The crew was composed of four people. There was a team of two collecting the macroinvertebrates and algae samples (Tom King and Traci Linder), and another team of two (Paul Salop and Lucile Paquette) behind the first team that would do the phab. The bio-team also did discharge upon arrival while Team 2 did the water chem upstream of Team 1 and around Transect A.

Item	Y	N	N/A	Comments
Ambient Water Quality Measurements				
Temperature – did the field crew measure the water temperature at the A transect and record the type of equipment used	√			YSI 556 MPS. Send in for yearly maintenance.
pH – did the field crew measure the pH at the A transect and record the type of equipment used	√			Used a "pen" for pH because YSI was giving them strange results.
Alkalinity – did the field crew measure the alkalinity at the A transect and record the type of equipment used	√			Lab analyte
Dissolved Oxygen – did the field crew measure DO at the A transect and record the type of equipment used	√			YSI 556 MPS.
Specific Conductance – did the field crew measure conductivity at the A transect and record the type of equipment used	√			YSI 556 MPS.
Equipment – when using colorimetric kits, did the field crew inspect the reagents for expiration dates	√			Chlorine kit K-2511 ULR CHEMets kit measures Free and Total Chlorine. Recorded expiration dates on field sheets.
Additional Chemical Measures – when collecting samples for additional chemicals, did the field crew have a copy of the appropriate SWAMP SOP	√			Nutrient suite: crew used gloves, well labeled bottles, triple rinsed grab bottles, field filter DOC and OP.
Holding Times – was the field crew aware of all appropriate holding times for the additional chemical measures	√			Yes, meeting all holding times (48 hr for nitrate, nitrite, OP). Lab picks up from office each evening.
Item	**Y**	**N**	**N/A**	**Comments**
Invertebrate Collection - Reach Wide Benthos Procedure				
Collection Location – did the field crew member properly determine where the net should be placed in relation to the transect	√			
Net Placement – did the field crew member place the sampling net correctly in the substrate and perpendicular to flow	√			
Substrate Excavation – did the field crew member adequately disturb and scrub the substrate to collect the invertebrates	√			
Substrate Excavation Duration – did the field crew member disturb the substrate for a consistent duration (1-3 minutes) and in accordance with the type of substrate	√			Kicks in fine sediment and sand substrates took 15-30 sec, while coarser substrates were collected within 1-2 minutes.

Substrate Excavation Depth – did the field crew member excavate the substrate to a depth (4-6 inches) adequate to collect all the invertebrates	√			Variable depths dependent upon substrate
Excavated Material Cleaning – did the field crew member take precautions that no invertebrates were lost when removing large material from the net	√			Yes, sampler carefully rinsed large root debris and put a sub portion of debris in sample
Handling of Excavated Material – did the field crew member take precautions that no invertebrates were lost when transporting the net between collection locations	√			Sampler puts transect sample in collection jar each time unless there is adequate flow then does 2-3 samples before depositing
Compositing of Excavated Material – did the field crew member take precautions that no excavated material was lost when compositing and placing material in jars	√			Used a tray below the jar to transfer from net into the composite jar.
Labeling of Samples – were the invertebrate collection jars labeled according to the SOP	√			
Collection of Duplicates – when collecting duplicate samples, did the field crew member determine the proper location and ensure the samples were not cross-contaminated	√			This was discussed at this sample was not a duplicate day. Crew doing field duplicates at 10% of sites.
Sample Integrity – were the sample jars kept out of direct sunlight, away from heat, and protected from desiccation during sampling, sample processing and sample storage	√			Yes, sample jar was wrapped in tape, with a lid on and processed in the truck under shade.

Item	Y	N	N/A	Comments
Algae Collection - Reach Wide Benthos Procedure				
Familiarity with SOP – did the field crew have a copy of the most recent SWAMP Algae Protocol	√			
Avoidance of cross-contamination – was all equipment that touches algae since previous site been scrubbed and rinsed	√			Tools are washed at the lab, and frozen overnight. A second set is available if sampling two sites in a day
Determine collection locations – were sample collection locations determined correctly, and according to procedures for high *vs.* low gradient	√			
Sampling spot – Substrate to be sampled at each point is correctly identified (and has not been recently disturbed by bug sampling or otherwise)	√			Samples collected in unbiased manner according to SOP.
Recording sampling area – did the crew	√			Recorded in fieldbook

members tally on data sheet the device (area) used for sampling at each transect				
Protection of sample integrity – were specimens kept out of direct sunlight, away from heat, and protected from desiccation during sampling and sample processing	√			Sample kept in jar with lid and colored tape around the side of the jar. Kept in shade for processing.
Sampling silt/sand/fine gravel substrates – PVC delimiter is filed to make bottom edge "sharp" and clearly marked with a 1-cm depth indicator; delimiter is inserted into substrate to a depth of 1 cm; no target material is lost in collecting; excess material is cleared off spatula prior to adding material to tub	√			Proper form described or displayed . Used squirt bottle to get material out of bottom of delimeter
Sampling macroalgal substrates – PVC delimiter is used; entire thickness of clump is collected within the delimiter; macroalgal mat is not unnaturally stretched nor bunched up prior to isolating the area to be sampled; excess material (outside of the PVC) is cleanly cut away (not pulled) prior to adding the specimen to the tub; no target material is lost in the process of collecting	√			Proper form described or displayed
Sampling cobble/wood/ substrates – Rubber delimiter is used on the appropriate spot on the substrate; specimen collection (*i.e.*, scrubbing, rinsing) occurs only on the area within the delimiter; the sampler checks to make sure area sampled is rough, possibly different color, and apparently free of algae	√			Proper form described or displayed
Sampling bedrock/boulders/concrete substrates– a properly constructed syringe scrubber is used; a new scrubber pad is used between sites; scrubber is rotated at least 3x flush against substrate, while maintaining a good seal with the barrel, and carefully removed from stream (fine-tipped forceps may be needed to remove any strands of filamentous algae); scrubber pad is rinsed thoroughly and squeezed to remove material; the scrubbed spot on substrate is checked to ensure adequate removal of sample material	√			Proper form described or displayed
Collection of qualitative soft-bodied algae sample – qualitative algal sample was collected and properly labeled and kept in the dark on wet ice; stream was examined with sufficient rigor to collect a reasonably	√			Kept in whirlpack in a bucket.

exhaustive sample				

Item	Y	N	N/A	Comments
Algae Sample Processing				
Composite sample preparation –total volume of composite liquid is measured, including rinse water, and recorded on data sheets and sample labels	√			
Aliquotting samples – sample is always adequately agitated immediately before pouring	√			
Macroalgal clump processing: soft-bodied sample – ¼ of the clump (representative of each taxon) is measured and isolated and placed in soft-bodied sample tube; the remainder is properly stored in cooler/dark on wet ice	√			No macroalgae present. However sampler correctly described process if macroalgae present. Had restoration worksheet instructions available.
Macroalgal clump processing: other samples – composite sample is agitated prior to pouring off properly calculated amount to restore ratio; ¾ remaining macroalgal clump is chopped into sufficiently fine pieces and homogenized adequately into liquid	√			No macroalgae present. However sampler correctly described process if macroalgae present. Had restoration worksheet instructions available.
Taxonomic ID sample fixing and storage – diatom sample is fixed immediately with formalin for final concentration of 2% and agitated to mix; and unfixed soft-bodied sample is stored immediately on wet ice and in the dark; all sample tubes are properly labeled and taped; proper safety precautions are taken when handling fixative (*i.e.*, done only in well ventilated area; goggles and gloves are worn; fixative is stored in an appropriate container; tubes are kept on a centrifuge rack to free up hands)	√			Soft algae sample fixed in lab within 3 hrs. Diatoms fixed in the field with formalin.
Biomass samples, general – filter tower apparatus is always cleaned before use and between uses, and rubber rings are confirmed to be in place; 25mL is measured in a small grad. cylinder (or a smaller volume is used, only if necessary); maximum allowable psi is not exceeded during filtering; proper pore size, glass-fiber filters used; filters are folded with sides containing material folded inward and are wrapped carefully in Whirlpak,	√			

labeled, and shoved into wet ice; final volumes that were filtered are recorded, for each filter, on the data sheet and sample labels				
Chlorophyll a – non-algal leaves are removed from filter; filter is placed in Petri dish and wrapped in foil	√			
AFDM – a precombusted filter used; non-algal organic material (*e.g.*, leaves, twigs, bugs) is removed from filter	√			Individually weighed and numbered filters
Item	**Y**	**N**	**N/A**	**Comments**
Reach-Wide Physical/Habitat Measurements				
Discharge Measurements – when using the Velocity Area Method or Buoyant Object Method (circle one), did the field crew choose an appropriate channel section and record all required measurements	√			Marsh McBirney Flow Mate used with velocity area method. Stream was shallow (<5-7 cm) so wading rod was not used.
Additional Cobble Embeddedness Measurements – did the field crew record any additional cobble embeddedness measures to equal a total of 25 and was a random method used to obtain the cobbles	√			Situations were discussed when less than 25 total cobbles could be encountered in the 150m reach (e.g. concrete lined channels).
Slope and Bearing – did the field crew use an auto-level for low gradient channels or a clinometer for high gradient channels and record information for each transect starting at K	√			Used a hand level for all streams. Use a modified protocol which only requires slope of the entire 150m reach.
Slope and Bearing – did the field crew record the bearing in degrees on the center of the transect starting at K			n/a	RMC specific protocol does not collect bearing
Slope and Bearing – did the field crew understand how and when to use the Supplemental Segment section of the form			n/a	RMC specific protocol does not collect bearing
Channel Alteration Visual – did the field crew assess channel alteration for the entire reach and discuss the assessment to come to an agreement on the final estimate	√			
Sediment Deposition Visual – did the field crew assess sediment deposition for the depositional zones of the entire reach and discuss the assessment to come to an agreement on the final estimate	√			
Epifaunal Substrate/Cover Visual – did the field crew assess epifuanual substrate/cover	√			

for the entire reach and discuss the assessment to come to an agreement on the final estimate				

Item	Y	N	N/A	Comments
Transect Based Physical/Habitat Measurements				
Wetted Width – did the field crew determine the wetted width measurement accurately	√			
Bankfull Width and Height – did the field crew determine the bankfull width and height measurement accurately			n/a	RMC protocol does not use this parameter
Depth and Substrate Measurements – did the field crew measure the depth and pick up the substrate in a systematic, unbiased manure	√			Field crew was instructed by manager to use size classes. Size classes are possible to enter into the database, but actual size classes should be recorded in general.
Transect Substrate Measurements – did the field crew measure the substrate particle properly and use the correct size class categories	√			
Cobble Embeddedness – did the field crew recognize cobble sized substrate and determine the percent embeddedness accurately	√			
CPOM – did the field crew recognize the correct material and location in relation to the substrate	√			Discussed how CPOM is determined as present based on the size of the substrate
Microalgae Thickness – was the field crew able to determine microalgae presence and correct thickness code	√			Note: crews said they get mostly micro 0 and 1.
Macroalgae – was the field crew able to determine the difference between attached and unattached macroalgae presence	√			
Canopy Cover – was the field crew able to properly use the modified densiometer and obtaining measurements correctly	√			Note: measured by biological crew
Bank Stability – did the field crew estimate the bank stability categories properly and for the correct bank zone	√			Discussed definition of bank
Riparian Vegetation – did the field crew understand and properly estimate the three canopy categories for the correct area and elevation zones			n/a	RMC protocol does not use this parameter
Instream Habitat Complexity – did the field crew understand and properly estimate the nine habitat categories for the correct	√			

channel area				
Human Influence– did the field crew understand and properly estimate the fourteen human influence categories for the correct zones relative to the channel	√			
Inter-Transect Substrate Measurements – did the field crew collect all the measurement similar to the major transects	√			
Flow Habitats – did the field crew recognize all the flow habitat categories and the definition of fast/slow and shallow/deep	√			
Photo-Documentation – did the field crew take photographs at the A, F and K transect and in the proper orientation to the channel	√			
Photo-Documentation – did the field crew properly record the photo code for all photographs including any supplemental pictures of the sampling reach	√			

Item	Y	N	N/A	Comments
Post Sampling Activities				
Sampling Team Debriefing – did the field team meet to discuss the post sampling activities and responsibilities	√			
Field Data Sheets – did the field crew completely and correctly fill out the field forms	√			
Verification and Agreement – did the field crew resolve all data disputes and discrepancies or record questions to be resolved later by the ABL			n/a	
Invertebrate Sample Integrity – were the invertebrate samples inspected for proper alcohol level, labels and secured for travel	√			Doesn't fill jar with more than half of the sample with material
Chain of Custody Form – was a COC form used for invertebrates samples and was it properly filled out	√			Fill out at the office
Additional Chemical Measures – if samples were collected for additional chemicals, did the field crew ensure the samples were labeled and stored properly for transportation to the Lab according to the appropriate SOP	√			Chemistry lab picks up samples from at the office at the end of the day.
Equipment Count – did the field crew account for all the equipment	√			
Aquatic Invasive Species Decontamination	√			

– was the equipment, including boots and waders, decontaminated according to the field crew's SOP				

I CERTIFY THAT THIS FIELD TEAM HAS ADEQUATELY FULLFILLED ALL REQUIRMENTS OF THE FIELD AUDIT FOR THE SWAMP BIOASSESSMENT PROCEDURE

Kevin B. Lunde
Environmental Scientist
San Francisco Bay Regional Water Quality Control Board

COMMENTS:

All members of this 4 person crew working for Applied Marine Sciences were trained by Jim Harrington at the 2012 RMC training, and participated in the 2013 RMC one day training and 2013 RMC inter-calibration exercise prior to 2013 sampling. They have experience sampling 30 sites in 2012 and will sample approximately 30 more in 2013. Some individuals have past experience working with the CSBP protocol.

This crew can sample 1-2 sites per day and takes approximately 4 hrs at a site.

The one recommendation I have for this crew is to have a discussion with their RMC program rep about collecting actual pebble sizes for the pebble count as opposed to use the classes. Recording actual sizes results in a more accurate representation of the substrate because averages of bins result in taking the intermediate value of the size bin. Collecting the actual measurements only takes 2-5 more minutes per site and should be considered as the SWAMP protocol states actual measurements are preferred.

Revision Date: May 2012

2012 SWAMP Bioassessment Procedure
Biological and Physical Habitat Field Audit

Field Team: Tom King, Scott Cressey, Lucille Paquette and Traci Linder

Field Location: Chabout Creek

Date of Audit: June 14, 2012

Background of Group and Audit Objectives:

The sampling crew work for Applied Marine Sciences, Inc., 4749 Bennett Dr., Ste L, Livermore, CA, 94551 (AMC) and are one of three crews sampling reaches for the Bay Area Regional Monitoring Coalition (RMC). The RMC consists of several Bay Area city and county stormwater agencies under a regional permit from the San Francisco Regional Water Quality Control Board. The three crews (AMC, EOA and the Regional Board) were trained together in March 2012. The RMC used a modified version of the SWAMP protocol.

Item	Y	N	N/A	Comments
Field Day and Sampling Site Preparations				
Sampling Team Briefing – did the field crew meet to discuss the project objectives, field conditions, safety procedures and any special situation associated with the site	√			Crew had a first aid kit
Quality Assurance Project Plan – was the field crew familiar with the project QAPP and the assigned QA Officer	√			
Permits – did the field crew have copies of DFG sampling MOU and LAI		√		Crew did not know that the LAI was in their field packet prepared by the AMC
Permits – did the field crew have a copy of the landowner permission letter	√			
SOP – did the field crew have a copy of the most recent SWAMP Bioassessment Protocol	√			
SOP – did the field crew have a project specific SOP which lines out the assignments for all crew members	√			
SOP – did the field crew have a system for adding, updating, and retiring the SOP, as	√			

necessary				
Equipment Inspection – did the field crew ensure that all the field equipment was present and in working order	√			
Equipment Calibration – did the field crew ensure that all equipment was calibrated according to SOPs and/or manufacturer instructions	√			
Field Data Sheets – did the field crew have the most recent copy of the SWAMP Bioassessment Field Forms	√			Used project specific forms modified from the SWAMP procedures
Reach Documentation – did the field crew fill in this section of the field forms before starting the actual field work	√			
Reach Documentation – did the field crew determine the Latitude and Longitude at the proper reach location and record the proper units and type of device use	√			
Reach Documentation – did the field crew get SWAMP site codes from the Regional SWAMP coordinator	√			
Reach Length – did the field crew determine the average stream width, decide the reach length according to the SOP and record any discrepancies from the required reach length	√			
Notable Field Conditions – did the field crew check the appropriate boxes and if necessary obtain the information from outside the reach area	√			
Decontamination – did the field crew previously decontaminate all equipment, including boots and waders for Aquatic Invasive Species (AIS)	√			Crew did 2 sites/day and used 2 sets of equipment which were frozen at the end of each day

Describe the Field Team Coordination (number of field personnel, how data is recorded, how the data collection is split among field personnel, how disputes or uncertainties in the data collection are dealt with, etc.):

The 4-person crew divided into a bio and phab team. Tom King and Scott Cressey who are very experienced in bioassessment techniques were the bio team. When they finished they also processed the algae samples in their vehicle. Lucille Paquette and Traci Linder worked together to collect the chemistry and phab measures. The teams did use a modified SWAMP protocols which eliminated some of the elements and reducing the time needed to complete survey.

Item	Y	N	N/A	Comments
Ambient Water Quality Measurements				
Temperature – did the field crew measure the water temperature at the A transect and record the type of equipment used	√			YSI 85
pH – did the field crew measure the pH at the A transect and record the type of equipment used	√			
Alkalinity – did the field crew measure the alkalinity at the A transect and record the type of equipment used	√			Determined in laboratory
Dissolved Oxygen – did the field crew measure DO at the A transect and record the type of equipment used	√			YSI 85
Specific Conductance – did the field crew measure conductivity at the A transect and record the type of equipment used	√			YSI 85
Equipment – when using colorimetric kits, did the field crew inspect the reagents for expiration dates	√			Determined chlorine using colorimetric
Additional Chemical Measures – when collecting samples for additional chemicals, did the field crew have a copy of the appropriate SWAMP SOP	√			RMC specific additions
Holding Times – was the field crew aware of all appropriate holding times for the additional chemical measures	√			Delivered samples each day to the lab
Item	**Y**	**N**	**N/A**	**Comments**
Invertebrate Collection - Reach Wide Benthos Procedure				
Collection Location – did the field crew member properly determine where the net should be placed in relation to the transect	√			
Net Placement – did the field crew member place the sampling net correctly in the substrate and perpendicular to flow	√			
Substrate Excavation – did the field crew member adequately disturb and scrub the substrate to collect the invertebrates	√			
Substrate Excavation Duration – did the field crew member disturb the substrate for a consistent duration (1-3 minutes) and in accordance with the type of substrate	√			
Substrate Excavation Depth – did the field crew member excavate the substrate to a depth (4-6 inches) adequate to collect all the invertebrates	√			

Excavated Material Cleaning – did the field crew member take precautions that no invertebrates were lost when removing large material from the net	√			
Handling of Excavated Material – did the field crew member take precautions that no invertebrates were lost when transporting the net between collection locations	√			
Compositing of Excavated Material – did the field crew member take precautions that no excavated material was lost when compositing and placing material in jars	√			Every collection was put in sample jar
Labeling of Samples – were the invertebrate collection jars labeled according to the SOP	√			RMC specific but followed SWMAP
Collection of Duplicates – when collecting duplicate samples, did the field crew member determine the proper location and ensure the samples were not cross-contaminated			√	Crew did a total of 3 for season but not at this site
Sample Integrity – were the sample jars kept out of direct sunlight, away from heat, and protected from desiccation during sampling, sample processing and sample storage	√			

Item	Y	N	N/A	Comments
Algae Collection - Reach Wide Benthos Procedure				
Familiarity with SOP – did the field crew have a copy of the most recent SWAMP Algae Protocol	√			
Avoidance of cross-contamination – was all equipment that touches algae since previous site been scrubbed and rinsed	√			
Determine collection locations – were sample collection locations determined correctly, and according to procedures for high *vs.* low gradient	√			
Sampling spot – Substrate to be sampled at each point is correctly identified (and has not been recently disturbed by bug sampling or otherwise)	√			
Recording sampling area – did the crew members tally on data sheet the device (area) used for sampling at each transect	√			Bio-crew kept good notes including this in notebook

Protection of sample integrity – were specimens kept out of direct sunlight, away from heat, and protected from desiccation during sampling and sample processing	√			Bio-crew used sample jar with dark colored bubble wrap for sample collection
Sampling silt/sand/fine gravel substrates – PVC delimiter is filed to make bottom edge "sharp" and clearly marked with a 1-cm depth indicator; delimiter is inserted into substrate to a depth of 1 cm; no target material is lost in collecting; excess material is cleared off spatula prior to adding material to tub	√			
Sampling macroalgal substrates – PVC delimiter is used; entire thickness of clump is collected within the delimiter; macroalgal mat is not unnaturally stretched nor bunched up prior to isolating the area to be sampled; excess material (outside of the PVC) is cleanly cut away (not pulled) prior to adding the specimen to the tub; no target material is lost in the process of collecting	√			
Sampling cobble/wood/ substrates – Rubber delimiter is used on the appropriate spot on the substrate; specimen collection (*i.e.*, scrubbing, rinsing) occurs only on the area within the delimiter; the sampler checks to make sure area sampled is rough, possibly different color, and apparently free of algae	√			
Sampling bedrock/boulders/concrete substrates– a properly constructed syringe scrubber is used; a new scrubber pad is used between sites; scrubber is rotated at least 3x flush against substrate, while maintaining a good seal with the barrel, and carefully removed from stream (fine-tipped forceps may be needed to remove any strands of filamentous algae); scrubber pad is rinsed thoroughly and squeezed to remove material; the scrubbed spot on substrate is checked to ensure adequate removal of sample material	√			
Collection of qualitative soft-bodied algae sample – qualitative algal sample was collected and properly labeled and kept in the dark on wet ice; stream was examined with sufficient rigor to collect a reasonably exhaustive sample	√			

Item	Y	N	N/A	Comments
Algae Sample Processing				
Composite sample preparation –total volume of composite liquid is measured, including rinse water, and recorded on data sheets and sample labels	√			
Aliquotting samples – sample is always adequately agitated immediately before pouring	√			
Macroalgal clump processing: soft-bodied sample – ¼ of the clump (representative of each taxon) is measured and isolated and placed in soft-bodied sample tube; the remainder is properly stored in cooler/dark on wet ice			√	No filamentous at this site
Macroalgal clump processing: other samples – composite sample is agitated prior to pouring off properly calculated amount to restore ratio; ¾ remaining macroalgal clump is chopped into sufficiently fine pieces and homogenized adequately into liquid			√	
Taxonomic ID sample fixing and storage – diatom sample is fixed immediately with formalin for final concentration of 2% and agitated to mix; and unfixed soft-bodied sample is stored immediately on wet ice and in the dark; all sample tubes are properly labeled and taped; proper safety precautions are taken when handling fixative (*i.e.*, done only in well ventilated area; goggles and gloves are worn; fixative is stored in an appropriate container; tubes are kept on a centrifuge rack to free up hands)	√			
Biomass samples, general – filter tower apparatus is always cleaned before use and between uses, and rubber rings are confirmed to be in place; 25mL is measured in a small grad. cylinder (or a smaller volume is used, only if necessary); maximum allowable psi is not exceeded during filtering; proper pore size, glass-fiber filters used; filters are folded with sides containing material folded inward and are wrapped carefully in Whirlpak, labeled, and shoved into wet ice; final volumes that were filtered are recorded, for each filter, on the data sheet and sample labels	√			

Chlorophyll a – non-algal leaves are removed from filter; filter is placed in Petri dish and wrapped in foil	√			Used pre-weighed drying plates specific for each filter
AFDM – a precombusted filter used; non-algal organic material (*e.g.*, leaves, twigs, bugs) is removed from filter	√			Used pre-weighed drying plates specific for each filter
Item	**Y**	**N**	**N/A**	**Comments**
Reach-Wide Physical/Habitat Measurements				
Discharge Measurements – when using the Velocity Area Method or Buoyant Object Method (circle one), did the field crew choose an appropriate channel section and record all required measurements	√			
Additional Cobble Embeddedness Measurements – did the field crew record any additional cobble embeddedness measures to equal a total of 25 and was a random method used to obtain the cobbles	√			
Slope and Bearing – did the field crew use an auto-level for low gradient channels or a clinometer for high gradient channels and record information for each transect starting at K	√			Used sighting scope with monopod
Slope and Bearing – did the field crew record the bearing in degrees on the center of the transect starting at K	√			RMC protocol did not measure bearing
Slope and Bearing – did the field crew understand how and when to use the Supplemental Segment section of the form	√			
Channel Alteration Visual – did the field crew assess channel alteration for the entire reach and discuss the assessment to come to an agreement on the final estimate	√			I discussed this element with the crew
Sediment Deposition Visual – did the field crew assess sediment deposition for the depositional zones of the entire reach and discuss the assessment to come to an agreement on the final estimate	√			I discussed this element with the crew
Epifaunal Substrate/Cover Visual – did the field crew assess epifuanual substrate/cover for the entire reach and discuss the assessment to come to an agreement on the final estimate	√			I discussed this element with the crew

Item	Y	N	N/A	Comments
Transect Based Physical/Habitat Measurements				
Wetted Width – did the field crew determine the wetted width measurement accurately	√			
Bankfull Width and Height – did the field crew determine the bankfull width and height measurement accurately	√			Not in RMC protocol
Depth and Substrate Measurements – did the field crew measure the depth and pick up the substrate in a systematic, unbiased manure	√			
Transect Substrate Measurements – did the field crew measure the substrate particle properly and use the correct size class categories	√			
Cobble Embeddedness – did the field crew recognize cobble sized substrate and determine the percent embeddedness accurately	√			
CPOM – did the field crew recognize the correct material and location in relation to the substrate	√			
Microalgae Thickness – was the field crew able to determine microalgae presence and correct thickness code	√			
Macroalgae – was the field crew able to determine the difference between attached and unattached macroalgae presence	√			
Canopy Cover – was the field crew able to properly use the modified densiometer and obtaining measurements correctly	√			Bio-crew did this measure
Bank Stability – did the field crew estimate the bank stability categories properly and for the correct bank zone	√			
Riparian Vegetation – did the field crew understand and properly estimate the three canopy categories for the correct area and elevation zones	√			Not in RMC protocol
Instream Habitat Complexity – did the field crew understand and properly estimate the nine habitat categories for the correct	√			

channel area				
Human Influence– did the field crew understand and properly estimate the fourteen human influence categories for the correct zones relative to the channel	√			
Inter-Transect Substrate Measurements – did the field crew collect all the measurement similar to the major transects	√			
Flow Habitats – did the field crew recognize all the flow habitat categories and the definition of fast/slow and shallow/deep	√			I discussed this element with the crew
Photo-Documentation – did the field crew take photographs at the A, F and K transect and in the proper orientation to the channel	√			
Photo-Documentation – did the field crew properly record the photo code for all photographs including any supplemental pictures of the sampling reach	√			

Item	Y	N	N/A	Comments
Post Sampling Activities				
Sampling Team Debriefing – did the field team meet to discuss the post sampling activities and responsibilities	√			
Field Data Sheets – did the field crew completely and correctly fill out the field forms	√			
Verification and Agreement – did the field crew resolve all data disputes and discrepancies or record questions to be resolved later by the ABL	√			
Invertebrate Sample Integrity – were the invertebrate samples inspected for proper alcohol level, labels and secured for travel	√			
Chain of Custody Form – was a COC form used for invertebrates samples and was it properly filled out	√			
Additional Chemical Measures – if samples were collected for additional chemicals, did the field crew ensure the samples were labeled and stored properly for transportation to the Lab according to the appropriate SOP	√			
Equipment Count – did the field crew account for all the equipment	√			
Aquatic Invasive Species Decontamination				Crew did 2 sites/day and used

– was the equipment, including boots and waders, decontaminated according to the field crew's SOP	√			2 sets of equipment which were frozen at the end of each day

I CERTIFY THAT THIS FIELD TEAM HAS ADEQUATELY FULLFILLED ALL REQUIRMENTS OF THE FIELD AUDIT FOR THE SWAMP BIOASSESSMENT PROCEDURE

9/24/2012

James M. Harrington
Staff Environmental Scientist
California Department of Fish and Game

COMMENTS:

This crew from AMC working for the Bay Area RMC was made up of 4 experienced and consciousness individuals. I think a 4 person team is idea and they split the duties in an effective way. I was concerned that they did not know they had the DFG issues LAI until after this event.

Although not a concern for this site, Tom King mentioned that at other sites where algae was excessive, he discarded some of the algae to prevent overloading the sample jars. He asked if that was an acceptable SWAMP procedure. This question has not come up before and my immediate answer was not to discharge any of the sampled material regardless of sample volume. However, I asked Tom to summarize the issue so I will can send the question to others to get feedback.

Integrated Monitoring Report

Part B: PCB and Mercury Loads Avoided and Reduced via Stormwater Control Measures

Prepared for

Bay Area Stormwater Management Agencies Association

Prepared by

Geosyntec consultants

engineers | scientists | innovators

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January 23, 2014

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B.1 BACKGROUND AND UNDERSTANDING

B.1.1 Introduction

Fish tissue monitoring in San Francisco Bay (Bay) has revealed bioaccumulation of polychlorinated biphenyls (PCBs), mercury, and other pollutants. The levels found are thought to pose a health risk to people consuming fish caught in the Bay. As a result of these findings, California has issued an interim advisory on the consumption of fish from the Bay. The advisory led to the Bay being designated as an impaired water body on the Clean Water Act "Section 303(d) list" due to PCBs, mercury, and other pollutants. In response, the California Regional Water Quality Control Board, San Francisco Bay Region (Regional Water Board) has developed Total Maximum Daily Load (TMDL) water quality restoration programs targeting PCBs and mercury in the Bay. The general goals of the TMDLs are to identify sources of PCBs and mercury to the Bay and implement actions to control the sources and restore water quality.

Municipal separate storm sewer systems (MS4s) are one of the PCB and mercury source/pathways identified in the TMDL plans. Local public agencies (i.e., Permittees) subject to requirements via National Pollutant Discharge Elimination System (NPDES) permits must implement control measures in an attempt to reduce PCBs and mercury from entering stormwater runoff and the Bay. These control measures, also referred to as best management practices (BMPs), are the tools that Permittees can use to assist in restoring water quality in the Bay.

NPDES permit requirements associated with Phase I municipal stormwater programs and Permittees in the Bay Area are included in the Municipal Regional Stormwater NPDES Permit (Order R2-2009-0074) (MRP), which was issued to 76 cities, counties and flood control districts in 2009. Consistent with the TMDL plans, provisions C.11 and C.12 of the MRP require the implementation of control measures to reduce PCBs and mercury in urban stormwater runoff. The results and findings of control measure implementation and effectiveness evaluations conducted to-date are presented in this Integrated Monitoring Report (IMR) Part B. The core objectives of IMR Part B are to:

- Demonstrate full compliance with the March 15, 2014 MRP reporting requirements associated with provisions C.11 (mercury) and C.12 (PCBs);
- Report on the effectiveness of PCB and mercury control measures implemented via the MRP, including estimates of loads reduced; and,
- Identify the chosen monitoring/measurement approach concerning PCB and mercury loads assessment and estimations of loads reduced.

Consistent with these objectives, IMR Part B is intended to answer the following core management questions:

- What are the approaches selected by Permittees to assess progress towards TMDL Waste Load Allocations?
- What mass of PCBs and mercury were reduced or avoided by control measures prior to the adoption of the TMDLs (e.g., baseline) and after TMDL adoption, including those implemented in compliance with the MRP?

B.1.2 PCBs and Mercury Total Maximum Daily Loads

Based on a determination of water quality impairment of the Bay associated with PCBs and mercury, the Regional Water Board developed TMDL plans for these pollutants. The purpose of the TMDL plans is to attain water quality standards that will protect sport fishing, human health, aquatic organisms, wildlife, and rare and endangered species in the Bay. To attain water quality standards, the TMDL plan sets regulatory targets and maximum total allowable pollutant loads from all sources combined (i.e., the TMDL). Load reductions needed to obtain the TMDL are assigned to sources through wasteload (point sources) and load (nonpoint sources) allocations. Urban stormwater runoff, which includes discharges from MS4s, was identified as an important contributor of pollutants to the Bay in both the PCBs and mercury TMDLs. Urban stormwater Permittees were therefore assigned wasteload allocations accordingly in the TMDLs.

B.1.2.1 TMDL Targets

On February 12, 2008, the U.S. Environmental Protection Agency (USEPA) approved a Basin Plan amendment incorporating a TMDL for mercury in the Bay (Mercury TMDL) and an implementation plan to achieve the TMDL. Prior to USEPA approval, the amendment was adopted by the Regional Water Board, the State Water Resources Control Board, and the state Office of Administrative Law. Mercury TMDL targets include:

- Bay-wide suspended sediment mercury concentration of 0.2 milligram (mg) mercury per kilogram (kg) dry sediment;
- Large fish target of 0.2 mg mercury per kg fish tissue that applies to striped bass; and
- Small fish target of 0.03 mg mercury per kg fish (average wet weight whole fish) for protection of wildlife (especially piscivorous birds).

The USEPA approved a TMDL for PCBs in the Bay on March 29, 2010. The Basin Plan amendment incorporating this TMDL and an implementation plan to achieve the TMDL was adopted or approved by the Regional Board, the State Water Resources Control Board, and the state Office of Administrative Law prior to the USEPA approval. The PCBs TMDL includes a

fish tissue target of 10 nanogram (ng) of Total PCBs[1] per gram (g) of fish tissue (white croaker or shiner surfperch).

B.1.2.2 TMDL Wasteload Allocations

To reach the TMDL targets described above and obtain water quality standards in the Bay for mercury and PCBs, pollutant reductions are required from each source causing or contributing to Bay impairment. For mercury, a 43 percent reduction of total mercury discharged to the Bay from all sources combined is required. The largest mercury reductions are required from the Guadalupe River (legacy mining), Central Valley watershed, and urban stormwater runoff. For PCBs, a 24 kg/yr (approximately 70 percent) load reduction of total PCBs in discharges to the Bay is required from all sources combined to obtain water quality standards. The largest PCB load reductions are required from the Central Valley watershed and stormwater runoff.

The PCBs and mercury TMDL Staff Reports (SFBRWQCB 2006, 2008) provide estimates of pollutants loads from urban stormwater runoff.[2] Wasteload allocations for urban stormwater runoff are assigned by county to Bay Area stormwater programs. Stormwater programs identified in the TMDLs that represent Permittees subject to MRP requirements include:

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

Mercury and PCB TMDL loads, wasteload allocations (WLA), and load reductions assigned to these stormwater programs are included in Table B.1.2.1. Pollutant load reductions are based on current understandings of pollutant contributions and represent the goal that stormwater programs should strive to attain through stormwater control measure implementation.

Wasteload allocations (WLAs) for urban stormwater runoff programs presented in Table B.1.2.1 implicitly <u>include all current and future permitted discharges</u> within the geographic boundaries of Permittees. Permitted discharges include those covered under municipal stormwater NPDES permits, and discharges attributable to the California Department of Transportation (Caltrans)

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[1] Based on the use the term "Total PCBs" in the PCBs TMDL, Total PCBs is defined as either: 1) sum of Aroclors; 2) sum of the individual congeners routinely quantified by the Regional Monitoring Program (RMP) for Water Quality in the San Francisco Estuary; or 3) sum of the National Oceanic and Atmospheric Administration (NOAA) 18 congeners converted to total Aroclors.

[2] As described in IMR Part C, loading estimates are currently under review and may be revised in the future.

roadways and non-roadway facilities and rights-of-way, atmospheric deposition onto the surface of the watershed, public facilities (e.g., schools), properties adjacent to stream banks, industrial facilities, and construction sites.

Table B.1.2.1. Mercury and PCB Loads, Wasteload Allocations and Load Reduction Goals for Bay Area Phase I Municipal Stormwater Programs

Entity	Mercury (kg/yr)			PCBs (kg/yr)		
	Load (2002)	Wasteload Allocation	Load Reduction[4]	Load (2002)	Wasteload Allocation	Load Reduction[4]
Santa Clara Valley Urban Runoff Pollution Prevention Program	44	23	21	5.5	0.5	5.0
Alameda County Clean Water Program	39	20	19	4.9	0.5	4.4
Contra Costa Clean Water Program	22	11	11	2.7	0.3	2.4
San Mateo County Water Pollution Prevention Program	16.4	8.4	8	2.1	0.2	1.9
City of Vallejo and VSFCD[1]	3.2	1.6	1.6	1.0[3]	0.1[3]	0.9[3]
Fairfield-Suisun Urban Runoff Management Program[2]	3.1	1.6	1.5			

[1] Vallejo Sanitation and Flood Control District
[2] Includes the City of Fairfield and Suisun City
[3] The PCB TMDL assigns a combined allocation to "Solano County", which only includes discharges from the cities of Vallejo, Fairfield, and Suisun City
[4] Load reductions presented in the table were calculated for each stormwater program by subtracting the applicable WLA (originally based on relative populations) from the pollutant load (originally based on relative population).

B.1.2.3 TMDL Implementation Framework

Even if loads from all sources are reduced according to the wasteload allocations set by the TMDLs, recovery of the Bay is expected to take decades due to the large existing reservoirs of PCBs and mercury within Bay sediments. The urban stormwater runoff wasteload allocation for PCBs represents a 90 percent reduction from the estimated existing load. The TMDL implementation plans set roughly 20-year timelines for achieving the reductions but also incorporate an adaptive implementation planning approach. The adaptive approach consists of the development of a plan that includes early implementation actions based on existing knowledge that have a reasonable probability of success and an overview of options for future actions. For PCBs and mercury in the Bay, the immediate or early implementation actions are not expected to completely eliminate the Bay impairment. Therefore, future actions must be evaluated based on continued monitoring and response to the early implementation actions, as well as based on well-designed studies used for model refinement.

The MRP Fact Sheet notes that the initial focus of provisions C.11/12 is on measures designed to reduce PCBs, while also evaluating opportunities for mercury reduction. Implementation actions

may fall into four categories depending on the available knowledge and confidence in a control measure's effectiveness (listed in decreasing order of confidence):

- Full-scale implementation throughout the region.
- Focused implementation in areas where benefits are most likely to occur.
- Pilot-testing in a few specific locations.
- Other: This may refer to experimental control measures, research and development, desktop analysis, laboratory studies, and/or literature review.

As described later in this introduction, control measures currently under implementation by Permittees vary in their phase of implementation.

B.1.3 PCB and Mercury Uses, Sources and Transport

B.1.3.1 Polychlorinated Biphenyls (PCBs)

PCBs are mixtures of up to 209 individual chlorinated compounds (known as congeners). PCBs were manufactured in the United States and used widely from the late 1920s through the 1970s. Due to their non-flammability, chemical stability, high boiling point, and electrical insulating properties, PCBs were used in hundreds of industrial and commercial applications including electrical, heat transfer, and hydraulic equipment; as plasticizers in paints, plastics, and rubber products; in pigments, dyes, and carbonless copy paper; and many other applications. Because of their persistent qualities and physical and chemical characteristics, PCBs are found in environmental media worldwide, including air, sediment from street sweeping and stormwater conveyance systems, sediment and water from flood control channels and receiving waters, and urban stormwater runoff.

Monsanto, an agricultural chemical company, commercially produced PCBs from 1929 to 1977 under the trade name Aroclor and is considered one of the major producers of this pollutant (McKee et al. 2006). According to Erickson (2001), PCBs use can be grouped into three main categories:

1. Controllable closed systems where leakage is avoided by design during the lifespan of the equipment;
2. Uncontrollable closed systems, which are technically closed but where leakage usually occurs (also referred to as nominally closed); and
3. Dissipative (open-ended) uses, which involves non-recoverable PCBs that come in direct contact with the environment (also referred to as open-ended applications).

Keeler et al. (1993) divided the dissipative category into two smaller groups of plasticizers and other uses (e.g., flame retardants, paints, inks, sealants, and carbonless copy paper). It is not known to what extent PCBs use in the Bay Area fell within the three categories described above.

The U.S. total production of PCBs by Monsanto has been reported to be approximately 640,000 metric tonnes (de Voogt and Brinkman 1989). Production peaked in 1970 at approximately 30,000 tonnes or about six percent of the total U.S. production (Figure B.1.1.). Approximately 57 percent of total production occurred between 1960 and 1974 and 73 percent of the U.S. production occurred between 1955 and 1977. Overall, it appears that total production is proportional to total consumption in the U.S. (Breivik et al. 2002).

Although total consumption of PCBs in the U.S. (and Bay Area) continues to be at zero due to the ban in 1977, PCBs still remain in use in certain closed system equipment and devices (e.g., transformers and capacitors) and may possibly continue to contribute to urban stormwater runoff discharges.

B.1.3.2 Mercury

Mercury is a naturally-occurring, persistent, bioaccumulative metal that can be present in the elemental, inorganic, or organic forms in the environment. It is both a legacy pollutant and a contemporary pollutant. Historically, mercury has been used in a variety of products. Primary among the over 3,000 historical industrial uses in the U.S. were battery manufacturing and chlorine-alkali production. Paints and industrial instruments have also been among the major uses. It is also used in laboratories for making thermometers, barometers, diffusion pumps, and many other instruments, including mercury switches and other electrical apparatuses. Mercury is used as an electrode in some types of electrolysis and in some types of batteries (mercury cells). Gaseous mercury is used in mercury-vapor lamps (e.g., fluorescent tubes) and advertising signs. Mercury is also the basis of dental amalgams and preparations, and can be a byproduct of burning fossil fuels and refining petroleum.

Peak production and use of mercury occurred twice in U.S. history (Figure B.1.2.). First, it was mined extensively during the Gold Rush in California, and a second time after World War II. In the Bay Area, production was almost entirely from the mercury-rich New Almaden Mining District in Santa Clara County.

The use of mercury in batteries and latex paint, two of the largest uses of mercury in the U.S. between 1950 and 1990, was banned in 1991. In addition, the mining of mercury as a primary mineral commodity was prohibited in the U.S. as of 1992 (McKee et al. 2006). As illustrated in Figure B.1.3., mercury consumption has also reduced substantially from 1970 to 2000 (Sznopek 2000) and the mass of mercury in the most current products and devices such as light bulbs and auto switches appear to also be decreasing (NEWMOA 2008). These decreases in mercury uses may assist the MRP Permittees in reducing loads of mercury to the Bay.

B.1.4 <u>Sources to Urban Stormwater Runoff</u>

The mass of a pollutant transported in stormwater in a particular particle size range is a product of the mass of the sediment load and the concentration of the pollutant in that particle size range (McKee et al. 2006). Finer particles typically have a greater surface area for constituents to

adsorb to, and therefore concentrations tend to be higher on these particles (EOA 2007). These smaller particles are mobilized more than larger particles at low flows and therefore constitute the majority of the sediment mass being transported. However, under high flows, larger particles can have a far greater mass of the total sediment load than the smaller particles.

In collaboration with BASMAA member agencies, McKee et al. (2006) conducted a thorough literature review on sources and loads of mercury and PCBs entering urban stormwater and developed a mass balance (or conservation of mass) conceptual model based on this information. The intent of the model was to assist managers by providing a framework for identifying the most important mercury and PCBs uses and sources that likely impact Bay Area stormwater runoff. Although disparate information was used to develop the model, it provides the current best estimate of the mass of PCBs and mercury that is contributed to urban stormwater under a steady state scenario. The model also serves as context for management decisions, especially for mercury given its ongoing use (although reduced) in the urban environment and transport via atmospheric deposition. The following sections present the inventory of mercury and PCB sources to urban stormwater runoff based on the current understanding of PCB and mercury uses and linkages to stormwater.

PCB Uses and Sources

As illustrated in Figure B.1.4., McKee et al. (2006) estimate that erosion from the surface of the urban watershed is the largest source of PCBs to Bay Area urban stormwater. Watershed surface erosion includes diffuse sources of sediment in urban areas associated with construction sites, vacant lots, unpaved foot paths, and wear debris from road and building surfaces and represents the mass of PCBs associated with over 50 years of legacy accumulation on the surface of the Bay watershed. Building demolition and remodeling, PCBs that continue to be in use in equipment and devices, and transformers and large capacitors represent the next largest sources. Smaller sources include atmospheric deposition and identified industrial contaminated areas.

Mercury Uses and Sources

Similar to PCBs, McKee et al. (2006) estimate that erosion from the surface of the urban watershed is also the largest source of mercury to Bay Area urban stormwater (Figure B.1.5.). However, unlike PCBs, atmospheric deposition of mercury to the Bay watershed is estimated to provide a much larger proportion (27 percent) of the total load to urban stormwater. This suggests that mercury from atmospheric deposition may continue to play an important role in loadings of mercury to the Bay from stormwater.

Accidental breakage during transport or disposal of instruments such as barometers, hydrometers, manometers, pyrometers, sphygmomanometers, and thermometers or switches and thermostats that contain relatively large masses of mercury is also suggested to be a large source of mercury to stormwater. Based on these estimates, fluorescent lamps and identified industrial sites with relatively elevated mercury concentrations are far less of a source to stormwater.

One property that distinguishes mercury from PCBs is the fact that mercury bioaccumulation occurs primarily after transformation to methylmercury (methylation). Recent scientific studies have identified monitoring tools to quantify the fraction of mercury most susceptible to methylation – the "reactive mercury" fraction of the total mercury measurement (Marvin-DiPasquale et al. 2009). Studies have also shown that mercury from atmospheric deposition is primarily reactive mercury (Butler 2007). This could mean that stormwater may contain a relatively larger fraction of reactive mercury compared to purely terrestrial sources. If so, water quality benefits could be attained in receiving waters by measures that reduce the fraction of reactive mercury present in the total load. Although there is not sufficient monitoring data at present to make the case for loads reduced or avoided based on reducing the fraction of reactive mercury, that information may be developed over time and submitted to the Regional Water Board for consideration.

B.1.4.1 Transport of PCBs and Mercury to MS4s

A project funded by a State of California Proposition 13 grant and conducted by the San Francisco Estuary Institute (SFEI) defined conceptual models of sources and pathways of mercury and PCBs in Bay Area urban watersheds (Mangarella et al. 2010). These conceptual models were adapted for use in a desktop analysis conducted by EOA (2012), with a focus on the transport of sediment-bound pollutants from source areas to MS4s in historical industrial land uses where PCBs were used. The purpose of the conceptual model (Figure B.1.6.) is to illustrate the movement of sediment-bound pollutants from source areas through the MS4 to receiving waters, and to identify areas of accumulations/storage within the MS4 where enhanced O&M activities could be applied to increase sediment removal from the system. The following terms, as defined previously (Mangarella et al. 2010), were included in the conceptual model:

- **Source Areas** - the geographic areas in the landscape where pollutants are or were used, released, systematically discarded, or accumulated and where such prior/current usage causes higher pollutant concentrations in the air, water, or sediment than in surrounding areas.
- **Pathways** - a conduit or process that delivers pollutants from the source through the MS4 to the receiving water. Because mercury and PCBs attach strongly to soil and sediment particles, typically in the smaller fractions (e.g., fine sand, silt, and clay), sediment transport pathways dominate.
- **Storage** - any location within the MS4 where sediment is likely to accumulate. May be a dispersed location (e.g., along roadways) or a point location (e.g., within a storm drain inlet). Sediment accumulation and storage within the MS4 may vary, depending on factors such as storage capacity, flow rate and volume of runoff, and surface topography.

Sediment-bound pollutants from source areas potentially enter the MS4 via three major transport pathways:

- **Wind Dispersal**: Dry soils and sediment may be susceptible to wind dispersal, which can transport polluted soils/sediment away from source areas to the MS4.
- **Vehicle Tracking and Road Deposits**: Polluted soils/sediment may be tracked onto nearby roadways by vehicles that drive on and off unpaved lots and roads in industrial areas. Typically, the majority of the soil is deposited onto roadways within a short distance of the source (e.g., one or two city blocks). Other types of road deposits from vehicles include leaking gasoline, diesel, transmission fluids, and motor oils that may contain trace amounts of mercury, and trash and debris that fall off of vehicles during haulage that may contain PCBs or mercury. Roads servicing recycling areas and municipal or private landfills and disposal areas likely receive a larger share of PCBs and mercury in road deposits.
- **Surface Runoff from Source Areas**: Polluted soils/sediments on impervious surfaces and erosional areas (e.g., unpaved or damaged pavement) are subject to wash off via surface runoff, which transports pollutants to the MS4.

Once polluted soil/sediment has been transported to the MS4, accumulation and storage may occur in a number of locations, such as roadways (including curbs and gutters), storm drain inlets/catch basins, stormwater pipelines, and other structures (e.g., stormwater pump stations). These storage locations are potential implementation points for enhanced O&M activities that remove sediment.

B.1.5 Urban Stormwater Control Measures

B.1.5.1 Control Measure Categories

Urban stormwater runoff control measures for PCBs and mercury generally fall into three categories:

- **True Source Controls (Load Avoidance)** - focus on the original source or use of a potential pollutant. Load avoidance controls include regulations and laws adopted to minimize or eliminate the use of a pollutant for specific applications and pollution prevention activities such as inspections that identify high risk practices that could generate PCBs/mercury into the environment. By minimizing/eliminating the source/use/risk, the amount of a pollutant that would have entered the environment without the true source control measure in place is avoided at its source (i.e., true source control), thus avoiding the need to reduce/intercept the pollutant once in the environment. The one true source control measure for mercury is the reduction in the content/mass of mercury in devices/equipment as a result of legislation or voluntary reduction by manufacturers. No true source controls are currently available for PCBs due to the banning of the distribution and sale of these organic compounds in the 1970s.
- **Source Controls (Load Reduction)** - Source controls are load reduction control measures that reduce the risk of the pollutant from entering the environment after it has

already been used in devices/materials/equipment (e.g., recycling) or intercept the pollutant before it is discharged to a receiving water body. The control measure types that fall into this category include: the identification of PCBs in industrial inspections, source property identification and abatement, enhanced street sweeping and MS4 operation and maintenance, and reduction of PCBs during building demolition.

- **Treatment Controls (Load Reduction)** – Treatment controls are load reduction control measures that remove pollutants via physical, biological, or chemical processes. The control measure types that fall into this category include stormwater treatment measures and diversions of stormwater to Publically Owned Treatment Works (POTWs).

The following sections provide brief summaries of each of the potential control measure types that may assist municipalities in reducing PCBs and/or mercury in urban stormwater runoff. Control measure descriptions are grouped by the three categories described above.

B.1.5.2 True Source Controls

- Reduction/Elimination of Mercury in Devices - Mercury is present in a number of types of devices, equipment and products that may be handled and disposed of improperly. First order estimates by McKee et al. (2006) attribute approximately 11-31% of the total mercury in urban stormwater discharges to the Bay comes from improperly disposed of florescent lamps, thermostats, switches and relays and many other types of devices (e.g., barometers, hydrometers, manometers, pyrometers, sphygmomanometers, and thermometers). True source control measures applicable to mercury-containing devices and equipment include the adoption of laws and regulations to reduce/eliminate mercury in devices/products/equipment.

B.1.5.3 Source Controls

- Recycling of Mercury Containing Devices, Products and Equipment - In addition to true source control measures applicable to mercury-containing devices and equipment, the Permittees also promote, facilitate, and/or participate in collection and recycling of mercury-containing devices and equipment at the consumer level (e.g., thermometers, thermostats, switches, and bulbs). Recycling mainly occurs through County, City, and POTW Household Hazardous Waste Programs.
- Identification of Pollutants during Industrial Inspections - PCBs were used in a variety of electrical devices and industrial equipment (i.e., uncontrollable closed systems) that may leak and come into contact with stormwater. PCB-containing equipment may be found during stormwater inspections at industrial facilities. If identified during stormwater inspections, current or future impacts to stormwater may be reduced via inspectors working with facility owners/operators or referring unresolvable issues to the appropriate regulatory agencies.

- Investigations and Abatement of Sources in Drainages - Identifying and targeting high priority properties in historically industrial land-use areas where PCBs were used, released, or disposed of and/or where sediment concentrations are elevated above urban background may provide an effective way to minimize or prevent the release of PCBs and mercury to urban stormwater. Once identified, Permittees work with facility owners and operators to reduce discharges to stormwater and/or refer unresolved issues to appropriate regulatory agencies for further investigation/controls.
- Enhanced Municipal Operation and Maintenance Practices - Routine MS4 operation and maintenance (O&M) activities include street sweeping, drain inlet cleaning, and pump station maintenance. In addition, culverts and channels are also routinely maintained (i.e., desilted). Enhancements to routine operations and new actions such as storm drain line and street flushing may enhance the Permittees' ability to reduce PCBs and mercury in stormwater.
- Control PCBs during Building Demolition and Renovation - Prior to the 1979 production ban, PCBs were commonly used in various building materials, including sealants that were applied around windows and doors, between concrete and other materials, and around openings for ducts and other conduits. During demolition or renovation of buildings containing PCBs, there is the potential for PCBs to enter the MS4 and ultimately discharge to the Bay. Thus, building demolition or renovation has been identified as a potential source of PCBs to the Bay. Control measures that focus on reducing PCB-containing materials during demolition and renovation may therefore reduce the mass of PCBs entering stormwater from this source.

B.1.5.4 Treatment Controls

- On-Site Stormwater Treatment - Stormwater treatment measures fall into two general categories: (1) post-development treatment measures for new development and redevelopment projects, and (2) stormwater retrofit projects implemented outside of the context of new and redevelopment projects. Permittees currently require the incorporation of appropriate source control, site design, and stormwater treatment control measures in new development and redevelopment projects to address stormwater runoff pollutant discharges and to prevent increases in runoff flows. The preferred method of achieving these goals is through the implementation of low impact development (LID) techniques. Strategically retrofitting the MS4 system in areas known to have elevated PCB and/or mercury concentrations with onsite treatment facilities may also provide pollutant load reduction benefits.
- Diversion to Publicly Owned Treatment Works - Diversion of dry weather and/or first flush events from MS4s to POTWs has been identified as a potential control measure to reduce loads of PCBs and mercury in urban stormwater runoff. Diversions may be passive or active systems and may occur at pump stations or other strategic locations in

the stormwater conveyance system. Coordination with POTWs and sanitary sewer agencies would be required prior to a diversion taking place.

B.1.6 Municipal Regional Stormwater Permit

B.1.6.1 Provisions C.11 (Mercury) and C.12 (PCBs)

In provisions C.11 and C.12, the MRP requires Permittees to implement a series of control measures intended to reduce mercury and PCBs in urban stormwater runoff. Based on the phased implementation approach described in the previous section, Permittees are currently implementing PCB and mercury control measures at varying levels consistent with MRP. Table B.1.6.1 lists each control measure currently under implementation, the associated MRP provision, current level of implementation, and the number of projects required by the MRP. Figure B.1.7. illustrates the location of each pilot-scale control measure currently under implementation by Permittees in compliance with the MRP.

B.1.6.2 Clean Watersheds for a Clean Bay

The Clean Watersheds for a Clean Bay (CW4CB) project is a collaboration among all the MRP Permittees designed to evaluate the effectiveness of stormwater controls for PCBs and mercury. The CW4CB project is implementing a number of priority urban stormwater-related actions called for by the Bay PCBs and mercury TMDLs and the MRP. The project is facilitated through a partnership among Bay Area municipalities and countywide municipal stormwater management programs and is funded by a grant to Bay Area Stormwater Management Agencies (BASMAA) from the USEPA.[3] The total project budget is $7.04 million - $5M from USEPA and $2.04M matching funds from the Bay Area municipal stormwater agencies, municipal wastewater treatment agencies, and industrial dischargers. In addition, the project's efforts are leveraged by in-kind assistance from Permittees participating in the project.

[3]Funding is through USEPA's San Francisco Bay Area Water Quality Improvement Fund.

Table B.1.6.1. Urban Stormwater Runoff Control Measures for PCBs and Mercury and Current Levels of Implementation

MRP Provision	Control Measure	Current Level of Implementation				# of Projects Required by MRP	Collaborating Agency/Program
		Full Scale	Focused	Pilot	R&D or Desktop		
C.11.a	Collection and Recycling of Mercury-containing Devices	X				N/A	N/A
C.12.a	Identification of POCs During Industrial Inspections	X				N/A	BASMAA
C.11.b	Monitoring Methylmercury	N/A				At POC Loads Monitoring Stations	BASMAA & RMP
C.12.b	Evaluations of BMPs for Building Demolition and Renovation				X	1	BASMAA
C.11/12.c	Investigations and Abatement of Sources in Drainages			X		5	BASMAA (via CW4CB)
C.11/12.d	Enhanced Municipal Operation and Maintenance Practices			X		5	BASMAA (via CW4CB)
C.11/12.e	On-Site Stormwater Treatment via Retrofits			X		10	BASMAA (via CW4CB)
C.11/12.f	Diversions to Publicly Owned Treatment Works			X		5	Stormwater Programs
C.11/12.g	Stormwater Loads and Loads Reduced	N/A				N/A	BASMAA
C.11/12.h	Fate and Transport Studies	N/A				N/A	BASMAA & RMP
C.11/12.i	Regional Risk Reduction	X				N/A	BASMAA (via CW4CB)
C/11.j	Mercury Allocation Sharing	N/A				N/A	BASMAA

In coordination with other control measure evaluations (e.g., POTW diversions), findings from the CW4CB project will contribute to developing a comprehensive regional strategy for reducing PCBs and mercury in urban stormwater runoff. Strategies are described in IMR Part C and are based on the cost-effectiveness of the range of potential pollutant control measures described above.

B.1.7 Progress Assessment Methods

MRP provisions C.11.g and C.12.g require Permittees to develop and implement a monitoring program to quantify mercury and PCB loads reduced through the implementation of these (and other) control measures and to compare these loads against the WLAs described in TMDLs. Consistent with the TMDLs, load reductions and progress toward urban stormwater runoff WLAs may be demonstrated through one of three methods:

1. Quantify through estimates the average annual load reduced by implementing pollution prevention, source control, and treatment control efforts required by the provisions of the MRP or other relevant efforts;
2. Quantify the load as a rolling five-year average using data on flow and water column PCB/mercury concentrations; or
3. Quantitatively demonstrate that the concentration of mercury/PCBs on suspended sediment that best represents sediment discharged with urban runoff is below the target of 0.2 mg mercury/kg dry sediment.

During the term of the MRP, the Permittees have and continue to conduct studies to demonstrate loads reduced and progress towards WLAs using each of the methods described above. Water quality monitoring activities conducted through the Regional Monitoring Program for Water Quality in the San Francisco Bay (RMP) and the Bay Area Stormwater Management Agencies (BASMAA) Regional Monitoring Coalition (RMC) are currently attempting to quantify pollutant loads (Method #2) and concentrations (Method #3). However, due to the diffuse nature of mercury and PCBs in the San Francisco Bay watershed, observable trends in loads and concentrations in creeks and rivers draining to the Bay may take decades to observe. The results of initial quantification of loads reduced or avoided through pollution prevention, source controls, and treatment controls (Method #1) are provided in this report. Methods described in this report are consistent with the preliminary methods described by BASMAA (2010) and submitted to the Regional Water Board in compliance with MRP provision C.11/12.g. The loads reduced quantification methods described in this report:

- Provide MRP Permittees with methodologies to assess progress towards WLAs assigned to urban stormwater runoff in the PCBs and mercury TMDLs;
- May be used to evaluate the effectiveness of true source controls, source controls, and treatment controls currently implemented or planned for implementation in the Bay Area; and

- Include concepts of "baseline," "current," and "enhanced" levels of control measure implementation, which will allow Permittees to calculate load reductions attributable to new or enhanced control measures.

Terminology used in this report includes the following:

- **Baseline Load** – The mass of a pollutant discharged annually to the Bay via urban stormwater or discharged to urban stormwater via a specific pollutant source or source category (e.g., mercury devices) at the time that the TMDL was developed. The baseline urban stormwater load to the Bay is typically included in a TMDL report. Baseline load of a pollutant to urban stormwater from a specific source or source category is generally estimated via studies or calculations.
- **Current Load** – The mass of a pollutant discharged annually to the Bay via urban stormwater or discharged to urban stormwater via a specific pollutant source or source category during a year of interest that occurs after the date used to establish the baseline load. The current urban stormwater load to the Bay is typically estimated based on the difference between baseline load and load reductions/avoided, or empirical estimates of current loads. The current load of a pollutant to urban stormwater from a specific source or source category is generally based on an estimate via studies or calculations.
- **Baseline Load Reduction/Avoidance** – The mass of a pollutant reduced or avoided (could be based on an average) on an annual basis prior to the collection of data used to develop a TMDL Urban Stormwater Waste Load Allocation. For PCBs and mercury, the applicable date is July 1, 2002.
- **Current Load Reduction/Avoidance** – The mass of a pollutant reduced or avoided (could be based on an average) in a year of interest that occurs after the date used to establish baseline.
- **Enhanced Load Reduction/Avoidance** – the difference between baseline and current loads reduced/avoided.

B.1.8 Organization of IMR Part B

Each of the following sections included in this report pertains to a specific type of control measure. Each section includes the following information:

- Summary of MRP requirements associated with the control measure type;
- Status of control measure implementation, including baseline (pre-TMDL), current (Post-TMDL), and enhanced implementation;
- Descriptions of loads avoided/reduced calculation methodology;
- Estimates of baseline and current loads avoided/reduced; and

- A summary of uncertainties associated with control measure effectiveness and loads avoided/reduced calculations.

Information available on the effectiveness of each control measure at the time the IMR Part B was developed is contained in each section. As additional information becomes available, Permittees may choose to update (through revisions or by addenda) this report.

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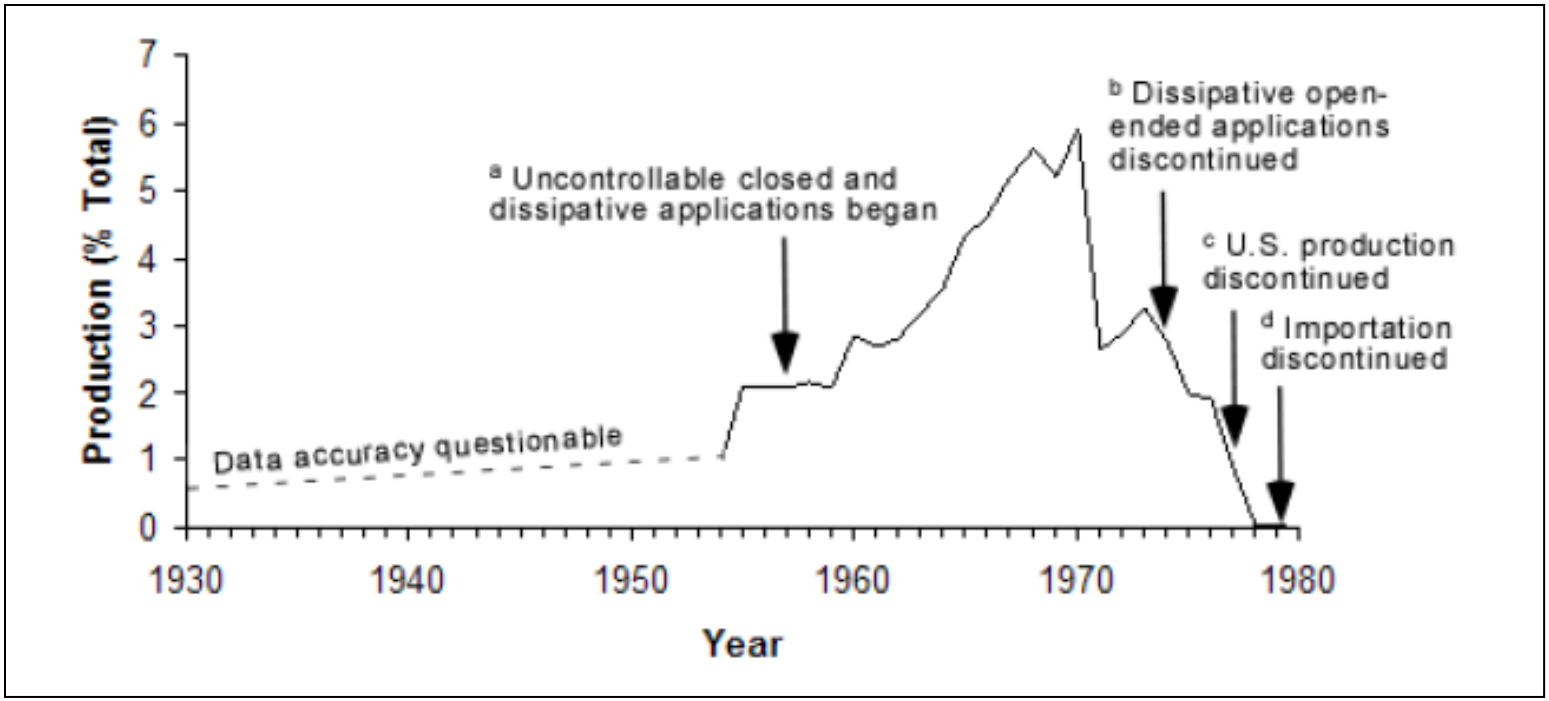
FIGURES B.1

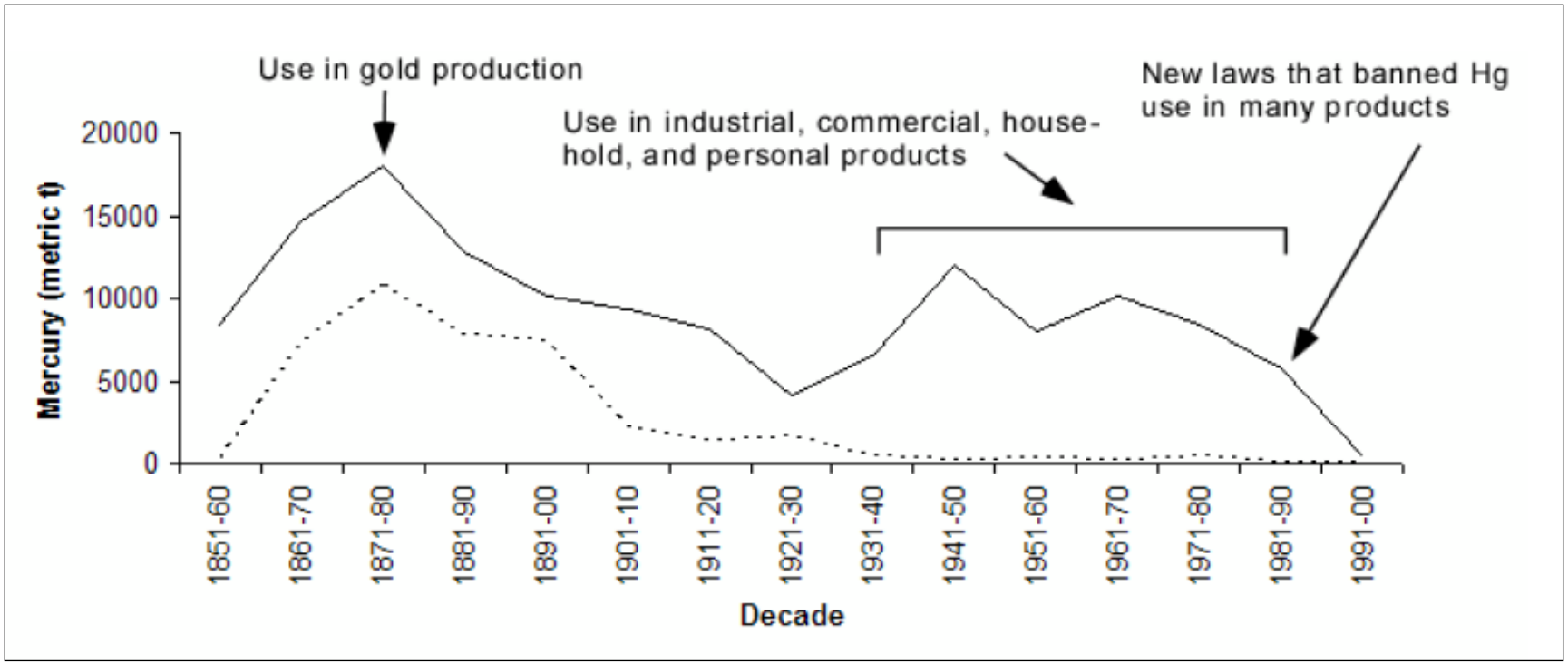


Source:	Notes:
United States Environmental Protection Agency (1987)	

Annual Production of Polychlorinated Biphenyls (PCBs) in the U.S. from 1930 to 1970

Entity	Date	
Bay Area Stormwater Management Agencies Association	November 2013	Figure B.1.1

internal info: path, date revised, author

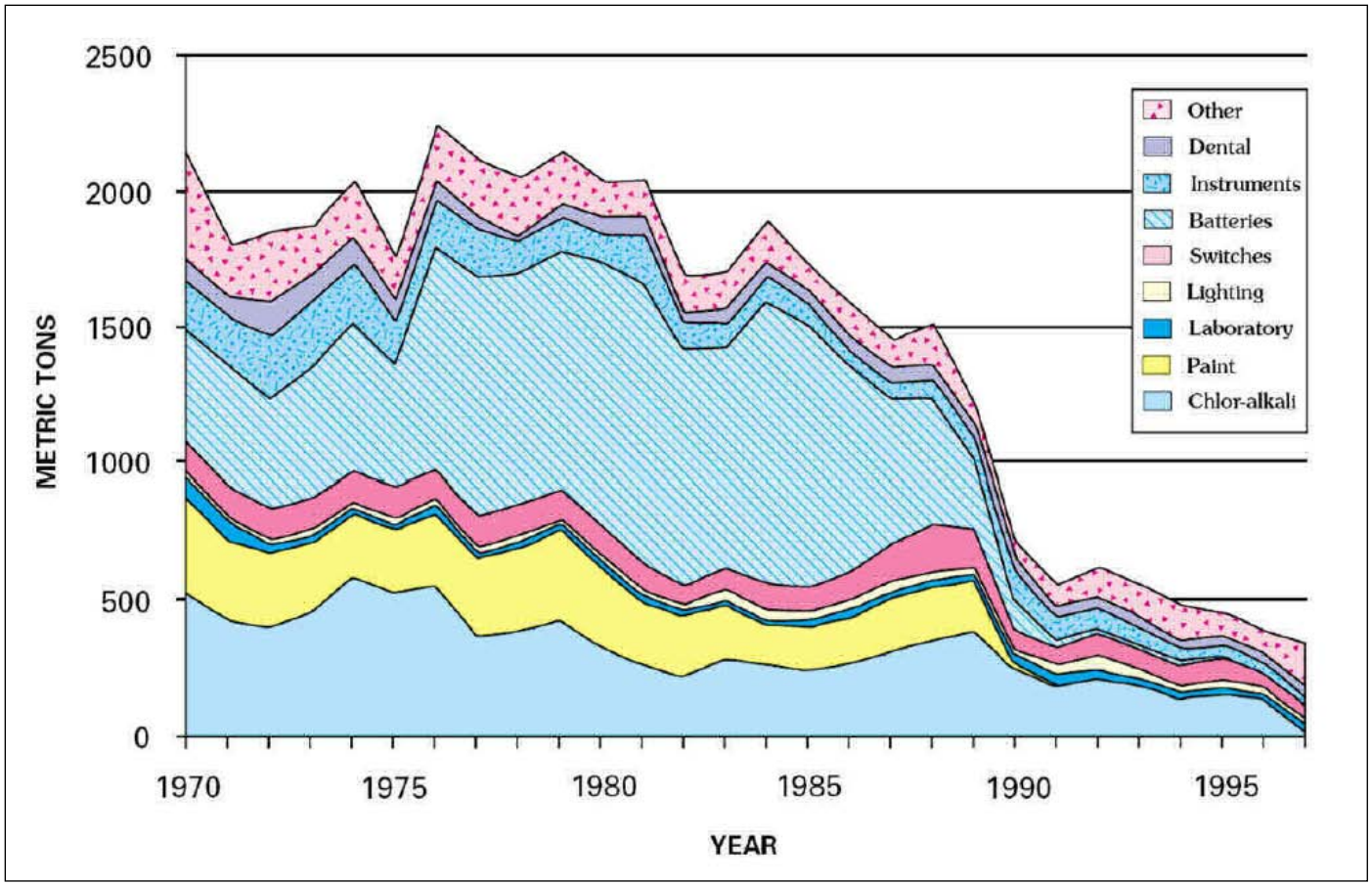


Mercury Production in the U.S and New Almaden Mining District between 1850 and 2000

Source:	Notes:
McKee et al. (2006)	Mercury Production in the U.S (dark line) New Almaden Mining District (dotted line)

Entity	Date	
Bay Area Stormwater Management Agencies Association	November 2013	Figure B.1.2

internal info: path, date revised, author

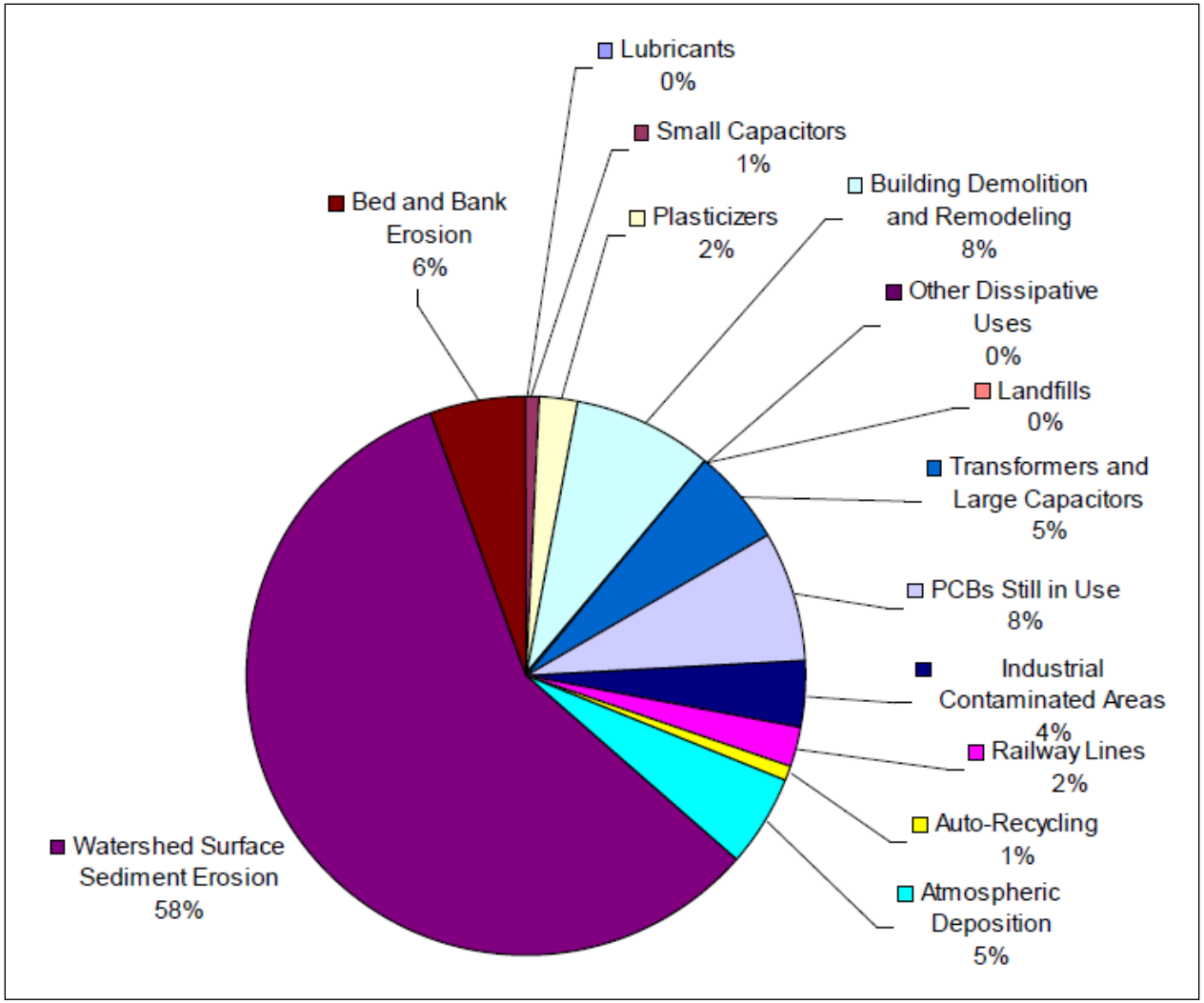


Mercury Use in the U.S. Between 1970 and 2000

Source:	Notes:
Sznopek (2000)	

Entity	Date	
Bay Area Stormwater Management Agencies Association	November 2013	Figure B.1.3

internal info: path, date revised, author

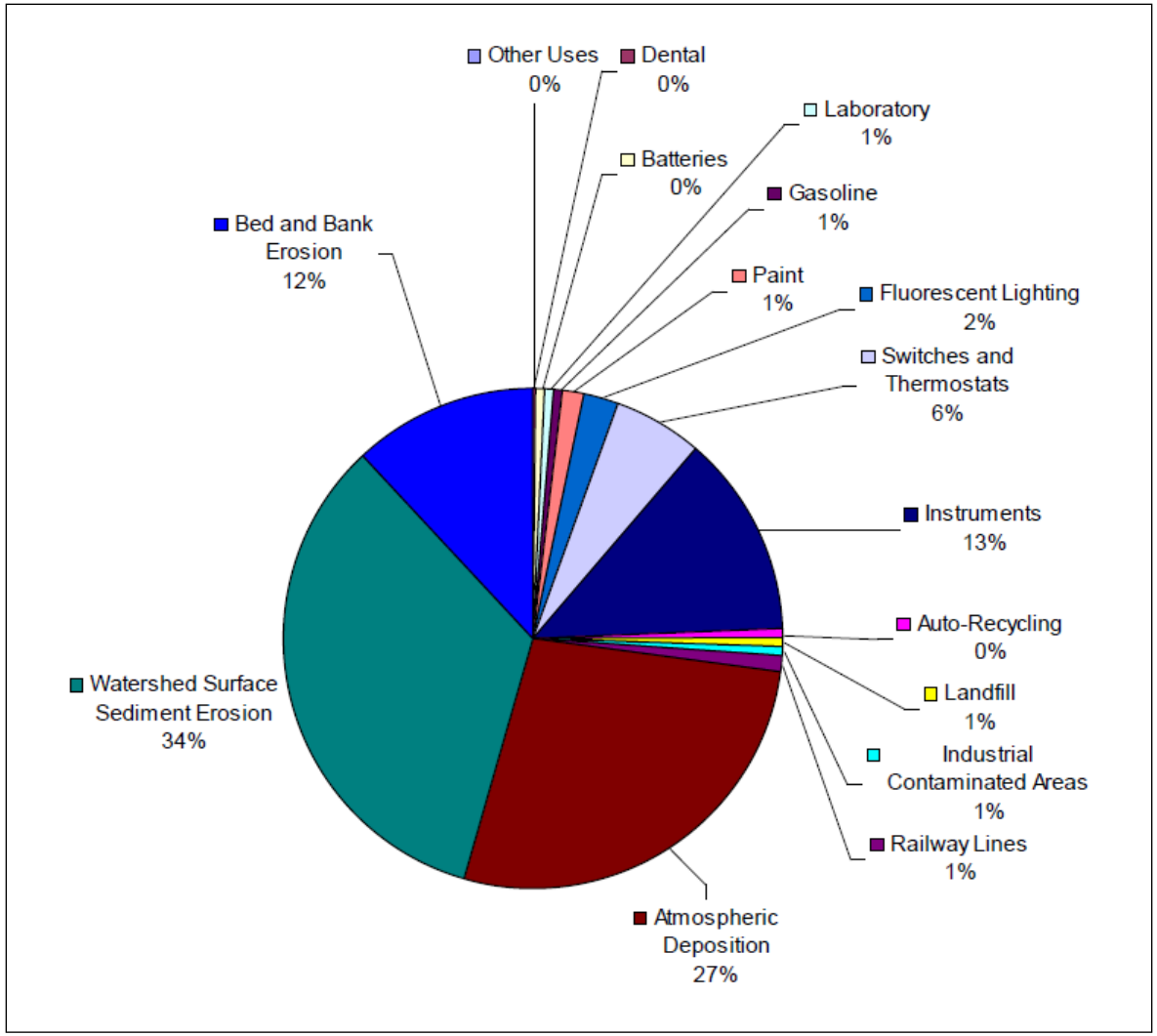


Estimated Relative Sources of PCBs to Bay Area Urban Stormwater Runoff

Source:	Notes:
McKee et al. (2006)	

Entity	Date	Figure
Bay Area Stormwater Management Agencies Association	November 2013	B.1.4

internal info: path, date revised, author

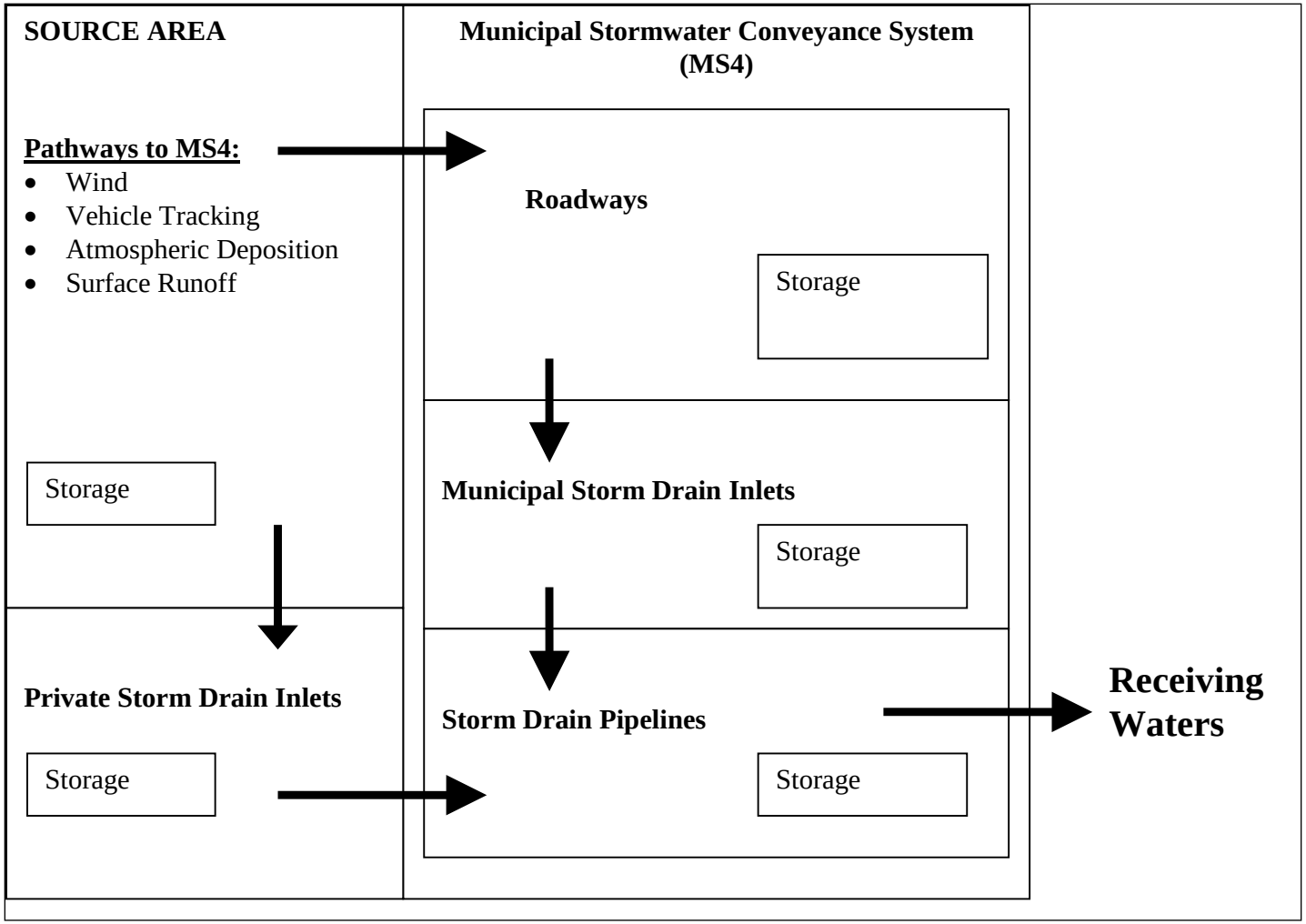


Estimated Relative Sources of Mercury to Bay Area Urban Stormwater Runoff

Source:	Notes:
McKee et al. (2006)	

Entity	Date	Figure
Bay Area Stormwater Management Agencies Association	November 2013	B.1.5

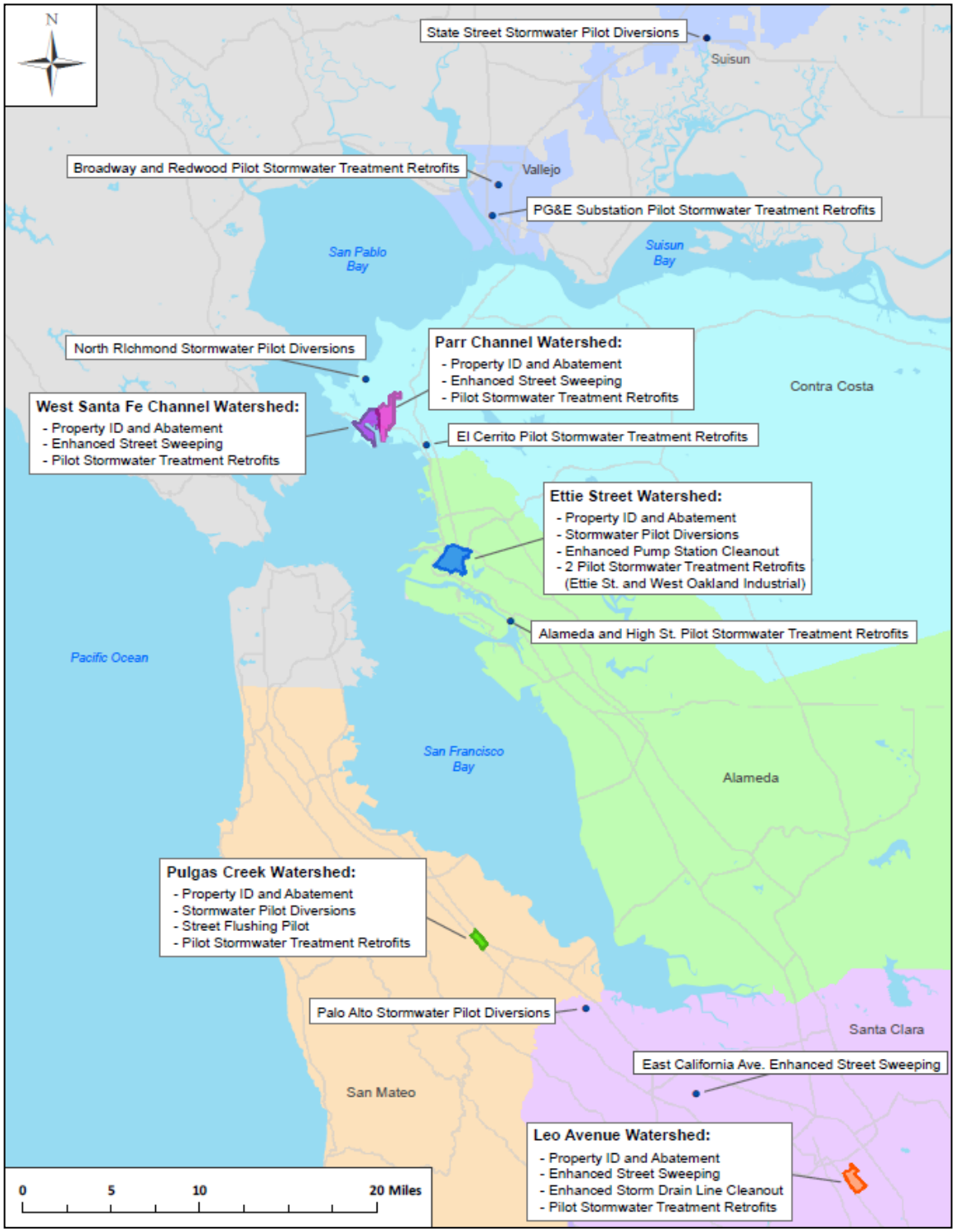
internal info: path, date revised, author



Conceptual Model of Pollutant Sources and Transport Pathways through an Urban Stormwater Conveyance System to Receiving Waters

Source:	Notes:	Bay Area Stormwater Management Agencies Association	November 2013	Figure B.1.6
EOA (2012)		Entity	Date	

internal info: path, date revised, author



Bay Area Pilot Stormwater Control Measures for PCBs and Mercury

Source:
EOA (2013)

Bay Area Stormwater Management Agencies Association

November 2013

Figure B.1.7

Entity

Date

internal info: path, date revised, author

B.2 MERCURY RECYCLING

B.2.1 Introduction

For over a century, mercury has been used in a wide variety of consumer devices, equipment and products. Because it is liquid at room temperature and it expands at a uniform rate with increasing temperature, mercury in its elemental form is used in measurement devices such as thermometers. Mercury is also used in a variety of electrical devices, such as switches and lamps (i.e., light bulbs) because it conducts electricity efficiently. These items can release mercury into the environment when broken or disposed of improperly. Once in the environment, mercury can potentially enter municipal separate storm sewer systems (MS4s) that discharge stormwater to San Francisco Bay.

First order estimates by McKee et al. (2006) attribute approximately 11-31% (18-53 kg/yr) of the total mercury in urban stormwater discharges to the Bay comes from improperly disposed mercury-containing devices and products. Control measures to reduce or avoid contributions of mercury to urban stormwater from these sources may assist municipalities in achieving water quality goals that were established through the adoption of the Total Maximum Daily Load (TMDL) for Mercury in San Francisco Bay (SFBRWQCB 2006).

Mercury production and use in the U.S. peaked in the1970s. Since that time, the total amount of mercury used in devices, products and other applications in the U.S. has been substantially reduced (Sznopek 2000). Additionally, since 2000 the mass of mercury in most new products and devices, such as lamps and auto switches has decreased on a per product/device basis (NEWMOA 2008). New regulations regarding the recycling of mercury-containing devices have also been enacted by the United States Environmental Protection Agency (USEPA) and the State of California since 2000, and local municipalities have increased their efforts to encourage individuals and businesses to recycle mercury-containing devices. These significant reductions in the amount of mercury used, and the enhanced recycling of mercury-containing devices/products suggests that the amount of mercury in Bay Area urban stormwater may have decreased since the monitoring data used to establish the load reduction goals in the TMDL was collected in 2002.

This purpose of this section of the Integrated Monitoring Report (IMR) – Part B is to:

- Describe control measures implemented to-date by Bay Area municipalities to effectively reduce the mass of mercury to the San Francisco Bay from MS4s from mercury-containing devices, products and equipment;
- Present a methodology for estimating the load avoidance or reduction that has been and will continue to be achieved as a result of enhanced management practices; and,
- Provide mercury load reduction estimates for Bay Area urban stormwater discharges that have occurred as a result of enhanced practices with a moderate level of confidence.

B.2.2 Summary of Major Types of Mercury-Containing Devices and Control Measures

B.2.2.1 MRP Requirements

Permittees are currently implementing controls measures to collect and recycle mercury-containing devices throughout the region. Provision C.11.a.i of the Municipal Regional Stormwater NPDES Permit (MRP) requires Permittees to promote, facilitate and/or participate in the collection and recycling of mercury-containing devices and equipment at the consumer level (e.g., thermometers, thermostats, switches, bulbs). Additionally, Provision C.11.a.ii requires Permittees to report on these efforts in their Annual Reports and provide an estimate of the mass of mercury collected via enhanced actions implemented post-TMDL (SFBRWQCB 2009).

Permittee and/or Countywide Program Annual Reports include descriptions of actions conducted by Permittees to promote and facilitate the collection and recycling of mercury–containing devices and equipment. Additionally, estimates of the mass of mercury collected via these actions are also provided. Summaries presented in this section of the IMR incorporate information gained from Annual Reports and other sources to provide a more robust estimate of mercury avoided via the collection and recycling of mercury-containing devices and equipment by Permittees and other entities. Part C of the IMR furthers the analysis by examining future implementation opportunities and benefits for these control measures.

B.2.2.2 Summary of Major Types of Mercury-Containing Devices and Control Measures

Mercury is present in a number of types of devices, equipment and products that may be handled and disposed of improperly. The types that represent the greatest mass of mercury potentially available to urban stormwater in the Bay Area are described below. Control measures applicable to mercury-containing devices and equipment that are discussed in this section of the IMR include the adoption of laws and regulations to reduce/eliminate mercury in devices/products/equipment (i.e., true source controls), and enhanced recycling of devices/products/equipment (i.e., source controls). Treatment controls are not discussed in this section.

Fluorescent Lamps

There are many types of lamps (i.e., light bulbs) manufactured and purchased in the U.S. The two main categories of lamps currently used in large quantities are incandescent and luminescent gaseous discharge lamps (e.g., fluorescent and low pressure sodium). High intensity discharge (HID) lamps (e.g., metal halide, ceramic metal halide, high pressure sodium, and mercury vapor) and neon lamps also comprise a portion of the lamp market, but to a much lesser degree than incandescent and luminescent gaseous discharge lamps.

Incandescent lamps do not contain mercury. Luminescent gaseous discharge lamps, specifically fluorescent lamps, contain mercury and are generally available in two types – tubular or compact. Tubular fluorescent lamps are mostly used in commercial or institutional buildings and

usage is believed to have generally remained consistent over time. Compact fluorescent lamps (CFLs), however, are mostly used as energy-saving alternatives to incandescent lamps in homes and their use has increased substantially in recent years (DTSC 2008).

Both true source controls and source controls are currently being implemented to reduce/avoid the mass of mercury in urban stormwater associated with fluorescent lamps. True source controls began in the early 2000s when the lamp manufacturing industry began minimizing the mass of mercury present in fluorescent lamps, which inherently reduced the amount of mercury available to urban stormwater via this source/use.

A source control for lamps in the form of recycling is also used to reduce mercury releases to the environment. Technologies to reclaim mercury from spent lamps through recycling were developed in the U.S. starting in 1989. However, recycling did not drastically increase until the USEPA announced the addition of lamps to the Universal Waste Rule (UWR) in 1999 (ALMR 2003). Today, the State California's UWR prohibits the disposal of fluorescent lamps into landfills, regardless of the waste generator (household or business), and the California Department of Toxic Substances Control (DTSC) requires the safe management and recycling of fluorescent lamps.

Thermostats

Thermostats are commonly used in most homes and commercial facilities to regulate room temperature. Older mechanical thermostats often contain elemental mercury in glass bulbs called ampoules. Through the mishandling of thermostats during demolition and waste transport, ampoules can break and mercury can be emitted to urban land uses and impervious surfaces. Once emitted, mercury may become available for transport to the Bay via urban stormwater runoff.

Similar to fluorescent lamps, both true source controls and source controls are currently being implemented to reduce/avoid the mass of mercury in stormwater associated with thermostats. True source controls for thermostats began in 2006 through California Senate Bill (SB) 633, which banned the sale and distribution of mercury thermostats in California. Additionally, recycling is the primary source control used to reduce mercury releases to the environment from thermostats. Mercury thermostats are recycled by many entities, including household hazardous waste facilities operated by Permittees and the Thermostat Recycling Corporation (TRC), which was developed as a result of California's *Mercury Thermostat Collection Act of 2008* (AB 2347).

Switches and Relays

A mercury switch is a product that opens or closes an electrical circuit or gas valve, such as float switches, tilt switches, pressure switches, temperature switches, and flame sensors. A mercury relay is a product or device that opens or closes electrical contacts to effect the operation of other devices in the same or another electrical circuit, such as displacement relays, wetted reed relays, and contact relays. Mercury switches and relays have been used in many types of equipment and

devices, including automobiles, where they for have been used in lighting controls (e.g., trunk lid lights), ride control, and anti-lock braking systems. Scrapped automobiles can leak mercury into the environment if these switches are not properly removed and managed.

Both true source controls and source controls are currently being implemented to reduce/avoid the mass of mercury in stormwater associated with switches and relays. True source controls began in 2005 as a result of the *California Mercury Reduction Act*, which banned the sale of vehicles manufactured on or after January 1, 2005, if they have light switches containing mercury. Source controls for auto-related switches and relays in the form of recycling are also used to reduce mercury releases to the environment from mercury switches and relays. Mercury switches and relays are recycled by many entities, including household hazardous waste facilities operated by Permittees and through the *National Vehicle Mercury Switch Recovery Program* (NVMSRP), which was initiated as a result of the *California Mercury Reduction Act*.

Other Instruments, Devices and Products

In addition to lamps, thermostats, switches and relays, many other types of devices, equipment and products contain mercury. For example, devices such as barometers, hydrometers, manometers, pyrometers, sphymonometers, and thermometers generally contain mercury. Mercury "button-type" batteries also can contain mercury. Additionally, novelty items used in practical jokes, figurines, toys, games, holiday decorations and footwear can also contain mercury.

Similar to other types of devices and products, both true source controls and source controls are currently implemented to reduce/avoid the mass of mercury in stormwater associated with instruments and novelty products. True source controls began to be implemented in 2003 as a result of the *California Mercury Reduction Act*, which banned the manufacture, sale, or distribution of mercury- added novelty items in California. Source controls for instruments and novelty products are also implemented in the form of recycling. Mercury products are recycled by household hazardous waste facilities operated by Permittees. Household hazardous waste facilities provide recycling opportunities for these devices/items, however tracking the amount of mercury recycled is challenging due to the heterogeneity in the types of novelties and the variability in the mass of mercury in each type.

B.2.3 Status of Control Measure Implementation

B.2.3.1 Baseline

Prior to 2002, the potential water quality impacts of improperly disposed of devices and products that contain mercury were known, but not widely publicized (USEPA 1997). Therefore, a very limited number of control measures designed to reduce the impacts of mercury devices/products on water quality were in place in the San Francisco Bay Area prior to the development of mercury load reduction goals for urban stormwater via the San Francisco Bay Area Mercury TMDL. Prior to 2002, mercury production and new uses in the U.S. continued to decrease,

however many devices and products currently on the market in the U.S. at that time contained mercury. Additionally, programs that recycle mercury devices/products had not yet matured enough to cause a significant reduction in the amount of mercury entering the environment.

In summary, the most significant mercury control measures for devices, equipment and products that occurred prior to 2002 were:

- The adoption of emergency regulations in March 2000 by the California Department of Toxic Substance Control (DTSC) regarding the collection, transportation, recycling and disposal of "universal wastes." The emergency regulations designated several commonly used materials (including many mercury-containing devices and products) as "universal wastes" when they were disposed. The emergency regulations closely mirrored the federal Universal Waste Rule that became effective on January 6, 2000.
- The signing of the *California Mercury Reduction Act* of 2001 (Senate Bill 633) into law on October 9, 2001. The Act supported the objectives to reduce mercury releases to the environment by restricting certain consumer products that contain mercury. This bill prohibited the sale of mercury fever thermometers and novelty items, restricted school purchases of mercury items, and required special handling of mercury switches from discarded vehicles. Table B.2.3.1 lists each of the requirements of the Act.

As a result of these two significant actions taken by the State of California and the California Legislature, a number of associated mercury control measures have gone into place since that time. These "enhanced" (i.e., Post-TMDL) actions are described in the next section.

Table B.2.3.1. California Mercury Reduction Act Requirements and Effective Dates

Applicable Device Type	Requirement	Effective Date
Thermometers & Measuring Devices	Prohibits any K-12 school from purchasing devices and materials containing mercury for use in classrooms and labs, except measuring devices when no adequate alternative exists.	January 2002
Automobile Switches	Encourages removal and recovery of switches containing mercury, i.e., convenience lights under the hood or in the trunk, from vehicles before disposal or recycling of the vehicle.	January 2002
	Bans the sale of vehicles manufactured on or after January 1, 2005, if they have light switches containing mercury.	January 2005
Thermostats	Bans the sale of mercury thermostats.	January 2006

Applicable Device Type	Requirement	Effective Date
Thermometers	Bans the sale or distribution of fever thermometers containing mercury without a prescription from a doctor, dentist, veterinarian or podiatrist.	July 2002
Novelty Items	Prohibits the manufacture, sale, or distribution of mercury-added novelty items in California.	January 2003

B.2.3.2 Current

Building on the regulations and laws adopted prior to 2002, municipalities have enhanced their implementation of control measures designed to achieve reductions of mercury in urban stormwater discharges. The following section describes Post-TMDL actions that were conducted or caused to be conducted by Bay Area municipalities.

True Source Control Programs/Regulations (Mercury Load Avoidance)

The *California Mercury Reduction Act* adopted by the State of California in 2001 contains a number of true source controls that began to be implemented after 2002, including bans on the:

- Sale of cars that have light switches containing mercury;
- Sale or distribution of fever thermometers containing mercury without a prescription;
- Sale of mercury thermostats; and
- Manufacturing, sale, or distribution of mercury- added novelty items.

The implementation of the Act serves as "enhanced" control measures that result in a load of mercury avoided from entering urban stormwater. The requirements of the Act are currently enforced by the State.

In addition to the *California Mercury Reduction Act*, fluorescent lamps manufacturers continue to reduce the amount of mercury in lamps sold in the U.S. For example, effective October 1, 2010, lamp manufacturers associated with the National Electrical Manufacturers Association (NEMA) voluntarily capped the mercury content at 4 mg per CFL < 25 watts, and at 5 mg for 25 to 40 watt CFLs (NEMA 2010).

Additionally, manufactures have significantly reduced the amount of mercury in fluorescent linear tube lamps. U.S. EPA (1998) estimated that prior to 1997, a four foot linear fluorescent tube averaged between 15 and 41 mg per tube, depending on the year of manufacture and tube type (T8 or T12 types). Since that time, the average amount of mercury per tube has decreased to roughly 8 mg (NEMA 2005). The decrease is largely attributable to manufacture cost-savings and consumers preferentially choosing lamps that are smaller and more energy-efficient (e.g., T8

types). These actions serve as enhanced control measures that reduce the mass of mercury available to enter urban stormwater.

Mercury Device Recycling Programs (Mercury Load Reduction)

With regard to the Universal Waste Rule, permanent regulations were approved by the California Office of Administrative Law (OAL) and adopted on February 20, 2003, to effectively replace the emergency regulations established in 2000. The permanent regulations are found in Title 22 (Division 4.5) of the California Code of Regulations (CCR). In California wastes become universal wastes when DTSC defines them in as such in State regulations. Devices, equipment and products defined as universal wastes to-date by DTSC's of include mercury-containing thermostats, switches and lamps.

The Universal Waste Rule and DTSC's designations apply to both large and small quantity handlers of universal waste. A large quantity handler is one who has more than 5,000 kilograms (5.5 tons) of universal waste onsite (at any one place of business) at any one time. A small quantity generator has less than this amount of waste onsite at any one time.

There are generally three types of programs that promote and facilitate the collection and recycling of mercury–containing devices and products:

1. Permittee managed household hazardous waste (HHW) drop-off facilities and curbside or door-to-door pickup;
2. Private business take-back and recycling programs (e.g., Home Depot); and,
3. Private waste management services for small and large businesses.

Enhanced control measures were implemented via each of these programs after 2002 and are summarized in the following sections.

HHW Drop-Off Facilities and Curbside or Door-to-Door Pickup

Bay Area household hazardous waste (HHW) facilities and associated activities target residents and exempted small universal waste generators (e.g., small businesses). Permittees effectively manage and/or promote permanent HHW drop-off facilities where residents and small business owners can recycle mercury-containing devices such as fluorescent lamps, thermostats and mercury thermometers. Permanent HHW drop-off facilities in the MRP area (five counties) are located in the cities of Oakland, Hayward, Berkeley, Freemont Livermore, Richmond, San Pablo, Martinez, Antioch, San Jose, Palo Alto, Fairfield, American Canyon (for Vallejo) and San Mateo. In addition, some Permittees work through agreements with their franchise waste haulers to have a door-to-door collection of mercury-containing universal wastes for residents. These Permittees include the cities of Belmont, Foster City, Hillsborough, Menlo Park, San Mateo, Cupertino, Albany, Emeryville, Piedmont, Union City, Clayton, Orinda, Daly City, Half Moon Bay, and Santa Clara. Many Permittees also facilitate and organize HHW drop-off events within

their jurisdiction, typically in conjunction with other events such as Earth Day. Permittee involvement ranges from promotion of the event to residents, to providing a facility for the event. These events range from one event per-year to weekly drop-off events.

Permittees promote mercury-recycling events via their own public outreach and through participation in countywide and region-wide programs. Permittees advertise events in local newspapers or on television, issue press releases to local media, and include articles in local newsletters. Some Permittees also include promotional material for mercury-recycling events on utility bills and City calendars. Collection sites and special drop-off events are often advertised on flyers posted in public places such as libraries, community centers, retirement communities, City/Town Hall and on maintenance trucks.

As a result of enhanced control measures to promote, facilitate and manage HHW activities, MRP Permittees have collectively collected and recycled nearly 2 million pounds of fluorescent lamps and over 9,000 pounds of mercury thermostats, switches and thermometers from households and small businesses between Fiscal Years 2002-03 and 2011-12. Table B.2.3.2 lists the pounds of mercury devices and products collected via HHW facilities and associated activities in each MRP county during this timeframe. As illustrated in Figure 1, mercury device recycling has consistently increased during this timeframe.

Table B.2.3.2. Mercury-Containing Device Collection by Permittee Managed HHW Facilities, Drop-Off Events and Door-to-Door Pickup Between 2002 and 2011

Device Type	Alameda	Contra Costa	San Mateo	Santa Clara	Solano	Total
Fluorescent Lamps (kg)	168,927	185,046	142,716	384,006	3,746	**884,440**
Mercury Thermostats (kg)	55	119	0	441	0	**615**
Mercury Switches & Thermometers (kg)	621	880	619	1,430	5	**3,554**

Device/Product Take-Back and Recycling Programs

In addition recycling at HHW facilities and events that are sponsored by Permittees, a number of businesses that sell, manufacture or remove mercury-containing devices also serve as collection sites. For example, California's *Mercury Thermostat Collection Act of 2008* (AB 2347) requires that by 2009 thermostat manufacturers establish a collection and recycling program for out- of-service mercury-added thermostats. The Thermostat Recycling Corporation (TRC) serves as the collection and recycling program for manufacturers in California (TRC 2010). The TRC provides collection containers to HVAC wholesalers, thermostat retailers, and HVAC contractors for a one-time charge. Collection containers are also provided by the TRC to HHW facilities at no cost.

Aside from HHW-related activities, mercury thermostats were not collected and recycled in the Bay Area prior to 2008. Since the TRC program began in Fiscal Year 2008-09, the TRC has collected nearly 8,000 mercury thermostats from Bay Area businesses (see Figure 2), in addition to thermostats collected via HHW activities.

The *National Vehicle Mercury Switch Recovery Program* (NVMSRP) also provides a mechanism for recycling mercury-containing devices. The NVMSRP, in coordination with the DTSC and the California Scrap Automobile Dismantlers Association, provides incentives to dismantlers to remove mercury-containing switches from scrap vehicles before they are shredded and used to make new steel. The NVMSRP began in 2006 when U.S. EPA announced a national program to recover 80-90 percent of available mercury switches from scrap automobiles. The NVMSRP, primarily through the End of Life Vehicles Solution (ELVS) Corporation, provides educational materials, collection supplies, free shipping and monetary incentives to automobile dismantlers.

An estimated 144,000 mercury-containing automobile switches have been recycled to-date in the Bay Area as a result of the NVMSRP (NVMSRP 2013). As illustrated in Figure 3, the number of switches recycled peaked in 2005-06 and has slowly declined since that time. In California, this may be partially due to the *California Mercury Reduction Act*, which banned the sale of vehicles manufactured on or after January 1, 2005, if they have light switches containing mercury. The NVMSRP is scheduled to continue until 2017, based upon an estimate that all available mercury vehicle switches will have been collected by that year.

In addition to recycling efforts to target specific mercury-containing devices, a number of businesses that sell devices, also serve as collection sites. Some of the larger participating businesses include hardware stores such as Ace Hardware, Home Depot, Lowe's and Orchard Supply Hardware. Home Depot in particular launched a national campaign to collect and recycle compact fluorescent lamps from consumers. Additional stores such as IKEA, Best Buy, Goodwill and the Salvation Army also provide collection points for universal wastes. These businesses work directly with waste management businesses to transport and recycle devices/products and not directly associated with the HHW facilities. Permittees, however, promote businesses that collect universal waste through using similar methods as those related to HHW facilities and events.

Private Waste Management Services

Non-exempt small and large universal waste generators are also required to properly manage and recycle mercury-containing devices and products in accordance with federal and State laws. For certain types of devices, small and large business likely generate significantly higher levels of universal waste than residents. Specifically, the Association of Lighting and Mercury Recycling estimates that businesses use approximately 80% of the fluorescent lamps in the U.S. (ALMR 2003). Similar to households and exempt small waste generators, moderate and large businesses are also required to recycle mercury lamps. Spent lamps from businesses are generally collected

through agreements with private waste management companies, which in turn ship lamps to recycling facilities. Although the number of fluorescent lamps has likely increased as a result of increased awareness of energy efficiency, data regarding the number of fluorescent lamps used by businesses annually and recycling rates are generally unknown.

B.2.4 Estimates of Loads Avoided/Reduced

B.2.4.1 Loads Avoided/Reduced Methodology

This section describes the methodology used to estimate urban stormwater load reductions that have occurred as a result of enhanced control measures for mercury- containing devices, equipment and products. The methodology is based on current and historical information regarding the baseline and current use of mercury devices, the mass of mercury in each type of device, the recycling rates of devices, and assumptions regarding the percentage of mercury that would enter Bay Area urban stormwater if the devices were not properly managed.

The methodology incorporates both mercury loads that were "avoided" via the implementation of true source controls, and loads "reduced" via enhanced source controls. The overall loads avoided/reduced formula for mercury-containing devices is as follows:

$$HgReductionL/S/T = BaseLoadL/S/T - CurLoadL/S/T \qquad Eq.\ 1$$

Where:

BaseLoadL/S/T = *Baseline load of mercury in urban stormwater in 2002 from lamps (L), switches (S), and thermostats (T)*

CurLoadL/S/T = *Current load of mercury in urban stormwater in year of interest from lamps (L), switches (S), and thermostats (T)*

And;

$$BaseLoadL/S/T = BaseMassL/S/T \bullet BaseNumL/S/T \bullet T \qquad Eq.\ 2$$

$$CurLoadL/S/T = CurMassL/S/T \bullet CurNumL/S/T \bullet T \qquad Eq.\ 3$$

Where:

$BaseMass_{L/S/T}$ = *Average mass of total mercury in each lamp (L), switch (S), and thermostat (T) in 2002*

$CurMass_{L/S/T}$ = *Average mass of total mercury in each lamp (L), switch (S), and thermostat (T) in year of interest*

$BaseNum_{L/S/T}$ = *Number of lamps (L), switches (S), and thermostats (T) improperly discarded into the environment in 2002*

$CurNum_{L/S/T}$ = *Number of lamps (L), switches (S), and thermostats (T) discarded into the environment improperly in year of interest*

T = *% of total mercury in lamps (L), switches (S), and thermostats (T) that when improperly discarded are transported to the Bay via urban stormwater*

And;

$$BaseNumL/S/T = BaseSpentL/S/T - BaseRecycleL/S/T \quad \text{Eq. 4}$$

$$CurNumL/S/T = CurSpentL/S/T - CurRecycleL/S/T \quad \text{Eq. 5}$$

Where:

BaseSpentL/S/T	=	*Number of lamps (L), switches (S), and thermostats (T) that reached their end-of-life in 2002*
BaseRcyL/S/T	=	*Number of lamps (L), switches (S), and thermostats (T) recycled in 2002*
CurSpentL/S/T	=	*Number of lamps (L), switches (S), and thermostats (T) that reached their end-of-life in year of interest*
CurRecycleL/S/T	=	*Number of lamps (L), switches (S), and thermostats (T) recycled in year of interest*

B.2.4.2 Loads Avoided/Reduced by Practices

The purpose of this section is to estimate the load reduction achieved through the implementation of enhanced management practices for the recycling of mercury-containing devices and equipment, and regulations and voluntary efforts to reduce the amount of mercury in such devices/equipment. As described in the previous section, estimates of loads reduced and avoided via these actions account for the mass of mercury removed prior to the enhancement of management actions implemented before the adoption of the Mercury TMDL for the San Francisco Bay. Mercury load reduction and avoidance estimates are based on the best available information and the assumptions described in the following sections.

Fluorescent Lamps

Information used to estimate mercury reductions to urban stormwater as a result of increased recycling of mercury-containing lamps and reduction in the mass of mercury in lamps was obtained from a variety of sources, but primarily the California Department of Resources Recycling and Recovery (CalRecycle). Assumptions used to estimate that mass of mercury reduced and avoided via management actions are included below.

- **Lamp Mercury Mass** *($BaseMass_L$ & $CurMass_L$)* – The mercury content can vary between bulb types, manufacturer and the date of production. Based on U.S. EPA (1999), the mercury content in linear tube fluorescent lamps sold before 1997 were between 3.75 and 10.25mg per linear foot of lamp, or 5.25mg on average per linear foot of lamp (T8 and T12 types). This mass per lamp foot estimate serves as the baseline mass estimate for the purposes of calculating load reduction estimates. Since 1999, manufactures have reported significant reductions in the mercury content in fluorescent linear tube lamps. The average mass of mercury per linear foot of fluorescent tube lamps reported currently averages 2 mg per foot (NEMA 2005). Additionally NEMA (2010) recently announced that participating manufacturers will cap the total mercury content in CFLs that are under

25 watts at 4mg per unit, and CFLs that use 25 to 40 watts of electricity will be capped at 5mg per unit. For the purpose of calculating load reductions, CFLs are assumed to contain an average of 4.5mg per unit.

HHW recycling data are collected in weight and therefore factors developed by CalRecycle (2013) were utilized to convert linear tube feet and CFL units to weight (mg). CalRecycle estimates that one-foot of linear lamp weighs 0.057 kg and each CFL unit weighs 0.113 kg, on average. Using the mercury mass per foot or CFL unit estimates presented in the previous paragraphs, and the conversion of linear tube foot and CFL unit to weight presented above, the baseline mass of mercury per kilogram of linear fluorescent lamps or CFLs is 93mg/kg. The mercury mass per linear foot or CFL in FY 2011-12 is assumed to be 35 mg/kg. The mercury content of lamps in years between baseline and FY 2011-12 were estimated based on interpolation of baseline and current masses. Mercury mass per kg of lamps are listed in Table B.2.5.

- **End-of-Life Lamps (**$BaseSpent_L$ & $CurSpent_L$**)** – Records of fluorescent lamps reaching their end-of-life in baseline and years of interest are not available. That said, the U.S. Department of Energy periodically conducts lighting market characterization studies that include surveys of the number and types of fluorescent lamps currently used in residential and commercial/industrial buildings around the U.S. (U.S. DOE 2011). Studies were conducted in 2001 and 2010, and results were used to estimate the lamps that reached their end-of-life in baseline (2001) and current (2010) years in the U.S. Numbers of lamps in the five MRP-associated counties were assumed to be proportional to population. For simplicity, estimates assume that the number of lamps reaching their end-of-life in a baseline year or in a year of interest is equal to the number of lamps purchased in that year. Standard conversion rates consistent with CalRecycle were used to convert numbers of lamps to pounds. Table B.2.4.1 provides a summary of estimated lamps reaching their end-of-life during baseline and current years. End-of-life estimates are provided for both residential and commercial/industrial facilities.

Table B.2.4.1. Estimates of Fluorescent Lamps Reaching Their End-of-Life in MRP-Counties during Baseline and Current Years

Land Use	CFLs (kg)	Linear Tube (kg)	Total (kg)
Residential			
Baseline (*circa* 2001)	154,430	2,440,798	2,595,229
Current (*circa* 2010)	2,758,777	2,483,895	5,242,672
Commercial & Industrial			
Baseline (*circa* 2001)	312,842	6,703,975	7,016,818
Current (*circa* 2010)	451,803	7,779,943	8,231,746

- **Lamps Recycled (*$BaseRecycle_L$ & $CurRecycle_L$)*** - Records of lamps that were recycled at Bay Area HHW facilities between FYs 1993-94 and 2011-12 were obtained from CalRecycle (2013). All data provided by CalRecycle were presented in weight. Lamps recycled in FY 2001-02 serve as baseline. Lamps recycled on a per year basis post-FY 2001-02 are assumed to represent current lamp recycling. Reported mass of lamps collected via MRP-associated HHW facilities are provided in Table B.2.4.2. Commercial and industrial facility recycling rates are not well understood and therefore are not included in load reduction calculations presented in this section.
- **% Transported via Stormwater (T) -** While the mechanics of elemental mercury portioning and runoff are complex, the estimated percentage of mercury in fluorescent lamps that is transported to the Bay via urban stormwater by Mangarella et al. (2010) as part of the *Desktop Evaluation of Controls for Polychlorinated Biphenyls and Mercury Load Reduction*. The estimate considers elemental mercury volatilization rates (Barr Engineering 2001), Henry's Law of water/air solubility, and water/soil portioning. Additionally, the level of imperviousness in the urbanized Bay Area is also taken into account. Based on these considerations, Mangarella et al. (2010) estimates that roughly 4.8% of mercury in fluorescent lamps is transported to the Bay via urban runoff.

Table B.2.4.2. Fluorescent Lamps Collected by Permittee Managed HHW Facilities, Drop-Off Events and Door-to-Door Pickup Between FY 1993-94 and FY 2011-12

Fiscal Year	Alameda (kg)	Contra Costa (kg)	San Mateo (kg)	Santa Clara (kg)	Solano (kg)	Total (kg)
1993-94	23	NR	NR	NR	NR	23
1994-95	139	NR	NR	NR	NR	139
1995-96	88	7	NR	140	NR	235
1996-97	311	2,933	NR	348	NR	3,592
1997-98	295	445	NR	208	NR	948
1998-99	596	4,655	NR	322	NR	5,572
1999-00	249	2,037	NR	289	NR	2,576
2000-01	1,110	2,741	NR	733	NR	4,584
2001-02 (Baseline)	1,384	3,210	1,371	2,241	NR	8,205
2002-03	2,183	2,538	3,737	3,592	217	12,268
2003-04	2,835	3,817	NR	6,216	139	13,008
2004-05	13,193	8,614	13,406	26,946	385	62,544
2005-06	3,806	4,460	7,975	22,714	93	39,049
2006-07	12,717	20,887	15,532	45,875	273	95,284
2007-08	25,007	27,234	22,385	67,192	494	142,311
2008-09	25,826	26,748	24,157	50,373	858	127,963
2009-10	20,407	25,511	28,282	50,130	988	125,318
2010-11	34,539	34,184	7,641	48,331	208	124,903
2011-12	28,414	31,052	19,601	62,636	90	141,792
Totals	**173,122**	**201,073**	**144,087**	**388,286**	**3,746**	**910,315**

The estimated mass of mercury avoided and reduced from urban stormwater in the Bay Area post-2002 as a result of the implementation of true source controls and source controls for fluorescent lamps is illustrated in Table B.2.4.3. Estimates of the mercury load reduced or avoided by each county are provided at the end of this section.

It is important to note that only the mass of mercury recycled from lamps collected at HHW facilities was considered in the loads avoided/reduced analysis described above. Additional recycling of residential lamps occurs at hardware stores and other take-back locations. Additionally, each year, a substantial number of fluorescent lamps are used and reach their end-of-life at commercial and industrial facilities. Due to the lack of information on the recycling rates associated with these facilities, the mass of mercury avoided or reduced as a result these enhanced management of lamps was not reported. Therefore, the reported mass of mercury avoided/reduced in Table B.2.4.3 may be biased low.

Table B.2.4.3. Estimated Mass of Mercury Avoided or Reduced in Urban Stormwater in the MRP Area as a Result of Fluorescent Lamp Control Measure Implementation during FY 2002-03 to FY 2011-12

Fiscal Year	Base/Cur $Mass_L$	$Base/CurNum_L$		T	Base/Cur $Load_L$	Load $Reduction_L$
		Base/Cur $Spent_L$	Base/Cur $Recycle_L$			
	mg/kg	kg	kg	%	kg	kg
2001-02 (Baseline)	93	2,595,234	8,205	4.8%	11.5	**-**
2002-03	86	2,889,395	12,268	4.8%	11.9	**-0.4**
2003-04	80	3,183,556	13,008	4.8%	12.2	**-0.7**
2004-05	73	3,477,717	62,544	4.8%	12.0	**-0.5**
2005-06	67	3,771,878	39,048	4.8%	12.0	**-0.5**
2006-07	61	4,066,039	95,284	4.8%	11.6	**-0.1**
2007-08	54	4,360,199	142,311	4.8%	11.0	**0.5**
2008-09	48	4,654,360	127,963	4.8%	10.4	**1.1**
2009-10	42	4,948,521	125,318	4.8%	9.6	**1.9**
2010-11	35	5,242,682	124,903	4.8%	8.7	**2.8**
2011-12	35	5,536,843	141,792	4.8%	9.1	**2.4**

Mercury Thermostats

Information used to estimate mercury reductions to urban stormwater as a result of increased recycling of mercury-containing thermostats was obtained from CalRecycle (2013) and the TRC (2013). Assumptions used to estimate the mass of mercury reduced via management actions are described below.

- **Mercury Mass in Thermostats** *($BaseMass_T$ & $CurMass_T$)* – The mercury content can vary between thermostat types, manufacturer and the date of production. Based on information from the Thermostat Recycling Corporation (TRC), mercury thermostats contain between 1 and 2 ampoules of mercury, or 1.4 ampoules on average (TRC 2010).

Each ampoule contains an average of 2.8 grams of mercury, and therefore each mercury thermostat collected and recycled is assumed to contain 4 grams of mercury on average during both baseline and current years.

- **Number of End-of-Life Thermostats (**$BaseSpent_T$ & $CurSpent_T$**)** – The sale of mercury thermostats was prohibited in California in 2006. Therefore, the existing inventory of mercury thermostats should decrease overtime. Records of the total number of mercury thermostats reaching their end-of-life and available for recycling in the Bay Area during baseline and years of interest are not available. However, the State of California recently commissioned Skumatz Economic Research Associates, Inc. (SERA) to develop statistically robust estimates of the flow of mercury thermostats from residential & commercial buildings in the State (SERA 2009). Numbers of thermostats reaching their end-of-life from 2009-2024 were estimated based on surveying of the existing inventory of thermostats and considering their average life spans. Results of the SERA study were then used to develop current and baseline end-of-life estimates for the five MRP-associated counties based on the assumption that thermostat inventories are proportional to population. The number of thermostats reaching end-of-life during the baseline year (FY 2001-02) were developed using the linear regression developed by SERA (2009). Estimates of mercury thermostats reaching end-of-life FY 2001-02 (baseline) and subsequent years are presented in Table B.2.4.4.
- **Number of Thermostats Recycled (**$BaseRecycle_T$ & $CurRecycle_T$**)** - Numbers thermostats recycled at Bay Area HHW facilities between FYs 1993-94 and 2011-12 were obtained from CalRecycle (2013). Additional numbers of thermostats collected and recycled via Bay Area HVAC businesses and contractors, and reported to the TRC were also included in recycling estimates. Based on these data, no mercury thermostats were recycled in the Bay Area prior FY 2001-02. Therefore, the baseline number of thermostats recycled is assumed to be zero. Thermostats recycled on a per year basis after FY 2001-02 are assumed to represent current thermostat recycling. HHW recycling data are reported in weight and TRC data are reported in numbers of units recycled. To standardize units, each thermostat recycled is assumed to weigh roughly 12 ounces.
- **% Transported via Stormwater (T) -** While the mechanics of elemental mercury portioning and runoff are complex, the estimated percentage of mercury in thermostats that is transported to the Bay via urban stormwater by Mangarella et al. (2010) as part of the *Desktop Evaluation of Controls for Polychlorinated Biphenyls and Mercury Load Reduction*. The estimate considers elemental mercury volatilization rates (Barr Engineering 2001), Henry's Law of water/air solubility, and water/soil portioning. Additionally, the level of imperviousness in the urbanized Bay Area is also taken into account. Based on these considerations, Mangarella et al. (2010) estimate that roughly 4.8% of mercury in end-of-life thermostats is transported to the Bay via urban stormwater runoff.

Table B.2.4.4. Thermostats Collected at Permittee Managed HHW Facilities, Drop-Off Events and Door-to-Door Pickup, and the Thermostat Recycling Corporation (TRC) in FYs 1993-94 Through FY 2011-12

Fiscal Year	Alameda (kg)	Contra Costa (kg)	San Mateo (kg)	Santa Clara (kg)	Solano (kg)	Total (kg)
1993-94	0	0	0	0	0	0
1994-95	0	0	0	0	0	0
1995-96	0	0	0	0	0	0
1996-97	0	0	0	0	0	0
1997-98	0	0	0	0	0	0
1998-99	0	0	0	0	0	0
1999-00	0	0	0	0	0	0
2000-01	0	0	0	0	0	0
2001-02 (Baseline)	0	0	0	0	0	0
2002-03	0	0	0	0	0	0
2003-04	0	0	0	0	0	0
2004-05	0	94	0	0	0	94
2005-06	0	0	0	251	0	251
2006-07	0	0	0	0	0	0
2007-08	0	0	0	0	0	0
2008-09	258	50	115	178	21	622
2009-10	256	161	93	295	37	842
2010-11	181	104	52	474	35	845
2011-12	259	54	52	267	52	683
Totals	954	464	312	1,465	145	3,339

The estimated mass of mercury avoided and reduced from urban stormwater in the Bay Area post-2002 as a result of the implementation of true source controls and source controls for thermostats is illustrated in Table B.2.4.5. Estimates of the mercury load reduced or avoided by each county are provided at the end of this section.

It is important to note that the water quality impacts associated with mercury thermostats will continue to be reduced due to the passing of the *Mercury Reduction Act* in 2001, which outlaws the sale or distribution of mercury thermostats, the *Mercury Thermostat Collection Act* in 2008, and new regulations recently adopted by DTSC (2013), which requires thermostat manufacturers to annually meet increasingly stringent recycling goals until 2017. By 2024, SERA (2009) estimates that 82% of the mercury thermostats in residential and commercial/industrial buildings will reach their end-of-life and based on the 2013 DTSC regulations, recycling rates should increase substantially.

Table B.2.4.5. Estimated Mass of Mercury Avoided or Reduced in Urban Stormwater in the MRP Area as a Result of Mercury Thermostat Control Measure Implementation during FY 2002-03 Through FY 2011-12

Fiscal Year	Base/Cur $Mass_L$	$Base/CurNum_L$		T	Base/Cur $Load_L$	Load $Reduction_L$
		Base/Cur $Spent_L$	Base/Cur $Recycle_L$			
	g/kg	kg	kg	%	kg	kg
2001-02 Baseline	2.3	107,753	0	4.8%	11.7	-
2002-03	2.3	105,496	0	4.8%	11.5	**0.2**
2003-04	2.3	103,240	0	4.8%	11.2	**0.5**
2004-05	2.3	100,984	459	4.8%	10.9	**0.8**
2005-06	2.3	98,727	1,218	4.8%	10.6	**1.1**
2006-07	2.3	96,471	0	4.8%	10.5	**1.2**
2007-08	2.3	94,215	2	4.8%	10.3	**1.5**
2008-09	2.3	91,958	3,027	4.8%	9.7	**2.0**
2009-10	2.3	90,440	4,092	4.8%	9.4	**2.3**
2010-11	2.3	86,266	4,110	4.8%	8.9	**2.8**
2011-12	2.3	84,242	3,320	4.8%	8.8	**2.9**

Other Devices, Equipment & Products

In addition to lamps and thermostats, switches, relays, barometers, hydrometers, manometers, pyrometers, sphymonometers, and thermometers generally contain mercury and may be recycled once reaching their end-of-life. Similar to lamps and thermostats, both true source controls and source controls are currently implemented to reduce/avoid the mass of mercury in Bay Area urban stormwater. Recycling data are collected by HHW facilities and the National Mercury Vehicle Switch Recycling Program (NMVSRP) and can be used to calculate the mass of mercury recycled, however, all data inputs needed to calculate loads avoided and reduced consistent with methodologies described in the section above are currently unavailable. Therefore loads avoided/reduced estimates for control measures associated with these devices could not be calculated at this time.

B.2.4.3 Summary of Key Uncertainties

There are a number of sources of uncertainty in accurately estimating PCB and mercury loads avoided/reduced to San Francisco Bay associated with baseline and enhanced mercury device true source controls (load avoidance) and source controls (load reduction).

- The mass of mercury in thermostats and lamps varies between types, manufacturer and the date of production. The variation has not been fully documented and therefore the average mercury mass in each device or per weight of a device was used in the absence of incorporating variations into calculations.

- To calculate the number of end-of-life thermostats and lamps in the Bay Area statewide or national literature values were obtained and interpolated to the MRP counties relative to population. It is unknown whether the usage of mercury-containing devices is consistent with population.
- To estimate the percentage of mercury that reaches the environment that is transported to the Bay via urban stormwater, considerations of water/air and soil/water portioning were included in this percentage. However, elemental mercury portioning and runoff are complex and challenging to average.

B.2.5 References

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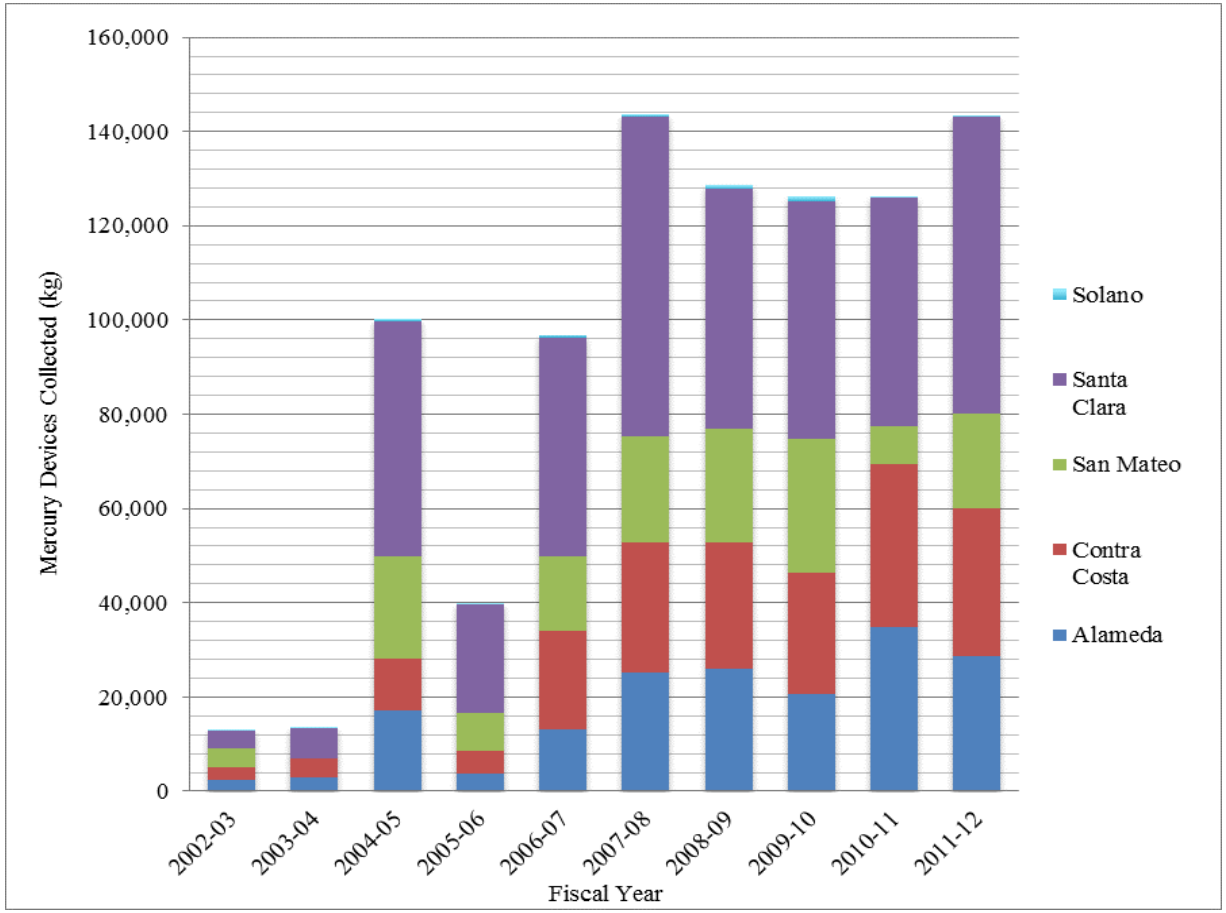
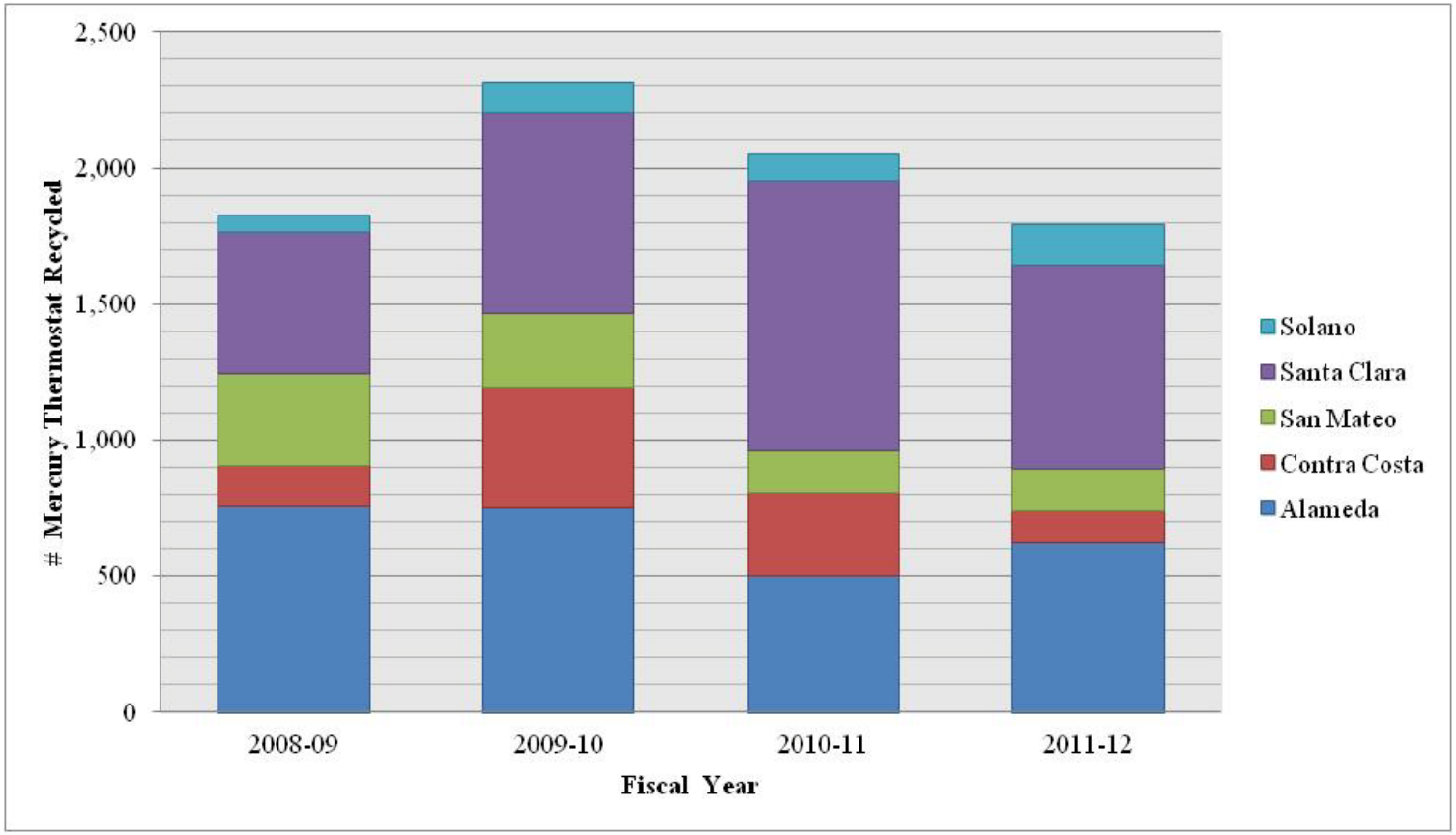
FIGURES B.2



Kilograms of Mercury-Containing Devices Collected at Permittee-Managed HHW Facilities, Drop-Off Events and Door-to-Door Pickup from FY 2002-03 to 2011-12

Source: CalRecycle 2012	Notes: Includes all data reported to CalRecycle by Permittees	Bay Area Stormwater Management Agencies Association	September 2013	Figure B.2.1
		Entity	Date	

internal info: path, date revised, author

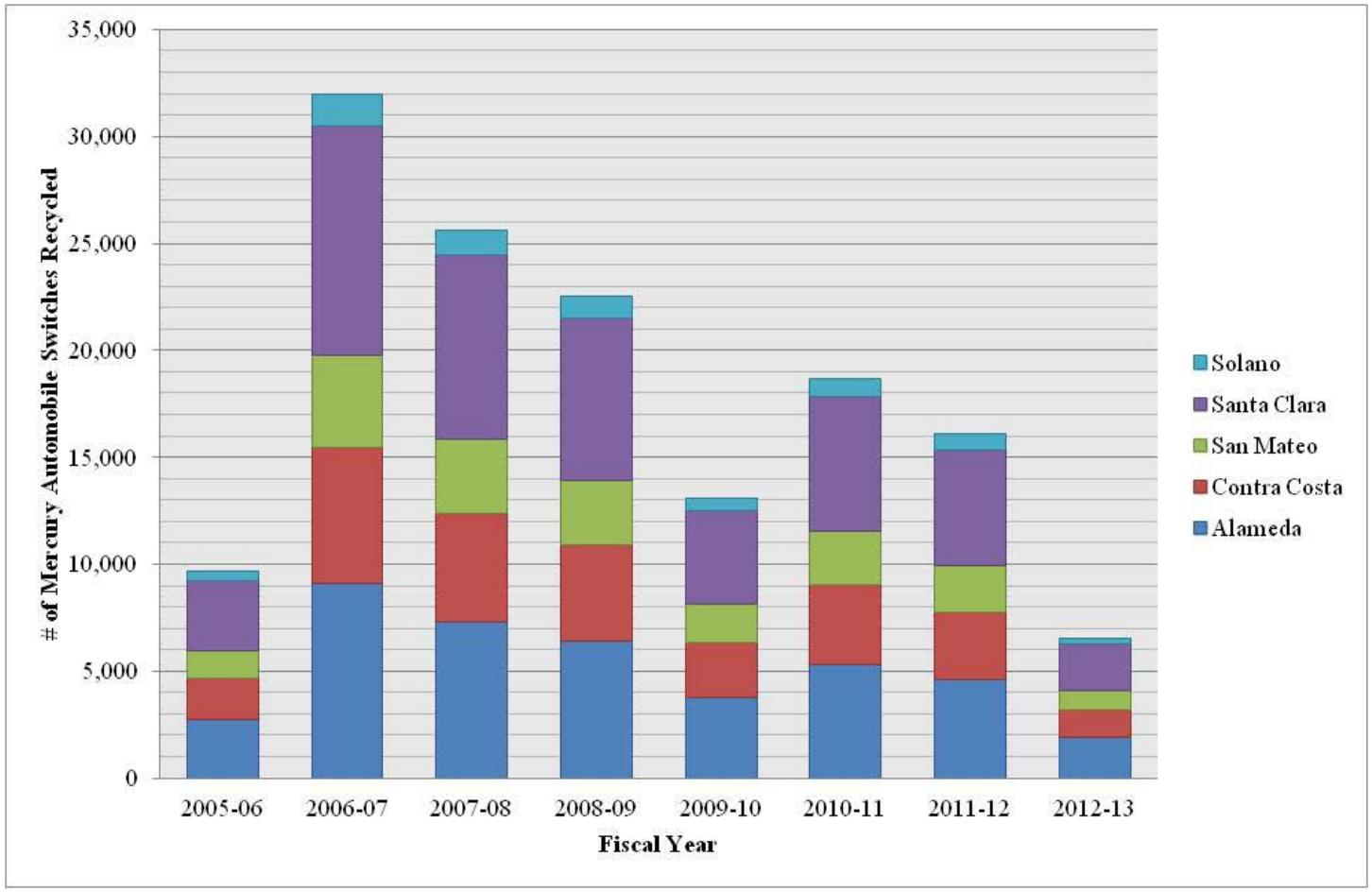


Number of Mercury-Containing Thermostats Collected and Recycled by the Thermostat Recycling Corporation (TRC) from Bay Area HVAC Contractors between FY 2008-09 to 2011-12

Source:	Notes:
Thermostat Recycling Corporation (2012)	May not include all thermostats collected by Household Hazardous Waste facilities

Entity	Date	
Bay Area Stormwater Management Agencies Association	September 2013	Figure B.2.2

internal info: path, date revised, author



Estimated Number of Mercury-Containing Automobile Switches in the Bay Area Collected and Recycled via National Vehicle Mercury Switch Recovery Program between FY 05-06 to 12-13

Source: National Vehicle Merucy Switch Recovery Program (2013)	Notes:	
Bay Area Stormwater Management Agencies Association	September 2013	Figure B.2.3
Entity	Date	

internal info: path, date revised, author

B.3 IDENTIFICATION OF PCBS DURING INDUSTRIAL INSPECTIONS

B.3.1 Introduction

This section of the IMR summarizes Permittee activities to implement actions required under Municipal Regional Stormwater NPDES Permit (MRP) provision C.12.a – Incorporating PCB Identification into Existing Industrial Inspections. The reasoning behind this control measure is that since PCBs (polychlorinated biphenyls) were used in a variety of electrical devices and industrial equipment, some may be found during industrial inspections. Provision C.12.a requires the Permittees to ensure that industrial inspectors can identify PCBs or PCB-containing equipment during their inspections and that appropriate agencies are notified if they are found.

B.3.2 Summary of Incorporation of PCB Identification into Existing Industrial Inspections

B.3.2.1 MRP Requirements

Permittees are currently implementing controls measures to identify PCBs during industrial inspections at a full scale of implementation. MRP Permittees are collectively required to develop training materials and train municipal industrial building inspectors to identify, in the course of their existing inspections, Pollutants of Concern (POCs) or POC-containing equipment. Inspectors are then required to incorporate POC identification into their inspections, document incidents in inspection reports, and refer incidents to the appropriate regulatory agency as necessary. Permittees agreed to conduct activities in compliance with provision C.12.a through a combination of regional and Permittee-specific activities. Training materials were developed collectively by Permittees as a regional project and inspections and reporting were conducted by each Permittee. Each of these activities is described in the following sections.

B.3.3 Status of Control Measure Implementation

This section summarizes the level of implementation taken by Permittees to incorporate PCBs and PCB-containing equipment into industrial inspections. This information was gathered from Section C.12.a. of the 2011 and 2012 Annual Reports that Permittees submitted to the Regional Water Board. While most municipalities defer to their countywide program's reports in their Annual Reports regarding training and inspections for PCBs, a few have reported additional actions that they have taken to assist in identification of PCBs in industrial inspections. Information on the development of training materials, municipal staff trainings conducted to-date, and the results of inspections are included in the following sections.

B.3.3.1 Training Materials

The Bay Area Stormwater Management Agencies Association (BASMAA) developed training materials in 2010 to assist industrial stormwater inspectors in identifying three pollutants of concern (POCs) (i.e., copper, mercury, and PCBs) during stormwater inspections (BASMAA 2011). The training materials summarize the historical uses of these POCs and products that

contain these POCs. The materials also discuss PCB identification strategies, possible pathways to the environment, ecological impacts, and applicable regulatory requirements and agencies. Included in the materials are a technical memorandum describing the materials, a guidance manual that provides information on sources, regulations, and proper management (storage, clean-up, and disposal) of POCs, a Microsoft PowerPoint™ presentation that may be used to train inspectors, and model inspection and reporting forms. Training materials were included in the BASMAA regional monitoring and pollutant of concern supplement to the FY 2009/10 Annual Report.

B.3.3.2 Staff Training

Using the training materials developed regionally, each countywide stormwater program has conducted multiple trainings on PCB identification for stormwater inspectors. Dates when trainings were conducted by the county-wide programs are provided in Table B.3.3.1. In addition, numerous Permittees have also supplemented the countywide program trainings within their municipalities.

B.3.3.3 Incorporation into Existing Inspections

As required by the MRP, Permittees reported the results of the initial training in their 2010 Annual Reports, and ongoing training and inspections for PCB identification in their 2011, 2012 and 2013 reports. Based on the review of Annual Reports, Permittees have incorporated PCB identification into their industrial stormwater inspection programs and utilized forms and checklists developed in the BASMAA regional project.

Table B.3.3.1. Training Dates for Identification of PCBs and PCB-Containing Equipment during Existing Industrial Inspections by Countywide Programs.

Countywide Program	Training Dates
Alameda Countywide Clean Water Program	June 2011 October 2012
Contra Costa Clean Water Program	July 2010 February 2011 October 2012 May 2013
San Mateo Countywide Water Pollution Prevention Program	June 2011 April 2012
Santa Clara Valley Urban Runoff Pollution Prevention Program	May 2011 June 2012 April 2013
Fairfield-Suisun Urban Runoff Management Program	August 2010 March 2012 February 2013

Some Permittees have integrated PCB identifications into all aspects of their existing industrial inspection programs. Others have focused on specific business types that have a relatively high

risk for PCBs on-site. For example, inspectors from Contra Costa County have begun to focus attention on facilities that have the SIC code 4911 (Electric Utilities including Generation, Transmission and Distribution Facilities) and other SICs that identify PCB activities (e.g., rail yards and salvage yards).

B.3.3.4 Distribution of Outreach/Education Materials to Focused Businesses

A number of Permittees have begun distributing outreach/educational material regarding PCBs to individual businesses. Many of these materials were developed through the BASMAA regional project for training materials. Additionally, Contra Costa County has also developed its own guidance booklet from the BASMAA training materials which was mailed to industrial and commercial businesses in unincorporated parts of the County that may have PCBs onsite[4]. Contra Costa County inspectors have also been trained to educate owners and operators of these facilities on PCB BMPs.

B.3.4 Results of Inspections

Based on Permittee annual reporting in 2010, 2011, 2012 and 2013, no Permittees have reported the identification of PCBs or PCB-containing equipment during industrial inspections. A number of reports did indicate, however, that education/outreach materials regarding PCBs and associated equipment were distributed to facility owners/operators where PCBs or PCB-containing equipment may be present.

Permittee reports also suggest that although PCBs have not been identified to-date, PCB identification can be efficiently incorporated into existing industrial inspections via staff trainings and the use of materials developed via the BASMAA regional training project. Given the mass of PCBs believed to be currently in use at industrial facilities, identifying mislabeled PCB-containing materials or the inappropriate storage of PCB-containing equipment during a stormwater inspection at an industrial facility may prevent discharges of PCBs in the future.

B.3.5 Estimates of Loads Avoided/Reduced

B.3.5.1 Loads Avoided/Reduced Methodology

This section presents the conceptual approach that will be used to estimate PCBs stormwater loads avoided/reduced due to the implementation of PCB and PCB-containing equipment identification during industrial stormwater inspections.

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[4] From the Contra Costa Clean Water Program 2011 Annual Report: "The educational booklet includes topics related to Best Management Practices for PCBs; TSCA Regulations; Provision C.12 PCB Controls; Sources of PCBs; PCB-Containing Equipment; PCB Sources in Older Buildings; Industrial/Commercial Facilities of Concern w/PCBs; PCB-Containing Equipment Requirements: Equipment Labeling, Facility Labeling, Recordkeeping & Reporting; Regulatory Agencies for PCB Referrals; and Joint Provision C.11Mercury & C.12 PCB Municipal Requirements"

The total PCB load avoided due to stormwater inspections is difficult to quantify due the lack of available information about the mass of PCBs on the site of a particular facility and the associated discharge to a stormwater conveyance system. Because various types of PCB-containing equipment and products are included in a stormwater inspection, the load avoided due to inspection actions (e.g., labeling, storing, record keeping, disposal, and PCB spill clean-up) must be included in the method used to estimate loads avoided from stormwater conveyances. Typically, estimates of loads reduced and avoided control measures should account for the mass of PCBs removed prior to the enhancement of management actions implemented before the adoption of the PCB TMDL for the San Francisco Bay. However, considering that the incorporation of PCB identification into industrial inspections did not begin until after the TMDL was adopted, consideration of baseline (pre-TMDL) PCB load reduction and avoidance estimates is unnecessary in the methodology presented.

The methodology described below assumes that the PCBs from equipment and the mass of PCBs in equipment are known. The method also assumes that the percentage of PCBs avoided as a result of inspections that would enter Bay Area urban stormwater if the devices were not properly managed is also known. The methodology incorporates PCB loads that were "avoided" via the implementation of industrial inspections. The overall loads avoided/reduced formula for PCB-containing equipment identified during industrial inspections is as follows:

$$PCBReductionInd = CurMassIdentifiedInd \bullet T \qquad Eq.\ 1$$

where:

CurMassIdentifiedInd = *Total PCB mass identified in Industrial Facilities that may have been discharged in year of interest if the inspection would not have identified the PCB-associated equipment or materials.*

T = *% of total PCBs identified in industrial facilities that would have been transported to the Bay via urban stormwater if not identified during industrial inspection(s)*

B.3.5.2 Baseline and Currents Loads Avoided/Reduced

Based on the information gained from Permittee annual reports, PCBs and PCB-containing equipment have yet to be identified during existing industrial inspections post-TMDL adoption (July 1, 2002). Therefore, no PCB load reduction/avoidance should be accounted for as a result of incorporating PCB identification into industrial inspections at this time. Should PCBs be identified during industrial inspections in the future, the methodologies included in this previous section should be used to calculate enhanced load reductions. The best available information should be used as inputs to the methodology and the assumptions used to calculate loads avoided should be clearly documented.

B.3.5.3 Summary of Key Uncertainties

There are a number of sources of uncertainty in accurately estimating PCB and mercury loads reduced to San Francisco Bay associated with baseline and current identifcaiton of PCBs during industrial inspections:

- The mass of PCBs in equipment and materials can vary between equipment/material type and age. Without a laboratory analysis of the concentration of PCBs in the material, average concentration would need to be assumed.
- To estimate the percentage of PCBs in the equipment or material that would have reached the environment and have been transported to the Bay via urban stormwater assumptions would need to be incorporated into the estimate.

B.3.6 References

BASMAA 2011. Pollutant of Concern Commercial/Industrial Inspector Training Materials – PCBs, Copper and Mercury. Prepared for the Bay Area Stormwater Management Agencies Association. Prepared by EOA, Inc. January.

CA Regional Water Quality Control Board, San Francisco Bay Region, 2009. Municipal Regional Stormwater NPDES Permit, Order R2-2009-0074, NPDES Permit No. CAS612008. October 14, 2009.

B.4 SOURCE PROPERTY IDENTIFICATION AND ABATEMENT

B.4.1 Introduction

Source control measures that target high priority properties in historically industrial land-use areas where polychlorinated biphenyls (PCBs) were used, released, or disposed of and/or where sediment concentrations are elevated above urban background may provide an effective way to minimize or prevent the release of polluted sediment into the stormwater system and protect receiving water quality. The goal of the source property investigation and referral pilot studies is to assist municipalities in identifying properties with potential for elevated PCB and/or mercury concentrations, including public rights-of-way and stormwater conveyances with accumulated sediments with elevated PCBs and/or mercury concentrations in Bay Area watersheds, and refer those properties to the Regional Water Board and other appropriate agencies for abatement. These pilot studies are being implemented through the Clean Watersheds for a Clean Bay (CW4CB) project.

This report describes the five Bay Area watersheds selected for implementation of CW4CB pilot studies, the source property identification and referral pilot studies conducted in these watersheds, including the results of surface soil/sediment monitoring completed to date, and the methods that will be used to evaluate the effectiveness and estimated load reductions of future abatement efforts. Load reduction calculations due to abatement efforts will be completed at a later date, after the abatements have been completed.

B.4.2 Summary of PCB and Mercury Control Pilot Studies

B.4.2.1 MRP Requirements and Implementation Approach

Permittees are currently implementing controls measures to identify and abate PCB source properties at a pilot scale. Municipal Regional Stormwater NPDES Permit (MRP) provisions C.11.c. (mercury) and C.12.c (PCBs) were written identically to reflect similarities between the respective Total Maximum Daily Loads (TMDLs) for these pollutants, based on the legacy and sediment-associated nature of their occurrence. These provisions require that Permittees work collaboratively to review pertinent existing data and identify five Bay Area watersheds that contain relatively high levels of PCBs and mercury and conduct pilot projects to investigate and abate PCB and mercury sources. Specifically, the MRP requires that Permittees investigate and abate PCBs/Hg sources in or to their storm drain systems in conjunction with the Regional Water Board and other appropriate regulatory agencies with investigation and cleanup authorities. Additionally, the MRP requires that Permittees quantify and report the amount of PCB/Hg loads abated resulting from implementation of these measures. Projects are required in five drainage areas (MRP area-wide) that contain elevated levels of PCBs/Hg.

B.4.2.2 Selection of Pilot Investigation Watersheds (CW4CB Task 2)

An important first step in the CW4CB project was to select the five Bay Area region watersheds for source property identification and referral pilot studies. Per the MRP, sites for pilot studies were primarily chosen on the basis of the potential for reducing PCB loads, but consideration

was given also to mercury removal in the final design and implementation of the studies. The CW4CB Project Management Team (PMT) developed a list of attributes and associated data sources to inform the selection of the five study watersheds, and then reviewed the available data (including analyzing appropriate data sets using Geographic Information System (GIS) software) in order to identify the five watersheds for pilot source property identification and referral investigations.

Table B.4.2.1 presents the list of attributes and associated data sources used to inform the selection of the five pilot watersheds. The majority of data were made available through a recent study conducted by the San Francisco Estuary Institute (SFEI) and funded by a State of California Proposition 13 grant that investigated options to better manage mercury and PCBs in urban stormwater (Yee and McKee 2010). The study developed and/or compiled a large amount of data related to the presence of PCBs and mercury in the Bay Area urban environment and indicators of potential sources of these pollutants.

The attributes used to conduct the analysis to identify the pilot watersheds (Table B.4.2.1) fell under three general categories: 1) presence of pollutants and indicators, 2) other desirable attributes, and 3) barriers.

Data related to the presence of pollutants and indicators included:

- Sediment chemistry. The SFEI Proposition 13 study compiled PCB and mercury chemical analysis results from about 600 sediment samples collected throughout the Bay Area from roadways and stormwater drainage infrastructure (e.g., storm drain inlets, pump house wet wells, piping beneath manholes, and open channels). About half of the sediment samples were collected by BASMAA agencies during studies conducted in the early to mid-2000s (Gunther et al. 2001; KLI and EOA 2002; EOA 2002; City of San Jose and EOA 2003; SMSTOPPP 2003; SMSTOPPP 2004; EOA 2004; Kleinfelder 2005; Kleinfelder 2006; and EOA 2007). The other half was collected during the more recent SFEI Proposition 13 study (Yee and McKee 2010).
- Pollutant indicators. SFEI Proposition 13 Study GIS layers containing data related to the following indicators of potential sources of PCBs and/or mercury:
    - Historic industrial land use.
    - Pacific Gas and Electric (PG&E) substations.
    - Auto dismantlers.
    - Railroad tracks.
    - Currently active PCB transformers.

Data regarding other desirable watershed attributes included the following:

- Watershed area. A model for CW4CB's property identification and referral process was a project conducted in the Ettie Street Pump Station watershed by the City of Oakland through a State of California Proposition 13 grant (Kleinfelder 2006). The project began a

process to identify PCB source properties within the watershed. Based on a comparison of the CW4CB and Ettie Street project budgets, the PMT determined the approximate five square kilometer area of the Ettie Street Pump Station watershed was an appropriate upper bound for the areas of the CW4CB study watersheds.

- Pump station presence at the bottom of a study watershed. This attribute was desirable because a pump station can serve as an integrative monitoring station to sample sediments and water for chemical and other analyses as part of a study's effectiveness evaluation.
- Municipal street and storm drain system operation and maintenance activities. CW4CB Task 4 will evaluate methods to enhance the pollutant load reduction benefits of municipal operation and maintenance activities that remove sediment from streets and storm drain system infrastructure (e.g., street sweeping and storm drain inlet cleaning). Selecting study areas where these activities were routinely conducted was desirable since some Task 4 activities will likely be carried out within one or more of the five pilot watersheds (see the section describing Task 4 later in this report).

Table B.4.2.1. Summary of Watershed Attributes Used to Inform Pilot Watershed Selection

Category	Watershed Attribute	Data Sources
Presence of Pollutants and Indicators	Are there relatively high (≥ 1.0 ppm) levels of PCBs and secondarily mercury in sediments collected from roadway and stormwater drainage infrastructure in the watershed?	SFEI Proposition 13 Study compilation of sediment chemistry data.
	Are there other indicators of potential sources of PCBs in the watershed?	SFEI Proposition 13 Study GIS layers: • Historic industrial land use. • PG&E substations. • Auto dismantlers. • Historic railroads. • Currently active PCB transformers.
Other Desirable Attributes	Is the watershed's size within an acceptable range for the pilot study work (i.e., less than 5 square kilometers)?	• SFEI Proposition 13 Study Bay Area watershed GIS layer. • Creek and storm drain system data from several sources, including Cities of San Carlos and San Jose, Alameda and Contra Costa Counties, Oakland Museum of California, and William Lettis Associates.
	Is there a pump station at the bottom of the watershed?	SFEI Proposition 13 Study Bay Area pump station GIS layer.
	Are municipal street and storm drain system operation and maintenance activities conducted routinely in the watershed?	CW4CB project management team knowledge, municipal staff interviews.
Barriers	Are there institutional, regulatory, political, technical, and/or organizational barriers to conducting a source property identification and referral study in the watershed?	CW4CB project management team knowledge, municipal staff interviews.

Finally, the PMT evaluated whether there were any indications of major institutional, regulatory, political, technical, and/or organizational barriers to conducting a source property identification and referral study in a candidate study watershed.

Based on the results of the above data analysis, the PMT identified the following five study watersheds (Figure B.4.1 provides an overview of their locations):

1. Ettie Street Pump Station watershed, City of Oakland, Alameda County (Figure B.4.2.).
2. Lauritzen Channel watershed, City of Richmond in Contra Costa County (Figure B.4.3.).
3. Leo Avenue watershed, City of San Jose, Santa Clara County (Figure B.4.4.)
4. Parr Channel watershed, City of Richmond in Contra Costa County (Figure B.4.5.).

5. Pulgas Creek Pump Station watershed, City of San Carlos, San Mateo County (Figure B.4.6.).

Table B.4.2.2 summarizes pertinent attributes of the five identified watersheds, which range in area from about two to five square kilometers. Two of the watersheds have pump stations at the bottom of the drainage (Ettie Street Pump Station and Pulgas Creek Pump Station watersheds). Sediment samples with PCB concentrations higher than 1.0 parts-per-million (ppm) were collected from all five watersheds and comprise about 15 to 32 percent of the total samples from each watershed.[5] The maximum concentrations in sediment samples from the watersheds ranged from 2 - 93 ppm for PCBs and 1 - 6 ppm for mercury.

All five watersheds also contained current (year 2000) and historic industrial land use,[6] with the historic industrial use ranging from about 17 to 72 percent of the total watershed area. One or more of three other potential pollutant source indicators (PG&E substations, auto dismantlers, and railroad lines) were present in each of the five watersheds. In addition, municipal street and storm drain system operation and maintenance activities are routinely conducted in each of the five watersheds. Finally, indications were not found of any major institutional, regulatory, political, technical, and/or organizational barriers to conducting future source property identification and referral studies.

[5] The number of sediment samples analyzed (Table B.4.2) is sometimes greater than the number of sample locations shown on Figures 2 - 6 because some locations were resampled one or more times.

[6] The SFEI Proposition 13 study developed the historic industrial land use data layer by intersecting areas classified "urban" in 1954 USGS maps and "industrial" in maps of land use in the year 2000 developed by the Association of Bay Area Governments.

Table B.4.2.2. Attributes of Pilot Study Watersheds.[1, 2]

Watershed Name	City *County*	Watershed Area (km^2)	Pump Station at Bottom of Watershed?	No. of Sediment Samples Total / ≥ 1.0 ppm PCBs	Max. Sediment PCB Concen-tration (ppm)	Max. Sediment Mercury Concen-tration (ppm)	Major Land Uses in Year 2000	Percent Historic Industrial Land Use[3]	No. of PG&E Sub-stations	No. of Auto Disman -tlers	Historic/ Current Rail[4] (m)
Ettie Street Pump Station	Oakland *Alameda*	4.9	Yes	96/28	93.4	1.6	Industrial Commercial Residential	34.9	0	2	4,226/ 7,140
Lauritzen Channel	Richmond *Contra Costa*	3.8	No	35/9	2.8	1.1	Industrial	23.3	0	0	3,836/ 9,770
Parr Channel	Richmond *Contra Costa*	4.3	No	19/6	2.3	1.4	Industrial	17.1	2	0	3,397/ 9,195
Pulgas Creek Pump Station	San Carlos *San Mateo*	1.4	Yes	48/8	11.5	0.9	Industrial Commercial	71.7	1	0	0/ 669
Leo Avenue	San Jose *Santa Clara*	2.2	No	26/4	26.7	6.2	Industrial Commercial	17.8	0	6	0/ 7,192

[1] Sources of data include the SFEI Proposition 13 study, SF Bay Area Regional Water Quality Control Board, Cities of San Jose and San Carlos, Contra Costa County, Oakland Museum of California, William Lettis and Associates, and past field studies (Gunther et al. 2001, KLI and EOA 2002, EOA 2002, City of San Jose and EOA 2003, SMSTOPPP 2003, SMSTOPPP 2004, EOA 2004, Kleinfelder 2005, Kleinfelder 2006, and EOA 2007), and municipal staff communications.

[2] All five watersheds share the following attributes: 1) routine municipal activities are conducted (e.g., street sweeping and storm drain inlet cleaning), 2) indications were not found of any major institutional, regulatory, political, technical, and/or organizational barriers to conducting future source property identification and referral studies, and 3) available records did not indicate the presence of active PCB transformers.

[3] The SFEI Proposition 13 study developed the historic industrial land use data layer by intersecting areas classified "urban" in 1954 USGS maps and "industrial" in maps of land use in the year 2000 developed by the Association of Bay Area Governments.

[4] The SFEI Proposition 13 study developed the historic rail layer by digitizing rail lines shown on georectified 1959 USGS topographic quads that were not present on a current rail layer included with the USGS Digital Line Graphic

B.4.2.3 Methods to Identify Specific PCB and Mercury Source Properties

The process to identify specific PCB and mercury source properties within the five project watersheds and refer these sites to regulatory agencies for cleanup and abatement consisted of the following five steps:

1. Records review. Review general information sources (e.g., spill site databases, historic land use and available sampling data) and records on specific properties/businesses to begin identifying potential source properties within the pilot watersheds.
2. Driving/walking survey. Perform a driving/walking survey of each pilot watershed to further identify potential source properties and begin looking for evidence that runoff from such locations is likely to convey pollutants to storm drains.
3. Facility inspections. Perform inspections of selected facilities within each pilot watershed.
4. Surface soil/sediment testing. Test surface soils/sediments from the public right-of-way and private properties in the pilot watersheds for PCBs, mercury and other particle-bound pollutants.
5. Property referrals. Where laboratory data confirm elevated pollutant concentrations, refer properties to regulatory agencies for cleanup and abatement.

One model for Task 3 of CW4CB was a recent project conducted by the City of Oakland through a Proposition 13 grant awarded by the California State Water Resources Control Board (Kleinfelder 2006). The project focused on identifying sources of PCB-containing sediments to the storm drain system in the Ettie Street Pump Station watershed in Oakland. The methods used for the source property investigations were generally based on the Ettie Street project experience. However, CW4CB adapted and refined the methods as appropriate for local conditions in each of the five pilot watersheds.

The methods that were used to implement the five steps of the property identification and referral process in each of the five project watersheds are described in detail below.

Step 1: Records Review

To begin identifying potential source properties within each of the five project watersheds, readily available general information sources (e.g., spill site databases, historic land use and available sampling data) and records on specific properties/businesses were reviewed. To the extent feasible within available project budget, appropriate records on all businesses in each pilot watershed were reviewed. Relevant and readily available databases (e.g., spill sites) and other general information sources were reviewed for evidence of pollutant use/release in the pilot watersheds, and at specific properties in each watershed. The type of information reviewed included the following:

- Records related to the use of hazardous materials and generation of hazardous waste (generally available from local fire departments, environmental agencies, or public health

agencies) - a list of PCB product trade names is attached to assist this effort (Attachment 1);

- Business licenses or permits for a description of current and historical businesses that were present on a property;
- Digital aerial and site photographs (e.g., Google Earth); and
- Records from stormwater industrial/commercial facility inspections.
- Code enforcement records for evidence of non-permitted uses and activities;
- Building department records for site plans, electrical and plumbing plans, and demolition and construction plans;
- General Plans and Zoning Ordinances for information on permitted, conditionally-permitted and non-permitted uses within the watersheds, including local plans and redevelopment area plans, as appropriate;
- Business tax data for lists of businesses within the watershed;
- Illicit discharge and source identification records; and
- Recorded land title records for evidence of Activity Use Limitations (AULs).

Based on the information sources reviewed by City of Oakland staff during the Ettie Street project (Kleinfelder 2006) data sources reviewed included those shown in Table B.4.2.3.

Table B.4.2.3. General Information Sources on Pollutant Use/Release

Name of Database or List	Internet URL	Agency that Developed and Maintains	Description
Geo-tracker	http://geotracker.swrcb.ca.gov	California State Water Resources Control Board	• Leaking Underground Tank (LUST) sites • Regional Water Quality Control Board cleanup sites • Land disposal sites • Military sites • Permitted Underground Storage Tank (UST) facilities • Monitoring wells • Department of Toxic Substances Control (DTSC) cleanup sites • DTSC hazardous waste permit sites
SLIC – Spills, Leaks, Investigations and Cleanups	http://www.waterboards.ca.gov/sanfranciscobay/resources/database/lustis/slic.xls.	California State Water Resources Control Board	• Spills, Leaks, Investigations, and Cleanups Sites

Name of Database or List	Internet URL	Agency that Developed and Maintains	Description
DTSC Envirostor	http://www.envirostor.dtsc.ca.gov/public/	California Department of Toxic Substances Control	• National Priorities List (Federal Superfund Sites) • State Response Sites • Voluntary Cleanup Sites • School Cleanup Sites • Corrective Action Sites • Tiered MRP Sites • Leaking Underground Fuel Tank (LUFT) cleanups (same as LUST) • Spills, Leaks, Investigations and Cleanups Sites (SLIC)
Coast Guard Spills Database	http://www.nrc.uscg.mil/nrsinfo.html	United States Coast Guard	• Incidents of spills of oil and other toxic substances into the environment.
PG&E Bay Area PCB equipment spills	Not Applicable	Pacific Gas and Electric (PG&E)	• List of spills of PCB-containing dielectric fluids from PG&E distribution line equipment in the Bay Area (1994 -2000). CW4CB is currently attempting to obtain an update of this list.
Cleanup Sites in California	http://www.epa.gov/region9/cleanup/california.html	US Environmental Protection Agency	• Superfund Sites - EPA's program to identify, investigate and clean up uncontrolled or abandoned hazardous waste sites throughout the United States. • Brownfields – EPA's Brownfields Program works to clean up and redevelop potentially contaminated lands.
PCB Waste Handlers Database	http://www.epa.gov/epawaste/hazard/tsd/pcbs/pubs/region9.pdf	US Environmental Protection Agency	• List of facilities that have notified the EPA of PCB activity, including storage, disposal and transformer registrations.
Toxic Release Inventory	http://www.epa.gov/tri/	US Environmental Protection Agency	• Data on toxic chemical releases and waste management activities reported annually by certain industries as well as federal facilities.
My Environ-ment	http://www.epa.gov/myenvironment/	US Environmental Protection Agency	• EPA-regulated facilities • Air Quality Index (AQI) • Water quality monitoring and conditions for local water bodies • Cleanup sites
Enviro-facts System	http://www.epa.gov/enviro/index.html	US Environmental Protection Agency	Allows retrieval of information from multiple databases including: • Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS), Brownfields, and other cleanup sites • MRP Compliance System (PCS) • Resource Conservation Recovery Act - RCRAInfo • Toxic Release Inventory (TRI) • Toxic Substances Control Act (TSCA)

Step 2: Driving/Walking Survey

The next step was to conduct driving/walking surveys of the entire public right-of-way of each pilot watershed. The surveys provided additional information about subject properties and a check of the information obtained during the records review to identify potential source areas and estimate the potential for stormwater runoff to convey surface soils/sediments with PCBs and/or mercury from such areas to the municipal stormwater collection system.

Watershed maps and a survey data form adapted from the inspection check list developed during the Ettie Street project (Kleinfelder 2006) were used during the driving/walking surveys (Appendix B.4.A). The data form included potential indicators of PCB/mercury release risk that may not have been readily available during the records review, such as indications of sediment erosion from a property and migration to the street or storm drains, evidence of pollutant use/release in visible outdoor areas of properties, and impacts to the adjacent public right-of-way. The maps included the locations of the watershed boundary, streets, property lines, storm drain inlets, and other stormwater collection system infrastructure (e.g., flood control channels) within the drainage.

During the driving/walking surveys, the entire public right-of-way of each pilot watershed was visited on foot and/or by car as appropriate for local conditions. Digital photographs of notable features in each pilot watershed were taken. Field staff looked for potential indicators of pollutant use and/or release from properties and impacts to the adjacent public right-of-way, including, but not limited to the following:

- Unpaved or other areas where sediment erosion may occur, especially when there is evidence of migration of sediments from a property to the public right-of-way;
- Electrical equipment (e.g., transformers);
- 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; and
- Unidentified puddles or stains.

These observations provided information used to evaluate the potential for migration of sediment-bound pollutants from suspect properties to stormwater conveyances.

Step 3: Facility Inspection

Based on the results of the records review and driving/walking survey, properties deemed to have higher potential to be a source of PCBs and/or mercury to storm drains were selected for

facility inspections. Table B.4.2.4 presents typical attributes of sites with higher, medium and lower potential for PCB/mercury release to streets and stormwater conveyances. Other factors/constraints that were considered included available budget, existing inspection schedules (e.g., CUPA[7] hazardous material inspections), and inspector availability. Resources for inspectors included the recently developed Pollutants of Concern Stormwater Inspectors' Guidance Manual (BASMAA 2010b), a companion PowerPoint presentation, and Section 9 of the ASTM Phase I Environmental Site Assessment guidance (ASTM 2005). These training materials describe the types of facilities where PCBs and/or mercury may be used and typical applications, how to identify associated products and equipment, proper disposal/recycling and spill cleanup practices, and guidance on referring facilities to regulatory agencies when appropriate.

Table B.4.2.4. Typical Attributes of Sites with Higher, Medium and Lower Potential for PCB/Mercury Release to Streets and Stormwater Conveyances [1]

Typical attributes of sites with higher potential for PCB/mercury release: • Records of PCB/mercury release at the site. • Indications of PCB/mercury-associated materials/processes. • Locations where sediment may erode and be mobilized off-site by stormwater runoff, vehicles, and/or wind (e.g., unpaved areas). • Illegal dumping occurs. • Outdoor hazardous material/waste storage areas (e.g., tanks, drums) with poor housekeeping.
Typical attributes of sites with medium potential for PCB/mercury release: • Industrial land uses. • Electrical equipment (e.g., transformers with PCBs). • Outdoor hazardous material/waste storage areas (e.g., tanks, drums) with fair to good housekeeping. • Unidentified barrels or drums. • Demolition, large-scale window replacements, or other renovations have occurred (potentially releasing PCB caulks/sealants).
Typical attributes of sites with lower potential for PCB/mercury release: • Non-industrial land uses. • Minimal potential for sediment loading to stormwater collection system. • No history of PCB/mercury-related activities.

[1]Adapted from the Ettie Street project (Kleinfelder 2006).

The checklist developed for property inspections during the Ettie Street project (Kleinfelder 2006) and information from the above Inspectors' Guidance Manual was adapted for use in the

[7]Certified Unified Program Agency.

field during the facility inspections in the five pilot watersheds. The inspection form included priority uses and activities potentially associated with PCBs and/or mercury, examples of questions for inspectors to ask current owners, tenants or site supervisors, and a space for inspectors to sketch the site and observations made in the field (Appendix B.4.B).

Inspections of selected high priority facilities were conducted by Stormwater Program and/or municipal staff in each watershed. The combined results of the records review, driving/walking survey, and the facility inspections were used to rank each inspected property as having higher, medium or lower potential to release PCBs and/or mercury to streets and stormwater conveyances. Figure B.4.7 provides a description of the criteria and decision-making process used to rank properties. It should be noted that in some watersheds some of the Steps 1 - 3 activities were conducted to varying extents in the past and thus the extent of additional effort needed varied.

Specifically for the Ettie Street Pump Station watershed, extensive sampling had previously been conducted during sediment sampling conducted by the City of Oakland between June 2004 and June 2006. Additionally, the City of Oakland abated two areas within the Ettie Street Pump Station watershed through power-washing between May 15 and 24, 2006. The Department of Toxic Substances Control (DTSC) also remediated the Former Giampolini industrial site, as part of the outcome of the City's efforts.

In 2012 as part of CW4CB Task 3, the City of Oakland and Alameda Countywide Clean Water Program (ACCWP) staff developed a rationale for additional site inspections, drafted a list of potential sites to inspect, and conducted site inspections between May and June 2012. A list of potential inspection sites was developed using a four-step process. First, data from the SFEI study and additional data obtained from the Department of Toxic Substances Control (DTSC) EnviroSTOR website were compiled into a database and mapped using GIS. Second, areas that were either considered for abatement or were actually abated in 2006 were delineated (Kleinfelder, 2006). Third, all sites that discharged runoff to proposed tree well locations, as part of the CW4CB Task 5 West Oakland Industrial Area Project, were identified and omitted to avoid conflicting Project objectives. The goal of the tree well retrofits is to evaluate the effectiveness in reducing PCBs from storm water runoff; whereas the CW4CB Task 3 Ettie Street Project goal is to identify the sources of PCBs within the watershed. Fourth, all compiled data was then grouped by facility, which included the sediment PCB concentrations that were either taken on-site, in the surrounding public right-of-way, and in public catch basins adjacent to the facility. Finally, the sample with the highest PCB concentration was identified at each facility grouping. These representative samples were used to identify the top 15 facilities for inspection.

Step 4: Surface Soil / Sediment Testing

The results from Steps 1 – 3 were used to inform the development of surface soil/sediment sampling and chemical analysis monitoring programs within each project watershed. During the previous Ettie Street project sediment samples were first collected in the public right-of-way adjacent to selected suspect properties (Kleinfelder 2006). The chemical analysis results from these samples were used to prioritize properties for on-site sampling and areas in the right-of-

way for abatement measures (e.g., removal of sediment via sweeping/shoveling or street flushing,). A similar two-phase sediment sampling approach was implemented here.

Prior to the start of the surface soil/sediment monitoring, the CW4CB PMT developed and submitted to EPA a draft Quality Assurance Project Plan (QAPP) and CW4CB Task 3 Sampling and Analysis Plan (SAP). EPA reviewed and approved these documents following recommended revisions. These documents provide detailed descriptions of the sample collection and chemical analysis methods, and quality assurance/quality control in the field and in the laboratory for all monitoring conducted under the source property identification and referral pilot studies (BASMAA 2012a,b).

The first phase of soil/sediment monitoring focused on sample collection from storm drain inlets, street curbs, driveways and other areas in the public right-of-way where sediment appeared to transport off priority properties and accumulate in the streets/storm drainage system. In order to finalize the list of right-of-way sample sites for Phase 1, locations of storm drain inlets in front of and nearby priority facilities as well as on those street segments that were also considered high priority were ground-truthed. All soil/sediment samples collected during Phase 1 monitoring were analyzed for PCBs, mercury, total organic carbon (TOC), and grain size. Approximately 10 percent of the samples (selected randomly) were also analyzed for dioxins, PBDEs, organochlorine pesticides, and PAHs.

Phase 2 is currently being planned (as of the writing of this report), and will focus on sample collection from private properties within the project watersheds based on the results of the Phase 1 monitoring and additional public right-of-way samples to further refine the location of POC sources in the watershed.

Step 5: Property Referrals

Where laboratory data confirm elevated pollutant concentrations, properties will be referred to regulatory agencies for cleanup and abatement. The CW4CB PMT is working with Regional Water Board staff to develop the referral process, including identification of the information required and the documentation that will be used to make referrals. As of the writing of this report, no referrals under CW4CB Task 3 have yet been made.

B.4.2.4 Results of the Source Property Identification and Referral Pilot Studies in Five CW4CB Project Watersheds

This section presents the results of the source property identification and referral pilot studies that have been conducted in the five CW4CB project watersheds. For each watershed, the relevant site history is presented followed by the results of each of the five steps of the process (described above) that have been completed as of the writing of this report.

Ettie Street Pump Station Watershed, Oakland CA

Site History

In 2000 and 2001 investigations by the Alameda Countywide Clean Water Program (ACCWP) suggested there were multiple sites in the Ettie Street Pump Station watershed that continued to discharge legacy PCBs to the storm drain system, but no specific current sources were identified. The City of Oakland sought funding from a State Water Resources Control Board Proposition 13 Grant to further investigate, identify, and remediate sources of PCBs in the watershed and evaluate control measures for addressing these sources of PCBs. The City was awarded $460,000 for the PCB Abatement Grant Project and initiated work in 2004. Project tasks included: surveying potential source areas for PCBs in the watershed, inspections of private properties, collection and chemical analysis soil/sediment samples from locations in the public right-of-way and on private properties, preparation of sampling reports, abatement of PCB-containing sediments in the public right-of-way, coordination with regulatory agencies for enforcement of PCB cleanup on private properties, and preparation and distribution of education and outreach materials (including a Fact Sheet). A case study and final report that details the methods and results for the PCB Abatement Grant Project was completed (Kleinfelder 2006). These efforts resulted in property referrals to regulatory agencies.

However, based on discussions with City of Oakland staff, additional work was needed to identify other contaminated properties for referral and abatement. The source property identification and referral pilot study in the Ettie Street Pump Station watershed builds upon the Kleinfelder study and the SFEI Proposition 13 study completed in 2010[8]. The methods used in the Ettie Street PCB Abatement Grant Project (Kleinfelder 2006) served as the model for the Clean Watersheds for a Clean Bay source property identification and referral pilot studies. Previous measurements of mercury and PCB concentrations in sediments collected from piping beneath manholes, drop inlets/catch basins, streets/gutters, and private properties in the watershed have ranged from 0.26 to 1.0 mg/kg for mercury and 0.039 to 93 mg/kg for PCBs (Gunther et al. 2001; KLI and EOA 2002; EOA 2002; Kleinfelder 2005; Kleinfelder 2006, Yee and McKee 2010).

Results of Source Property Identification and Referral Process

The source property identification and referral process in the Ettie Street Pump Station watershed has been conducted by the City of Oakland, with support provided by ACCWP.

Steps 1-3: Records Review, Driving Walking Survey, Property Inspections

Much of the property identification and referral process was conducted in the Ettie Street Pump Station watershed prior to Clean Watersheds for a Clean Bay, as described above. This pilot study built upon those results to identify additional properties for referral to regulatory agencies. ACCWP provided funding for Geosyntec Consultants to work with the City of Oakland staff to

[8]Spatial analysis results from the San Francisco Estuary Institute's 13 study (Yee and McKee 2010) showed, that in 15 locations of the Bay Area, elevated concentrations of PCBs or Hg were clustered together within 3 kilometers of one another, which may be due to similarities in land use or transport of shared pollutant sources. The watershed was identified as one of the 15 locations in the Bay Area with several elevated concentrations in the same general vicinity.

review the previous project's inspection reports and sampling data, and recommend 15 sites for additional inspections and sampling based on evidence of potential mercury and/or PCB sources and potential for sediment transport off the property.

In May and June 2012, the City of Oakland and Geosyntec staff inspected or re-inspected these 15 industrial sites to evaluate whether the properties were potential sources of PCBs. Based on data from these inspections, over 30 locations were recommended for sampling via the CW4CB. Some of the recommended locations were industrial properties that were considered "high priority" sites based on historic sources of PCB and/or current inspection information, but lacked sufficient sampling data to determine if the property was a potential source. Other locations were selected to evaluate the long-term effects of sediment abatement conducted in the street right-of way during 2006.

Step 4: Soil/Sediment Testing

Applied Marine Sciences (AMS) and ADH Environmental were selected through a competitive process as the CW4CB monitoring contractor team for the Ettie Street Pump Station watershed. AMS/ADH conducted right-of-way surface soil/sediment sampling at the sites selected by the City of Oakland/Geosyntec, according to the methods and procedures documented in the project QAPP and Task 3 SAP (BASMAA 2012 a, b). All Phase 1 samples in this watershed were collected between September 27, 2012 and October 2, 2012. A field methods report is provided in Appendix B.4.C.

The chemical analysis results for PCBs and mercury have undergone QA/QC review and are presented below. These data are considered preliminary, pending finalization of the QA/QC review for all Phase 1 data. A summary of the data quality review completed to-date for Phase 1 field and chemistry data in all five project watersheds is provided in Appendix B.4.D.

A total of 27 soil/sediment samples were collected during Phase 1 at the locations identified in Figures B.4.8 and B.4.9. Concentrations of total PCBs (sum of 40 congeners) ranged from 0.027 – 5.7 mg/kg (Figure B.4.8). Concentrations of mercury ranged from 0.07 – 1.6 mg/kg (Figure B.4.9).

As of the writing of this report, the Phase 1 sediment testing results are being used to select private property and/or additional public right-of-way sampling locations for Phase 2, which is anticipated to occur during May 2013. Chemical analysis results from the Phase 2 sampling effort are expected to be available within three months following completion of all field sample collection.

Step 5: Referrals

Based on the results of the public right-of-way and private property sediment testing, ACCWP and the City of Oakland will submit a list of facility referrals to the Regional Water Board for follow-up investigations at these facilities. The information requirements and documentation that will be used to make these referrals are currently being developed by the CW4CB PMT in cooperation with Regional Water Board staff. It is anticipated referrals will be made within six months of completion of the second phase of soil/sediment testing.

Lauritzen Channel and Parr Channel Watersheds, Richmond CA

Site Histories

This section describes activities undertaken going back to the year 2000 to investigate and abate PCB concentrations in sediments within the Lauritzen and Parr Channel pilot watersheds of the Santa Fe Channel drainage in the City of Richmond (Richmond), CA.

In 2000 and 2001, sediment samples were collected from drainage inlets throughout the Bay Area, in response to direction from the Regional Water Board (EOA, Inc., 2002). The sampling design targeted different land use types (residential, commercial, industrial) as a means of testing the working hypothesis that older industrial areas where PCBs have been used and / or released have higher concentrations in urban sediments. All of the analysis relied upon EPA Method 1668, and summed up the 41 congeners relied upon by the San Francisco Bay Regional Monitoring Program to quantify total PCB concentrations.

In Contra Costa County, the highest PCB concentrations in sediments collected from the MS4 system in 2000 and 2001 were found in Richmond, along Cutting Boulevard, and on Wright Avenue. Total PCB concentration found in 2001 along Cutting Blvd in a composite sample of four catch basins was 1,100 µg/kg; PCB concentrations in sediments from catch basin composites sampled at Wright Avenue at Harbour Way was 1,900 µg/kg. These two locations represented the highest concentrations in Contra Costa County for sediments collected from the MS4 system, and so warranted additional follow up.

Follow up sampling in 2002 resulted in catch basin samples along Cutting Boulevard near 1st and 2nd Streets which were generally above 700 µg/kg, and as high as 2,000 µg/kg; concentrations in catch basin sediments to the west along Cutting Boulevard dropped off. Individual catch basins sampled near the Wright and Harbor intersection in 2002 had PCB concentrations of 540, 150, and 180 µg/kg, respectively. At that time, the data suggested a local source in either the Cutting Boulevard or the Wright and Harbor area, with some trackout from the local source potentially involved.

At least four potential source areas were noted, based on the land use and activities:

- An electric substation located 1st Street and Cutting Boulevard (Older electric transformers are known to contain PCBs)
- A forklift and equipment repair shop on 2nd Street at Cutting Boulevard (old hydraulic fluids and lubricants are a potential PCB source)
- A scrap metal recycler located along 4th Street (The recycler shreds old equipment, including in the past used electric transformers, that could contain PCBs)
- Railroad tracks that crisscross City streets throughout the drainage

Detailed follow-up studies by CCCWP and Richmond during 2005 – 2007 presented a more comprehensive picture and helped pinpoint potential source areas (EOA Inc., May 2007; EOA Inc., October 2007). Surface street and gutter samples along Cutting Boulevard were generally

lower than catch basin samples. Street sweeping samples evaluated to the north generally indicated low to moderate PCB concentrations, consistent with the "halo" effect of PCB concentrations in urban sediments that are moderately elevated in city streets and MS4 conveyances in areas near PCB sources (Yee and McKee 2010). In contrast, surface street samples collected from locations bracketing the metal recycler were consistently above 700 µg/kg.

The metal recycler, at the conclusion of the 2007 studies, was a high priority for follow-up and investigation, because of the elevated PCB concentrations on surface streets adjacent to the property. The evidence remained inconclusive, at that time, as to the potential for the fork lift repair shop or the transformer yard, to be causing the elevated PCB concentrations in the storm drain catch basins along Cutting Boulevard; other potential explanations could include tidal intrusion of sediments from the Richmond Harbor (the conveyance system in that area is partly tidal) and vehicle trackout from the metal recycler or some other as yet unidentified source.

The Total Maximum Daily Load for PCBs in San Francisco Bay was adopted in 2008. The MRP required control measures for PCBs, including the source identification and reporting project that is within the scope of this section. Concurrently, Richmond worked with the metal recycler to get them to initiate enhanced BMPs, including near continuous street sweeping on adjacent streets. While that enhanced BMP likely helps reduce trackout of potentially contaminated sediments, street sweepers cannot get complete removal because of the soft shoulder and lack of curb and gutter in the area. In addition, airborne transport of dust and shredder fluff (the fine, particulate grindings associated with metal shredding) may transport solids offsite beyond the activity area of high frequency street sweepers. Anecdotal evidence suggests that dust accumulation on cars is a nuisance for nearby residents.

Richmond also directed the metal recycler to cease discharging stormwater into the MS4 system, unless they could demonstrate attainment of EPA Benchmark levels for industrial stormwater and characterize the stormwater using methods with appropriately low detection limits. Since that direction, the metal recycler has stored stormwater onsite, and re-used onsite process water for dust control. Stored stormwater is currently discharged by the recycler into the sanitary sewer. Rainy weather has been anomalously light for the past few years, so the ability of the recycler to store water during larger events is as yet unproven.

Results of Source Property Identification and Referral Process

The source property identification and referral process in the Lauritzen Channel and Parr Channel watersheds in Richmond, CA, has been conducted by the City of Richmond, with support provided by CCCWP.

Steps 1-3: Records Review, Driving Walking Survey, Property Inspections

The source property identification and referral process in the Richmond watersheds built upon the source investigations conducted prior to the start of the pilot studies as described above. Records review, driving/walking surveys, and onsite inspections of properties in catchments draining into the watersheds were conducted by CCCWP during 2010 and 2011.

CCCWP assisted Richmond with a desktop reconnaissance of properties using a GIS parcels database provided by Richmond, combined with a review of Department of Toxics Substances Control (DTSC) cleanup databases and records of code enforcement. The desktop reconnaissance criteria included parcel size, current use, history of cleanup or prior code violations, and notably presence of potential sediment trackout as seen from Google Earth.

Of 165 parcels identified in those watersheds, 62 parcels were inspected from outside the property line, and 13 were inspected onsite. The focus of the inspections was to identify any sources of bare dirt on the property that could serve as a sediment source, and determine whether any known or suspected current or past activities could involve materials containing PCBs (i.e. transformers, wire insulation, hydraulic fluids, caulks and paints). Inspection results included field logs, photographs, site flow path sketches, and aerial photos from Google Earth. Inspection results were compiled in a simple Excel-based database.

Streetside inspections were performed May 18 through June 19, 2011. Onsite property inspections were performed June 9 through June 23, 2011. The master list of inspections was organized as a linked spreadsheet database so that each parcel was linked to the transcribed onsite inspection, photos taken, DTSC database entries, and Google Earth views of the property.

Based on information from the inspections, one property owner was notified by the City of Richmond that they are not allowed to discharge stormwater from the property into the MS4 system unless they provide detailed monitoring results for PCBs using appropriately low detection limit, and could demonstrate attainment of EPA benchmark values for other constituents. The property owner stored and re-used stormwater onsite during the 2011 – 2012 storm season.

Step 4: Soil/Sediment Testing

Applied Marine Sciences (AMS) and ADH Environmental were selected through a competitive process as the CW4CB monitoring contractor team for the Lauritzen Channel and Parr Channel watersheds. AMS/ADH conducted right-of-way surface soil/sediment sampling at the sites selected by the City of Richmond and CCCWP, according to the methods and procedures documented in the project QAPP and Task 3 SAP (BASMAA 2012 a, b). The locations to be monitored were based on lessons learned from 2001 – 2007, plus site reconnaissance conducted through this Task and Task 5 (stormwater treatment retrofits). Phase 1 samples in the Lauritzen Channel were collected on October 3, 2013. Phase 1 samples in the Parr Channel watershed were collected on October 4, 2013. A field methods report is provided in Appendix B.4.C.

The basis of the monitoring design was as follows (Figure B.4.10):

- Par- 01 and Parr-02: Railroad track crossings
- Parr-03: Follow up from earlier assessment
- Parr-04 and Parr-05: New assessment adjacent to an industrial facility where onsite inspection detected historic utility pad that may have had a transformer.
- Parr-06, Parr-07, Parr-08, and Lau-01: Metal recycler

- Lau-02: Railroad track crossing
- Lau-03 and Lau-04: Forklift repair
- Lau-05 and Lau-06: Transformer yard

The chemical analysis results for PCBs and mercury have undergone QA/QC review and are presented below. These data are considered preliminary, pending finalization of the QA/QC review for all Phase 1 data. A summary of the data quality review completed to date for Phase 1 field and chemistry data in all five project watersheds is provided in Appendix B.4.D.

A total of 14 soil/sediment samples were collected during Phase 1 at the locations identified in Figure B.4.10. Concentrations of total PCBs (sum of 40 congeners) ranged from 43 – 1,500 µg/kg (Figure B.4.10). Concentrations of mercury ranged from 20 – 1,900 µg/kg (Figure B.4.11).

Based on the results from Phase 1, CCCWP and the City of Richmond determined no additional soil/sediment monitoring was needed prior to making referrals to the Regional Water Board.

Step 5: Referrals

Based on a review of the inspections database and sediment sampling results in the Lauritzen and Parr Channel Watersheds, the following summaries informed the identification of properties for referral to the Regional Water Quality Control Board in compliance with MRP provision C.12.c:

1. The California Oils Corp at 1145 South Harbour Way had visible trackout and dirt that led up to drainage inlets. Onsite inspectors noted old concrete mounting pads that were stained and other signs of historic electrical transformers and substations. Sediment outside this property was targeted for follow-up collection and analysis. The PCB concentrations of sediment samples (71 – 119 µg/kg) were comparable to background concentrations for older urban industrial areas. No property referral to the Regional Water Board is recommended at the present time.
2. The PG&E Substation at 1st St. and Cutting Boulevard has a considerable number of live transformers known or suspected to contain PCBs. Sediment outside this property was targeted for follow-up collection and analysis. The PCB concentrations of sediment samples on the north and east sides of the property (47 – 106 µg/kg) were comparable to background concentrations for older urban industrial areas. No property referral to the Regional Water Board is recommended at the present time.
3. There are several areas throughout both pilot watersheds where railroad right of way, often abutted by empty dirt lots, shows visible trackout onto adjacent streets. Three of these railroad crossing areas were targeted for sediment sampling and analysis. The PCB concentrations of sediment samples from the locations sampled (47 – 119µg/kg) had PCB concentrations comparable to background concentrations for older urban industrial areas. No property referral to the Regional Water Board is recommended at the present time. The property is currently being redeveloped. Construction BMPs have reduced trackout

from the dirt lot. Post-construction BMPs are likely to reduce dirt generation onto city streets, although the configuration along the railroad line is unknown.

4. Rickert International, a forklift repair business, has old equipment stored onsite that inspectors noted was a risk for leaking hydraulic fluid. This location was targeted for sediment sampling from a storm drain inlet in front of the driveway entrance to the forklift repair yard. Sampling crews were able to collect soil directly adjacent to the property of the forklift storage yard, between the fence and the sidewalk in the public right of way. Sediment samples from the storm drain had PCB concentrations of 367 µg/kg; sediment samples collected adjacent to the fence had PCB concentrations of 326 µg/kg. These are consistent with prior PCB measurements in the area, and above what is considered urban background for the area. Although direct flow paths from the property to the storm system were not obvious to inspectors, the driveway entrance appears to be a visible trackout source onto city streets. This property is recommended for referral to the Regional Water Board.
5. SIMS Metal Management is located on the former United Heckathorn property, a Superfund site that is under remediation for DDT contamination. During the superfund investigation of the site, it was discovered that scrap metal previously recycled at this facility included used transformers. That practice is believed to have ceased, and the property owner has implemented Best Management Practices. Onsite inspectors noted activities on the large dirt lot of the facility had potential to generate trackout; there was also visible standing water as a result of dust control. The front entrance is a potential trackout source that is swept regularly as a BMP; however, sediment accumulates in crevices along the fence line on Fourth Street that appears to be beyond the reach of street sweepers. Sediment also accumulates in railroad track grooves adjacent to the rear entrance of the facility and on Hoffman Boulevard on the east side of the facility. Those sediments in adjacent streets have PCB concentrations ranging from 932 to 1,450 µg/kg, well above typical urban background. Those 2012 measurements are consistent with previous measurements in the area in 2006 and 2007. The property will be recommended for referral to the Regional Water Board. A pilot operations and maintenance enhancement will be evaluated along Hoffman Boulevard.

The information requirements and documentation that will be used to make referrals are currently being developed by the CW4CB PMT in cooperation with Regional Water Board staff. It is anticipated referrals will be made within six months.

Leo Avenue Watershed, San Jose, CA

Site History

Elevated PCB concentrations in sediments have been identified in the Leo Avenue area in past studies (KLI 2001 and 2002, City of San Jose and EOA Inc. 2002, City of San Jose and EOA Inc. 2003, and Yee et al. 2010). Previous case studies consisted of researching records of stormwater-related violations (e.g., washing sediment into storm drains) and Illegal Connection

and Illicit Discharge (ICID) reports, researching current and historical land uses, and sampling bedded sediment within the stormwater conveyance system in the Leo Avenue area. Sampling results indicated that the highest PCB concentrations were found in sediments collected from the Leo Avenue stormwater conveyance system and sediments associated with the unpaved Union Pacific railroad track right-of-way area located at Leo Avenue's cul-de-sac. These studies indicated vehicular traffic between Leo Avenue and the right-of-way area, as well as stormwater runoff, likely facilitated the transport of sediments from the right-of-way area to storm drain inlets located on Leo Avenue. Other potential source areas included other properties located on Leo Avenue.

In 2004, City of San Jose staff observed that sediment appeared to accumulate in the Leo Avenue stormwater conveyance system and may have been trapped there for many years. In response, the City hired Clean Harbors, an environmental services company, to clean out the Leo Avenue storm drain inlets, publicly-owned laterals, and Leo Avenue main line from the western cul-de-sac to S. 7th Street in 2005. The San Jose Department of Transportation (DOT) took video of the main line and discovered a section of the western end of the line was substantially blocked with accumulated sediment. Subsequent to the line cleaning, DOT performed follow-up video of the Leo Ave main storm sewer line and did not find a break in the line but did find a dip in the storm drain line where much sediment had accumulated. With the exception of accumulated sediment remaining in the line at the low point (dip in the line), the follow-up video of the line taken by DOT showed that it was clean. Follow-up sampling was not conducted after the line cleaning.

The source property identification and referral pilot study in the Leo Avenue watershed builds upon the 2002-2003 Leo Avenue Case Study, the City's subsequent work in 2004/2005, and the SFEI Proposition 13 study completed in 2010. The boundaries of the Leo Avenue watershed expanded from the Leo Avenue vicinity to the entire Leo Avenue watershed[9]. Previous measurements of mercury and PCB concentrations in sediments collected from piping beneath manholes, drop inlets/catch basins, streets/gutters, and private properties in the Leo Avenue watershed have ranged from 0.089 to 6.2 mg/kg for mercury and ND to 27 mg/kg for PCBs (KLI and EOA 2002; EOA 2002; City of San Jose and EOA 2003, Yee and McKee 2010).

Results of Source Property Identification and Referral Process

The source property identification and referral pilot study in the Leo Avenue watershed has been conducted by the Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP) and the City of San Jose.

Step 1: Records Review

The records review was initiated in December 2010. In total, 230 parcel numbers were obtained from the Santa Clara County Assessor's Office 'Assessment Roll Information Inquiry and Retrieval' website (http://www.scc-assessor.org/ari/home.do) for properties in the Leo Avenue watershed, most of which were matched with addresses using the virtual mapping website Google Maps and other online sources (e.g., 'yellow pages'). The list of properties was updated

[9] Spatial analysis results from the San Francisco Estuary Institute's 13 study (Yee and McKee. 2010) showed, that in 15 locations of the Bay Area, elevated concentrations of PCBs or Hg were clustered together within 3 kilometers of one another, which may be due to similarities in land use or transport of shared pollutant sources. The watershed was identified as one of the 15 locations in the Bay Area with several elevated concentrations in the same general vicinity.

from 230 to 233 properties using The City of San Jose's City Hall Records Imaging System (CHRIS) database which contains information from the Planning, Code Enforcement, Fire Prevention, Building and Public Works Departments.

The search of online databases identified a total of 62 of these properties with an enforcement history with a regulatory agency. Of the 62 properties, one business (with two properties next to each other), Lorentz Barrel and Drum Co., was found to be responsible for contaminating groundwater with PCBs in the past. Lorentz Barrel and Drum Co., formerly located at 1507 and 1515 S. 10th Street, is a Federal Superfund Site due to contaminated soil and groundwater from drum reconditioning. Pollutants identified include dioxin, metals, organochlorine pesticides, herbicides, PCBs, and volatile and semi-volatile organics. Through the subsequent reconnaissance survey, it was found this site is now paved and is being monitored by the appropriate agencies. It is unknown whether residue from this location may have been carried by wind to other properties in the watershed while it was operational.

A hard copy list of PG&E spills from the San Jose Division for 1997, 1998, and 1999 and the DeAnza Division for 1997 and 1999 did not reveal any PG&E spills in the watershed. Lists of spills since 2000 may be obtained in the future with the assistance of the Regional Water Board.

Using Google Earth, the list of 233 properties was reduced to 138 by removing land uses such as residential units and commercial buildings that are not considered to be a high priority.

Step 2: Driving/Walking Survey

The list of properties increased from a total of 138 to 159, due to additional identified properties during the driving/walking survey. The property data were filtered to remove properties that closed, relocated, or were paved or remediated. In addition, Google Earth was revisited to determine whether certain businesses should remain on the list as potential inspection sites. The results of the reconnaissance survey and these additional filtering steps led to reducing the list of 159 properties to 36. This list was then used to determine the locations and priority for the facility inspections.

Twenty-nine sites were categorized as high priority and seven as medium priority. In addition, four vacant facilities were identified as potential PCB sources due to insufficient information. It was determined that, although the facilities would not be inspected, they would be added to the list of potential right-of-way sampling sites.

Step 3: Facility Inspections

In September and October 2011, SCVURPPP and the City of San Jose staff conducted property inspections at the 36 sites. All properties were inspected within the planned budget and schedule. Of those 29 high priority sites, three sites could not be accessed. Despite repeated attempts to locate a person on the property, one of the three sites was removed from the list due to insufficient information. However, for the two remaining sites, observations were made from the street, while additional information was obtained about one site from a neighboring business owner, allowing for sufficient information to determine their sampling priority. Of the seven medium priority sites, one site was also observed from the street, which also allowed for enough information to determine its sampling priority.

Prior to the inspections, the City Stormwater Inspector provided an inspection history report, as available, for each facility. As a result of previously-established relationships with the property

owners or site contacts, the Inspector provided access to the properties and facilitated the information gathering at each site. At each visit, the Inspector introduced the SCVURPPP staff member(s), explained the general purpose of the project, and carried out a general stormwater inspection. Meanwhile, the SCVURPPP staff member(s) asked the property owner or site contact questions about the property and surrounding area and filled out the facility inspection form (Appendix B.4.2.). In addition, for each inspection, relevant notes, such as locations of existing on-site private storm drain inlets or potential areas of concern, were drawn on a site map created using Google Maps. A site map, facility inspection form and a copy of the City stormwater inspection report were collected and completed as appropriate for each property.

No obvious sources of PCBs (i.e., no transformers, old hydraulic fluid, etc.) were identified during inspections. Fourteen properties were ranked as high or medium priority for right-of-way sediment sampling based on the degree of evidence that PCBs may be on the property and mobilized via stormwater/sediment transport.

Step 4. Soil/Sediment Testing

Kinetic Laboratories, Inc. (KLI) was selected through a competitive process as the CW4CB monitoring contractor for the Leo Avenue watershed. KLI conducted the Phase 1 right-of-way surface soil/sediment sampling at the sites selected by SCVURPPP and the City of San Jose, according to the methods and procedures documented in the project QAPP and Task 3 SAP (BASMAA 2012 a, b). All Phase 1 samples in this watershed were collected on October 1 and October 2, 2013. A field methods report is provided in Appendix B.4.E.

The chemical analysis results for PCBs and mercury have undergone QA/QC review and are presented below. These data are considered preliminary, pending finalization of the QA/QC review for all Phase 1 data. A summary of the data quality review completed to date for Phase 1 field and chemistry data in all five project watersheds is provided in Appendix B.4.D.

A total of 19 soil/sediment samples were collected during Phase 1 at the locations identified in Figures B.4.12 and B.4.13. Concentrations of total PCBs (sum of 40 congeners) ranged from 0.012 mg/kg to 7.1 mg/kg (Figure B.4.12). Concentrations of mercury ranged from 0.012 mg/kg to 8.1 mg/kg (Figure B.4.13).

As of the writing of this report, the Phase 1 sediment sampling results are being used to select private property and/or additional public right-of-way sampling locations for Phase 2, which is anticipated to occur during May 2013. Chemical analysis results from the Phase 2 sampling effort are expected to be available within three months following completion of all field sample collection.

Step 5: Referrals

Based on private property sampling results, SCVURPPP and the City of San Jose will submit a list of facility referrals to the Regional Water Board for follow-up investigations at these facilities. The information requirements and documentation that will be used to make these referrals are currently being developed by the CW4CB PMT in cooperation with Regional Water

Board staff. It is anticipated referrals will be made within six months of completion of the second phase of soil/sediment testing.

Pulgas Creek Pump Station Watershed, San Carlos, CA

Site History

In 2000 and 2001, a collaboration of BASMAA member agencies, termed the Joint Stormwater Agency Project (JSAP), measured concentrations of PCBs, mercury and other POCs in embedded sediments within stormwater conveyance systems throughout the Bay Area and identified the Pulgas Creek Pump Station area in the City of San Carlos as a potential source of elevated PCB concentrations (KLI, 2002). In 2002 and 2003, the San Mateo Countywide Stormwater Pollution Prevention Program (SMCWPPP) performed PCB source identification studies (i.e., case studies) in the Pulgas Creek Pump Station watershed (EOA, 2003). The JSAP sampling locations were re-sampled, and new locations were also sampled. Sampling results and records research showed the presence of potential PCB sources in the watershed such as a PG&E substation and a remediation property. However, based on the spatial distribution of PCBs in storm drain sediments, other sources remained unidentified. More recently, results from a 2010 study by the San Francisco Estuary Institute identified the watershed as one of 15 locations in the Bay Area with several elevated concentrations in the same general vicinity (Yee and McKee, 2010).

The source property identification and referral pilot study in the Pulgas Creek Pump Station watershed builds upon these previous efforts. Previous measurements of mercury and PCB concentrations in sediments collected from the pump station, piping beneath manholes, channels, drop inlets/catch basins, streets/gutters, and private properties have ranged from 0.042 to 0.92 mg/kg (mercury) and ND to 12 mg/kg (PCBs).

Results of Property Identification and Referral Process

The source property identification and referral process in the Pulgas Creek Pump Station watershed has been conducted by SMCWPPP.

Step 1: Records Review

The records review process began in November 2010 by accessing the San Mateo County (County) assessor website (http://www.smcare.org/apps/ParcelMaps/default.aspx) to obtain addresses and parcel information of the 480 properties located within the watershed. This information was entered into a spreadsheet to which all new information has since been added. Next, the addresses and parcel numbers of these properties were used to search several online databases that contain data about PCB waste, toxic chemical releases, regulated facilities and other useful information. Online databases that were accessed during the records review include, but are not limited to: State Water Resources Control Board's Geotracker (http://geotracker.swrcb.ca.gov/); CA Department of Toxic Substances Control (http://www.envirostor.dtsc.ca.gov/public/); U.S. Environmental Protection Agency's (EPA) Envirofacts (http://www.epa.gov/enviro/); and U.S. EPA's PCBs database (http://www.epa.gov/epawaste/hazard/tsd/pcbs/pubs/data.htm).Fifty-two of properties were identified which had an enforcement history with a regulatory agency. Of the 52, three properties

were identified that had been responsible for contaminating groundwater with PCBs or storing drums containing PCBs. Google Earth™ satellite and aerial imagery software were used to preliminarily identify current land use of properties located within the watershed, including screening out low priority properties such as residential units and commercial buildings. Google Earth™ was also used to collect preliminary information about apparent housekeeping and current property condition, including the existence of unpaved areas and the condition of paved areas such as parking lots and driveways. In total, the records review process identified 140 properties as potential source properties.

Step 2: Driving/Walking Survey

Program staff then conducted a driving and walking reconnaissance survey during March 2012 in the watershed's public right-of-way areas to collect additional information about subject properties and verify information collected during the records review. A global positioning system camera was used to capture locations and photographs of suspect properties that may be PCB or mercury sources, including those with the potential for sediment mobilization to the public right-of-way. Following the survey, the list of potential source properties was reduced to 40.

Step 3: Facility Inspections

Facility inspections were coordinated with the City and the San Mateo County Department of Environmental Health (SMCDEH), the agency that routinely conducts stormwater inspections in the city. Prior to property inspections, SMCDEH sent out letters to each property owner informing them of SMCWPPP's upcoming visit to inspect their sites. Inspections were conducted by SMCWPPP and SMCDEH staff in April 2012. Thirty-four properties were inspected. During the inspections, SMCWPPP staff asked the property owner or site manager questions about the property and surrounding area and completed facility inspection forms. Notes were kept about each property and the surrounding area, including locations of existing on-site private storm drain inlets or potential areas of concerns, which were mapped using Google Maps™. There were six properties from the list of 40 that were not inspected due to lack of access (no known owner, closed business, unsuccessful repeated attempts to contact owner). Those properties were surveyed to the extent possible from outside the property boundaries.

The results of the records review, field survey, and inspections were used to rank each inspected property as high, medium or low priority for right-of-way sampling based on the degree of evidence that PCBs may be on the property and potential for sediment mobilization via stormwater off the site. The inspections identified 8 properties with medium or high potential PCB sources on the property. Of these, five also had medium or high potential for sediment erosion. Another 8 properties had low potential PCB sources on the property, but medium or high potential for sediment erosion. In total, 16 properties were ranked medium or high priority for adjacent right-of-way sampling.

In order to inform selection of potential sediment sampling locations, Program staff ground-truthed locations of storm drain inlets and other features adjacent to medium and high priority properties in May 2012, and identified areas where sediment had accumulated. Accumulation of between 1 and 12 inches of sediment was observed in a number of storm drain inlets in the watershed at the end of the 2011/12 wet season. The results of the inspections were used to identify locations for sediment sampling in the public right-of-way and on private properties.

Step 4: Soil/Sediment Testing

Kinetic Laboratories, Inc. (KLI) was selected as the CW4CB monitoring contractor for the Pulgas Creek Pump Station watershed. KLI conducted right-of-way surface soil/sediment sampling at the sites selected by SMCWPPP, according to the methods and procedures documented in the project QAPP and Task 3 SAP (BASMAA 2012 a, b). All Phase 1 samples in this watershed were collected on September 24 and September 25, 2012. A field methods report is provided in Appendix B.4.E.

The chemical analysis results for PCBs and mercury have undergone QA/QC review and are presented below. These data are considered preliminary, pending finalization of the QA/QC review for all Phase 1 data. A summary of the data quality review completed to date for Phase 1 field and chemistry data in all five project watersheds is provided in Appendix B.4.D.

A total of 12 soil/sediment samples were collected during Phase 1 at the locations identified in Figures B.4.14 and B.4.15. Concentrations of total PCBs (sum of 40 congeners) ranged from 0.017 mg/kg to 2.5 mg/kg (Figure B.4.14). Concentrations of mercury ranged from 0.035 mg/kg to 1.1 mg/kg (Figure B.4.15).

As of the writing of this report, the Phase 1 monitoring results are being used to select private property and/or additional public right-of-way sampling locations for Phase 2, which is anticipated to occur between May and July 2013. Chemical analysis results from the Phase 2 sampling effort are expected to be available within three months following completion of all field sample collection.

Step 5: Referrals

Based on private property sampling results, SMCWPPP will submit a list of facility referrals to the Regional Water Board for follow-up investigations at these facilities. The information requirements and documentation that will be used to make these referrals are currently being developed by the CW4CB PMT in cooperation with Regional Water Board staff. It is anticipated referrals will be made within six months of completion of the second phase of soil/sediment testing.

B.4.3 Status of Control Measure Implementation

This section summarizes the baseline and enhanced level of implementation of the source property identification and referral pilot studies for each of the five CW4CB project watersheds.

B.4.3.1 Baseline

Prior to the TMDL (July 1, 2002) no source property identification and referral control measures for mercury and/or PCBs were implemented in any of the pilot watersheds. Thus the baseline level of implementation is no implementation for this control measure type.

B.4.3.2 Current

Ettie Street Pump Station Watershed, Oakland CA

Summary of Pre-CW4CB Level: 2002-2010

In 2000 and 2001, ACCWP investigations suggested there were multiple sites in the Ettie Street Pump Station watershed that continued to discharge legacy PCBs to the storm drain system, but no specific current sources were identified. In 2004, the City of Oakland was awarded funding from a State Water Resource Control Board Proposition 13 Grant to further investigate, identify, and remediate sources of PCBs in the watershed and evaluate control measures for addressing these sources of PCBs. Starting in 2004, the City surveyed potential source areas for PCBs in the watershed, conducted inspections of private properties, sampled and performed chemical analysis of soil/sediment samples from locations in the public right-of-way and on private properties, prepared sampling reports, coordinated with regulatory agencies for enforcement of PCB cleanup on private properties, and prepared and distributed of education and outreach materials. In 2006, these efforts led to abatement of two sites in the public right-of-way and remediation of one site on private property. In 2007, subsequent sampling was performed to evaluate the effectiveness of the abatement and remediation efforts.

Current Status of Implementation of the CW4CB Process: 2010 – Present

In 2011, as part of the CW4CB project, the Ettie Street Pump Station watershed was identified as one of five pilot study watersheds for pilot source property identification and referral investigations. In May and June 2012, the City of Oakland and Geosyntec staff inspected or re-inspected these 15 industrial sites to evaluate whether the properties were potential sources of PCBs. In September and October 2012, a total of 27 Phase 1 right-of-way surface soil/sediment sampling were collected by AMS/ADH. As of spring of 2013, the Phase 1 sediment sampling results are being used to select private property and/or additional public right-of-way sampling locations for Phase 2, which is anticipated to occur in the summer of 2013. Based on the results of the Phase 2 sampling, ACCWP and the City of Oakland will submit a list of facility referrals to the Regional Water Board for follow-up investigations at these facilities.

Lauritzen Channel and Parr Channel Watersheds, Richmond CA

Monitoring information collected by Contra Costa Clean Water Program (CCCWP) and Richmond in response to regulatory direction by the Regional Water Board from 2000 to the present helped prioritize property referrals to the Regional Water Board that are required under the MRP. For prioritization, this analysis divides PCB concentrations into three categories:

- Urban Background (< 200 µg/kg)
- Potentially high, to be further investigated (200 to 700 µg/kg)
- Actionable (>700 µg/kg)

Those three categories are simply tools of convenience to establish priorities for property referrals. Concentrations in sediments below 200 µg/kg will also need to be addressed; however,

to the extent that such concentrations persist in the public right of way after source control actions have been completed, the appropriate abatement tools may be more along the lines of enhanced municipal operations and treatment retrofits. Sediments with PCB concentrations in the range of 50 – 200 µg/kg may be too widespread and diffuse to be abated via source control alone.

Summary of Pre CW4CB Level: 2002-2010

In 2000 and 2001, CCCWP and the City of Richmond investigations suggested there were multiple sites in the Santa Fe Drainage (which includes the Lauritzen and Parr Channels) that continued to discharge legacy PCBs to the storm drain system, but no specific current sources were identified. Follow up studies during 2005 – 2007 presented a more comprehensive picture and helped pinpoint potential source areas, including surface street samples collected from locations bracketing a metal recycler. Other potential source properties contributing to elevated PCB concentrations in storm drain catch basins in the drainage included a fork lift repair shop and PG&E transformer yard, although the evidence at that time remained inconclusive; other potential explanations were tidal intrusion of sediments from the Richmond Harbor (the conveyance system in that area is partly tidal) and vehicle trackout from the metal recycler or some other as yet unidentified source.

The TMDL for PCBs in San Francisco Bay was adopted in 2008. The MRP required control measures for PCBs, including the source identification and reporting project that is within the scope of this section. Concurrently, Richmond worked with the metal recycler to get them to initiate enhanced BMPs, including near continuous street sweeping on adjacent streets. While that enhanced BMP likely helps reduce trackout of potentially contaminated sediments, street sweepers cannot get complete removal because of the soft shoulder and lack of curb and gutter in the area. In addition, airborne transport of dust and shredder fluff (the fine, particulate grindings associated with metal shredding) may transport solids offsite beyond the activity area of high frequency street sweepers. Anecdotal evidence suggests that dust accumulation on cars is a nuisance for nearby residents.

Current Status of Implementation of the CW4CB Process: 2010 – Present

In 2011, as part of the CW4CB project, the Lauritzen Channel and Parr Channel watersheds were identified as two of five pilot study watersheds for pilot source property identification and referral investigations. In May and June 2011, the City of Richmond and CCCWP inspected industrial sites to evaluate whether the properties were potential sources of PCBs. CCCWP coordinated with other BASMAA member agencies through the CW4CB work groups to share lessons learned by CCCWP about the onsite property inspections.

Based on information from the inspections, Richmond directed the metal recycler to cease discharging stormwater into the MS4 system unless they provide detailed monitoring results for PCBs using appropriately low detection limit, and could demonstrate attainment of EPA benchmark values for industrial stormwater for other constituents. Since that direction in 2011, the metal recycler has stored stormwater onsite, and re-used onsite process water for dust control. Stored stormwater is currently discharged by the recycler into the sanitary sewer. Rainy weather

has been anomalously light for the past few years, so the ability of the recycler to store water during larger events is as yet unproven.

In 2011 CCCWP also collected a sediment sample from a storm drain near a potential source area in the Lauritzen Channel watershed where a storm drain inlet plugged with sediment had been discovered. The sediment sampled from the storm drain was analyzed for PCBs using EPA Method 8020. PCB results were non-detect (<250 µg/kg total PCBs), indicating that the sediment did not have PCB concentrations greater than would be expected from an industrial urban setting.

In September and October 2012, a total of 14 Phase 1 right-of-way surface soil/sediment samples were collected by AMS/ADH. Monitoring through CW4CB Task 3 has brought into focus next steps based on confirmation of previous monitoring conducted 2000 – 2006. Referral of the Metal recycling property to the Regional Board is a logical next step pursuant to MRP Provision C.12.c. The desired information would be an assessment of PCB concentrations in soils and solids onsite, an assessment of pathways (trackout and aerial transport) that convey PCB-contaminated sediments onto Richmond Streets, and a proposed plan to prevent sediments with substantially elevated PCB concentrations from accumulating in the curb and gutter of adjacent streets. A similar referral is appropriate for the fork lift repair shop: trackout is visible from the driveway. A sediment sample collected just outside the fence line, in the public right of way, but obviously influenced by the shop yard, had 326 µg/kg PCBs, consistent with previous observations. It should be kept in mind that the concentrations observed near the Forklift shop may be the result of trackout from other potential source areas nearby; however, the elevated concentrations have been consistent at this location, over time, making it worthwhile to conduct sediment sampling onsite at the forklift repair shop.

CCCWP and the City of Richmond will submit these referrals to the Regional Water Board for follow-up investigations at these facilities. No other property referrals are immediately obvious at this time.

Approaches to abate sediments with PCB concentrations below 200 µg/kg identified in this study will be evaluated, including opportunities for enhanced municipal operations (MRP Provision C.12.d) in the pilot watersheds, working with property owners to reduce offsite sediment transport, improving curbs and gutters in the public right of way to enhance street sweeping efficiency, and design and construction of stormwater treatment retrofits. Although those activities are outside the scope of this source investigation and property referral task, they are mentioned briefly here because the source investigations informed those other activities, to help show how various required PCB control measures fit together. Those activities are described elsewhere in this report.

Leo Avenue Watershed, San Jose, CA

Summary of Pre CW4CB Level: 2002-2010

Elevated PCB concentrations in sediments have been identified in the Leo Avenue area in studies from 2001 through 2010 (KLI 2001 and 2002, City of San Jose and EOA Inc. 2002, City of San Jose and EOA Inc. 2003, and Yee et al. 2010). Case studies conducted in the watershed in 2002-

2003 consisted of records reviews, researching current and historical land uses, and sampling bedded sediment within the stormwater conveyance system in the Leo Avenue area. The highest PCB concentrations were found in sediments collected from the Leo Avenue stormwater conveyance system and sediments associated with the unpaved Union Pacific railroad track right-of-way area located at Leo Avenue's cul-de-sac. Additional potential source areas included other properties located on Leo Avenue but no conclusive evidence implicated any specific properties in the area. In 2005, the City of San Jose hired contractors to clean out accumulated sediment from the main storm drain line on Leo Avenue. Approximately four cubic yards of sediment containing of PCBs was removed from the line. However, the source(s) of PCBs and sediment in the line were not identified.

Current Status of Implementation of the CW4CB process: 2010 – present

In 2011, as part of the CW4CB project, the Leo Avenue watershed was identified as one of five pilot study watersheds for source property identification and referral investigations. In May and June 2012, SCVURPPP performed records reviews and watershed surveys and identified 36 potential source properties in the watershed for follow-up inspections. Inspections were conducted at those properties in September and October 2011 by SCVURPPP and the City of San Jose staff to evaluate whether the properties were potential sources of PCBs. Fourteen inspected properties were ranked as high priority for right-of-way sediment sampling based on the degree of evidence that PCBs may be on the property and mobilized via stormwater/sediment transport. In October 2012, a total of 19 Phase 1 right-of-way surface soil/sediment samples were collected by KLI Inc. The sampling results confirmed previously elevated sediment PCB concentrations in the Leo Avenue main storm drain line. As of spring of 2013, the Phase 1 sediment sampling results are being used to select private property and/or additional public right-of-way sampling locations for Phase 2, which is anticipated to occur in the late spring of 2013. Based on the results of the Phase 2 sampling, SCVURPPP and the City of San Jose will submit a list of facility referrals to the Regional Water Board for follow-up investigations at these facilities.

Pulgas Creek Pump Station Watershed, San Carlos, CA

Summary of Pre CW4CB Level: 2002-2010.

In 2000 and 2001 the JSAP investigations identified the Pulgas Creek Pump Station area in the City of San Carlos as a potential source of elevated PCB concentrations in embedded sediments within the stormwater conveyance system (KLI, 2002). In 2002 and 2003, follow-up PCB source identification studies were conducted in the watershed by SMCWPPP which involved both new sampling and re-sampling of previous JSAP locations. These case studies identified the presence of potential PCB sources in the watershed such as a PG&E substation and a remediation property. However, based on the spatial distribution of PCBs in storm drain sediments other sources remained unidentified. More recently, results from a 2010 study by the San Francisco Estuary Institute identified the watershed as one of 15 locations in the Bay Area with several elevated concentrations in the same general vicinity (Yee and McKee, 2010).

Current Status of Implementation of the CW4CB Process: 2010 – Present.

In 2011, as part of the CW4CB project, the Pulgas Creek Pump Station watershed was identified as one of five pilot study watersheds for source property identification and referral investigations. In 2011 and early 2012, SMCWPPP performed records reviews and watershed surveys and identified 40 potential source properties in the watershed for follow-up inspections. Inspections were conducted at those properties in April 2012 by SMCWPP staff to evaluate whether the properties were potential sources of PCBs. Sixteen inspected properties were ranked as high or medium priority for right-of-way sediment sampling based on the degree of evidence that PCBs may be on the property and mobilized via stormwater/sediment transport. In September 2012, a total of 12 Phase 1 right-of-way surface soil/sediment samples were collected by KLI Inc. The sampling results confirmed previously elevated sediment PCB concentrations in the watershed. As of spring of 2013, the Phase 1 sediment sampling results are being used to select private property and/or additional public right-of-way sampling locations for Phase 2, which is anticipated to occur in the late spring of 2013. Based on the results of the Phase 2 sampling, SMCWPPP will submit a list of facility referrals to the Regional Water Board for follow-up investigations at these facilities.

B.4.4 Estimates of Loads Avoided/Reduced

B.4.4.1 Loads Avoided/Reduced Methodology

This section presents the conceptual approach that will be used to estimate mercury and PCB stormwater loads avoided/reduced due to source property investigation and abatement efforts. The key assumptions and data requirements will also be discussed. The proposed methods are based on previous studies, and will be refined and updated as additional information becomes available. The loads avoided/reduced methodology involves the following three steps:

1. Estimate the baseline annual stormwater load from a given source property prior to abatement.
2. Apply abatement effectiveness scenario(s) to the baseline source property load to estimate the loads avoided/reduced due to abatement.
3. Refine above estimates as more data become available.

In order to estimate the loads avoided/reduced due to abatement efforts, the annual stormwater load of mercury and PCBs for a given source property prior to abatement will be estimated, and a range of assumed load reduction effectiveness for all abatement measures implemented on that property will be applied to the baseline load. The loads avoided/reduced estimates will be refined as additional data on stormwater concentrations and watershed loads, and load reduction effectiveness for specific abatement measures become available. Additional details on each of these steps are provided below.

Step 1: Estimate the baseline annual stormwater load from a given source property prior to abatement.

There are a number of potential methods that may be used to estimate the baseline stormwater load from a given source property. Existing models (e.g., the SFEI spreadsheet model) can be used to estimate stormwater loads at the watershed level; however, developing accurate estimates at the property scale is incredibly difficult given the need for site specific data and understandings of sediment movement at that spatial scale. Based on the limited data likely available at the property scale, a simpler method using an average annual sediment yield (sediment mass/acre) for industrial properties and average concentrations of PCBs or mercury on sediment collected on the property, or on sediment that likely originated from the property, is recommended. This method would provide first-order PCB or mercury baseline load estimates for abated properties.

Alternatively, the baseline annual load of mercury and PCBs coming off an individual property can be calculated directly using the simple method. Required property-specific inputs include stormwater concentrations, annual precipitation, runoff coefficient(s) and the area of the property. Stormwater concentration measurements are typically unavailable at the property-scale. However, a range of locally measured or modeled stormwater concentrations are available that could be applied to a given property. The following assumptions may be helpful in assigning stormwater concentrations to a given property: properties with higher POC sediment concentrations and higher potential for sediment release to stormwater have higher stormwater concentrations compared with properties that have lower sediment POC concentrations and lower potential for sediment release to stormwater.

Another possibility to estimate property-level stormwater concentrations is to apply the method used by Mangarella et al. (2010) in which stormwater concentrations were estimated from measured sediment data. In this method, the concentrations of mercury and PCBs on TSS in stormwater was assumed to be equivalent to the concentration of mercury and PCBs measured in depositional sediments in the area. Data on TSS concentrations by land use in the Bay Area are available, and the concentrations of mercury and PCBs in surface soil/sediment on a given property or in public right-of-ways adjacent to a given property were quantified in the pilot studies.

Step 2: Apply abatement effectiveness scenarios to the baseline source property load to estimate the load avoided/removed due to abatement

Once the baseline annual load for a given property has been established, a range of abatement effectiveness scenarios could be applied to estimate the loads avoided/reduced of the abatement measures for a given property. The assumed abatement effectiveness scenarios may include one or more of the following: (1) 100% effective (e.g., annual load equals zero following abatement); (2) sediment concentrations remaining on the property following abatement are reduced to urban background concentrations; (3) assumed effectiveness derived from the International BMP Database for any specific BMP measures applied as part of the property abatement(s); (4) measured sediment (or stormwater) concentrations from follow-up monitoring on an abated property. For each abatement effectiveness scenario, the annual load avoided/reduced would be calculated by subtracting the post-abatement property load from the baseline load. The same

methods used to calculate the baseline load would be used to calculate the post-abatement property load, but with different inputs appropriate for the post-abatement conditions (e.g., reduced sediment concentrations/stormwater concentrations).

The total mass of mercury and PCBs removed from a property during abatement could also be calculated and compared with the annual baseline load to understand the implications of abatement efforts over time. For example, a given mass removed divided by the baseline annual load would yield the total number of years of loads avoided due to the abatement, assuming all of the mass would otherwise be released to stormwater at a steady rate over time. Furthermore, scenarios could be applied in which the sediment concentrations are reduced each year to estimate the annual stormwater loads over time as sediment concentrations gradually decrease down to an urban background concentration.

Step 3: Refine above estimates as more data become available

All of the above can be refined as additional/better data become available. For example, follow-up sediment sampling on the properties could help determine how effective the abatement was in reducing sediment concentrations (and thus subsequent stormwater loads from the property). Additional data on the distribution of pollutant concentrations on different particle size fractions could be used to refine the stormwater concentration estimates derived from sediment concentrations. Finer particles typically have a greater surface area for constituents to adsorb to, and therefore concentrations tend to be higher on these particles. Smaller particles are mobilized more readily than larger particles at low flows, and therefore constitute the majority of the sediment mass being transported. However, under high flows, larger particles can have a far greater mass of the total sediment load than the smaller particles. Information on the concentrations of mercury and PCBs on different particle size fractions in sediment would allow for better understanding of the fraction of the sediment mass that is likely to be mobilized during storm events, and thus how well the pollutant sediment concentrations represent the pollutant suspended sediment concentration in stormwater.

B.4.4.2 Summary of Key Uncertainties

There are a number of sources of uncertainty in accurately estimating PCB and mercury loads reduced to San Francisco Bay associated with baseline and current source property identification and abatement:

- Due to the limited stormwater loading data for the Pilot watersheds, baseline (pre-abatement) loading estimates could vary by an order-of-magnitude, depending on the method used to estimate loadings.
- Limited information is currently available on the ability of property-based control measures to effectively reduce PCBs in stormwater runoff. Additionally, abatement effectiveness scenarios are likely to be site-specific and may not be transferable between properties.

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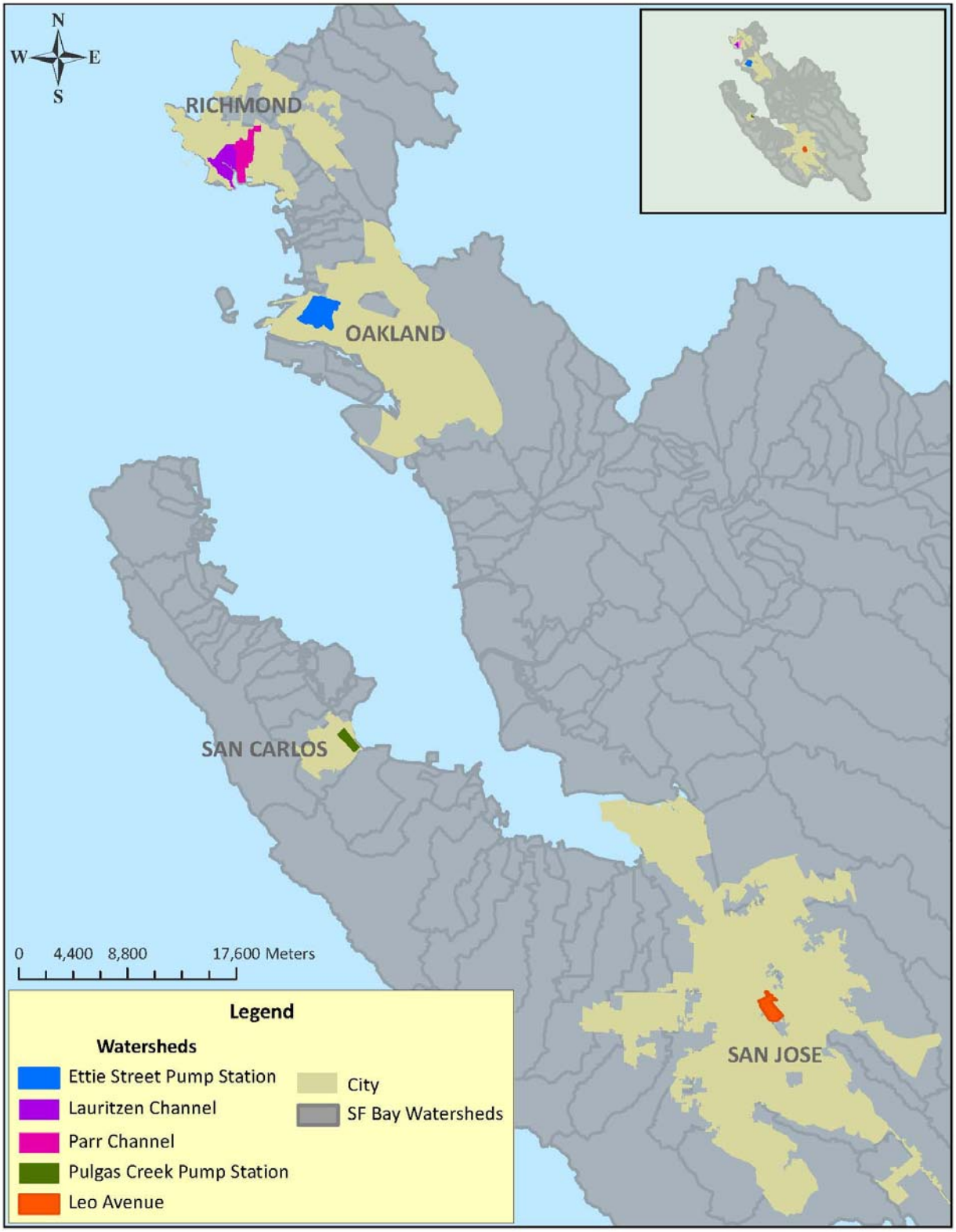
FIGURES B.4



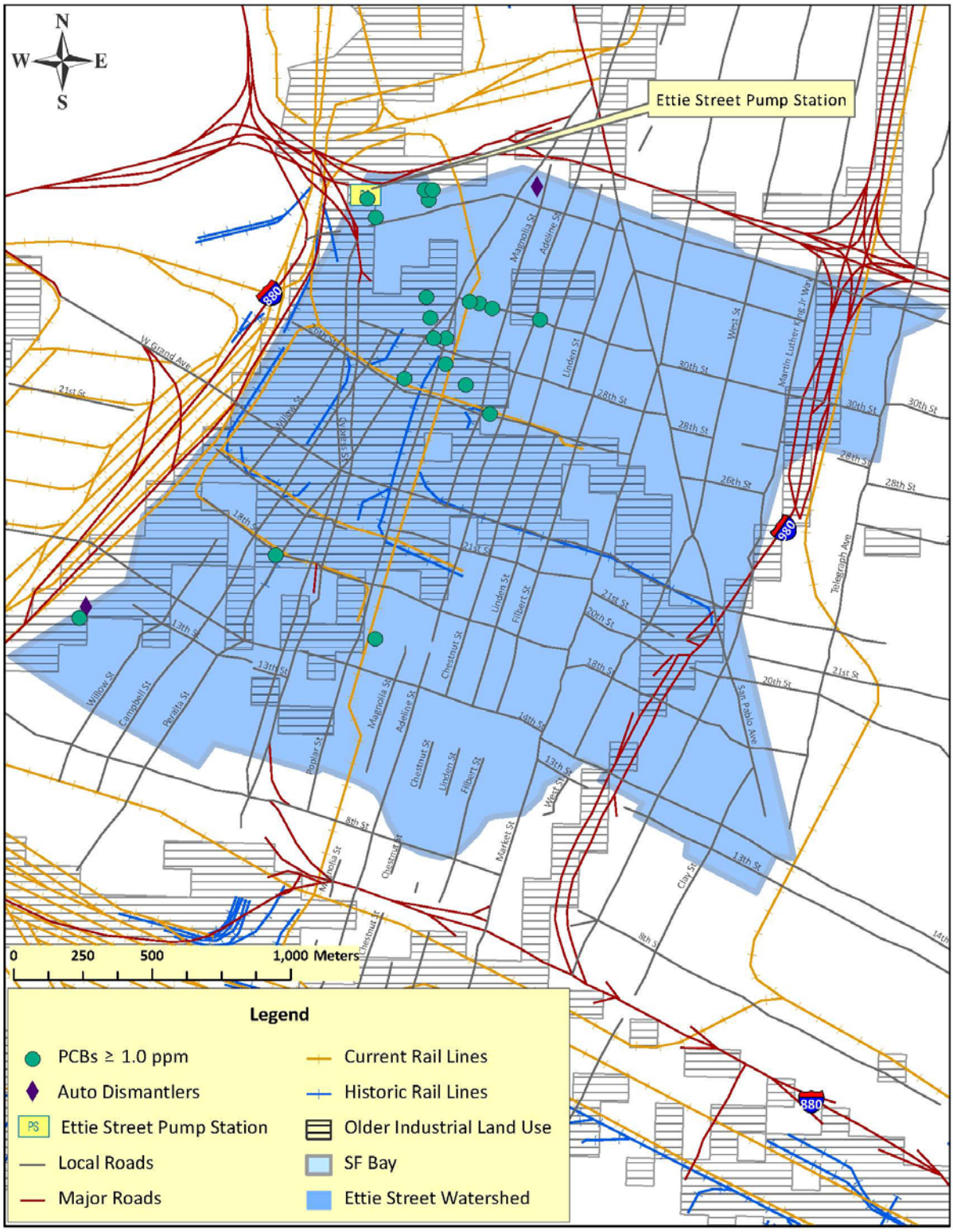
CW4CB Pilot Investigation Watersheds

Source:

EOA, Inc. (2011)

Entity	Date	
Bay Area Stormwater Management Agencies Association	May 2, 2011	Figure B.4.1

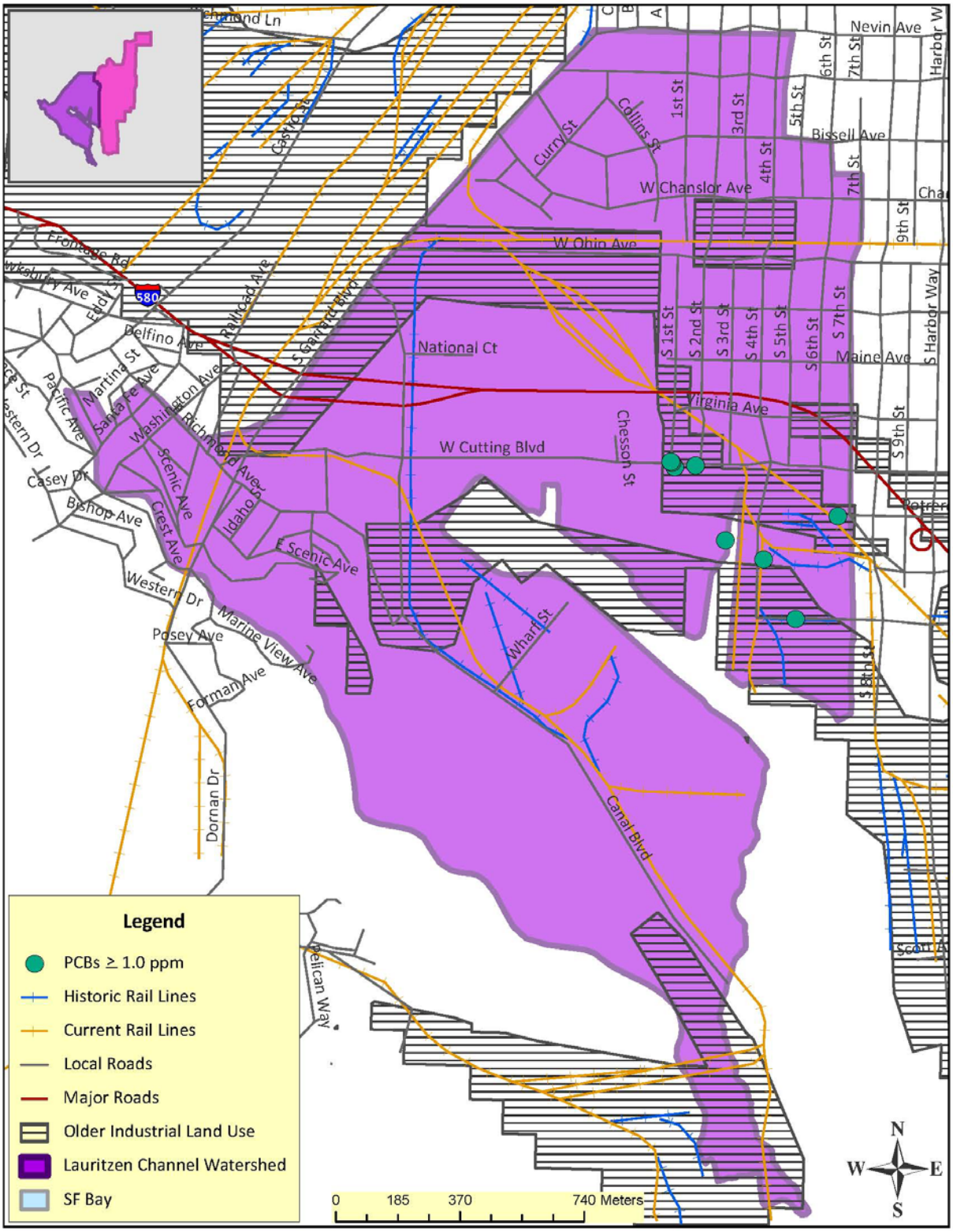
internal info: path, date revised, author



Ettie Street Pump Station Watershed in the City of Oakland, Alameda County

Source:	Bay Area Stormwater Management Agencies Association	May 2, 2011	Figure B.4.2
EOA, Inc. (2011)	Entity	Date	

internal info: path, date revised, author



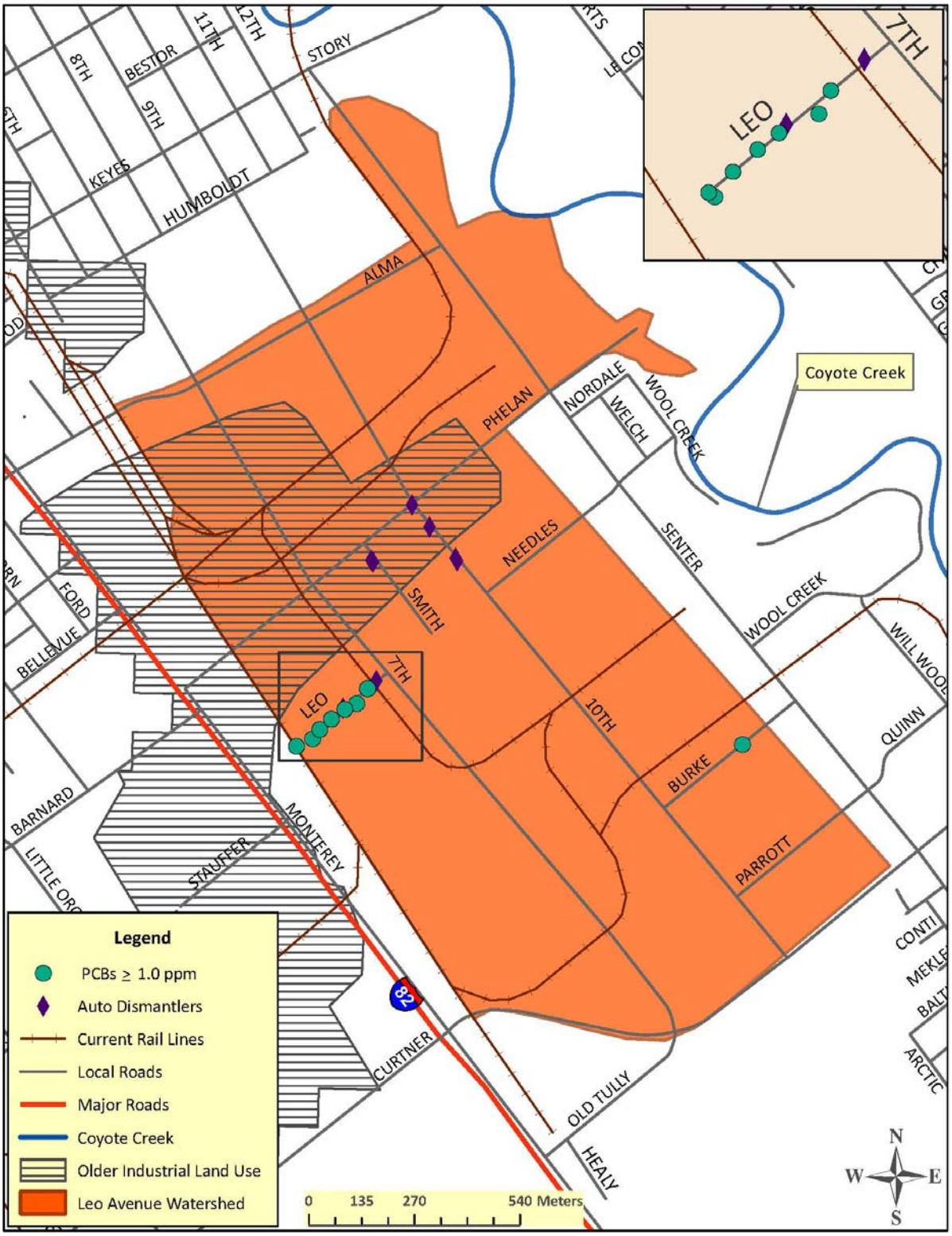
Lauritzen Channel Watershed in the City of Richmond, Contra Costa County

Source:

EOA, Inc. (2011)

Entity	Date	
Bay Area Stormwater Management Agencies Association	May 2, 2011	Figure B.4.3

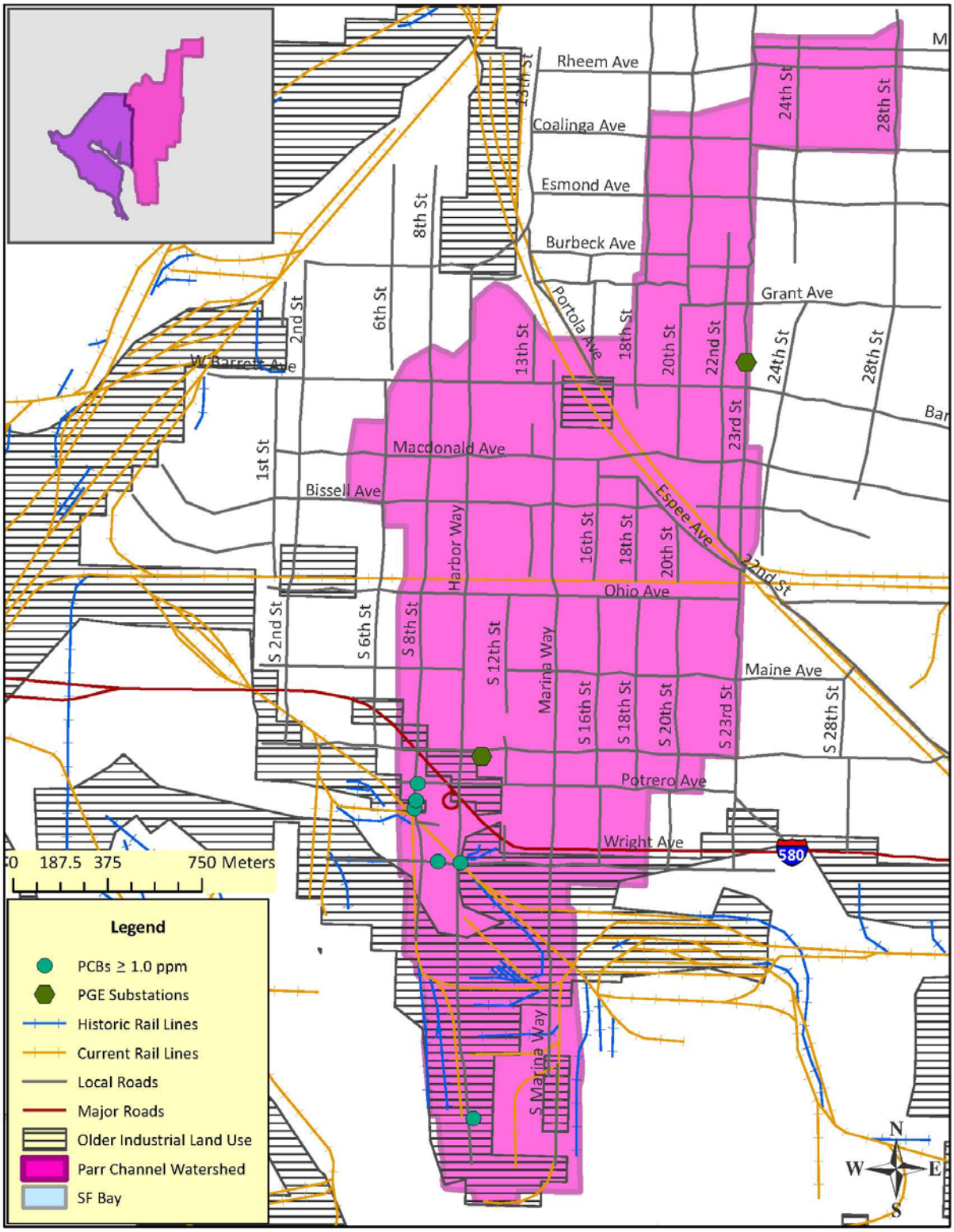
internal info: path, date revised, author



Leo Avenue Watershed in the City of San Jose, Santa Clara County

Source:	Bay Area Stormwater Management Agencies Association	May 2, 2011	Figure B.4.4
EOA, Inc. (2011)	Entity	Date	

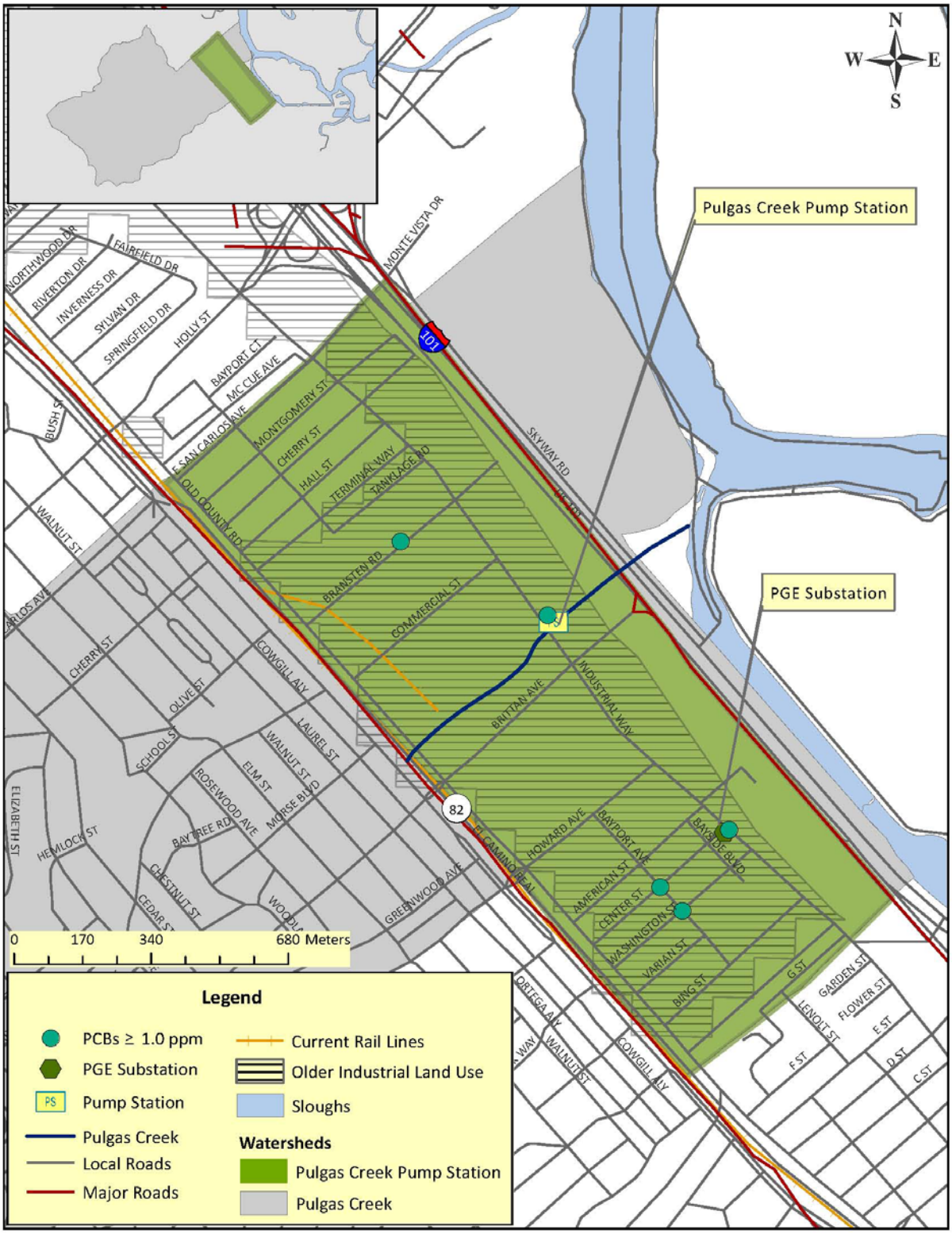
internal info: path, date revised, author



Parr Channel Watershed in the City of Richmond, Contra Costa County

Source:	Entity	Date	Figure
EOA, Inc. (2011)	Bay Area Stormwater Management Agencies Association	May 2, 2011	B.4.5

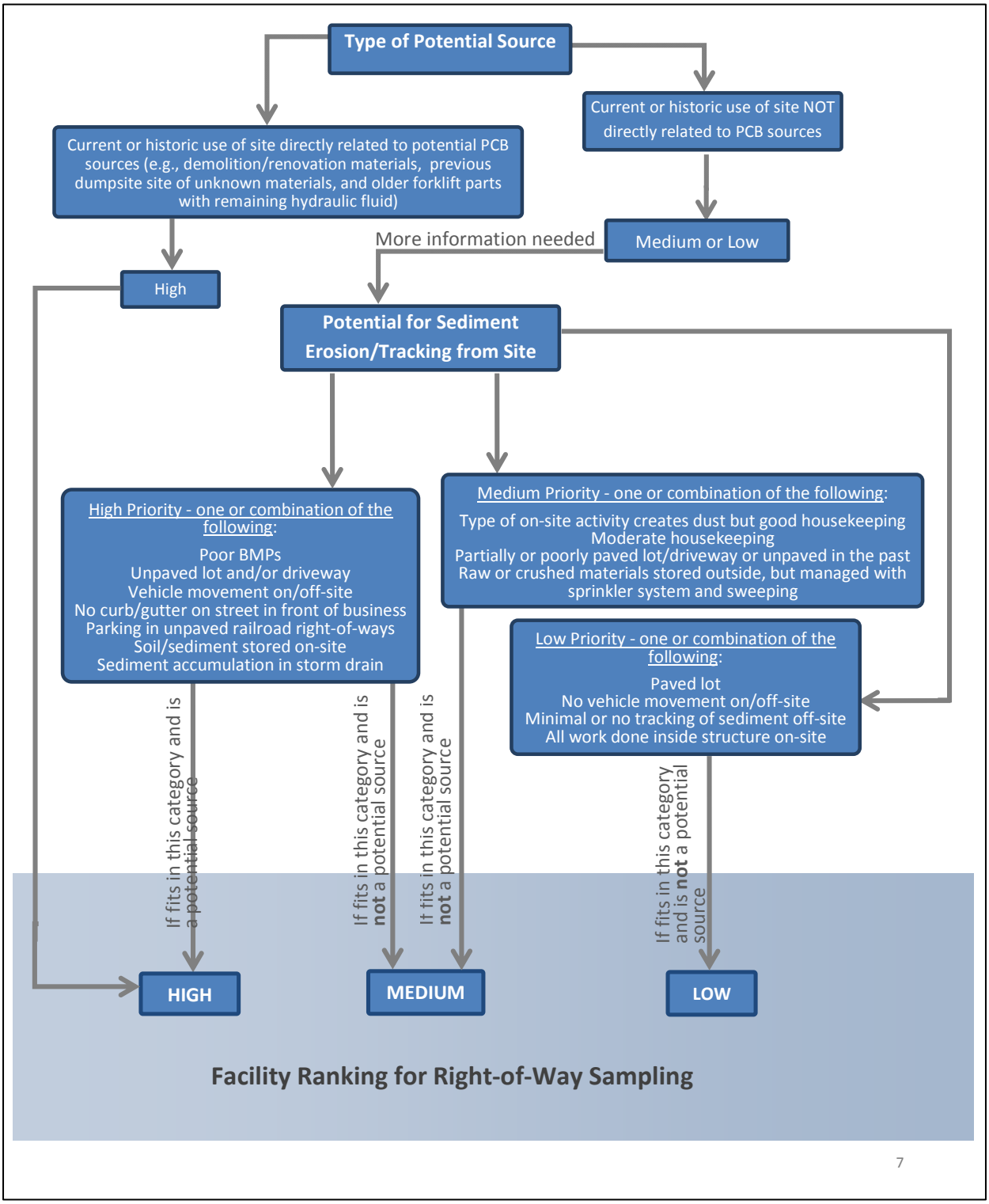
internal info: path, date revised, author



Pulgas Creek Pump Station Watershed in the City of San Carlos, San Mateo County

Source: EOA, Inc. (2011)	Bay Area Stormwater Management Agencies Association	May 2, 2011	Figure B.4.6
	Entity	Date	

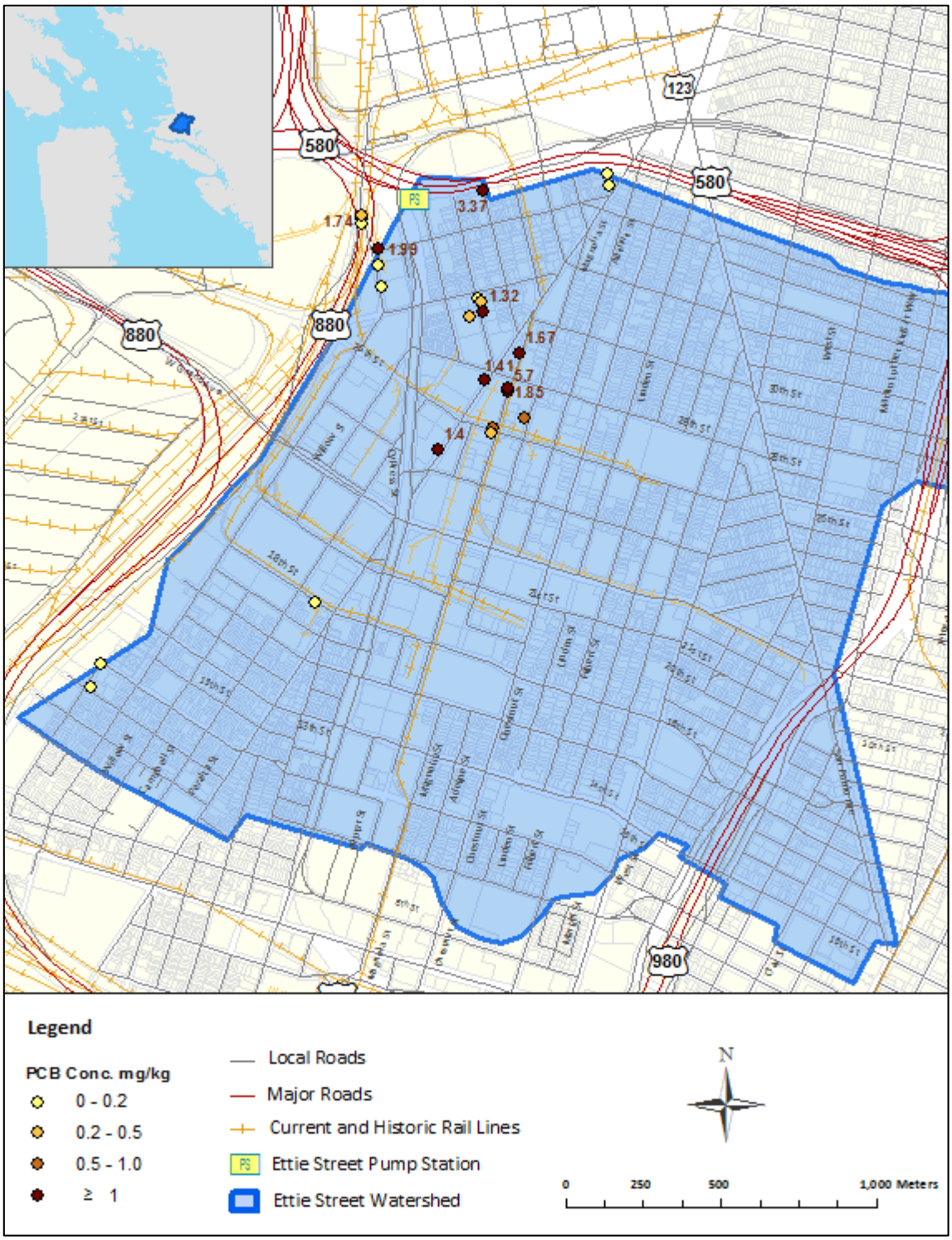
internal info: path, date revised, author



Decision Tree for Determining Facility Sampling Priority

Source:	Bay Area Stormwater Management Agencies Association	October 2013	Figure B.4.7
	Entity	Date	

internal info: path, date revised, author



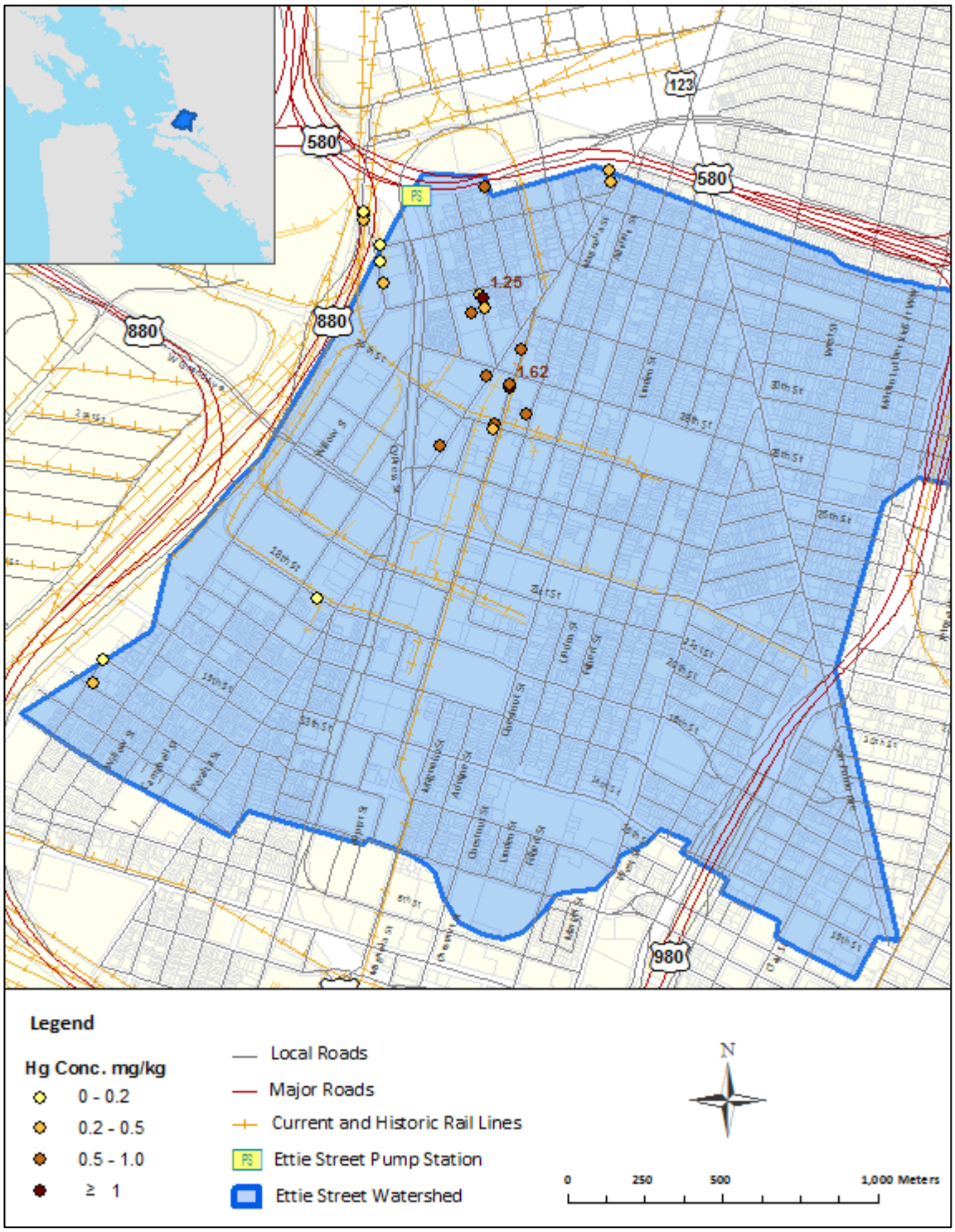
PCB Concentrations in Sediment Collected in the Public Right-of-Way in the Ettie Street Pump Station Watershed, Oakland, CA, September – October 2012

Source:

EOA, Inc. (2013)

Entity	Date	
Bay Area Stormwater Management Agencies Association	October 1, 2012	Figure B.4.8

internal info: path, date revised, author



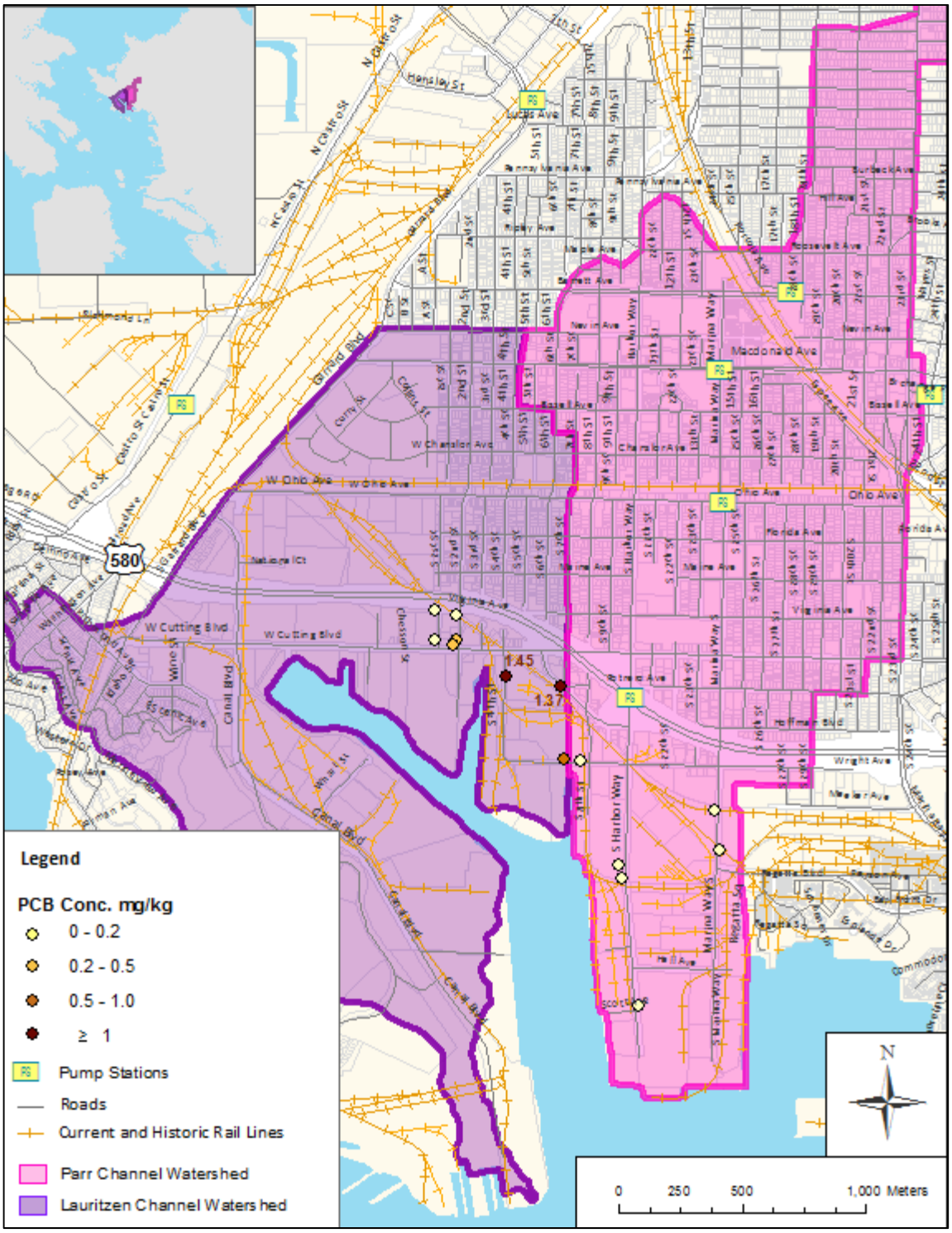
Mercury Concentrations in Sediment Collected in the Public Right-of-Way in the Ettie Street Pump Station Watershed, Oakland, CA, September – October 2012

Source:

EOA, Inc. (2013)

Entity	Date	
Bay Area Stormwater Management Agencies Association	October 1, 2012	Figure B.4.9

internal info: path, date revised, author



Sampling Locations and PCB Concentrations for CW4CB Monitoring in the Lauritzen Channel and Parr Channel Watersheds

Source: EOA, Inc. (2013)	Bay Area Stormwater Management Agencies Association	October 1, 2012	Figure B.4.10
	Entity	Date	

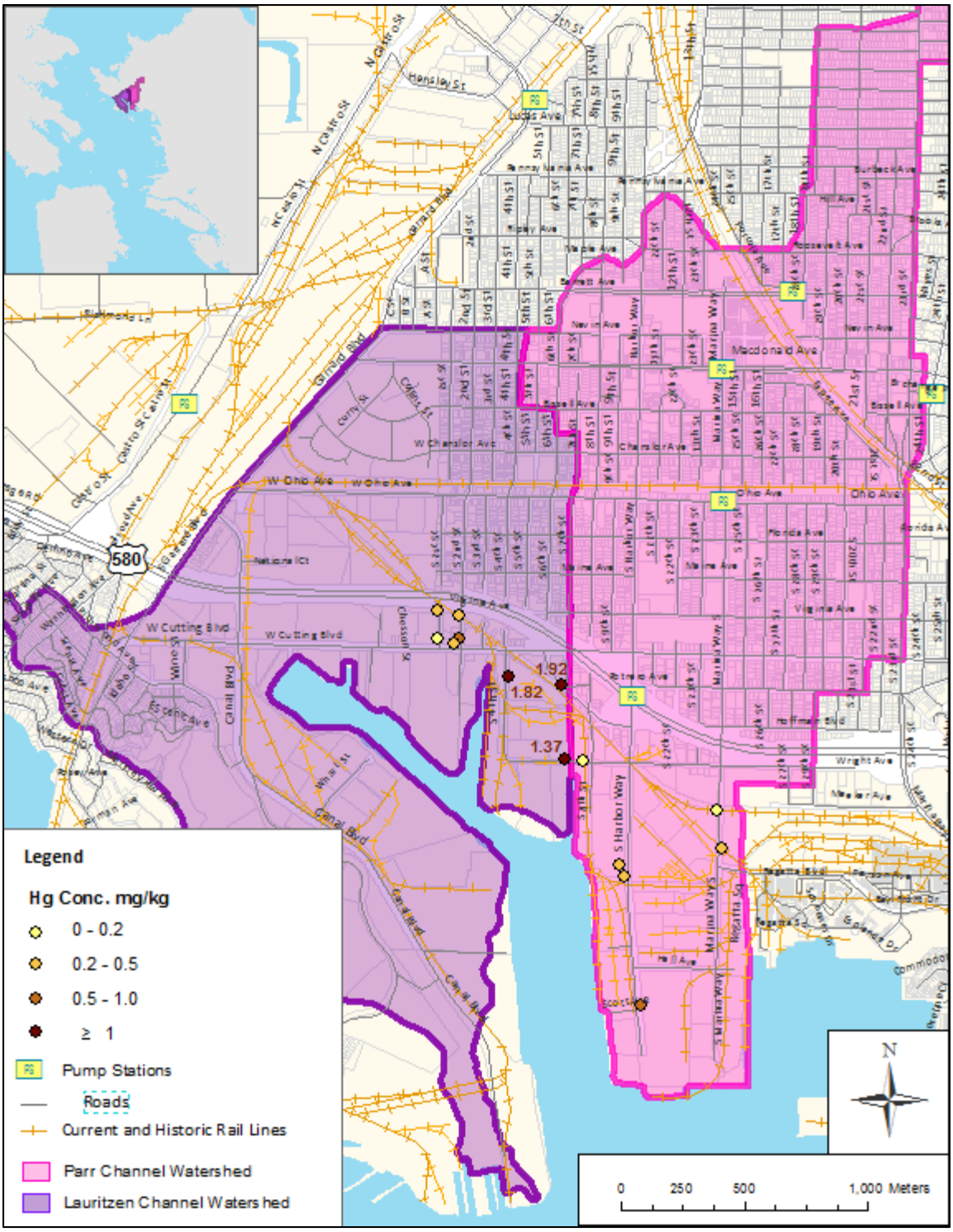
internal info: path, date revised, author

Sampling Locations and PCB Concentrations for CW4CB Monitoring in the Lauritzen Channel and Parr Channel Watersheds

Bay Area Stormwater Management Agencies Association	October 1, 2012	Figure B.4.11
Entity	Date	

Source:	**Notes:** *Values in parentheses indicate PCB concentrations (µg/kg) measured in samples collected in October 2012 through CW4CB Task 3.*

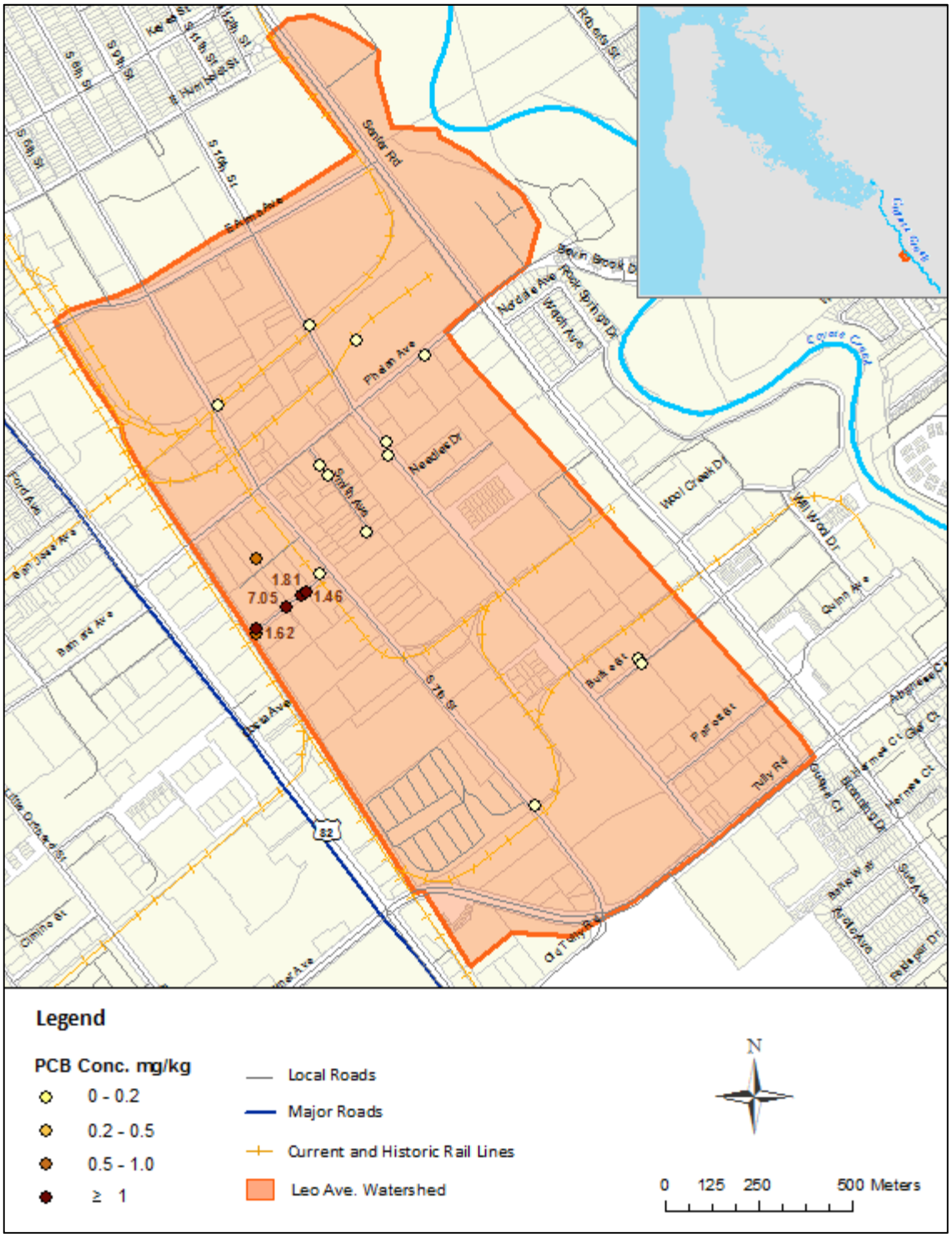
internal info: path, date revised, author



Sampling Locations and Mercury Concentrations for CW4CB Monitoring in the Lauritzen Channel and Parr Channel Watersheds

Source:	Bay Area Stormwater Management Agencies Association	October 1, 2012	Figure B.4.12
EOA, Inc. (2013)	Entity	Date	

internal info: path, date revised, author



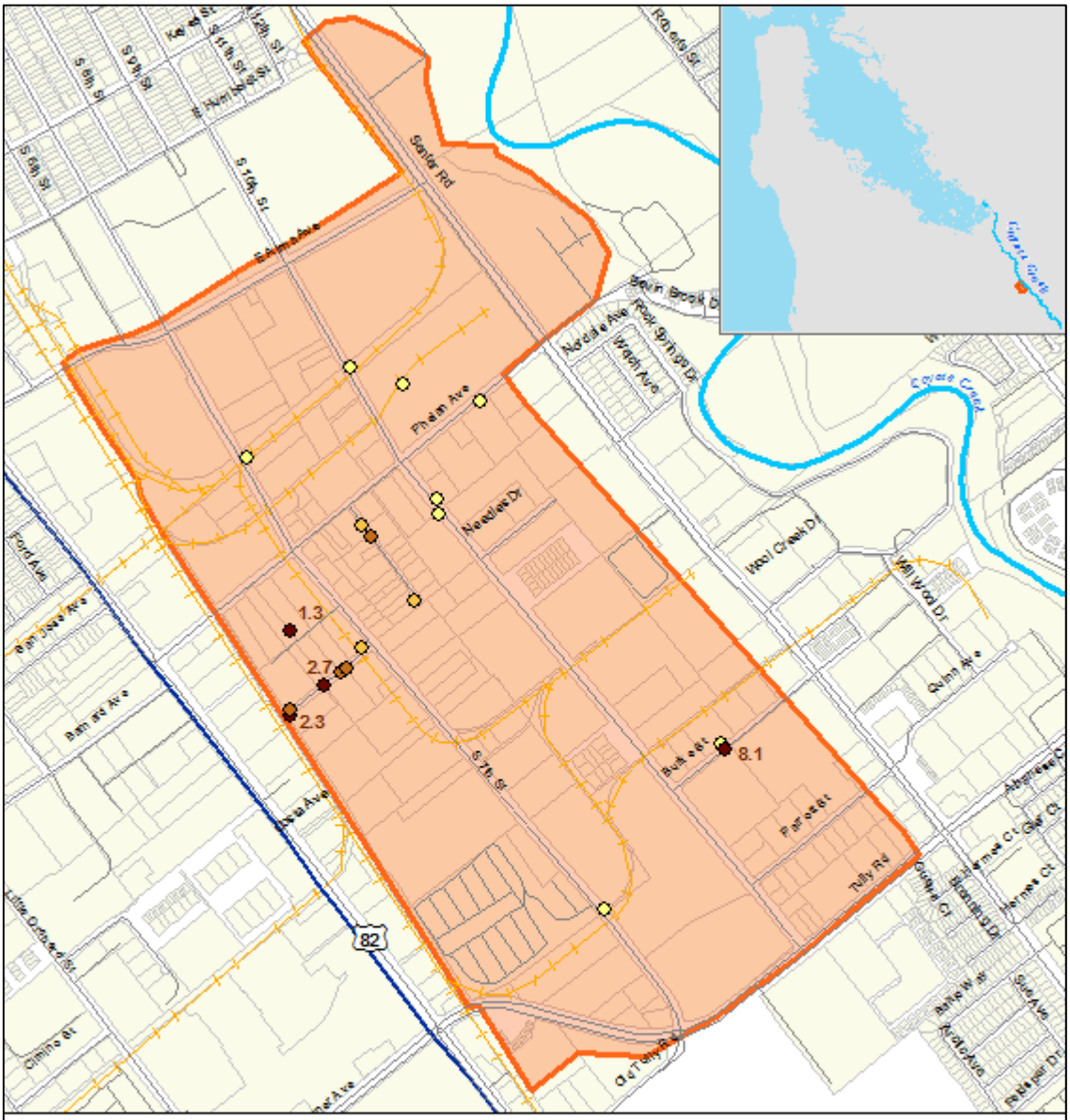
PCB Concentrations in Sediment Collected in the Public Right-of-Way in the Leo Avenue Watershed, San Jose, C, October 2012

Source:

EOA, Inc. (2013)

Entity	Date	
Bay Area Stormwater Management Agencies Association	October 1, 2012	Figure B.4.13

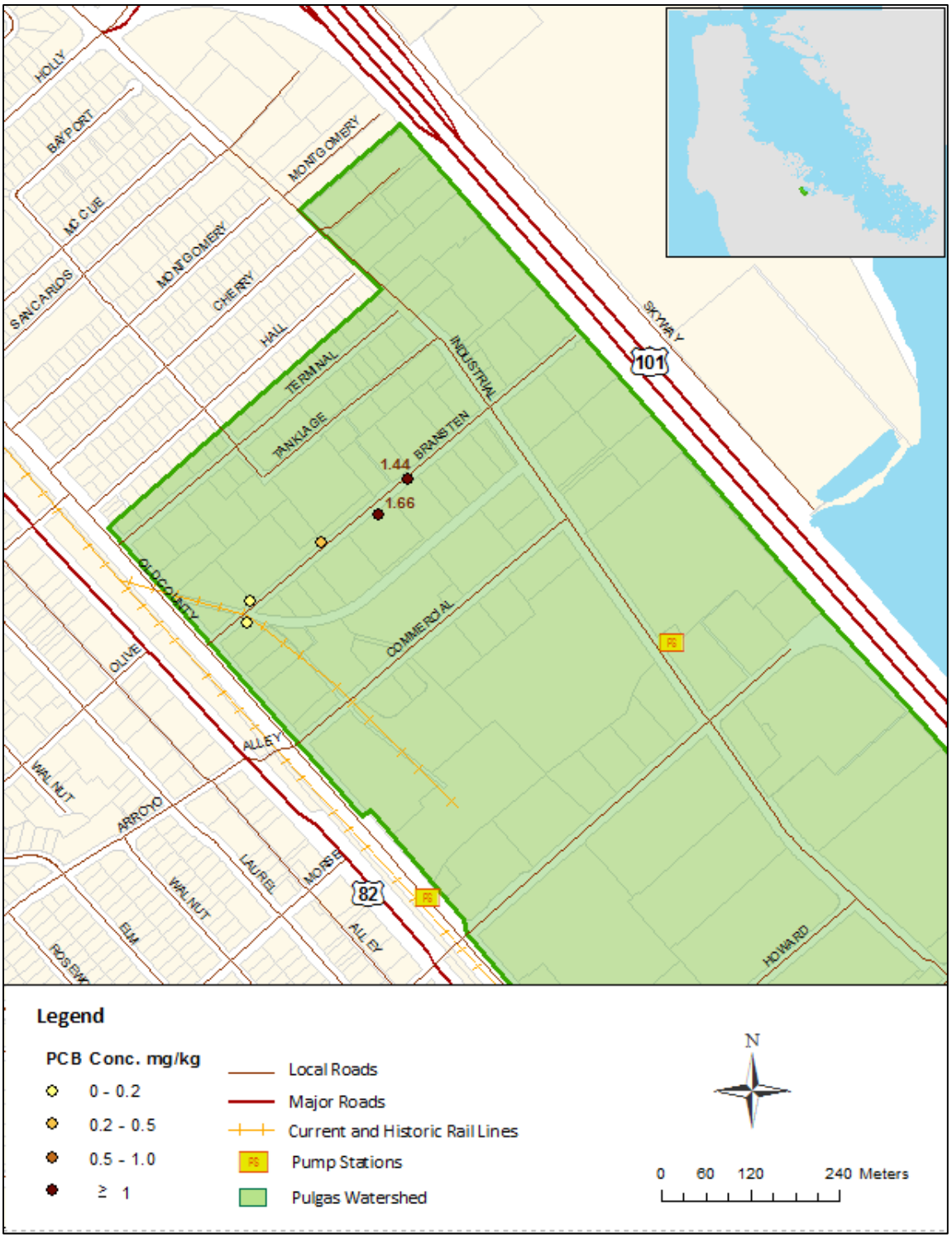
internal info: path, date revised, author



Mercury Concentrations in Sediment Collected in the Public Right-of-Way in the Leo Avenue Watershed, San Jose, CA, October 2012

Source: EOA, Inc. (2013)	Bay Area Stormwater Management Agencies Association	October 1, 2012	Figure B.4.14
	Entity	Date	

internal info: path, date revised, author



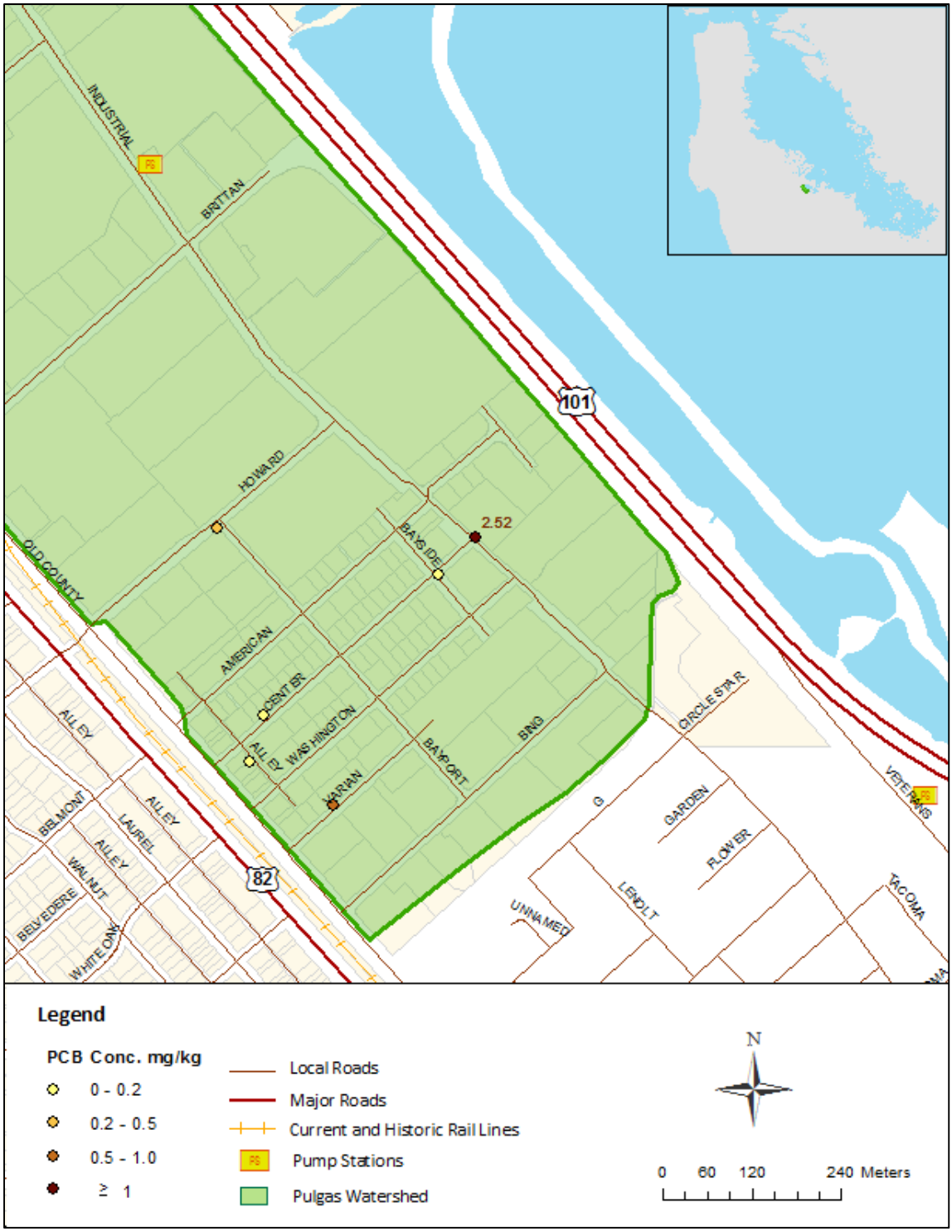
PCB Concentrations in Sediment Collected in the Public Right-of-Way in the Pulgas Creek Pump Station Watershed North (a), San Carlos, CA October 2012

Source:

EOA, Inc. (2013)

Entity	Date	
Bay Area Stormwater Management Agencies Association	October 1, 2012	Figure B.4.15

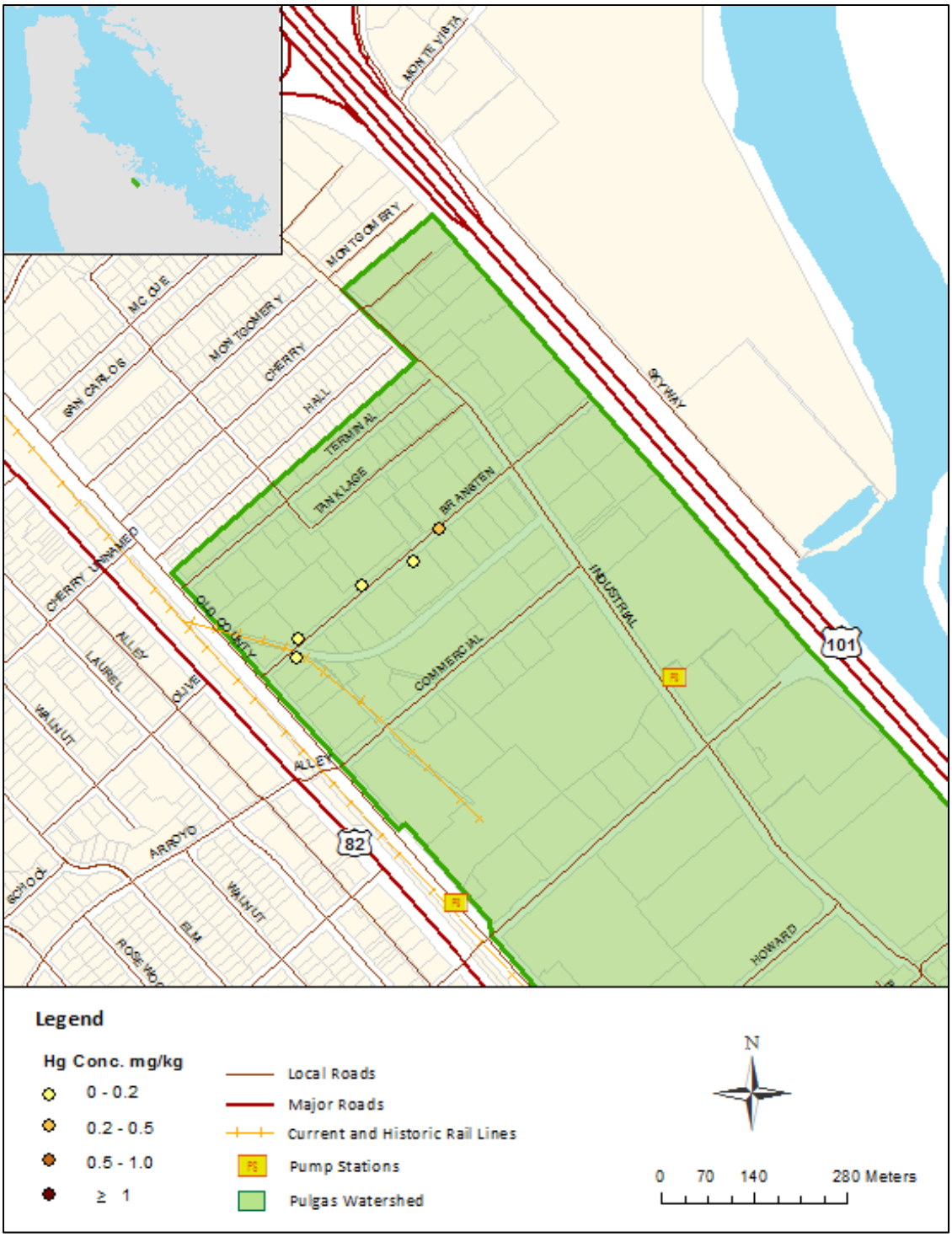
internal info: path, date revised, author



PCB Concentrations in Sediment Collected in the Public Right-of-Way in the Pulgas Creek Pump Station Watershed South, San Carlos, CA October 2012

Source:	Bay Area Stormwater Management Agencies Association	October 1, 2012	Figure B.4.16
EOA, Inc. (2013)	Entity	Date	

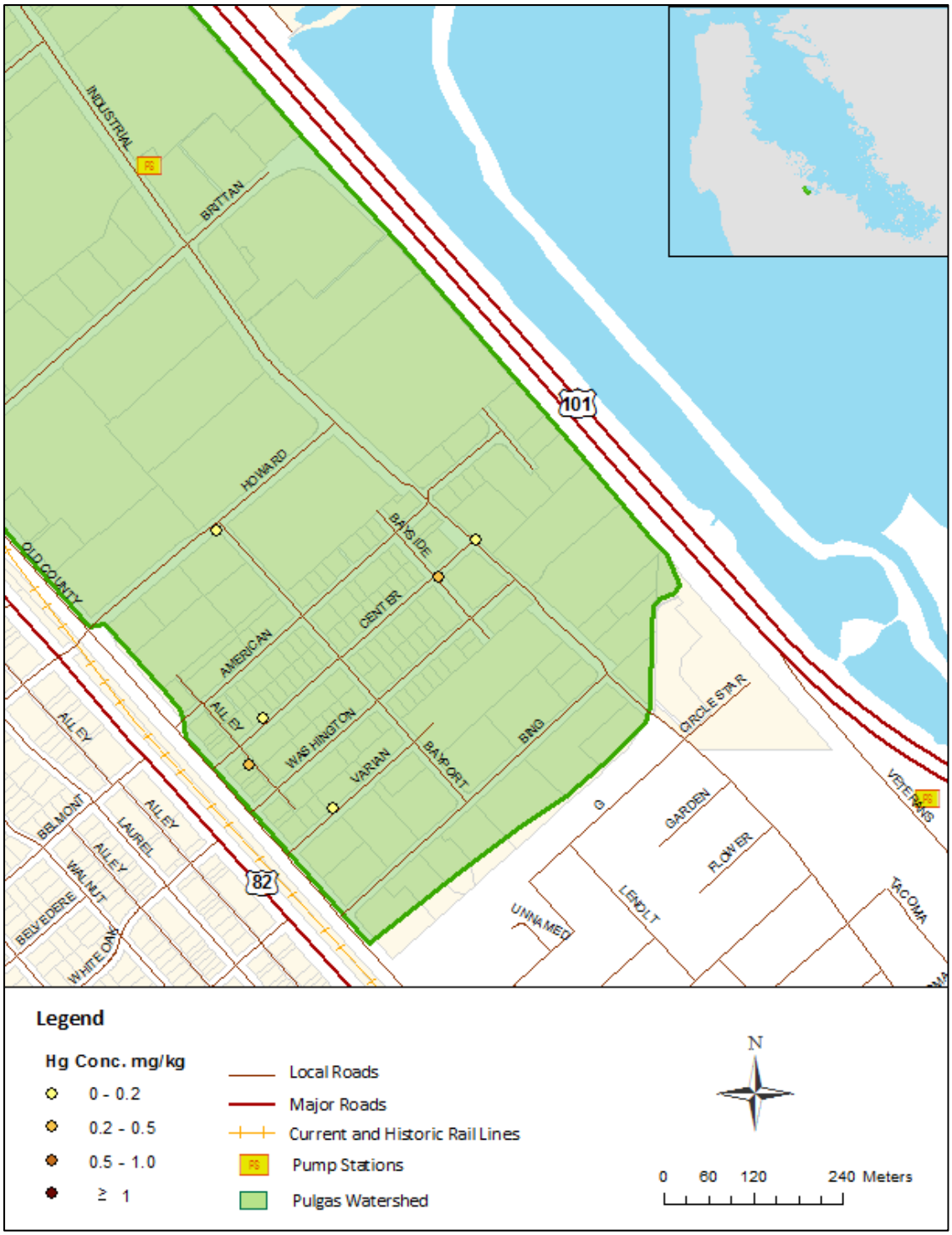
internal info: path, date revised, author



Mercury Concentrations in Sediment Collected in the Public Right-of-Way in the Pulgas Creek Pump Station Watershed North San Carlos, CA, October 2012

Source:	Bay Area Stormwater Management Agencies Association	October 1, 2012	Figure B.4.17
EOA, Inc. (2013)	Entity	Date	

internal info: path, date revised, author



Mercury Concentrations in Sediment Collected in the Public Right-of-Way in the Pulgas Creek Pump Station Watershed South San Carlos, CA, October 2012

Source:	Bay Area Stormwater Management Agencies Association	October 1, 2012	Figure B.4.18
EOA, Inc. (2013)	Entity	Date	

internal info: path, date revised, author

B.5 ENHANCED STREET SWEEPING

B.5.1 Introduction

The effectiveness of municipalstreet sweeping for reducing street sediment loading and improving stormwater runoff quality has been evaluated since the 1970s. Street sweeping was evaluated in the Nationwide Urban Runoff Program at a number of sites including a site in the Castro Valley Creek watershed (Pitt and Shawley 1981). The effectiveness of street sweeping for reducing sediment loads (and sediment-bound pollutants of concern) and improving stormwater runoff quality based on studies conducted in the San Francisco Bay Area and elsewhere is summarized in the *Sediment Management Practices Clean Watersheds for a Clean Bay Task 4 Literature Review* (EOA, Inc. and Geosyntec Consultants 2011). The discussion below is based on the findings of the report by EOA, Inc. and Geosyntec Consultants (2011).

The effectiveness of enhanced street sweeping practices is being evaluated because of the documented effect that municipal street sweeping has on removing sediment from streets. Street sweeping is a common practice for managing litter on municipal streets and because it is a routine municipal maintenance operation, street sweeping has the potential to be enhanced to target sediment and sediment-associated pollutants of concern.

Several variables and factors influence the effectiveness of municipal street sweeping, which include:

- **Climate** - The effectiveness of street sweeping depends on being able to reduce (in a cumulative way) street loadings prior to storm events. Thus seasonal variation in precipitation combined with rainfall intensity and spacing can affect the efficiency of street sweeping. In semi-arid climates where precipitation is limited to a wet season, the ability of street sweeping to reduce street surface loads prior to the first flush event and other early events in the season is considered critical.
- **Street Sediment Loading** - The sediment street loading is a measure of the mass of sediment on the street surface per unit length of roadway. Much of this mass tends to located adjacent to the curb and therefore sweepers that have access to the curb will be more efficient. Particle size also is important as some pollutants have a tendency to attach to the smaller size fractions, which also tend to be more easily mobilized during storm events.
- **Frequency of Sweeping** - Sweeping effectiveness is limited in time due to accumulation of pollutants on street surfaces on days following sweeping. As it is infeasible to sweep in response to weather forecasts, it is generally considered that sweeping would be more effective if it can be conducted as frequently or more frequently that the mean frequency of storm events in the area.

- **Sweeper Condition** - Sweepers must be maintained in good condition to be effective, including for example, brooms, filters, vacuums and nozzles. The effectiveness of the unit in cleaning close to the curb is critical.
- **Operator Skill** - Operator skill in negotiating the sweeper and being aware of the effectiveness of sweeping and modifying operation accordingly in response to local conditions is important.
- **Parking Restrictions** - The presence of parked vehicles prevents the sweeper for being able to access the curb, which is where the majority of sediments are deposited.
- **Road Condition** - Many studies indicate that road condition influences sweeping efficiency more than the sweeper type, at least for dirty streets. Generally sweeping is more effective on dirty streets than on clean streets. Streets are often dirty because of poor condition.
- **Sweeper Type** - The primary difference between mechanical broom sweepers and advanced sweepers is the effective particle size range for street sediment removal. Advanced street sweepers, including regenerative air and vacuum assisted models, are better at removing fine (<63 µm) particulates than mechanical broom sweepers. Finer street dirt particles typically have higher concentrations of mercury and PCBs, based on Bay Area sample data collected by EOA, Inc. (2007a) and Salop (2006), and finer particles, unless trapped in cracks in the road surface, are more easily mobilized by storm events. However, the greatest mass of certain sediment-bound pollutants such as PCBs may be associated with larger particles[10], which is the most effective particle size range for the sweeper to capture. Significant scatter in the field study data (primarily because of the varying conditions in which the studies were performed) make it difficult to assess if one sweeper type is more effective than another based on the amount of solids removed per curb mile. There have been no studies conducted recently in the Bay Area that reflect improvements in sweeper technology over approximately the last decade.
- **Sweeper Seasonal Timing** - In semi-arid climates, the timing of sweeping in relation to the first significant storm event of the season and subsequent events throughout the wet season is a critical efficiency factor, although difficult to study through field testing or modeling. Unfortunately, this factor cannot be controlled because it is impractical for municipal street sweeping programs to schedule sweeping based on weather forecasting. Some references suggest conducting on average one or two sweepings between storms. In

[10] This management hypothesis that the greatest mass of PCBs on roadways and in the MS4 system is associated with coarser fractions (e.g., <63um) is based primarily on a preliminary particle settling experiment as reported by SFEI (2010). Other evidence supporting the concept that a substantial mass fraction of PCBs in urban sediments is associated with larger particles is the nature of contemporary PCB sources in urban settings, e.g., construction debris and auto shredder waste are potential sources that would generate coarser material, prior weathering in the environment. Finally, there is good evidence that coarse fractions are a greater proportion of the overall mass of sediment in urban drainages *(*Selbig and Bannerman, 2007*)*.

semi-arid climates such as the Bay Area, some references recommended more intensive sweeping prior to the onset of the wet season (Pitt and Shawley 1981).

Sediment collected by street sweepers in the Bay Area contains detectable concentrations of polychlorinated biphenyls (PCBs) and mercury. In studies conducted in Alameda and Contra Costa Counties, street sweeper sediments were found to fall into three tiers of PCB concentrations (EOA 2007a; EOA 2007b; Salop 2006):

1. Cities Developed in Early 20th Century - Samples from Richmond, Martinez, and Berkeley had higher concentrations (> 0.10 mg/kg);
2. Cities Developed in Mid-Century - Samples from Walnut Creek, Pinole, Orinda, and Brentwood had relatively moderate concentrations (0.05 - 0.10 mg/kg); and
3. Cities Developed in Late 20th Century - Samples from Newark, Pleasanton, Concord, and Livermore had relatively low concentrations (<0.05 mg/kg).

The following results were noted for mercury concentrations:

1. Locations with higher mercury concentrations (>0.2 mg/kg) were from Berkeley, Richmond, Martinez and Pinole;
2. Locations with moderate concentrations (0.1-0.2 mg/kg) included Orinda, Walnut Creek, and Concord;
3. Locations with the lowest observed mercury concentrations (< 0.1 mg/kg) included Hayward, Newark, Pleasanton, Fairfield-Suisun, and Livermore.

Sample concentrations were likely affected by the age of urbanization of the municipality. Generally cities with elevated PCB concentrations also had elevated mercury concentrations, but that was not always the case.

As part of the Sediment Literature Review, Geosyntec Consultants estimated the load reductions that could potentially be achieved with a range of sweeping scenarios based on Bay Area sediment concentration data compiled by the San Francisco Estuary Institute (SFEI 2010). The concentration data were based on 15 sites in the database where street sediment data were in the upper 10th percentile. This analysis indicated that the 90th percentile concentration for PCBs was approximately 0.28 mg/kg and the corresponding total mercury concentration was 0.51 mg/kg. Two street sweeping scenarios were conducted for each of the 15 sites. A “lower bound” scenario assumed a 10 km road segment was swept monthly with a technology that reduced the street loading by 100 pounds/curb mile, and an “upper bound” scenario which assumed a 10 km road segment was swept by-monthly with a technology that reduced the street loading by 300 pounds/curb mile. The total annual mass of PCBs removed ranged from 0.035 kg to 0.21 kg, and the total annual mass of Hg removed ranged from 0.038 kg to 0.22 kg. This analysis shows that the annual mass of PCBs and mercury collected in areas with the highest concentrations is low relative to the Total Maximum Daily Load (TMDL) targets.

The effectiveness of municipal street sweeping for improving runoff water quality is not well understood and is therefore difficult to quantify. Most field studies have not been able to demonstrate a statistically reliable improvement in water quality, likely because the studies were not designed with sufficient statistical power to distinguish effects given the variability in stormwater quality loads (Kang et al. 2009), and because it is difficult to isolate the effect of roadway runoff from other sources (e.g., roofs and sidewalks) in designing monitoring studies.

The remainder of this section describes the enhanced street sweeping pilot study and presents a methodology for estimating the load reduction that could be achieved as a result of implementing enhanced street sweeping practices.

B.5.2 Summary of PCB and Mercury Control Pilot Studies

B.5.2.1 Implementation Approach to Meeting MRP Requirements

During FY 2010/11, existing literature was reviewed for information on previous studies related to sediment and pollutant removal during municipal operation and maintenance activities and other information relevant to the pilot evaluations (EOA, Inc. and Geosyntec Consultants 2011). The key data gaps and recommendations for the design of future studies in the literature review are summarized in the Bay Area Stormwater Management Agencies Association (BASMAA) Regional Pollutants of Concern Report FY2010-2011 (BASMAA 2011).

Based on the results of the literature review and discussions with municipal staff, the Clean Watersheds for a Clean Bay (CW4CB) Task 4 sediment management workgroup developed study designs and a monitoring plan for conducting sediment management studies that will be implemented in 2013-2014. The pilot street sweeping study that is included in the monitoring plan is briefly described below.

Because the street sweeping pilot study was not be implemented in time for completion of the Integrated Monitoring Report (IMR), hopper data collected by Permittees for inclusion in their Annual Reports was used to evaluate the load reductions achieved by implementing enhanced street sweeping activities. The methodology for estimating the benefits of enhanced street sweeping will be replaced by the WinSLAMM model (described below), which will be used to evaluate the load reduction achieved through enhanced street sweeping. However hopper data could be used to calibrate the WinSLAMM model.

Pilot Study Implementation

The pilot study implementation approach entails conducting a hybrid monitoring and modeling study in four older industrial watersheds where elevated PCB concentrations were observed. The monitoring phase will be conducted to study the baseline sweeping condition, and the Windows version of the Source Loading and Management Model (WinSLAMM) will be used to model the effects of various enhancements including improved sweeper technology, more frequent street cleaning, restrictions on parking, and improved road conditions. The purpose of monitoring the

baseline sweeping condition is to develop a baseline productivity function for each pilot test area, where the productivity function is the equation that describes how the post-sweeping street loading varies as a function of the pre-sweeping street loading. This and other information will then be used to calibrate WinSLAMM for local conditions in the Bay Area. The calibrated model then will be applied to evaluate the increase in loads avoided/reduced as a result of enhanced sweeping practices.

Field monitoring began in November 2013. The objective is to collect the data when street sediment loads are the highest, which is before and early into the wet season. The WinSLAMM modeling component would begin after the quality assurance quality control review of the data has been completed by SFEI. The WinSLAMM modeling component for the pilot study areas will likely be completed by fall 2014.

B.5.2.2 Pilot Study Description

Monitoring of the Current Conditions

Monitoring of the existing condition will occur in four industrial watersheds: (1) the Leo Avenue watershed in San Jose; (2) East California Avenue between North Fair Oaks and North Sunnyvale Avenue in Sunnyvale; (3) Hoffman Boulevard in Richmond; and (4) Cutting Boulevard in Richmond. Figure B.6.1 (in the Enhanced Operation and Maintenance section) shows the locations where the monitoring will be conducted. The sampling methodology is described in the *Clean Watershed for a Clean Bay (CW4CB) Study Designs for Five O&M Pilot Projects* (Geosyntec Consultants and CSU/OWP 2013).

The monitoring component entails sampling the baseline sweeping condition in the three test locations. Currently, street sweeping is not conducted along Hoffman Boulevard (Richmond). For the pilot study, Hoffman Boulevard sweeping would be conducted weekly using a regenerative air sweeper. The sweeper types and frequencies for the Cutting Boulevard (Richmond), San Jose and Sunnyvale locations are listed in Table B.5.4.4. A primary objective is to collect samples during periods when street loads are high (e.g., before and early in the wet season, for a normal wet year).

Sampling will involve vacuuming street sediment in narrow transects (approximately 4 inch swath corresponding to the width of the vacuum nozzle) extending from curb to curb. The vacuuming will be conducted before and after each sweeper pass, following methods described in Selbig and Bannerman (2007). Transects will be marked off approximately every 100 feet of roadway, and vacuuming will be conducted at approximately 10 strips selected randomly along the selected road segment, making sure that the post-sweeping transects are not the same as the pre-sweeping transects. Sediments will automatically be composited in the vacuum, dried if necessary, and screened to eliminate gross solids defined as > 2 mm prior to analysis. For each sampling round, there will be one composite sample for the pre-sweeping sampling, and one composite sample for the post-sweeping. The total number of samples to be analyzed for the 10

sampling rounds at each site will then be 20. Field work will also include observations and documentation (including photos) of street sweeping activities, traffic conditions, and pre- and post-storm event observations.

WinSLAMM Modeling

WinSLAMM is a continuous pollutant loading model which simulates pollutant loading from small developed urban catchments as well as the effectiveness of various source controls and treatment control measures in reducing overall pollutant concentration and loads. The types of street sweeping enhancements that can be modeled in WinSLAMM include:

- Street cleaning frequency;
- Type of sweeper (e.g., mechanical broom, vacuum assisted); and
- Street texture, parking density, and parking controls are collectively modeled by adjusting cleaner productivity, which defines the relation between pre- and post-sweeping street surface loading (pounds/curb-mile).

The field data will be used to develop the baseline productivity function for each pilot area for the model, and the model will then be used to model the effect of implementing enhanced street sweeping practices in each pilot study area.

B.5.3 Status of Control Measure Implementation

The status of baseline, current, and enhanced implementation was evaluated using readily available data reported by the municipalities on their street sweeping efforts in Annual Reports.[11] Data reported in Annual Reports included total volume of material removed by the sweeper and curb miles swept (determined by sweeper odometer readings); the type of sweeper utilized was not reported in Annual Reports. Baseline implementation refers to actions occurring prior to and including Fiscal Year 2001-02. Current implementation refers to actions occurring post Fiscal Year 2001-02. Enhanced implementation refers to actions occurring post Fiscal Year 2001-02 that are above and beyond baseline implementation.

Data reported for individual municipalities are summarized in Appendix B.5.A for the baseline and current periods. The various counties have different periods over which street sweeping level of effort data were recorded. For example, Fairfield and Suisun City have continuous data from Fiscal Year 93-94 through Fiscal Year 08-09. However there were no available compiled data for Vallejo. In contrast, data are available for Alameda County only for Fiscal Years 92-93 through Fiscal Years 96-97; therefore, no data are available for the enhanced period. Therefore, the reporting periods are noted in Appendix Table B.5.A.1 and Table B.5.A.2, to explain some of the variability in the curb miles swept and total volume of material removed. The data are

[11] Data for this evaluation were provided by EOA, Inc. (compiled in May 2011) and the Contra Costa Clean Water Program.

normalized by calculating a "rate", which is the volume of material removed per curb mile swept. In addition, the latest year of data collected by any municipality is Fiscal Year 09-10, as the MRP does not require the municipalities to report this information.

B.5.3.1 Baseline and Current

Figure B.5.1 illustrates the difference between the average volume (cy) of material removed per curb mile swept for each countywide program for the baseline and current periods, using the information in Appendix Table B.5.A.1 and Table B.5.A.2. Note there were no baseline data available for Santa Clara County municipalities and no current data for Alameda County municipalities. For the three countywide programs with both baseline and current data, the data showed an overall reduction in the volume of material removed per curb mile swept from the baseline to the current period. Summary statistics for each countywide program are provided in Table B.5.3.1.

Table B.5.3.1. Annual Material Collected per Curb Mile Summary Statistics

County	Baseline Material Collected per Curb Mile (cy/mi)					Current Material Collected per Curb Mile (cy/mi)				
	25th Percentile	Mean	Standard Deviation	50th Percentile	75th Percentile	25th Percentile	Mean	Standard Deviation	50th Percentile	75th Percentile
Solano	0.30	0.33	0.08	0.33	0.36	0.25	0.26	0.05	0.26	0.28
San Mateo	0.16	0.32	0.22	0.26	0.40	0.16	0.25	0.15	0.21	0.27
Santa Clara	No Data	No Data	No Data	No Data	No Data	0.27	0.37	0.15	0.32	0.48
Alameda	0.16	0.30	0.17	0.28	0.40	No Data	No Data	No Data	No Data	No Data
Contra Costa	0.22	0.97	2.11	0.31	0.53	0.19	0.67	1.07	0.34	0.50
All Municipalities	0.20	0.68	1.58	0.30	0.52	0.18	0.43	0.67	0.27	0.45

Because information about how the street sweeping programs changed from the baseline to the current periods (such as a reduced sweeping frequency due to budget cuts) is not included in the Annual Reports, it is not feasible to evaluate why the data appear to indicate a reduction in the volume of material removed per curb mile for the current period.

B.5.4 Estimates of Loads Avoided/Reduced

This section presents the methodology for estimating loads reduced by baseline and current municipal street sweeping efforts, and provides load reduction estimates for the baseline and current level of implementation for each municipality. In addition, annual load reductions are provided for the pilot study areas based on current practices.

B.5.4.1 Loads Avoided/Reduced Methodology

The baseline, current and enhanced load reduction methodology presented herein has been adapted based from the methodology presented in the Draft Technical Memorandum entitled

"*Methods for Quantifying Mercury and PCB Loads Reduced from Urban Stormwater Runoff, Assessing municipal stormwater program progress towards TMDL wasteload allocations through control measure implementation*" (EOA, Inc. 2011). The baseline and current load reduction achieved by street sweeping may be calculated as follows:

$$Baseline_{SS} = Vol_{Baseline\ SS} \bullet \%Sed_{SS} \bullet \rho_{SS} \bullet Conc_{SS}$$

and

$$Current_{SS} = Vol_{Current\ SS} \bullet \%Sed_{SS} \bullet \rho_{SS} \bullet Conc_{SS}$$

Where:

$Vol_{BaselineSS}$ =	Average volume of street sweeping material collected in baseline years (prior to an including Fiscal Year 2001-02)
$Vol_{CurrentSS}$ =	Average volume of street sweeping material collected in current years (post Fiscal Year 2001-02)
$\%Sed_{SS}$ =	Percent of material collected by the street sweeper that is "sediment"[12] (by volume)
ρ_{SS} =	Sediment density of the street sweeper material (weight per unit volume)
$Conc_{SS}$ =	Average (or measured) concentration of mercury or PCBs in street sweeping sediments collected. Note that the same concentration was used for baseline and current load reductions

Note that units and unit conversation factors must be supplied by the user.

Therefore, the enhanced load reduction may be calculated as follows:

$$Enhanced_{SS} = Current_{SS} - Baseline_{SS}$$

Assumptions and Data Inputs

- Volume of Material Collected ($Vol_{Baseline\ SS}$ and $Vol_{Current\ SS}$). As stated above, the volume of material collected annually by street sweepers has been reported by the municipalities in their Annual Reports (see Appendix Table B.5.A.1 and Table B.5.A.2). Note that the years for which these data are available vary by municipality, and different years form the basis for the baseline and enhanced periods depending on the municipality.

[12] For purposes of this document, street sweeping sediment is defined as all street sweeping material that would pass through a 2mm sieve.

- Percent of Street Sweeping Material That is "Sediment" ($\%Sed_{SS}$). For the purposes of this analysis, it is assumed than material less than 2 mm is sediment. The estimate for the percent of material removed by street sweepers that is less than 2 mm comes from Salop (2006). Salop evaluated the characteristics of gross solids collected during street sweeping operations in Bay Area cities and estimated sediment/vegetative debris less than 2 mm in diameter accounted for approximately 55 percent (by mass) of total solids collected during street sweeping operations in Alameda County. Therefore $\%Sed_{SS}$ was assumed to be 55 percent for the baseline and enhanced load reduction analysis.
- Street Sweeping Sediment Density (ρ_{SS}) – The material collected by street sweepers is typically reported as a volume (cy). To calculate pollutant loads reduced, the volume of material must be converted into a mass using an assumed bulk density for the material. In support of the California Integrated Waste Management Act of 1989, FEECO International developed densities for a variety of waste materials. These densities continue to be utilized by the California Department of Resources Recycling and Recovery (CalRecycle 2013). In addition FEMA (2010) developed the "Debris Estimating Field Guide" which has densities for waste materials. The dry bulk density used for this analysis was estimated using the average density determined by these two sources; the selected density assumes the material is 30 percent vegetative debris by volume and the remaining volume is dry sand. Therefore, the assumed bulk density for dry material[13] less than 2 mm is 1,811 pounds per cubic yard.
- Concentration of Mercury/PCBs in Street Sweeping Sediment ($Conc_{SS}$) EOA developed representative concentrations for PCBs and mercury in street sweeping sediments using data collected from various studies in Contra Costa (EOA 2007a), Alameda (Salop and Akashah 2004) and Solano (EOA 2006) counties. Pollutant concentrations were compared to sweeper type, land use and age-of-urbanization to determine if significant relationships exist. Based on the results, concentrations of PCBs in street sweeping sediments appear to be dependent upon the very coarse age-of-urbanization categories assigned to cities in Contra Costa and Alameda Counties where street sweeping characterization occurred. Bay Area age-of-development categories include:
    - Early 20th Century – Represents the earliest and most extensive degree of urbanization/industrialization. May include municipalities where shipping and railways were used extensively for transporting industrial materials. Example cities include Richmond, Hayward, Oakland and Martinez.

[13] FEMA estimate was calculated from the conversion factor given for 70% dry sand, 30% vegetation and trash of 69 pounds per cubic foot or 1,870 pounds per cubic yard. CalRecycle estimate was calculated from the conversion factor given for "wet sand" of 110-130 pounds per cubic foot, and converting to a dry density by applying a porosity of 0.35 (porosity from Linsley and Franzini, Water Resources Engineering, 1964), which results in a dry bulk density of 1,752 pounds per cubic yard. The "best" (average) density estimate, 1,811 pounds per cubic yard, is equivalent to 821.5 kg per cubic yard.

- Mid-Century – Represents the intermediate range in both time and degree of urbanization/industrialization. Example cities include Pinole, Concord, Orinda and Walnut Creek.
- Late 20th Century – Represents the geographical area with the most recent urbanization. Includes areas where heavy industry never or minimally existed. Example cities include San Ramon, Livermore, Dublin, Brentwood and Clayton.

Table B.5.4.1 summarizes the low (25th percentile), average (mean) and high (75th percentile) concentrations of mercury and PCBs based on the age of urbanization of the municipality. For the load reduction analysis, each municipality was assigned an age, and the average PCB and mercury concentration for that age was used for the analysis.

Table B.5.4.1. Estimated PCB and Mercury Concentrations in Sediment Collected by Street Sweepers

Concentration of Pollutant of Concern (mg/kg)	Municipality's Age-of-Urbanization								
	Early 20th Century			Mid-Century			Late 20th Century		
	Low	Ave	High	Low	Ave	High	Low	Ave	High
Total PCBs	0.10	0.18	0.22	0.01	0.03	0.44	0.01	0.03	0.44
Total Mercury	0.17	0.25	0.32	0.05	0.11	0.14	0.03	0.05	0.07

B.5.4.2 Loads Avoided/Reduced by Implementing Municipal Street Sweeping

Using the methodology described above, Appendix Table B.5.A.3. summarizes the estimated PCB and mercury loads reduced by municipal street for the baseline and current periods. Because the period of data collection varies for the baseline and current periods for each municipality, the load reductions were normalized by reporting the data on an annual basis for the baseline and current periods. Table B.5.4.2. and Table B.5.4.3. provide the summary statistics for the data in Appendix Table B.5.A.3, for PCB and mercury load reductions, respectively.

Figure B.5.2 (PCBs) and Figure B.5.3 (mercury) show the average total annual loads reduced for each countywide program, for the baseline and current periods (each countywide program shows the sum of the annual load reductions for each municipality within the program for which data were available). For the three countywide programs for which both baseline and current data were available (Solano, San Mateo, Contra Costa), there does not appear to be a significant difference between the baseline and current period load reductions. PCB load reductions for each countywide program (Figure B.5.2) ranged from 621 grams to 5,280 grams for the baseline period, and ranged from 632 grams to 5,737 grams for the current period. Mercury load reductions for each countywide program (Figure B.5.3) ranged from 863 grams to 7,870 grams for the baseline period, and ranged from 878 grams to 8,461 grams for the current period.

Figure B.5.4 and Figure B.5.5 show the total load reduced per curb mile swept for the baseline and current periods, for PCBs and mercury, respectively. Using the current PCB load reduction per curb mile for Contra Costa County municipalities (8.1 mg/mile), there would need to be about 123 million miles swept throughout the county for remove 1 kg of PCBs. For Santa Clara County municipalities (29.2 mg/mile), there would need to be about 34 million miles swept throughout the county for remove 1 kg of PCBs.

B.5.4.3 Estimates of Current Loads Avoided/Reduced in Pilot Study Areas

Table B.5.4.4 summarizes the loads reduced in the pilot study areas based on current sweeping practices using the below methodology. The concentration data used for the load reduction estimates include pilot study area-specific concentrations (which are included in Table B.5.4.4.) and average concentrations from Table B.5.4.1 for early 20th century municipalities. The notes for Table B.5.4.4 further detail the data sources and methodology.

This methodology is currently being used in lieu of having the pilot study results (WinSLAMM), which will quantify the current load reductions. Improved estimates will be obtained through implementation of the pilot study. Note that there is currently no street sweeping program being implemented along Hoffman Avenue in Richmond.

Because the exact location in the Leo Avenue watershed where the pilot study would be performed is yet to be determined, the existing load reduction resulting from street sweeping was estimated for the entire Leo Avenue drainage. The annual mass of PCBs reduced ranges from 13 grams to 43 grams per year, depending on PCB concentration used for the estimate (concentrations representing street sediment data collected in the Leo Avenue watershed and an average concentration based on the age of urbanization were used). Annual mercury mass reduced ranges from 17 grams to 41 grams depending on the concentration used. The high range for load reduction estimates resulted from using Leo Avenue watershed-specific concentrations for mercury and PCBs in street sediment as shown in Table B.5.4.4.

For the Sunnyvale location along East California Avenue, the current load reduction estimate for annual PCB mass reduced ranges from 0.59 g to 1.1 g per year, depending on PCB concentration used for the estimate (concentrations representing street sediment data collected in Sunnyvale and an average concentration based on the age of urbanization were used). The current annual load reduction estimate for mercury ranges from 0.9 to 1.5 grams depending on the concentration used. Conversely to Leo Avenue, the low range for load reduction estimates resulted from using Sunnyvale-specific concentrations for mercury and PCBs in street sediment as shown in Table B.5.4.4.

Table B.5.4.2. Annual PCB Load Reduced Summary Statistics for Countywide Programs

County	Baseline Average Annual PCB Load Reduced (g)					Current Average Annual PCB Load Reduced (g)				
	25th Percentile	Mean	Standard Deviation	50th Percentile	75th Percentile	25th Percentile	Mean	Standard Deviation	50th Percentile	75th Percentile
Solano	228.8	310.6	231.5	310.6	392.5	227.0	316.2	252.1	316.2	405.3
San Mateo	9.2	104.0	133.7	21.3	190.8	8.5	97.0	106.7	47.7	193.8
Santa Clara	No Data	No Data	No Data	No Data	No Data	19.5	409.8	656.9	62.7	567.5
Alameda	23.5	377.2	676.3	50.8	496.6	No Data	No Data	No Data	No Data	No Data
Contra Costa	9.4	44.4	53.5	21.4	61.3	15.3	54.2	56.8	29.3	97.8
All Municipalities	10.2	159.4	370.4	32.6	145.2	13.4	169.0	364.0	34.1	171.4

Table B.5.4.3. Annual Mercury Load Reduced Summary Statistics for Countywide Programs

County	Baseline Average Annual Hg Load Reduced (g)					Current Average Annual Hg Load Reduced (g)				
	25th Percentile	Mean	Standard Deviation	50th Percentile	75th Percentile	25th Percentile	Mean	Standard Deviation	50th Percentile	75th Percentile
Solano	317.8	431.5	321.6	431.5	545.2	315.3	439.1	350.1	439.1	562.9
San Mateo	15.5	157.2	181.3	75.0	265.0	16.8	134.4	140.5	63.3	256.8
Santa Clara	No Data	No Data	No Data	No Data	No Data	71.3	604.4	893.0	230.0	788.2
Alameda	62.6	562.1	926.4	121.6	689.8	No Data	No Data	No Data	No Data	No Data
Contra Costa	23.2	79.3	84.9	48.0	101.3	26.0	98.4	99.5	56.2	129.1
All Municipalities	22.1	241.9	512.1	75.8	256.8	26.3	247.9	493.6	92.1	256.8

Table B.5.4.4. Current Annual Loads Avoided/Reduced in Pilot Study Areas

Pilot Study Area	San Jose, Leo Avenue Watershed	Sunnyvale E. California Ave between N. Sunnyvale Ave and N. Fair Oaks Avenue	Richmond, Hoffman Boulevard	Richmond, Cutting Boulevard
Sweeper Type	Mechanical rear broom sweeper	To be determined	Street sweeping is currently not performed in the area	Regenerative air
Curb Miles Swept per Event	15	0.94		
Sweeping Frequency [days]	14	14		7
Annual Curb Miles Swept	387	24.4		This site was added to the pilot study in October 2013. Current load estimates were therefore not performed.
Volume of Material Removed per Curb Mile [CY]	0.4	0.55		
Annual Volume of Material Removed [CY]	154.8	13.42		
Annual Mass of Material Removed [kg]	142,188	12,327		
Annual Mass of Sediment Removed [kg]	78,203	6,780		
Load Estimates Calculated Using Concentrations in Table B.5.4.1				
PCB Concentration [mg/kg]	0.18	0.18	0.18	
Mass PCBs Removed [g]	13	1.1	NA	
Hg Concentration [mg/kg]	0.25	0.25	0.25	
Mass Hg Removed [g]	17	1.5	NA	
Load Estimates Calculated Using Area-Specific Concentrations (See notes)				
PCB Concentration [mg/kg]	0.62	0.10	0.95	
Mass PCBs Removed [g]	43	0.59	NA	
Hg Concentration [mg/kg]	0.59	0.15	0.76	
Mass Hg Removed [g]	41	0.9	NA	

Notes:

Leo Avenue Watershed:

- The specific location within the Leo Avenue watershed where the pilot study will be conducted will be determined based on field reconnaissance.
- Sweeper type, sweeping frequency, annual curb miles swept and volume of material removed per curb mile from EOA, Inc., 2012.
- PCB and Hg area-specific concentrations represent street sediment samples collected in the Leo Avenue watershed. Data are from the SFEI database (SFEI 2010, KLI and EOA, 2002, City of San Jose and EOA, 2003), and CW4CB Task 3 data collected in the fall 2012 (n = 11 for PCBs and 18 for mercury).

Sunnyvale:

- PCB and Hg area-specific concentration data represent street sediment samples collected in Sunnyvale. Data are from SFEI database (SFEI 2010, KLI and EOA, 2002) (n = 6).

San Jose and Sunnyvale

- Density of the material assumed to be 1,811 pounds per cy (821.5 kg/cy)

Richmond

- PCB and Hg concentration 2 data represent street sediment samples collected in the Inner Richmond Harbor watershed. Data are from SFEI database (n = 6).

B.5.4.4 Estimate of Loads Reduced through Enhanced Street Sweeping in Pilot Study Areas

The increase in loads reduced in the pilot study locations due to implementing an enhanced street sweeping program will be modeled using WinSLAMM. In lieu of having the WinSLAMM results, the improvement in load reduction could be expressed through an enhancement factor (F_e) based on the literature, where:

> F_e = Load reduction from enhanced street sweeping/Load reduction from current street sweeping

Estimates for Fe resulting from enhanced sweeping practices based on a review of the literature (EOA Inc. 2012) are as follows:

- F_e for upgrading from a mechanical broom sweeper to a regenerative air sweeper ranges from 1.2-5.0.
- F_e for upgrading from a mechanical broom sweeper to a vacuum assisted sweeper ranges from 2.2-6.0.
- F_e for upgrading from a regenerative air sweeper to a vacuum assisted sweeper ranges from 1.2-1.5.
- In terms of the frequency of sweeping, for a mechanical broom sweeper, changing from monthly to weekly sweeping results in an F_e range of 1.3-1.4, and going from weekly to semi-weekly results in an F_e of 1.2.
- For a regenerative air or vacuum assisted sweeper, increasing the sweeping frequency from monthly to weekly results in an F_e of 1.4 and an F_e of 2 if going from weekly to semi-weekly sweeping.
- Changing from monthly sweeping with a mechanical broom sweeper to weekly sweeping with a regenerative air or vacuum assisted sweeper results in an F_e range of 3.3-3.45.

Data evaluated as part of the *Sediment Management Practices Clean Watersheds for a Clean Bay Task 4 Literature Review* showed a lot of variability in the productivity functions for different sweepers, primarily because the data reflect numerous studies where conditions are sufficiently different so it difficult to isolate the effects of improved technology (Figure B.5.6). The goal of the pilot studies will be to develop consistent productivity functions for each of the three pilot study areas.

B.5.4.5 Estimation of PCB Loads Reduced as a Result of New Street Sweeping Areas in Richmond and North Richmond

As part of MRP implementation, the City of Richmond and unincorporated Contra Costa County made specific changes to their street sweeping programs that have quantifiable benefits for additional PCB loads prevented from entering the MS4 system. These include implementing a curb and gutter improvement project in the North Richmond Stormwater Pump Station watershed, and initiation of high efficiency street sweeping adjacent to a potential source area in the Santa Fe Channel watershed. A summary of the documented changes in municipal street sweeping practices in these areas is included as Appendix Table B.5.A.2.

B.5.4.6 Summary of Key Uncertainties

There are a number of sources of uncertainty in accurately estimating PCB and mercury loads avoided/reduced to San Francisco Bay associated with baseline and enhanced street sweeping.

- It is not known what factors contributed to the change in the baseline and enhanced sweeping rate (volume of material removed per mile) reported by the permittees in the annual reports. It is not known if an increase in the rate is the result of actual enhanced sweeping practices such as upgrading to an advanced sweeper or increasing the sweeping frequency. Similarly, it is not known if a decreased rate is due to reduced implementation.
- The same PCB and mercury concentrations were applied to the baseline and current periods to calculate the loads reduced. Separating data collected during the baseline from the current period was not possible due to the variability of the data (and separating the data infers that any difference in concentration is statistically significant).
- The PCB and mercury concentrations assigned to the municipalities were a representative concentration based on the age of urbanization of the municipality. The uncertainty in using this method is reflected in the range of loads reduced calculated for the pilot study areas using both the "representative" concentration and data collected specifically within or near the pilot study area.
- A bulk density of 1,811 pounds per cy (821.5 kg/cy) was applied to all street sediment picked up by sweepers.
- It was assumed that 55% of the total volume collected by sweepers was in the fraction less than 2 mm, which was considered to be the amount of sediment removed.

B.5.5 References

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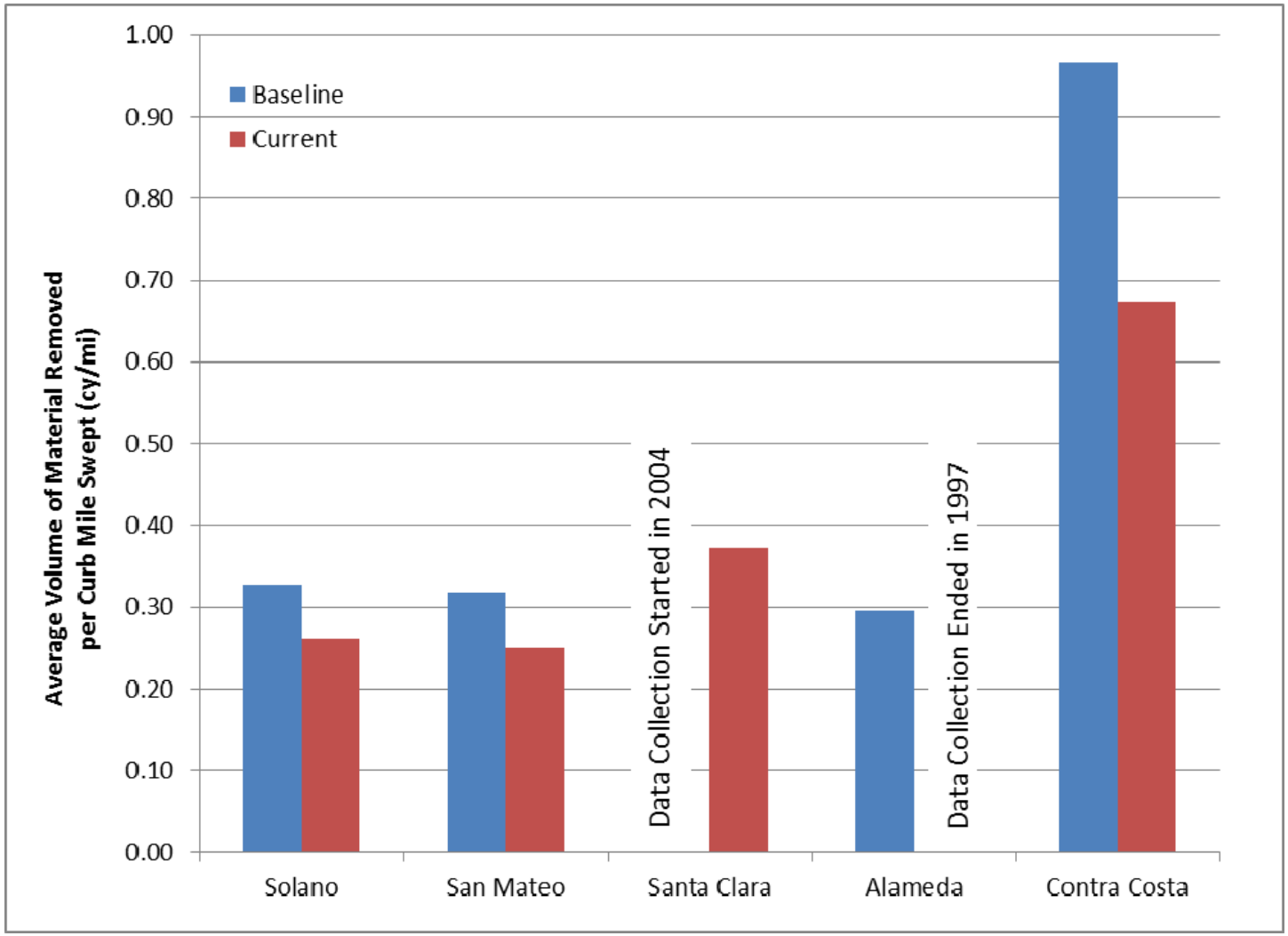
FIGURES B.5



Average Volume of Material Removed per Curb Mile Swept

Source: Data per Appendix Table B.5.1-1 and Table B.5.1-2.	Notes:	Bay Area Stormwater Management Agencies Association	December 2013	Figure B.5.1
		Entity	Date	

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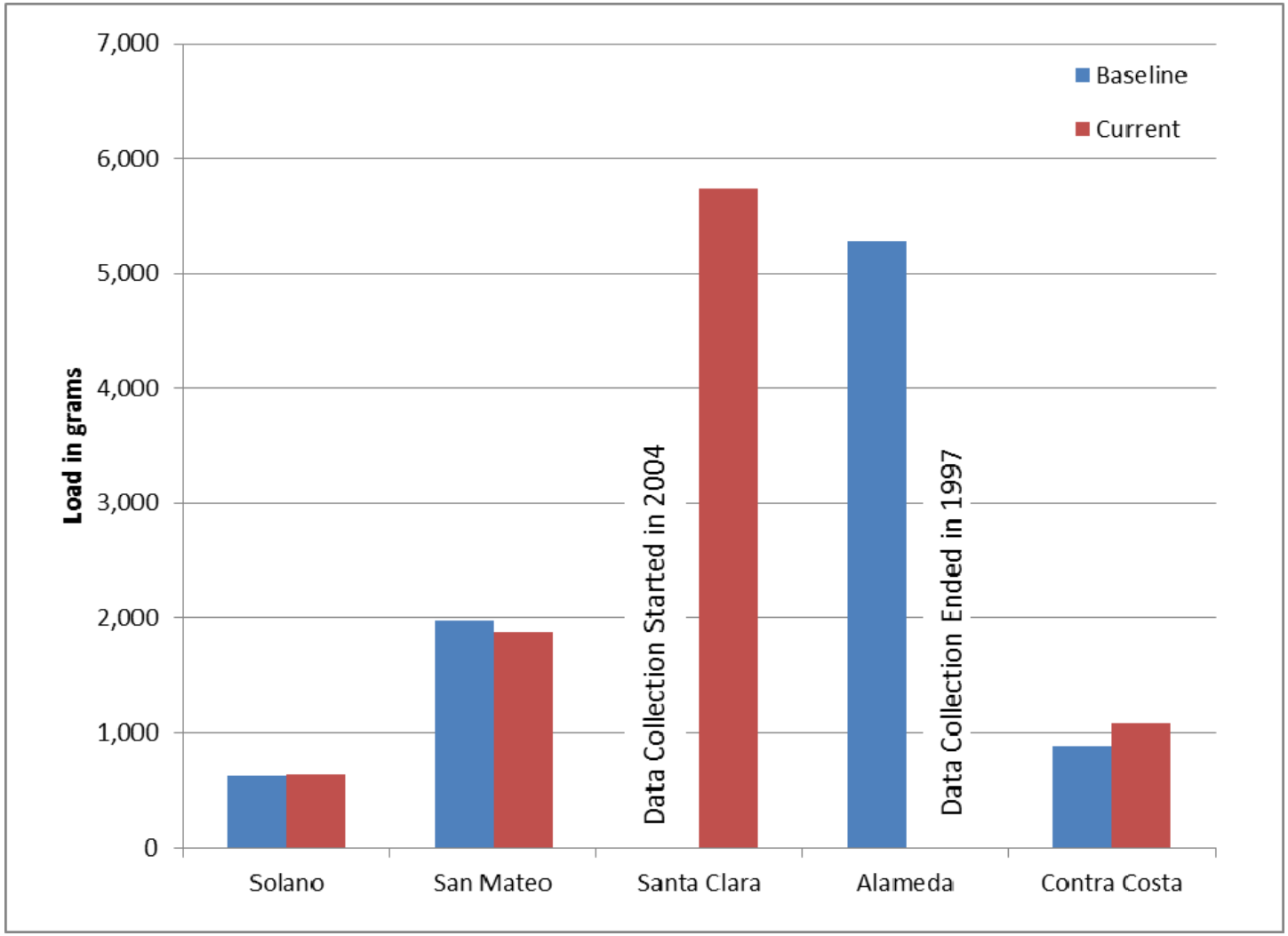
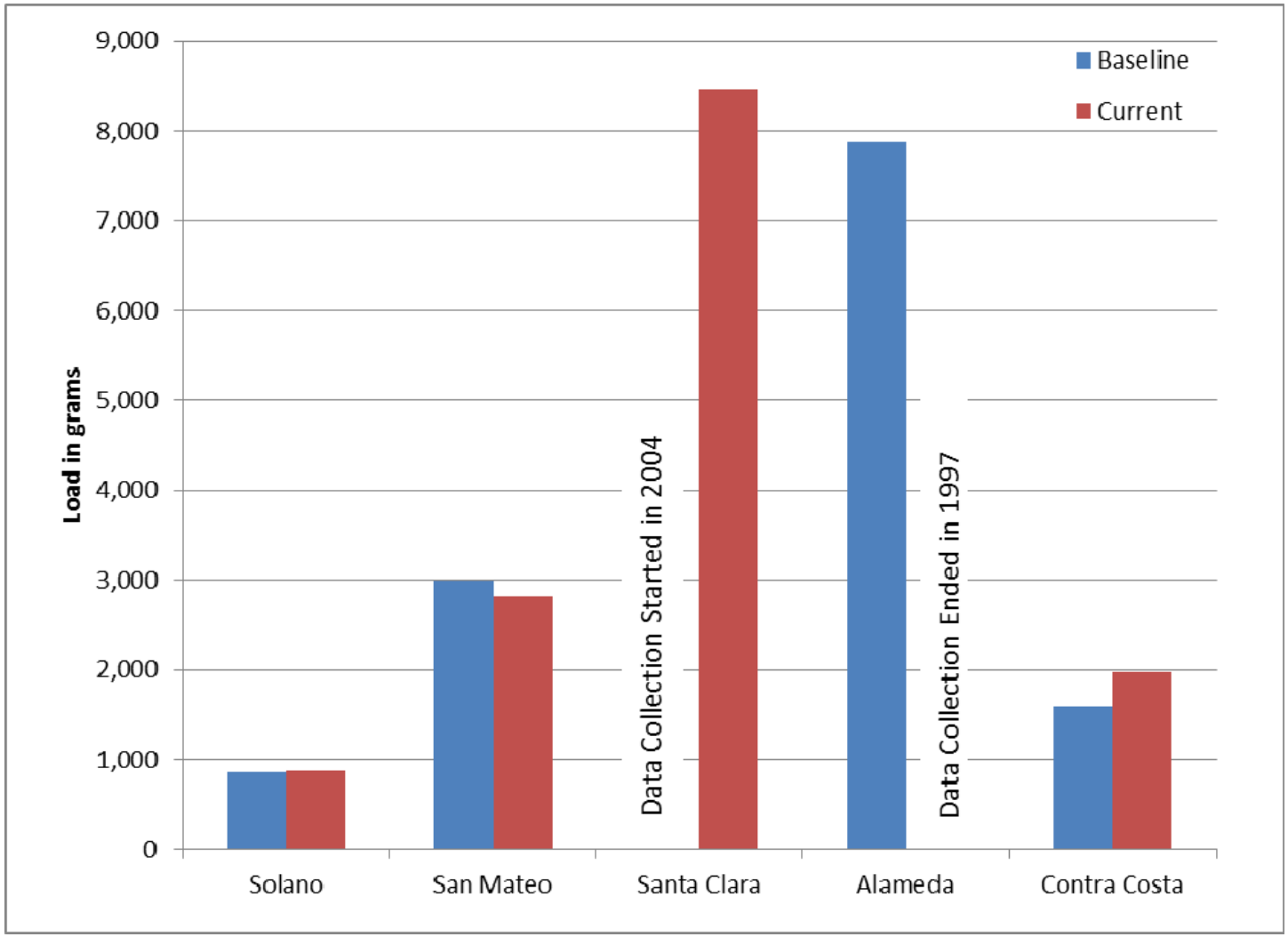


Average Total Annual PCB Load Reduced from Street Sweeping

Source: Data per Appendix Table B.5.1-3	Notes:	Bay Area Stormwater Management Agencies Association	December 2013	Figure B.5.2
		Entity	Date	

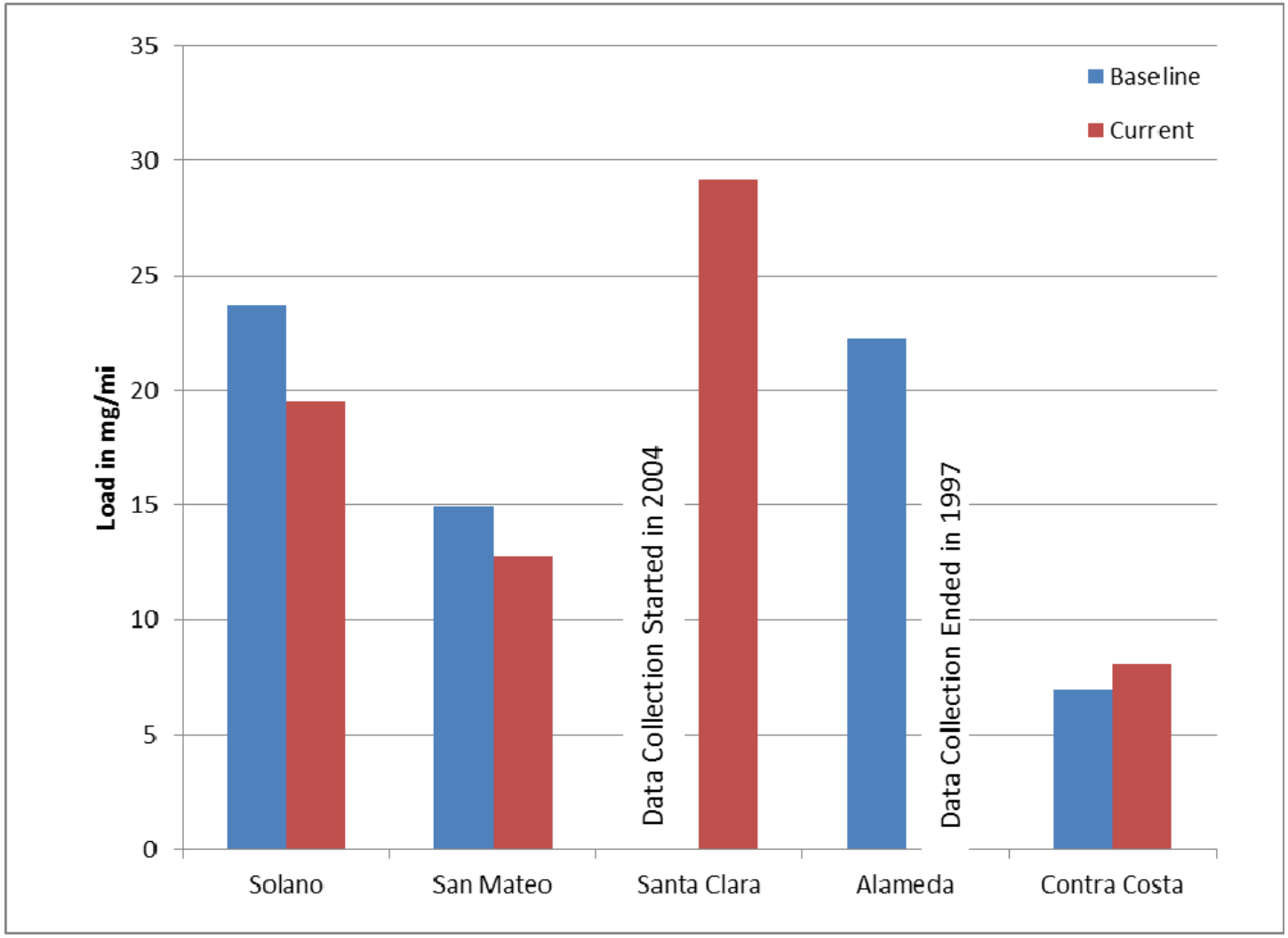
internal info: path, date revised, author



Average Total Annual Mercury Load Reduced from Street Sweeping

Source: Data per Appendix Table B.5.1-3	Notes:	Bay Area Stormwater Management Agencies Association	December 2013	Figure B.5.3
		Entity	Date	

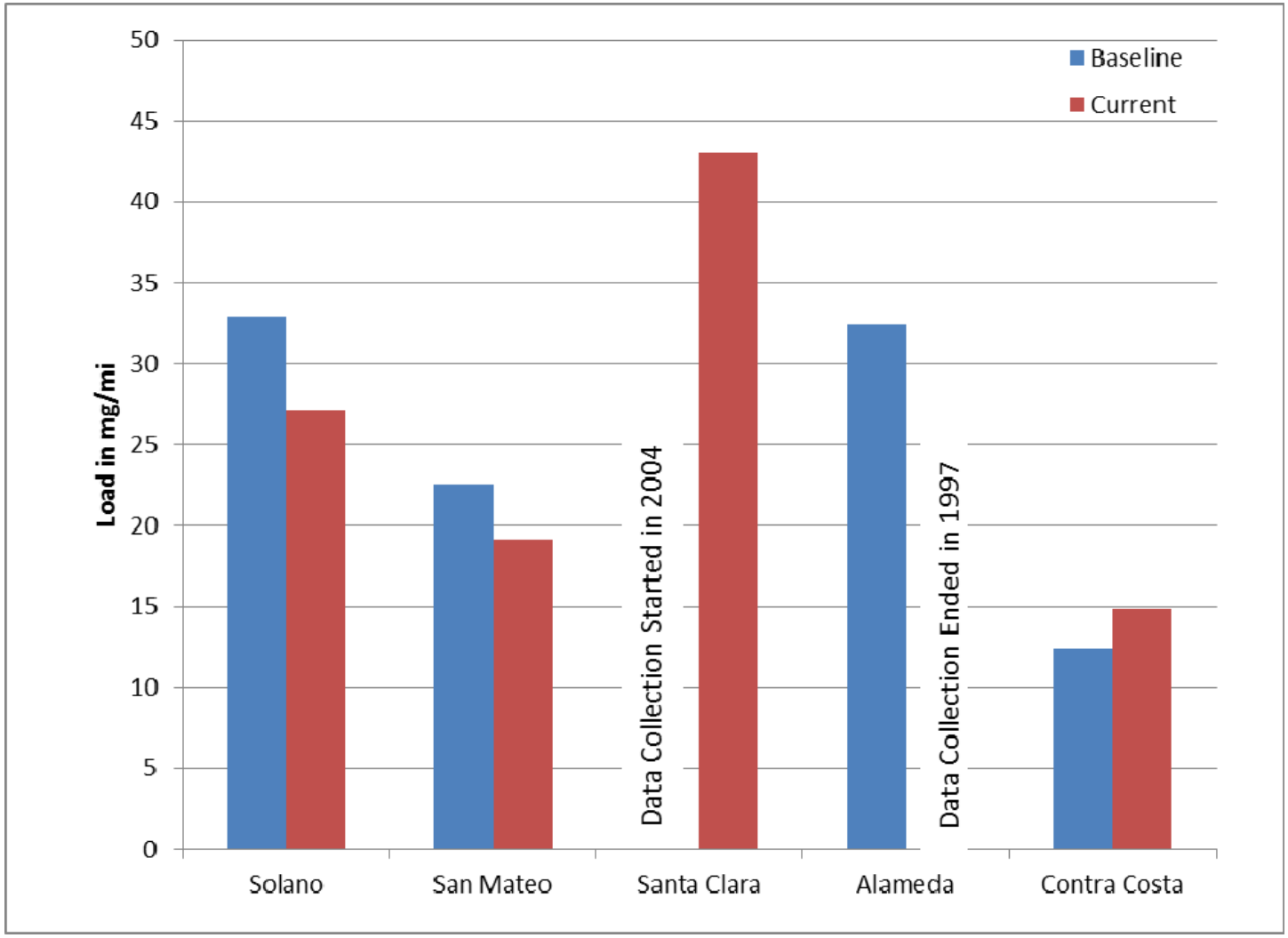
internal info: path, date revised, author



Total PCB Load Reduced per Curb Mile Swept

Source: Data per Appendix Table B.5.1-3	Notes:	Bay Area Stormwater Management Agencies Association	December 2013	Figure B.5.4
		Entity	Date	

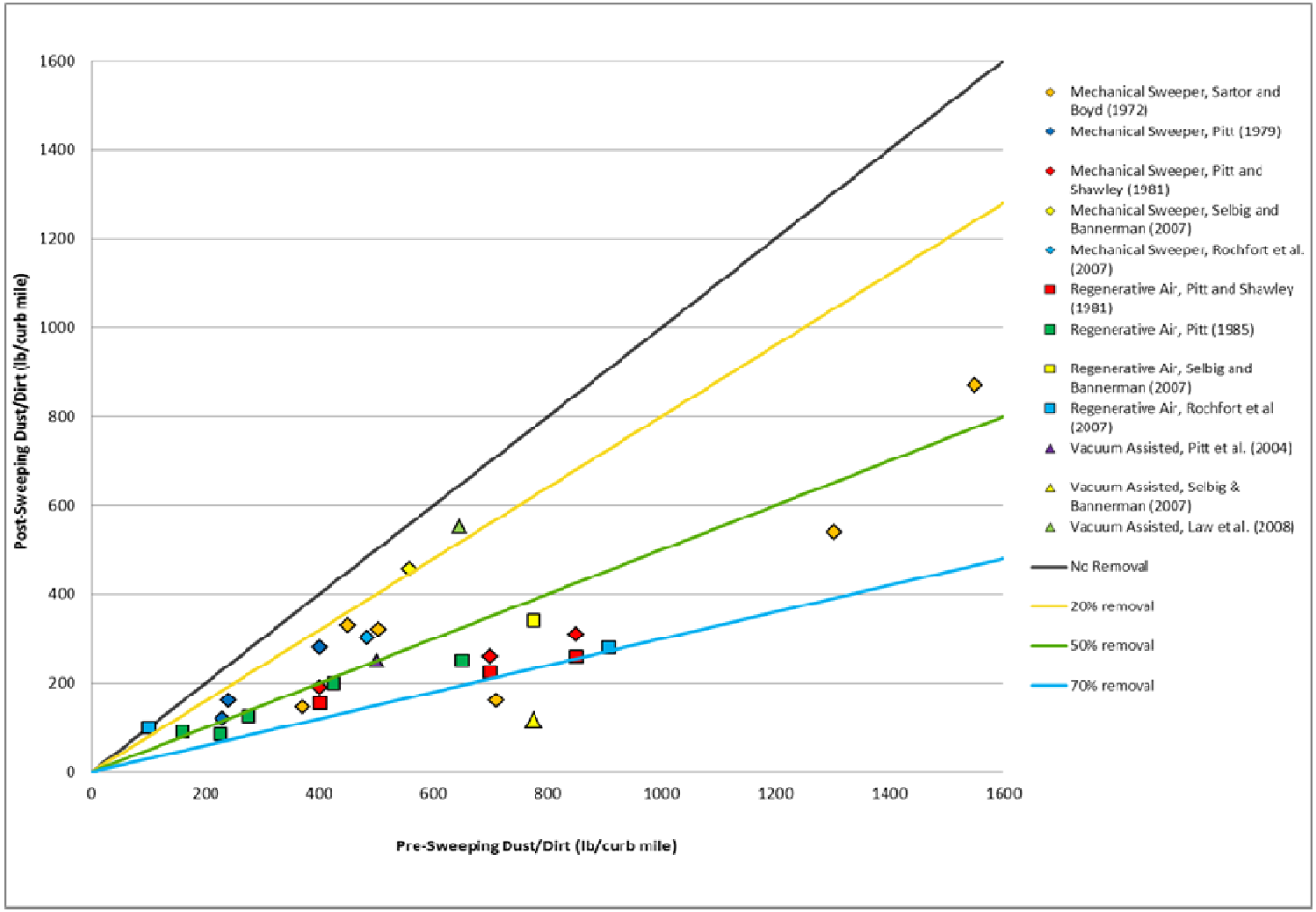
internal info: path, date revised, author



Total Mercury Load Reduced per Curb Mile Swept

Source: Data per Appendix Table B.5.1-3	Notes:	Bay Area Stormwater Management Agencies Association	December 2013	Figure B.5.5
		Entity	Date	

internal info: path, date revised, author



Effectiveness of Different Types of Street Sweepers

Source: EOA Inc. and Geosyntec Consultants (2011)	Notes:	Bay Area Stormwater Management Agencies Association	December 2013	Figure B.5.6
		Entity	Date	

internal info: path, date revised, author

B.6 ENHANCED OPERATION AND MAINTENANCE

B.6.1 Introduction

The term "stormwater conveyance system" refers to the constructed conveyance system designed to transport stormwater to receiving waters during runoff events. The conveyance system includes storm drain inlets, underground pipes, and pump stations. Routine stormwater conveyance system operation and maintenance (O&M) activities include drain inlet cleaning and pump station maintenance. In addition, culverts and channels are also routinely maintained (i.e., "desilting"). A literature review prepared for the Clean Watersheds for a Clean Bay (CW4CB) project entitled *Sediment Management Practices* (EOA, Inc. and Geosyntec Consultants 2011) summarizes municipal sediment management practices and discusses studies that evaluate the effectiveness of stormwater conveyance system maintenance as well as street flushing.

The *Sediment Management Practices* literature review includes a summary of storm drain inlet and catch basin cleaning studies. The majority of these studies focus on the effectiveness of catch basins (with sumps) versus drop inlets (without sumps). Of those, most do not define effectiveness or carry out comprehensive effectiveness evaluations. The studies indicated that pollutant removal effectiveness is affected by various factors including catch basin sump configuration, particle size of the material entering the inlet, maintenance frequency (increased frequency generally increases mass removal), rainfall patterns, and runoff velocity. Inlet cleaning is not being evaluated through an O&M pilot study; however, drain inlet cleaning information provided in the Annual Reports is summarized in Section 3 (as readily available compiled data) to describe the baseline (pre-TMDL[14]) and current (post-TMDL) level of drain inlet cleaning implementation; baseline and current loads reduced from drain inlet cleaning are estimated in Section 4. This analysis demonstrates that cleaning storm drain inlets has some effectiveness for reducing mass loading of polychlorinated biphenyls (PCBs) and mercury to the Bay.

Information from the *Sediment Management Practices* literature review about the effectiveness of pump station cleaning, storm drain line flushing, and street flushing, which are the O&M activities being evaluated through the O&M pilot studies, is briefly summarized below.

B.6.1.1 Pump Station Cleaning

The *Sediment Management Practices* literature review identified very few studies on pump station cleaning effectiveness. Salop (2006) analyzed PCB and mercury concentrations in material collected from two pump stations in September and October 2004, the Ettie Street Pump Station (ESPS) in Oakland, and a pump station associated with a railroad overpass in Pleasanton, adjacent to Valley Avenue near the intersection with Stanley Boulevard. The estimated volume of solids removed during the Pleasanton pump station clean out was 2.4 cubic yards (cy). The

[14] Total Maximum Daily Load

ESPS was not cleaned out during the study, but the estimated amount of solids accumulated in its four wet wells was 33 cy, which did not account for the material accumulated in the pump station forebays. Based on the amounts of solids and the corresponding pollutant concentrations measured, the study estimated that a relatively small mass of PCBs and mercury are removed during cleanouts of most pump station sumps- less than 0.01 kg of PCBs and less than 0.03 kg of mercury from each facility. The study also estimated the PCB mass that would be removed during a single cleanout of the ESPS based on the highest PCB concentration measured in the sumps (since 2000) is 0.3 kg. This demonstrates that estimates of pollutant mass contained within any one depositional facility can vary extensively based on pollutant concentrations measured at one point in time. The study concluded that it is unlikely that any depositional facility but the largest in the most industrialized areas would be expected to exhibit high enough concentrations of a pollutant of concern (POC) to make the accumulated waste at any one time contain a large mass of that POC.

A report for the City of Oakland's source identification project in the Ettie Street Pump Station watershed indicated that since the Alameda County Flood Control and Water Conservation District (ACFCWCD) took over the operation and management of the ESPS in March 1999, sediments in the pump station have been periodically removed (Kleinfelder 2006). The first sediment removal under the ACFCWCD's management was performed in 2001, when 29 cy of material was removed. In 2003, 14 cy of material were removed and in 2006, 61 cy of material were removed (the increased volume removed in 2006 was likely due to heavy rains during the 2005-2006 wet season). The approximate cost for the 2006 cleanout was $27,500, which included labor but not disposal costs as the ACFCWCD disposed of the material at the County yard in Hayward. (Note that the 2006 information differs from the ESPS cleanout information summarized in Section *Estimates of Loads Avoided/Reduced through Enhanced O&M Activities* for the current level of implementation, due to different data sources. Where there are discrepancies, information provided in Section *Estimates of Loads Avoided/Reduced through Enhanced O&M Activities* should be given more weight because it is more recent.)

B.6.1.2 Storm Drain Line Cleaning/Flushing

The *Sediment Management Practices* literature review also identified very few studies about the effectiveness of storm drain line cleaning/flushing. Storm drain cleanout effectiveness is influenced by the frequency of and method of cleanout (Center for Watershed Protection 2006) and the design of the conveyance system. A one-time survey of sediment accumulation in a stormwater conveyance system found that storm drain pipes with significant amounts of sediment accumulation were either sloped less than 1.5% or located close to a source of sediment (Pitt and Field 2004).

In 2005 the City of San Jose cleaned out storm drain inlets, publicly-owned laterals, and the Leo Avenue main line from the western cul-de-sac to South 7th Street (KLI and EOA 2002). Prior to the storm drain line cleaning, the City performed a camera inspection which revealed a dip in the storm drain line where sediment accumulated. It was estimated that the line flushing removed

3,500 kg of solids and approximately 4 grams to 70 grams of PCBs, based on the range of PCB concentrations previously measured in the Leo Avenue storm drain line sediments. The maintenance contractor and City costs for the one-time cleanout was estimated to be about $50,000.

B.6.1.3 Street Flushing

Street flushing was conducted in May 2006 in two areas (totaling 921 linear feet) in the ESPS watershed as a result of abatement activities required by regulatory agencies (Kleinfelder 2006). Excess dry sediment was removed from the streets using a Bobcat excavator or a brush and shovel. Then the streets were cleaned with a high pressure washer (3,000-6,000 pounds per square inch) and the material was collected for disposal. (Note that this activity is a combination of street sweeping and flushing, while the pilot studies will evaluate these components separately.) The abatement removed approximately 1.1 cy of material including 0.6 cy of dry sediment and 0.5 cy of wet sediment from Area 1 (approximately 1.2 tons of sediment assuming a density of 2,925 pounds/cy). For Area 2, 16 cy of dry sediment and 0.6 cy of wet sediment were removed (approximately 18.7 tons of sediment). Based on PCB concentrations of the dry sediment abated, the mass of PCBs removed was 2.8 grams from Area 1 and 5.7 grams from Area 2. The cost for the abatement was approximately $100,000, or $11 per mg of PCBs removed. This included sediment disposal at a hazardous waste facility due to elevated lead concentrations. A year later (in May 2007), Kleinfelder (2007) resampled the two areas to evaluate the effectiveness of the abatement activities. Post-abatement PCB concentrations in sediments were 27 to 94 percent lower than the pre-abatement results; however abatement at a private facility in drainage Area 2 may have contributed to the observed reduction in the post-abatement results.

A study conducted in Paris, France estimated that daily street flushing in a densely populated residential/commercial area contributed 15 percent in loads of suspended solids, organic matter and copper from the catchment to the combined sewer system (Gromaire et al. 2000).

B.6.2 <u>Summary of PCB and Mercury Control Pilot Studies</u>

Implementation Approach

CW4CB Task 4 is anticipated to result in Permittee compliance with Municipal Regional Stormwater NPDES Permit (MRP) Provisions C.11/12.d. This task is pilot-scale evaluation of methods to enhance the pollutant load reduction benefits of municipal operation and maintenance activities that remove sediment from streets and storm drain system infrastructure. Most of the pilot studies will be conducted within the five Bay Area region watersheds with elevated PCB levels selected in CW4CB Task 3.

During FY 2010/11, existing literature was reviewed for information on previous studies related to sediment and pollutant removal during municipal operation and maintenance activities and other information relevant to the pilot evaluations (EOA, Inc. and Geosyntec Consultants 2011)

(Section B.6.1 summarizes the major findings of the *Sediment Management Practices* literature review). The key data gaps and recommendations for the design of future studies in the literature review are summarized in the BASMAA Regional Pollutants of Concern Report FY2010-2011 (BASMAA 2011).

Based on the results of the literature review and discussions with municipal staff, the CW4CB Task 4 sediment management workgroup developed study designs for the O&M pilot studies that will be implemented in 2013, entitled *Clean Watershed for a Clean Bay (CW4CB) Study Designs for Five O&M Pilot Projects* (Study Designs) (Geosyntec Consultants and CSU/OWP 2013). Because the O&M pilot studies were not implemented in time for completion of the IMR, they are described briefly below based on information in the Study Designs. Figure B.6.1 shows the locations of the three O&M pilot studies (the fourth pilot study is an enhanced street sweeping study, which is described in Section B.5).

B.6.2.1 O&M Pilot Study Descriptions

The O&M pilot studies (Figure B.6.1) are designed such that the results are comparable to the extent feasible, by standardizing the analytical suite for the sediment sample analyses to include particle size distribution (PSD), mercury, PCBs, and total organic carbon. In addition, sediment samples may be analyzed for the mercury and PCB concentration in the particle size fraction less than and greater than 63 microns (representing the division between coarse and fine sediment), based on the initial PSD, mercury and PCB results for the whole sample.

Enhanced Pump Station Cleanout Pilot Study

The pilot study entails an enhanced cleanout of the ESPS, which is located in West Oakland at 3465 Ettie Street, adjacent to MacArthur Freeway to the north and Nimitz Freeway to the west. Its drainage catchment is comprised of approximately 954 acres in west Oakland and includes residential, commercial, and industrial land uses. The pump station has four wet wells and a forebay. Cleanout practices have varied over the years; however, the current cleanout protocol consists of an annual dewatering and cleanout (if warranted based on inspection) of the two southern wet wells in late spring or summer (after the rainy season). The cleanout is performed with a vactor truck. Per discussions with pump station personnel, a rough rule of thumb is that if upon inspection greater than 50% of the wet well floor has sediment accumulation greater than 1 foot, the wet well is cleaned out. The two northern wet wells are not cleaned out as part of the annual procedure because these wells cannot be accessed with the existing vactor truck. The forebay is also usually not cleaned as part of the annual maintenance activity.

The pilot study entails enhancing the current annual cleanout to include a clean out of the two northern wet wells, if warranted based on the sediment accumulation observations. This would be achieved via a manual cleanout with wheelbarrows and shovels, cleanout with a new vactor truck planned to be purchased in the summer of 2013, or by renting a more powerful vactor truck that creates more suction and is effective with the longer hose lengths needed to access the north wet wells.. The study will evaluate the increase in load reduction associated with cleaning all

four wet wells and the forebay. Data representing the current O&M activity were collected during the May 2013 cleanout of the southern wet wells and forebay. These data included sediment accumulation measurements and analysis of sediment samples for specific gravity, particle size distribution, and mercury and PCBs and will be used in the evaluation of the pilot study data. The May 2013 data were collected consistent with the methods described in the Study Designs. These data are further discussed in Section *Estimates of Loads Reduced by O&M Activities.*

Key variables that will be measured for the pilot study are as follows:

- Volume and mass of sediment removed in each wet well.
- Particle size distribution of sediment removed.
- Concentration and mass of PCBs and mercury contained in the sediment removed.
- Spatial variation in depth of sediment in the wet wells.
- Costs for implementing the enhancement.

Street Flushing Pilot Study

The street flushing pilot study was implemented in the Pulgas Creek Pump Station watershed in the City of San Carlos. The watershed includes 1.1 km^2 (272 acres) of industrial and commercial land uses. Historically up to 72% of the area was comprised of industrial land use and there is a PG&E substation in the catchment (EOA, Inc. 2012). The pilot study focused on the area south of Brittan Avenue.

The primary objective of the pilot study was to determine the mass of mercury and PCBs removed by street flush and capture. A secondary study objective was to estimate the buildup rate of mercury and PCBs following a flush/capture effort. These data may be helpful in improving the effectiveness of various sediment maintenance efforts such as street sweeping and flushing.

The City of San Carlos maintenance staff implemented single flush and capture events on four dates: September 13, 16, 18 and 20th, 2013. Each event covered 500 to 1,000 feet of complete street width (curb to curb). Each event used two vactor trucks and four maintenance staff for a single day of flushing. The first vactor truck was the water source and used a wand attachment for flushing. The second vactor truck captured the debris and wash water using its vacuum, with no (or little) water allowed to enter the storm system. Wastewater was decanted and disposed of into the sanitary sewer system via an existing hose connection on the vactor truck. The remaining sediment slurry was emptied and dried at the municipal corporation yard and disposed of with other debris routinely collected by maintenance staff.

The current O&M activity in the pilot study area is weekly street sweeping, in addition to annual drain inlet cleaning. Although street flushing could be performed as an enhancement to street

sweeping for future enhanced O&M implementation by the Permittees, street sweeping activities were stopped in two of the four pilot study sub-areas in June 2013. The pilot study was conducted in September 2013. The objective was to evaluate the effectiveness of street flushing with and without the confounding effects of street sweeping. Consistent with the street sweeping pilot study, street sediment samples were collected with a vacuum before and after each flushing event to evaluate street sediment loading.

Due to the availability of field crews, the sampling activities could not be planned to coincide with the wet season. It is recognized that a more practical evaluation of the effectiveness of street flushing requires knowledge of buildup/wash-off phenomena and what is available for wash-off during discrete storm events; this evaluation was beyond the scope of the study design.

The key variables involved in the study design (in addition to cost) are as follows:

- Volume and mass of sediment removed;
- Particle size distribution
- PCB and mercury concentrations in the sediment and decant water from the flushing activity;
- Water used; and
- Water pressure.

Storm Drain Line Cleanout Pilot Study

The pilot project is located in the Leo Avenue watershed in San Jose, CA. The pilot study will be focused on the main storm drain line along Leo Avenue between the western Leo Avenue cul-de-sac and South 7th Street. The pilot study is designed to estimate the load reduction benefit of cleaning out the Leo Avenue main storm drain line in an area with known legacy contamination. This study also aims to document how a video inspection of the stormwater drainage system can facilitate load reduction by identifying sources of polluted sediment in the main line (e.g., surface infiltration in areas with storm drain lines located below legacy contamination or from sediment coming into the main line from private lateral connections).

The goals of this pilot project are as follows:

- Remove accumulated sediment from the Leo Avenue main storm drain line between 7th Street and the Leo Avenue cul-de-sac in San Jose, including any public laterals connected to the line, to the extent possible. Quantify the volume and mass of sediment removed;
- Characterize concentrations of mercury and PCBs in sediments that are removed from the storm drain line;
- Perform a post-cleanout video inspection of the storm drain line to better delineate the stormwater drainage system and identify all private properties that are connected to the

public storm drain line (some connections/line locations are uncertain), and to determine whether cracks or joint separations exist that may allow infiltration of sediment into the storm drain from surrounding buried soils;

- Establish a baseline for comparison.

Current O&M activities conducted by the City of San Jose in the Leo Avenue watershed include street sweeping twice per month and annual drain inlet cleaning. In addition, a previous one-time cleanout of the Leo Avenue storm drain line was conducted in 2005 (as described in Section B.6.1).

B.6.3 Status of Control Measure Implementation

B.6.3.1 Drain Inlet Cleaning

The status of the baseline and current level of implementation was evaluated using readily available drain inlet cleaning data reported by the Permittees in their Annual Reports.[15] (Readily available data means data that were compiled in spreadsheets.) Baseline implementation refers to actions occurring prior to and including Fiscal Year 2001-2002. Current implementation refers to actions occurring post Fiscal Year 2001-2002. Enhanced implementation refers to actions occurring post Fiscal Year 2001-2002 that are above and beyond baseline implementation.

The Permittees reported in their Annual Reports on the total number of drain inlets, the number inspected and/or cleaned, and the volume of material removed from the inlets. Note that the reported number of drain inlets inspected/cleaned is often greater than the total number of inlets in the municipality. This is because some drain inlets were inspected and potentially cleaned more than once per year. The Permittees also record the number of inlets that require more frequent cleaning in their Annual Reports (based on information reported by Contra Costa County Permittees); but this information does not clearly link to the types of O&M enhancements implemented. Data were not available that documented the cleaning frequency for individual inlets. The format of the information available groups inlets that were inspected and cleaned together; therefore it was not possible to identify inlets that were inspected and cleaned versus inlets inspected but not cleaned because of low material accumulation and/or resources.

For each municipality, different years of data were available for the baseline and current implementation periods. For example, baseline data for the San Mateo County municipalities were available for Fiscal Years 2000-2001 and 2001-2002 only, while Alameda County municipalities have baseline data going back to Fiscal Year 1996-1997. San Mateo County municipalities have current data through Fiscal Year 2008-2009 while there are only current data for Alameda County municipalities through Fiscal Year 2004-2005. No drain inlet data were

[15] Data for this evaluation were compiled by EOA, Inc. (data were compiled in May 2011) and the Contra Costa County Clean Water Program. These data are compiled in Appendix Table B.6-1.

compiled for Vallejo and the Annual Reports are not available online. Santa Clara County municipalities do not collect information on drain inlet cleaning.

In addition, there were no drain inlet inspection and cleaning data collected for the MRP permit period because the MRP does not require the Permittees to track and report this type of information. Also, there is no information available to determine the number of drop inlets versus catch basins, but based on personal communications with a number of Permittee staff, it is believed that a majority of the storm drain inlets in the Bay Area are drop inlets and not catch basins that include a sump for sediment/debris storage.

Appendix Table B.6.A.1 summarizes the baseline and current implementation efforts in terms of average number of drain inlets inspected/cleaned per year, the average annual volume of material removed by inlet cleaning, and the average volume of material removed per inlet inspected/cleaned (rate) for each individual municipality.

It is challenging to compare the baseline and current level of implementation in terms of the change in the average volume of material removed per inlet inspected/cleaned (rate). This is because the number of inlets inspected but not cleaned was grouped with the number of inlets that were cleaned out; this effectively decreases the rate because it distributes the total volume of material removed over more inlets, an unknown number of which did not have any material removed. Further, it cannot be assumed that an increase in the rate for the current period for any individual municipality is due to an increased level of implementation, as this does not efficiently capture an increased inspection frequency.

The inlet cleaning data for Fairfield, Woodside, unincorporated Alameda County, Suisun City, and San Leandro showed (potentially unrealistically) high rates for the baseline and/or current implementation periods (unincorporated Alameda County had the highest rates; e.g., high means more than 1 cy of material removed per inlet inspected/cleaned). This variation could reflect that the municipality cleaned out more catch basins rather than drop inlets. Catch basins in some areas may have accumulated more vegetative waste or illegally dumped material. Potentially, material removed from culverts was included in the drain inlet estimates. Incorporate these high removal rates would skew the average amount of material removed when evaluating the level of implementation for each countywide program area.

Summary statistics for the volume of material removed (cy) per drain inlet inspected/cleaned for each countywide program are provided in Table B.6.3.1. and

Table B.6.3.2. for the baseline and current conditions, respectively, based on the Permittee reported values in Appendix Table B.6.A.1. Appendix Figure B.6.A.1 illustrates the information in Appendix Table B.6.A.1 graphically for each countywide program.

Table B.6.3.1. Summary Statistics on Reported Values for Volume of Material Removed per Drain Inlet Inspected/Cleaned for the Baseline Condition (per Appendix Table B.6.1-1)

Countywide Program	25th Percentile (cy/inlet)	Average (cy/inlet)	Standard Deviation (cy/inlet)	50th Percentile (cy/inlet)	75th Percentile (cy/inlet)
Solano	2.18	3.74	4.41	3.74	5.30
San Mateo	0.14	0.39	0.39	0.36	0.48
Alameda	0.04	0.72	1.81	0.12	0.48
Contra Costa	0.06	0.32	0.39	0.16	0.53
All Municipalities	0.07	0.57	1.28	0.20	0.54

Table B.6.3.2. Summary Statistics on Reported Values for Volume of Material Removed per Drain Inlet Inspected/Cleaned for the Current Condition (per Appendix Table B.6.1-1)

Countywide Program	25th Percentile (cy/inlet)	Average (cy/inlet)	Standard Deviation (cy/inlet)	50th Percentile (cy/inlet)	75th Percentile (cy/inlet)
Solano	1.21	1.70	1.38	1.70	2.19
San Mateo	0.15	0.35	0.28	0.24	0.46
Alameda	0.05	4.77	4.40	0.11	0.39
Contra Costa	0.03	0.18	0.22	0.07	0.30
All Municipalities	0.06	1.54	7.47	0.19	0.41

Because data from certain municipalities were causing the countywide estimates to be biased high, an alternate method was used to evaluate level of effort on a countywide program basis, which entailed assigning "representative" "low", "medium" and "high" removal rates based on a statistical analysis of the Permittee baseline and current data set. "High" removal rates were considered to be the 75th percentile rate and above; "medium" rates were between the 25th and 75th percentile; and "low" removal rates were values less than the 25th percentile for all countywide program data. The baseline and current 25th, 50th and 75th percentile values are provided in

Table B.6.3.3, for the entire data set. Each individual municipality was assigned a new removal rate based on the ranking method (see Appendix Table B.6.A.2) and then the countywide rate was calculated as the average rate of all the individual municipalities within that countywide program. The new rates assigned for each countywide program based on the statistical, for the baseline and current periods, are summarized in

Table B.6.3.4 and Table B.6.3.5, and also illustrated in Figure B.6.2. Per Figure B.6.2, the current average volume of material removed per inlet is lower than the baseline rate for all countywide programs. Baseline rates ranged from 0.24 cy/inlet to 0.54 cy/inlet. Current rates ranged from 0.13 cy/inlet/inlet to 0.31 cy/inlet.

Table B.6.3.3. Rank (Percentile) Values Calculated for Volume of Material Removed per Drain Inlet Inspected/Cleaned for the Baseline and Current Conditions

Countywide Program	Low (25th Percentile) (cy/inlet)	Medium (50th Percentile) (cy/inlet)	High (75th Percentile) (cy/inlet)
Baseline	0.07	0.20	0.54
Current	0.04	0.11	0.31

Table B.6.3.4. Summary Statistics for Volume of Material Removed per Inlet Cleaned/Inspected for Baseline Period Using the Ranking Method (Table B.6.3.3.)

County	25th Percentile (cy/inlet)	Average (cy/inlet)	Standard Deviation (cy/inlet)	50th Percentile (cy/inlet)	75th Percentile (cy/inlet)
Solano	0.54	0.54	0.00	0.54	0.54
San Mateo	0.20	0.25	0.15	0.20	0.20
Alameda	0.07	0.24	0.20	0.20	0.37
Contra Costa	0.07	0.24	0.18	0.20	0.29
All Municipalities	0.10	0.25	0.18	0.20	0.45

Note: See Appendix Table B.6-2 for ranking values assigned to individual municipalities.

Table B.6.3.5. Summary Statistics for Material Collected per Inlet Cleaned/Inspected for Current Period Using the Ranking Method (Table B.6.3.3.)

County	25th Percentile (cy/inlet)	Average (cy/inlet)	Standard Deviation (cy/inlet)	50th Percentile (cy/inlet)	75th Percentile (cy/inlet)
Solano	0.31	0.31	0.00	0.31	0.31
San Mateo	0.11	0.19	0.10	0.11	0.31
Alameda	0.09	0.14	0.10	0.11	0.16
Contra Costa	0.04	0.13	0.10	0.11	0.11
All Municipalities	0.11	0.16	0.11	0.11	0.31

Note: See Appendix Table B.6-2 for ranking values assigned to individual municipalities.

B.6.3.2 Pump Station Cleaning

Information about the number of pump stations cleaned out each year and the volume of material removed was not available in a compiled format. Information about pump stations in the MRP area was provided by EOA, Inc.[16] Pump station attribute data was also accessed from a data base provided by SFEI, containing data from 279 pump stations in the Bay Area. These data include the pump station location, maximum pumping capacity, tributary area, and dominant land uses.

[16] SFBRWQCB 2010. Compiled version of Municipal Regional Permit Associated Stormwater Pump Station Locations and Characteristics. Submitted by Permittees to the San Francisco Bay Regional Water Quality Control Board (SFBRWQCB) in compliance with Provision C.2.d.ii.(1) of the MRP (Board Order No. 2009-R2-0074). March.

Table B.6.3.6 summarizes the number of pump stations from the database in each countywide program area, including the total number of pump stations, the number of Caltrans operated pump stations and the number of non-Caltrans operated pump stations with dominant industrial land use in the tributary area. The number of pump stations with industrial land use was derived from the pump stations listed as having dominant industrial land use in the tributary area in the database and pump stations within 200 feet of old industrial land use based on the old industrial GIS layer.[17]

The database was used to characterize the distribution, pumping capacity, tributary area, and dominant land use of pump stations around the bay area. Since Ettie Street is a highly industrialized watershed, the database was filtered to only include pump stations with a tributary area that is dominated by industrial land use or is within 200 feet of land areas that have been classified as old industrial. Additionally, to limit the analysis to municipally operated pump stations, all pump stations that are operated by Caltrans were filtered out as well. A summary of the pump station attributes is provided in Table B.6.3.6 and

Table B.6.3.7 includes information for the non-Caltrans operated pump stations with tributary areas containing dominant industrial land use.

Table B.6.3.6. No. Pump Stations in MRP Area

	Alameda County	Contra Costa County	San Mateo County	Santa Clara County	Solano County	Total
Total Pump Stations	68	28	67	111	4	279
Caltrans Operated Pump Stations	20	5	8	28	0	62
Non-Caltrans Operated Pump Stations with Industrial Land Use	9	1	22	17	0	49

Table B.6.3.7. Average Maximum Pumping Capacity and Tributary Area for Non-Caltrans Pump Stations with Industrial Land Use.

Non-Caltrans Pump Stations with Industrial Land Use	Alameda County	Contra Costa County	San Mateo County	Santa Clara County
Average Maximum Pumping Capacity (Gal/Min)	148,728	45,000	18,719	23,761
Average Tributary Area (Acres)	737	666	65	129

[17] SFEI and EOA, 2013. Draft GIS datalayers depicting Old Industrial (constructed pre-1968).

This information was used to estimate PCB and mercury load reductions from pump station cleaning, based on more detailed information known about pump station cleanouts at the ESPS. Load reduction estimates are discussed in the next section.

B.6.4 Estimates of Loads Avoided/Reduced

This section presents the methodology for estimating loads reduced by baseline and current implementation efforts for drain inlet cleaning and pump station cleaning, and a methodology for evaluating the increase in load reduction from enhanced O&M implementation, which includes drain inlet cleaning and pump station cleaning. Two different load reduction methodologies are presented for pump stations. This section also includes load reduction estimates for the baseline and current level of implementation for each countywide program. In addition an estimate of the annual load reduced is provided for the pilot study areas based on current practices, as is an evaluation of how the additional load reductions achieved from implementing O&M enhancements could be quantified.

B.6.4.1 Loads Avoided/Reduced Methodology (Bay Area-Wide)

The baseline, current and enhanced load reduction methodology presented in this section has been adapted from the methodology presented in the Draft Technical Memorandum entitled "*Methods for Quantifying Mercury and PCB Loads Reduced from Urban Stormwater Runoff, Assessing Municipal Stormwater Program Progress Towards TMDL Wasteload Allocations Through Control Measure Implementation*" (EOA, Inc. 2011).

Drain Inlet Cleaning

The baseline and current load reduction achieved by drain inlet cleaning may be calculated as follows:

$$Baseline_{DI} = Vol_{Baseline\ DI} \bullet \%Sed_{DI} \bullet \rho_{DI} \bullet Conc_{DI}$$

And:

$$Current_{DI} = Vol_{Current\ DI} \bullet \%Sed_{DI} \bullet \rho_{DI} \bullet Conc_{DI}$$

Where:

$Vol_{BaselineDI}$ = Average volume of drain inlet material collected in baseline years (prior to and including Fiscal Year 2001-2002)

$Vol_{CurrentDI}$ = Average volume of drain inlet material collected in current years (post Fiscal Year 2001-2002)

$\%Sed_{DI}$ = Percent of material collected from drain inlets that is "sediment"[18] (by volume)

[18] For purposes of this document, drain inlet sediment is defined as the material that would pass through a 2 mm sieve.

ρ_{DI} = Density of the drain inlet sediment (weight per unit volume)

$Conc_{DI}$ = Average (or measured) concentration of mercury or PCBs in street sweeping sediments collected. Note that the same concentration was used for baseline and current load reductions

Note that units and unit conversation factors must be supplied by the user.

Therefore, the enhanced load reduction may be calculated as follows:

$$Enhanced_{DI} = Current_{DI} - Baseline_{DI}$$

Assumptions and Data Inputs

- Volume of Material Collected ($Vol_{Baseline\ DI}$ and $Vol_{Current\ DI}$). The volume of material removed from drain inlets has been reported by the Permittees in their Annual Reports (see Appendix Table B.6-1 for baseline and current level of implementation). Note that the years for which these data are available vary by municipality, and different years form the basis for the baseline and current periods depending on the municipality. Therefore the average annual volume of material removed for the baseline and current implementation period was used for this load reduction analysis.
- Percent of Drain Inlet Material That is "Sediment" ($\%Sed_{DI}$). For the purposes of this analysis, it is assumed than material less than 2 mm is sediment. The estimate for the percent of drain inlet material that is less than 2 mm comes from Salop (2006). Salop evaluated the characteristics of gross solids collected during drain inlet cleaning operations in Bay Area cities and estimated sediment/vegetative debris less than 2 mm in diameter accounted for approximately 60 percent (by volume) of total solids collected during street sweeping operations in Alameda County. Therefore $\%Sed_{DI}$ was assumed to be 60 percent for the baseline and current load reduction analysis.
- Drain Inlet Sediment Density (ρ_{DI}) – The material removed from drain inlets is typically reported as a volume (cy). To calculate pollutant loads reduced, the volume of material must be converted into a mass using an assumed bulk density for the material. In support of the California Integrated Waste Management Act of 1989, FEECO International developed densities for a variety of waste materials. These densities continue to be utilized by the California Department of Resources Recycling and Recovery (CalRecycle 2013). In addition FEMA (2010) developed the "Debris Estimating Field Guide" which has densities for waste materials. The dry bulk density used for this analysis was estimated using the average density determined by these two sources; the selected density assumes the material is 30 percent vegetative debris by volume and the remaining volume

is dry sand. Therefore, the assumed bulk density for dry material[19] less than 2 mm is 1,811 pounds per cubic yard.

- Concentration of Mercury/PCBs in Drain Inlet Sediment ($Conc_{DI}$) Concentration data for sediment samples collected from drain inlets in the Bay Area and compiled into the SFEI database (SFEI 2010; KLI and EOA 2002; City of San Jose and EOA 2003) were used to represent the concentrations in sediment removed by drain inlet cleaning. Table B.6.4.1 summarizes the mean mercury and PCB concentrations from the SFEI database for each county, which were used to estimate the load reductions (the median concentrations are also included). If the total number of drain inlet sediment samples was eleven (11) or greater for a specific municipality (a reasonable cut off based on the data analysis), the municipality-specific mercury or PCB concentration was used to estimate the load reduction for that municipality. If the number of samples for a municipality was less than eleven, the mean concentration for the county was used to estimate the load reduction for that municipality. The same concentration was used to estimate the baseline and current load reductions. So it is assumed that there was no significant decrease in POC concentrations for the current period due to true source control or POC transformation/degradation.

Pump Station Cleaning

The baseline and current load reduction achieved by pump station cleaning may be calculated as described above in Section *Drain Inlet Cleaning*. The volume of material removed is reported in Annual Reports; the data are not included in this section because the information was not compiled and available in spreadsheet form.

[19] FEMA estimate was calculated from the conversion factor given for 70% dry sand, 30% vegetation and trash of 69 pounds per cubic foot or 1,870 pounds per cubic yard. CalRecycle estimate was calculated from the conversion factor given for "wet sand" of 110-130 pounds per cubic foot, and converting to a dry density by applying a porosity of 0.35 (porosity from Linsley and Franzini, Water Resources Engineering, 1964), which results in a dry bulk density of 1,752 pounds per cubic yard. The "best" (average) density estimate, 1,811 pounds per cubic yard, is equivalent to 821.5 kg per cubic yard.

Table B.6.4.1. Drain Inlet Sediment Concentration Data Used to Estimate Load Reductions

Municipality	PCBs			Mercury		
	No. Drain Inlet Sediment Samples	Mean PCB DI Sediment Concentration (mg/Kg)	Median PCB DI Sediment Concentration (mg/Kg)	No. Drain Inlet Sediment Samples	Mean Mercury DI Sediment Concentration (mg/Kg)	Median Mercury DI Sediment Concentration (mg/Kg)
Fairfield & Suisun	8	0.244	0.055	16	0.510	0.228
San Mateo County Municipalities	29	0.318	0.123	28	0.160	0.147
San Carlos	22	0.267	0.129	25	0.167	0.147
Alameda County Municipalities	47	0.294	0.122	75	0.384	0.204
Berkeley	8	0.147	0.122	11	0.343	0.241
Oakland	24	0.402	0.155	28	0.539	0.297
San Leandro	11	0.219	0.106	21	0.230	0.151
Contra Costa County Municipalities	46	0.515	0.168	48	0.413	0.308
Richmond	31	0.736	0.482	28	0.460	0.349

Notes:
Mean and median drain inlet sediment concentrations were calculated from the SFEI database (SFEI 2010, KLI and EOA 2002; City of San Jose and EOA 2003).

The percent of material that is sediment was assumed to be 60% for drain inlet materials. Even though pump stations include trash and debris, data are often reported as the volume of sediment removed, as opposed to the volume of total material (as is the case for the ESPS clean out data discussed in this section). Therefore, it is assumed that the reported volume of material removed from pump stations is primarily sediment, which is consistent with Salop (2006); therefore the percent of material removed that is sediment is assumed to be 100 percent.

Concentration data for sediment samples collected from pump stations in the Bay Area and compiled into the SFEI database (SFEI 2010; KLI and EOA 2002, City of San Jose and EOA 2003) were used to represent the concentrations in sediment removed by pump station cleaning. Table B.6.4.2 summarizes the mean mercury and PCB concentrations from the SFEI database for each county, which may be used to estimate the load reductions (the median concentrations are also included). There are no pump station sediment data for Contra Costa or Solano County municipalities.

Table B.6.4.2. Pump Station Sediment Concentration Data That May be Used to Estimate Load Reductions

County	PCBs			Mercury		
	No. Pump Station Sediment Samples	Mean PCB Pump Station Sediment Concentration (mg/Kg)	Median PCB Pump Station Sediment Concentration (mg/Kg)	No. Pump Station Sediment Samples	Mean Mercury Pump Station Sediment Concentration (mg/Kg)	Median Mercury Pump Station Sediment Concentration (mg/Kg)
San Mateo[1]	17	0.628	0.116	9	0.176	0.100
Santa Clara[1]	6	0.026	0.018	7	0.179	0.160
Alameda[1]	5	0.900	.315	2	0.579	0.575
Contra Costa[2]	NA	0.518	NA	NA	0.311	NA

[1] Data for San Mateo and Santa Clara are entirely from the SFEI Database. Alameda County statistics were calculated from five samples collected from the ESPS in 2000, 2001, 2004, 2006, and 2013.
[2] In the absence of pump station sediment data for Contra Costa County, the Contra Costa County concentrations are an estimate derived from the arithmetic mean of the other counties.

Storm Drain Line Cleaning

Storm drain line cleaning is not a regular O&M activity.

Street Flushing

Street flushing is not a regular O&M activity.

B.6.4.2 Alternate Method for Estimating Load Reductions from Pump Station Cleaning

Because information about the volume of material removed during pump station cleaning was not available as compiled information, load reduction achieved by pump station cleaning was estimated using ESPS information on mass load reductions of PCBs and mercury, and the volume of material removed, to estimate mass removal from the other pump stations with dominant industrial land use in the tributary area (Table B.6.3.6) based on the ratio of the maximum pumping capacity and tributary area (ratio between ESPS and selected pump station of interest). Two different methods were used as described below.

Method 1: Normalization Based on ESPS PCB and Mercury Mass Load Reductions

Method one estimates a range of potential PCB and mercury load reductions at each non-Caltrans operated pump station with industrial land use by normalizing the ESPS load reductions (Table B.6.4.3.) by the catchment area or the pumping capacity at the ESPS and the pump station of interest. The data were normalized using both the maximum pump station capacity and tributary because there was no correlation observed between pump station capacity and tributary area as follows:.

$$PCB\ or\ Hg\ removal = PCBor\ Hg\ Removal\ at\ Ettie\ Street \times \frac{Tributary\ Area}{Ettie\ Street\ Tributary\ Area}$$

Or

$$PCB\ or\ Hg\ removal = PCB\ or\ Hg\ Removal\ at\ Ettie\ Street \times \frac{Maximum\ Pump\ Station\ Capacity}{Ettie\ Street\ Pump\ Station\ Capacity}$$

A high and low estimate was calculated for each normalization method, based on the highest and lowest load reduction estimate at the ESPS (Table B.6.4.3.).

Method 2: Normalization Based on ESPS Volume of Material Collected

Method 2 estimates a high and low range of PCB and mercury load reductions at each non-Caltrans operated pump station with industrial land use by normalizing the volume of material removed at the ESPS (Table B.6.4.3., a high and low estimate of the volume of material removed was used) by the catchment area or the pumping capacity at ESPS and the pump station of interest (as described above). A mass removal was then estimated using the ESPS sediment density (measured from May 2013 samples) and county-specific sediment concentrations summarized in Table B.6.4.2. Using Method 2, ESPS sediment concentrations are not biasing the load reduction estimates for pump stations in other countywide program areas.

B.6.4.3 Methodology for Evaluating Loads Avoided/Reduced through Enhanced O&M in the Pilot Study Areas

The increase in loads reduced in the pilot study areas due to the enhanced O&M activities that will be implemented for the pilot studies can be expressed through an enhancement factor (F_e), where:

$$\textbf{Load Reduction}_{\textbf{Enhanced}} = \textbf{Load Reduction}_{\textbf{Current}} \bullet F_e$$

B.6.4.4 Estimates of Loads Avoided/Reduced through Enhanced O&M Activities

Bay-Area Wide Drain Inlet Cleaning

Using the methodology described above in Section *Drain Inlet Cleaning*, Appendix Table B.6-3 summarizes the estimated average annual PCB and mercury loads reduced by drain inlet cleaning for the baseline and current implementation periods, using the reported data. Appendix Table B.6-4 summarizes the average annual load reductions using the ranking method, and this is illustrated in Figure B.6.3 for PCBs and Figure B.6.4 for mercury. As shown in Figure B.6.3 for PCBs and Figure B.6.4, average annual load reductions are higher for the current period than for the baseline period for all countywide programs, for both PCBs and mercury. The average load reduction per inlet inspected/cleaned is provided in Figure B.6.5 and Figure B.6.6, for PCBs and mercury respectively.

Bay-Area Wide Pump Station Cleaning

Using the methodologies described above in Section *Alternate Method for Estimating Load Reductions from Pump Station Cleaning*, Figure B.6.7 through Figure B.6.10 show estimates of high and low PCB and mercury load reductions from non-Caltrans-operated pump stations with dominant industrial land use based on ESPS mass load reduction estimates; these figures show estimates based on normalizing the ESPS load reduction based on maximum pumping capacity and tributary area. Figure B.6.11 through Figure B.6.14 show estimates of high and low PCB and mercury load reductions from non-Caltrans-operated pump stations with dominant industrial land use based on ESPS material volume removal estimates and county-specific pump station sediment concentrations as summarized in Table B.6.4.2. Whether the tributary area or maximum pumping capacity normalization method yielder the higher estimate depending on the specific countywide program. Method 1(using ESPS load reduction calculations as the basis for all pump stations) yielded higher estimates than Method 2, which entailed estimating load reductions based on ESPS material volume removal and county-specific pump station sediment concentrations.

Bay-Area Wide Storm Drain Line Flushing

Load reduction estimates are not provided because storm drain line flushing is not a regular O&M activity.

Pilot Study Areas

This section provides projected estimates of loads reduced in the pilot study areas for the current implementation period, which have been compiled from various data sources. This section also provides summaries of enhancement factors, cited from other data sources, which could be achieved by implementing enhanced O&M practices in the pilot study areas.

Ettie Street Pump Station Cleanout

Table B.6.4.3 summarizes the volume of material removed annually by the pump station cleanouts and the estimated loads of mercury and PCBs reduced. This information is summarized from the Task 4 Study Designs (Geosyntec Consultants and CSU/OWP 2013) and Kleinfelder (2006). The load reduction methodology is consistent with the methodology described in Section *Loads Avoided/Reduced Methodology (Bay Area-Wide)*, except that all of the material removed from the pump station was documented as being sediment (therefore a percentage of the total volume of material that is sediment was not estimated), and the material was assumed to have a dry sediment density 1,376 kg per cy, which is the actual measured bulk density for the samples from ESPS wet wells 3 and 4, collected on May 14, 2013. The ESPS sediment concentrations were from data collected between 2001 and 2013. Load reduction estimates are provided using the low, high, and average concentrations in sediment removed during pump station cleanouts.

As a comparison, Table B.6.4.4 provides the influent load estimates for mercury and PCBs from the ESPS wastewater treatment plant diversion study (EBMUD 2010). The annual PCB influent loading calculated based on the diversion study data (Table B.6.4.4) is 172 grams compared to an annual load reduced by pump station cleaning based on the mean ESPS sediment concentration (Table B.6.4.3), which ranges from about 2.5 to 69 grams per year, depending on the year (and excluding years when no sediment was removed). The annual mercury influent loading calculated based on the diversion study data (Table B.6.4.4) is 186 grams compared to an annual load reduced by pump station cleaning based on the mean sediment concentration (Table B.6.4.3), which ranges from about 2.4 to 45 grams per year, depending on the year (and excluding years when no sediment was removed).

The enhancement factor F_e will be determined based on the increase in the mass of mercury and PCBs removed by cleaning out the two northern wet wells and the forebay, which is the enhancement over the current condition. It is reasonable to expect that F_e will be approximately 2.

Pulgas Creek Pump Station Watershed Street Flushing

Street Flushing is currently not performed in this watershed (other than the pilot study), and the current O&M activity is drain inlet cleaning (in addition to street sweeping). Current load reductions from drain inlet cleaning activities in the watershed were estimated in the Task 4 Desktop Analysis (EOA 2012), and are summarized in Table B.6.4.5. Depending on the concentration used, the annual PCB load reduction from drain inlet cleaning ranges from 0.09 to 0.73 grams per year, and the annual mercury load reduction ranges from 0.2 to 0.66 grams per year.

Table B.6.4.3. Estimated Current Annual Load Reduction from ESPS Cleanouts

Year	Number of Cleanings Per Year	Material Removed Per Year (cy)	Mass of PCBs Removed (grams)[1]			Mass of Mercury Removed (grams)[1]		
			Low (28 µg/kg)	High (3263 µg/kg)	Mean[2] (900 µg/Kg)	Low (270 µg/kg)	High (940 µg/kg)	Mean[2] (579 µg/kg)
2001	1	29	1.12	130.2	35.92	10.78	37.52	23.10
2003	1	14	0.54	62.9	17.34	5.20	18.11	11.15
2004	1	3	0.08	13.5	3.72	1.11	3.88	2.39
2005	1	14	0.36	62.9	17.34	5.20	18.11	11.15
2006	3	56	1.44	251.5	69.37	20.81	72.44	44.60
2008	2	26	0.67	116.8	32.21	9.66	33.63	20.71
2009	0	0	0	0.0	0.00	0.00	0.00	0.00

Year	Number of Cleanings Per Year	Material Removed Per Year (cy)	Mass of PCBs Removed (grams)[1]			Mass of Mercury Removed (grams)[1]		
			Low (28 µg/kg)	High (3263 µg/kg)	Mean[2] (900 µg/Kg)	Low (270 µg/kg)	High (940 µg/kg)	Mean[2] (579 µg/kg)
2011	0	0	0	0.0	0.00	0.00	0.00	0.00
2013[3]	1	13.3	--	--	2.49	--	--	3.23

[1] The mass removal calculations use a dry bulk density of 1,376 kg/cubic yard, which is the density measured for samples from Wet Wells 3 and 4, collected May 14, 2013.
[2] The mean concentration was calculated using the data included in the Study Designs Table 2-1 (Geosyntec Consultants and CSU-OWP. 2013), and the Ettie Street wet well data from samples collected on May 14, 2013.
[3] The 2013 mass removed was calculated using the mean concentration for the samples collected on May 14, 2013, and not the mean concentration listed above. The mean PCB concentration was 132 µg/Kg and the mean mercury concentration was 225 µg/kg.

Table B.6.4.4. ESPS Influent Loading Estimates from EBMUD Diversion Study

Weather Type	Days of weather condition	PCBs			Mercury		
		ESPS Influent Average Concentration (pg/L)	Total ESPS Influent Pollutant Loading (kg/day)	Annual Load [g]	ESPS Influent Average Concentration [µg/L]	Total ESPS Influent Pollutant Loading [kg/day]	Annual Load [g]
Dry Weather	300	4,647	0.00001	3	0.01	0.00003	9
Wet Weather	60	50,517	0.00270	162	0.04	0.0024	144
First Flush	5	36,816	0.00133	7	0.18	0.0065	33
Total	365			172			186

Source: EBMUD, 2010

Table B.6.4.5. Load Reduction Estimates from Current Annual O&M Activities in the Pulgas Creek Pump Station Watershed

O&M Activity	Current Activity	Current Annual PCB Load Reduction [g]			Current Annual Mercury Load Reduction [g]		
		10th Percentile	*50th Percentile*	*90th Percentile*	*10th Percentile*	*50th Percentile*	*90th Percentile*
Storm Drain Inlet Cleaning	Annual Sediment Removal	0.09	0.29	0.73	0.2	0.35	0.66

Source: EOA 2012.
The load was calculated using the 10th, 50th, and 90th percentile concentrations for sediment from drain inlets in the Pulgas Creek Pump Station Watershed.

The Task 4 Desktop Analysis provides estimates of the additional load reduction opportunities that could be achieved by street flushing (EOA 2012), which are summarized in Table B.6.4.6. An enhancement factor was not calculated in the Desktop Analysis because street flushing is not a current activity in the watershed. The enhancement factor may be calculated from the additional mass of PCBs and mercury removed over the mass removed by drain inlet cleaning and street sweeping activities.

Table B.6.4.6. Estimates of Load Reduction Enhancements Associated with Street Flushing in the Pulgas Creek Pump Station Watershed

Street Flushing Enhancement Scenario	Annual PCB Load Reduction Opportunity [g]		Annual Mercury Load Reduction Opportunity [g]	
	Median	Range	Median	Range
Annual flush of 1,000 linear feet of street/curb/sidewalk	0.33	0.054-0.96	0.094	0.071-0.47

Source: EOA 2012.
The range was calculated using the 10th and 90th percentile concentrations in street sediment from the watershed.
The estimate assumes 1.24 kg of wet sediment is removed per linear foot flushed (from Kleinfelder 2006).

Leo Avenue Watershed Storm Drain Line Flushing

A discrete storm drain line flushing event was conducted by the City of San Jose in 2005, but storm drain flushing is not performed regularly as an O&M activity. The current O&M activity is drain inlet cleaning (and street sweeping, which is discussed in Section B.5). Current load reductions from drain inlet cleaning activities in the watershed were estimated in the Task 4 Desktop Analysis (EOA 2012), and are summarized in Table B.6.4.7. Depending on the concentration used, the PCB annual load reduction from drain inlet cleaning ranges from 0.005 to 0.31 grams per year, and the mercury annual load reduction ranges from 0.15 to 0.82 grams per year.

Table B.6.4.7. Load Reduction Estimates from Current O&M Activities in the Leo Avenue Watershed

O&M Activity	Current Activity	Current PCB Load Reduction [g]			Current Mercury Load Reduction [g]		
		10th Percentile	*50th Percentile*	*90th Percentile*	*10th Percentile*	*50th Percentile*	*90th Percentile*
Storm Drain Inlet Cleaning	Annual Sediment Removal	0.005	0.05	0.31	0.15	0.24	0.82

Source: EOA 2012.
The load was calculated using the 10th, 50th, and 90th percentile concentrations for sediment from drain inlets in the Pulgas Creek Pump Station Watershed.

The Task 4 Desktop Analysis (EOA 2012) provides a range of enhancement factors and the additional mass of mercury and PCBs that could be removed by storm drain line flushing, based on the information collected during the 2005 flushing event at Leo Avenue (Table B.6.4.8). Table B.6.4.8 indicates that an enhancement factor of 1.25 to 1.75 can be achieved each time an additional flushing event is conducted. The additional load reduction opportunity ranges from 0.05 to 29 grams of PCBs and 0.33 to 2.6 grams of mercury, per flushing event. The actual enhanced mass removed will be calculated as the product of the volume of sediment removed, an assumed density, and the concentration of PCBs and mercury measured in composite samples collected during the pilot study.

Table B.6.4.8. Estimates of Enhancement Factors and Load Reduction Opportunities in the Leo Avenue Watershed

Enhancement Scenario	Range of Enhancement Factors	Annual PCB Load Reduction Opportunity [g]		Annual PCB Load Reduction Opportunity [g]	
		Median	Range	Median	Range
Additional flush of Leo Avenue line on a one-time basis	1.25-1.75	2.1	0.05-29	1.2	0.33-2.6

B.6.4.5 Summary of Key Uncertainties

There are a number of sources of uncertainty in accurately estimating PCB and mercury loads reduced to San Francisco Bay associated with baseline and current O&M practices (drain inlet cleaning).

- There are only limited data available for drain inlet cleaning (e.g., amount of sediment removed and pollutant concentrations in the sediment), but this potential BMP is not being evaluated through a pilot study.
- For the drain inlet cleaning data, the number of municipalities that showed an increase in the drain inlet cleaning rate (amount of material removed/number of inlets inspected/cleaned) was about the same as the number of municipalities that showed a decrease in the rate. It is not certain if the positive changes are the result of a true enhancement in O&M implementation. This is because information about what enhancements have been implemented is not readily available. In addition, there are uncertainties about data quality, such as estimates of the volume of material removed. In addition, a few municipalities reported very high rates which could potentially mean the municipality has more catch basins than drop inlets, material volumes from culvert cleaning were included in the drain inlet cleaning data, or an error was made in the reporting of the data. Therefore, the data were reevaluated using a ranking method based on a statistical analysis of the data. The high, medium, and low rates assigned to each

municipality were based on 25th percentile, 50th percentile and 75th percentile values derived from the statistical analysis.

- The same PCB and mercury concentrations were applied to the baseline and current implementation periods to calculate the loads avoided from drain inlet cleaning. Separating data collected during the baseline from the current period would imply that any differences between the data sets are statistically significant.
- For the load reduction estimates from drain inlet cleaning, the PCB and mercury concentrations assigned to the municipalities were from the SFEI database and a mean concentration obtained for a specific county was applied to all of the municipalities within that county (with the exception of municipalities that had more than 11 data points). It is assumed that the county-wide concentrations are representative concentrations to be used for the analysis.
- A dry bulk density of 1,376 kg/cubic yard (representing dry sand and 30 percent vegetative debris) was applied to all drain inlet sediment to calculate mass loads reduced, although the density of the material is likely to vary.
- It was assumed that 60% of the total volume of material removed from drain inlets was in the fraction less than 2 mm, which was considered to be the amount of sediment removed.
- As no pump station cleaning information was readily available, an analysis was developed to extrapolate annual load reductions for non-Caltrans-operated pump stations with dominant industrial land use. The analysis was based developing a potential correlation between the specific pump station of interest and the ESPS using the pump station spreadsheet data from the Regional Water Board. Information available on pump stations with industrial land use does not general include information about the pump station, such as the presence of a forebay or wet wells, does not allow for identification pump stations that trap sediment versus those that do not. Therefore the estimates are based on the sediment trapping dynamics at the ESPS and ESPS mass removal estimates, which may not necessarily apply to other pump stations with potential source areas within their tributary areas.

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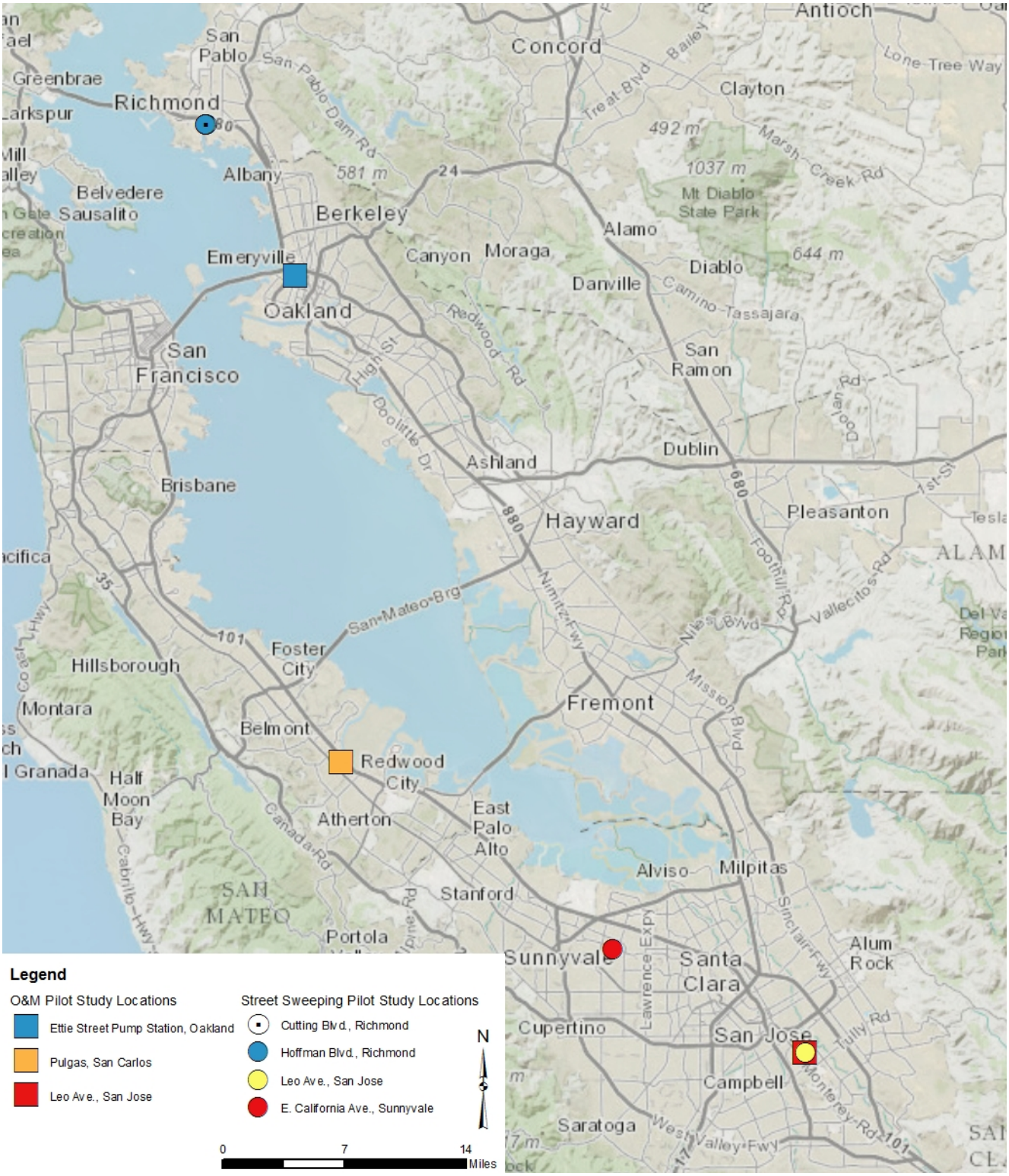
FIGURES B.6



Enhanced O&M Pilot Study Locations

Source:

Bay Area Stormwater Management Agencies Association

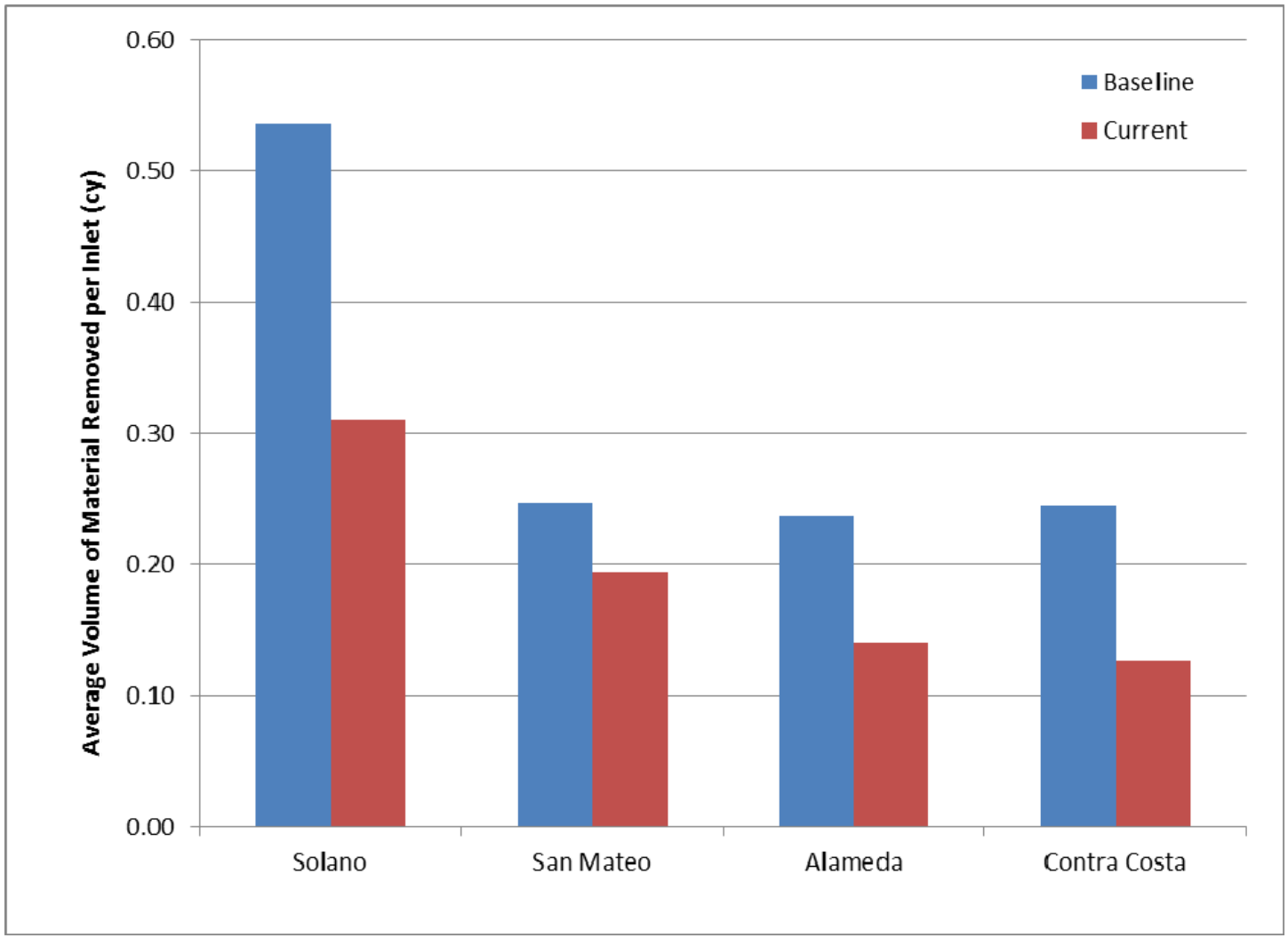
Entity

December 2013

Date

Figure B.6.1

internal info: path, date revised, author



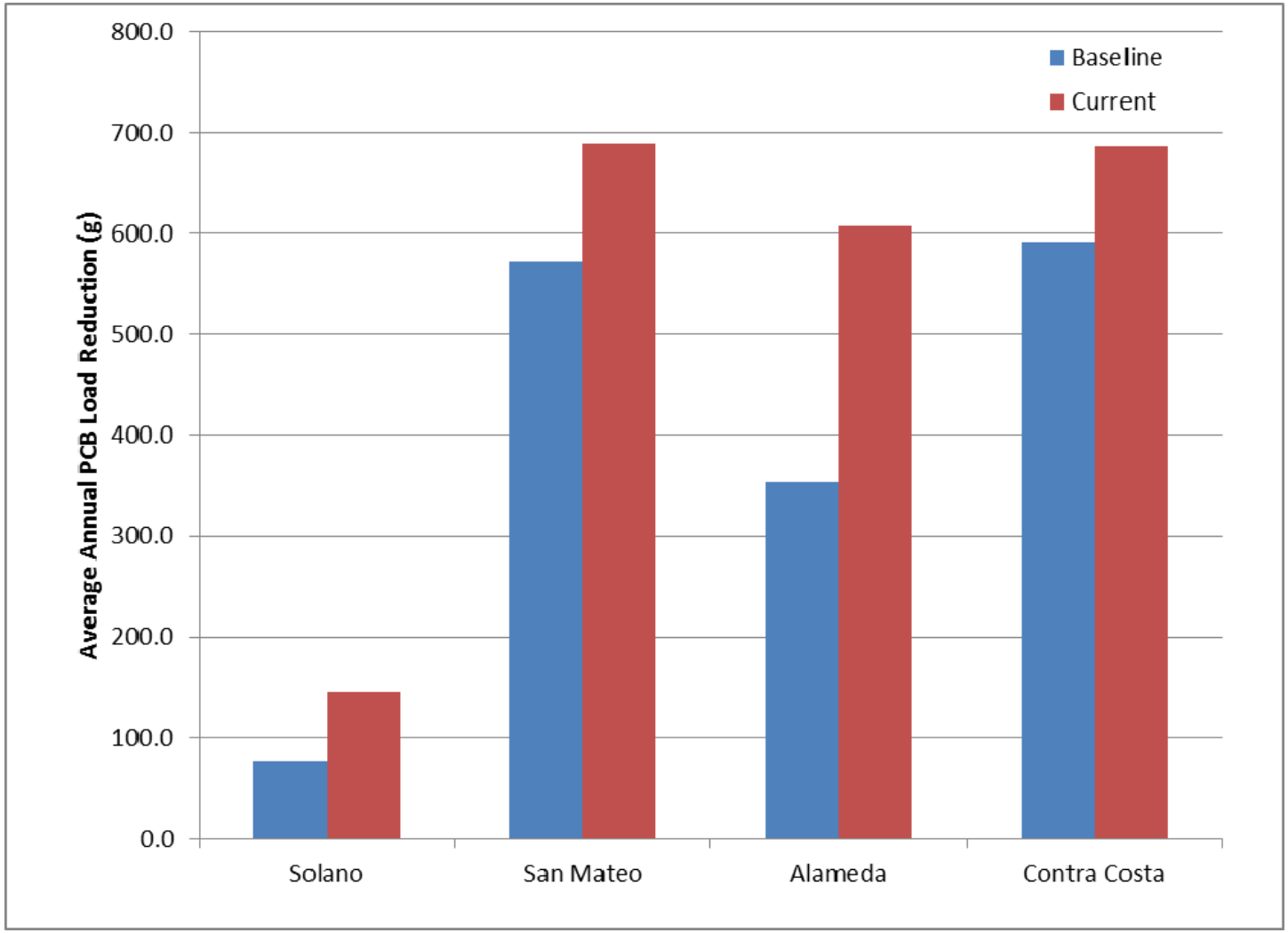
Estimated Average Volume of Material Removed per Drain Inlet Inspected/Cleaned (Using Ranking Method)

Bay Area Stormwater Management Agencies Association	December 2013	Figure B.6.2
Entity	Date	

Source:
Data per Appendix Table B.6-2

Notes:
Drain inlet cleaning data were not available for Santa Clara County

internal info: path, date revised, author

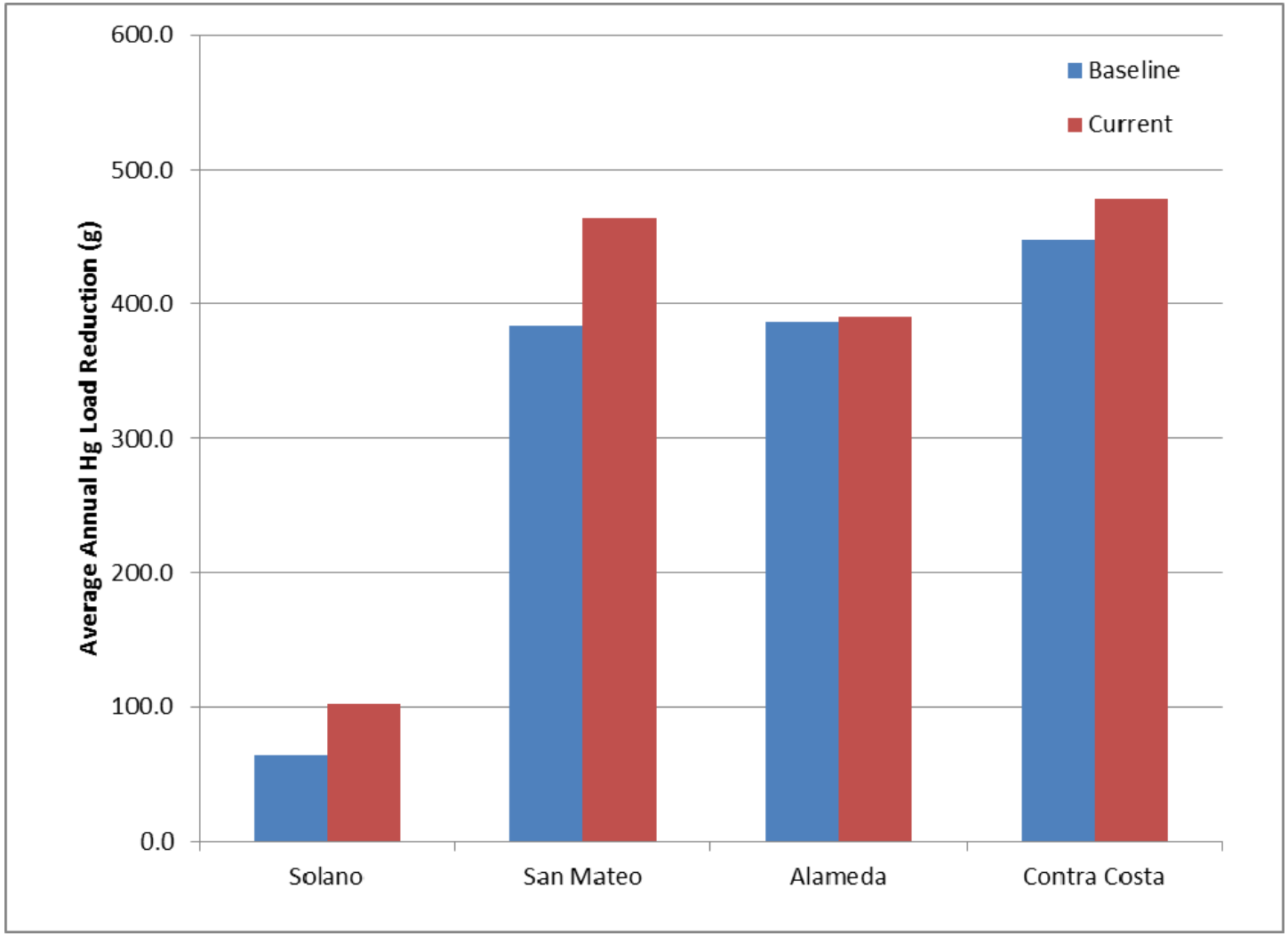


Average Annual Total PCB Load Reduction from Drain Inlets Cleaned/Inspected (Using Ranking Method)

Source:	Notes:
Data per Appendix Table B.6-4	Drain inlet cleaning data were not available for Santa Clara County

Entity	Date	
Bay Area Stormwater Management Agencies Association	December 2013	Figure B.6.3

internal info: path, date revised, author



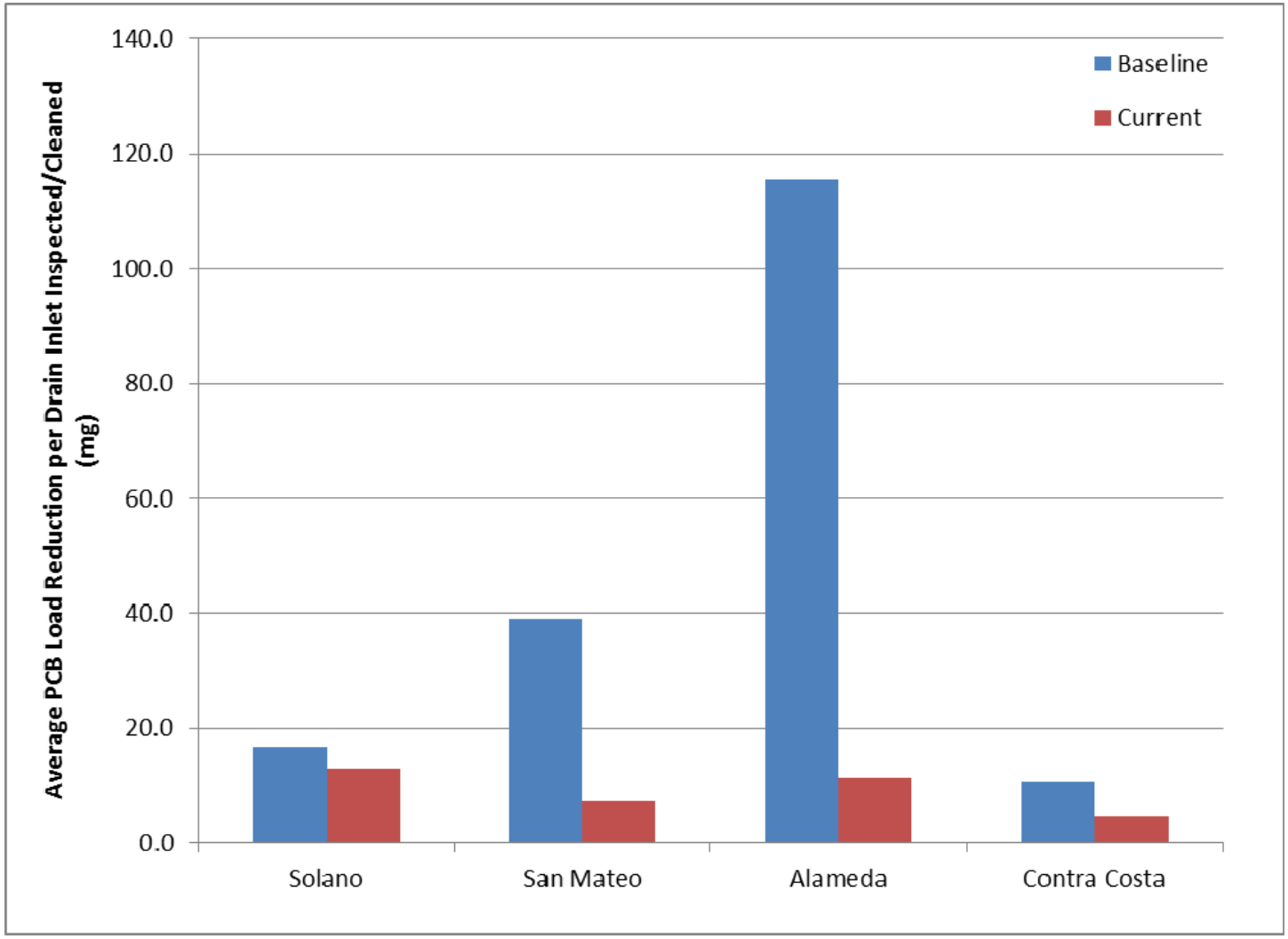
Source:
Data per Appendix Table B.6-4

Notes:
Drain inlet cleaning data were not available for Santa Clara County

Average Annual Total Mercury Load Reduction from Drain Inlets Inspected/Cleaned (Using Ranking Method)

Entity	Date	
Bay Area Stormwater Management Agencies Association	December 2013	Figure B.6.4

internal info: path, date revised, author



Source:
Data per Appendix Table B.6-4

Notes:
Drain inlet cleaning data were not available for Santa Clara County

Average PCB Load Reduction per Drain Inlet Inspected/Cleaned (Using Ranking Method)

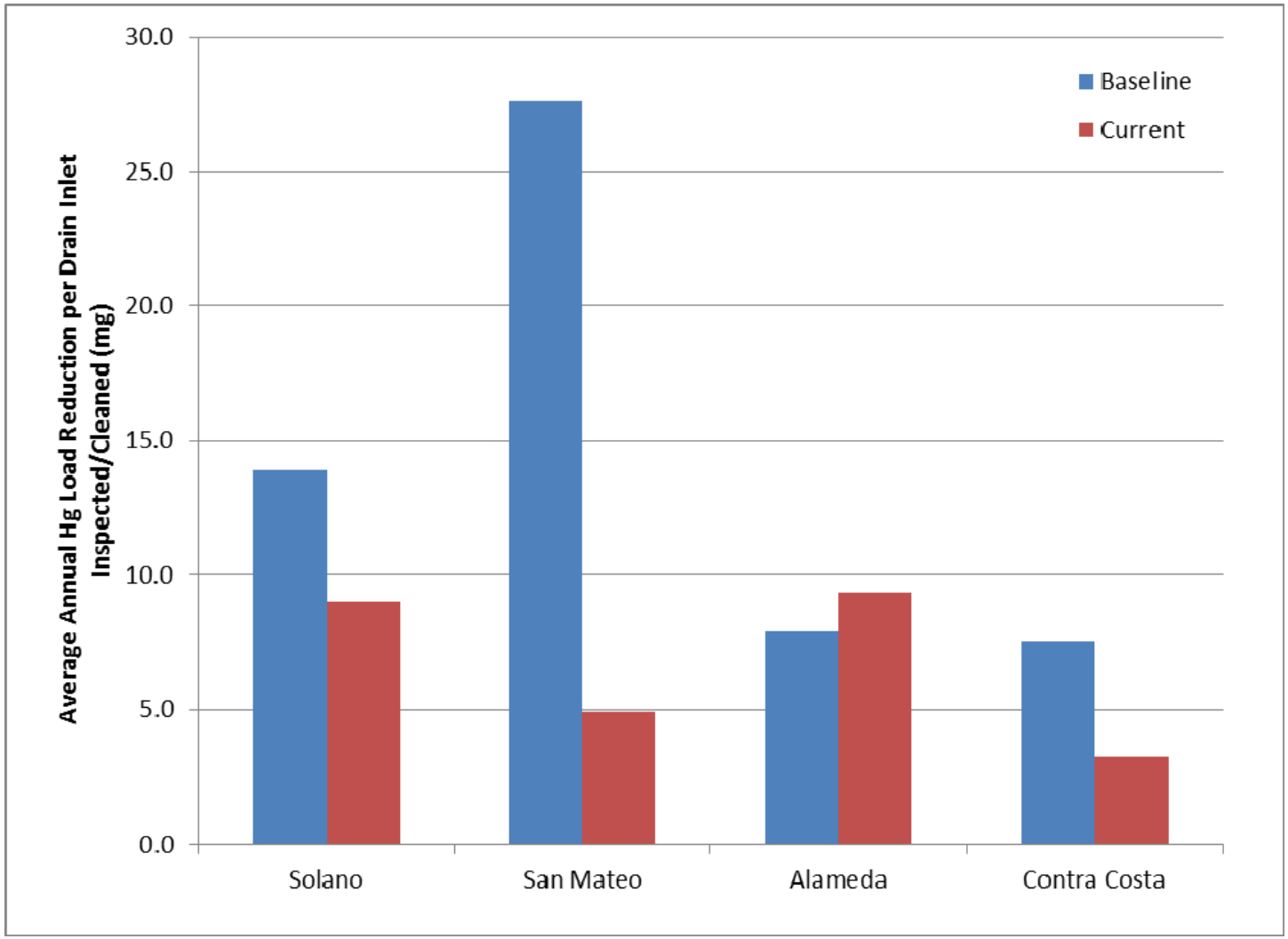
Bay Area Stormwater Management Agencies Association

December 2013

Figure B.6.5

Entity | Date

internal info: path, date revised, author

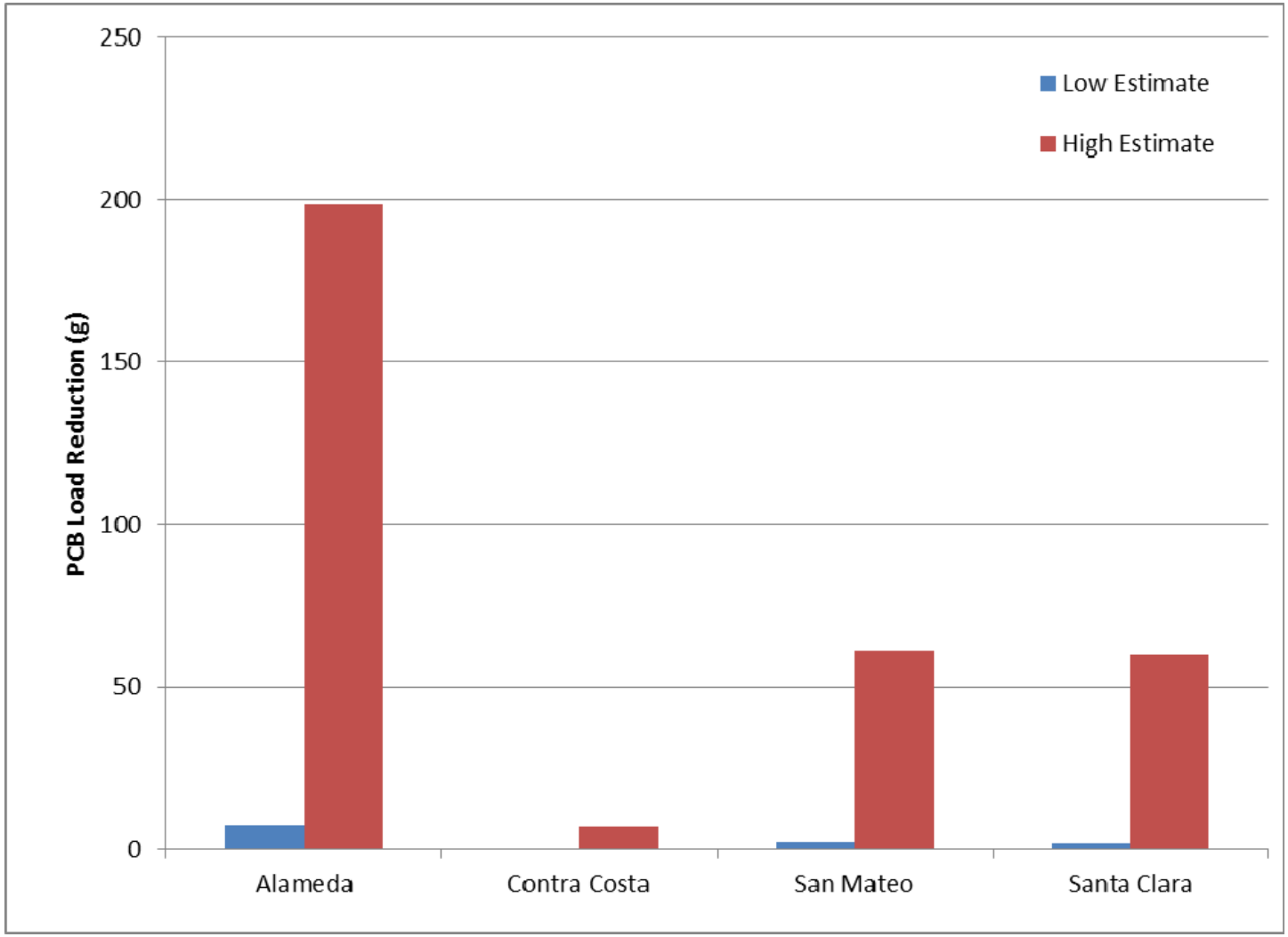


Average Mercury Load Reduction per Drain Inlet Inspected/Cleaned (Using Ranking Method)

Source:	Notes:
Data per Appendix Table B.6-4	Drain inlet cleaning data were not available for Santa Clara County

Entity	Date	
Bay Area Stormwater Management Agencies Association	December 2013	Figure B.6.6

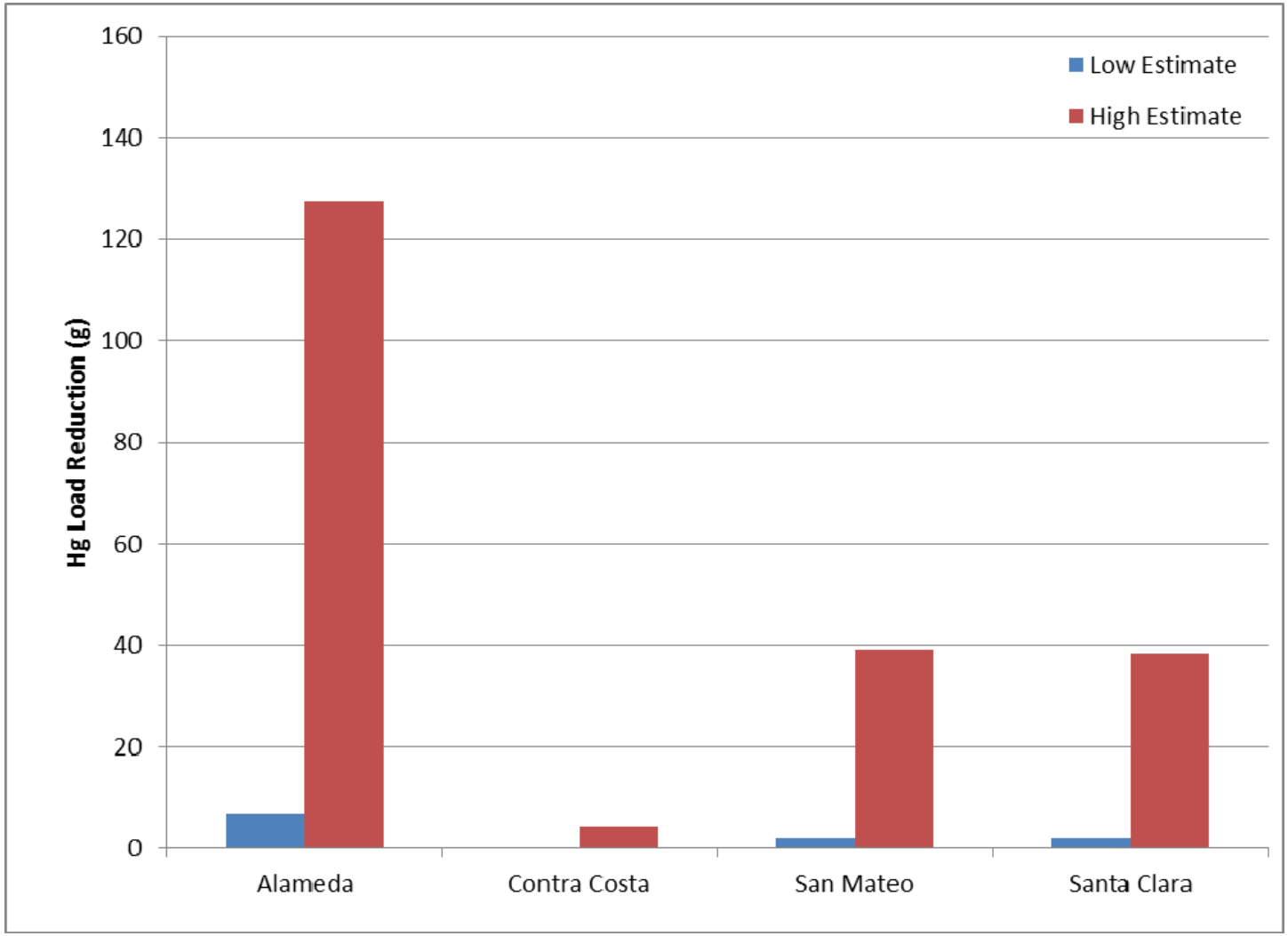
internal info: path, date revised, author



Estimated Average Annual PCB Load Reduction from Pump Station Cleaning Method 1, Normalized Using Max Pumping Capacity

Source:	Notes:	Bay Area Stormwater Management Agencies Association	December 2013	Figure B.6.7
Data per Appendix Table B.6.2-1	Estimates only conducted for pump stations with industrial land use or within 200 feet old industrial land	Entity	Date	

internal info: path, date revised, author

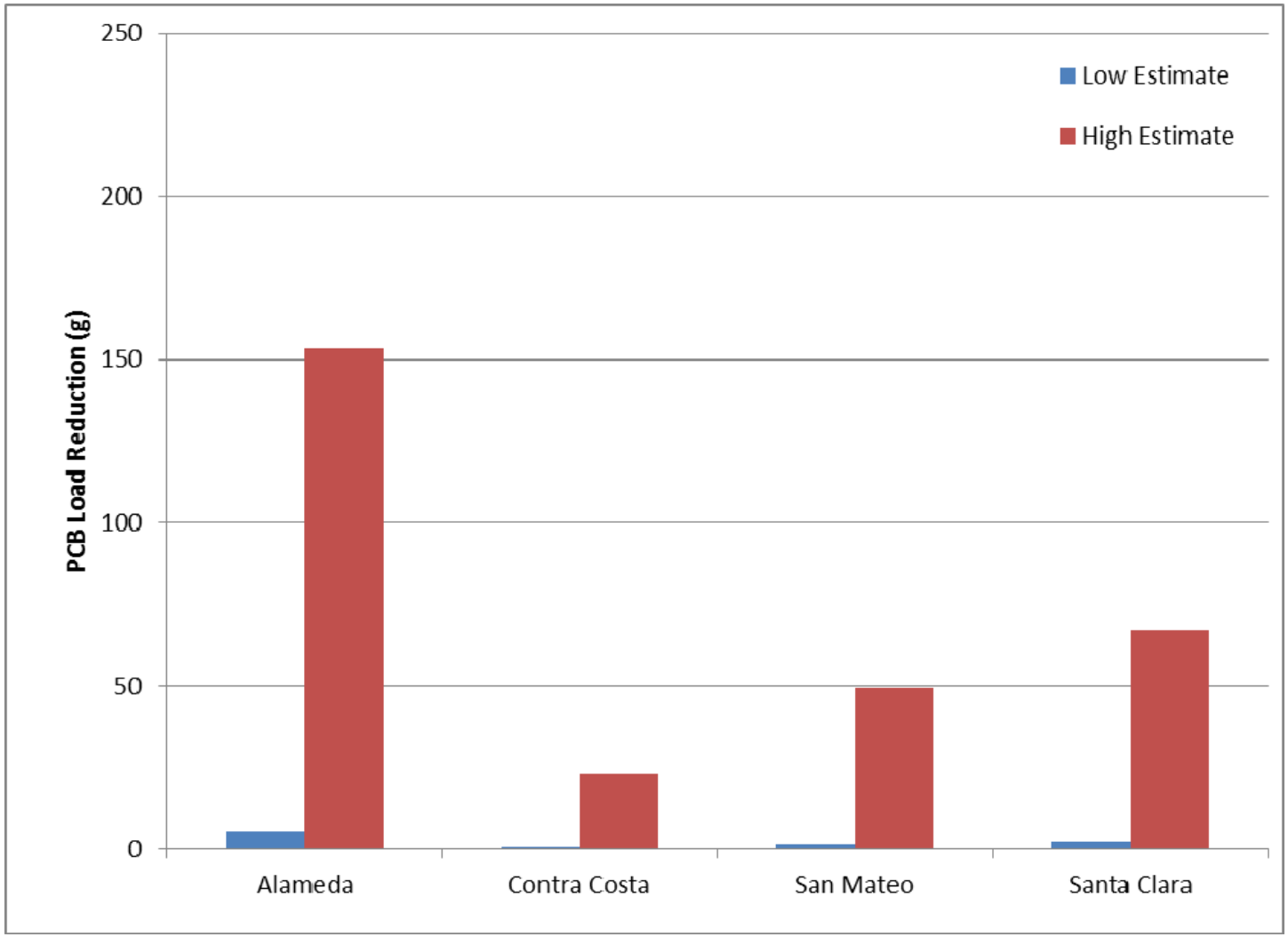


Estimated Average Annual Hg Load Reduction from Pump Station Cleaning Method 1, Normalized Using Max Pumping Capacity

Source:	Notes:
Data per Appendix Table B.6.2-1	Estimates only conducted for pump stations with industrial land use or within 200 feet old industrial land

Entity	Date	
Bay Area Stormwater Management Agencies Association	December 2013	Figure B.6.8

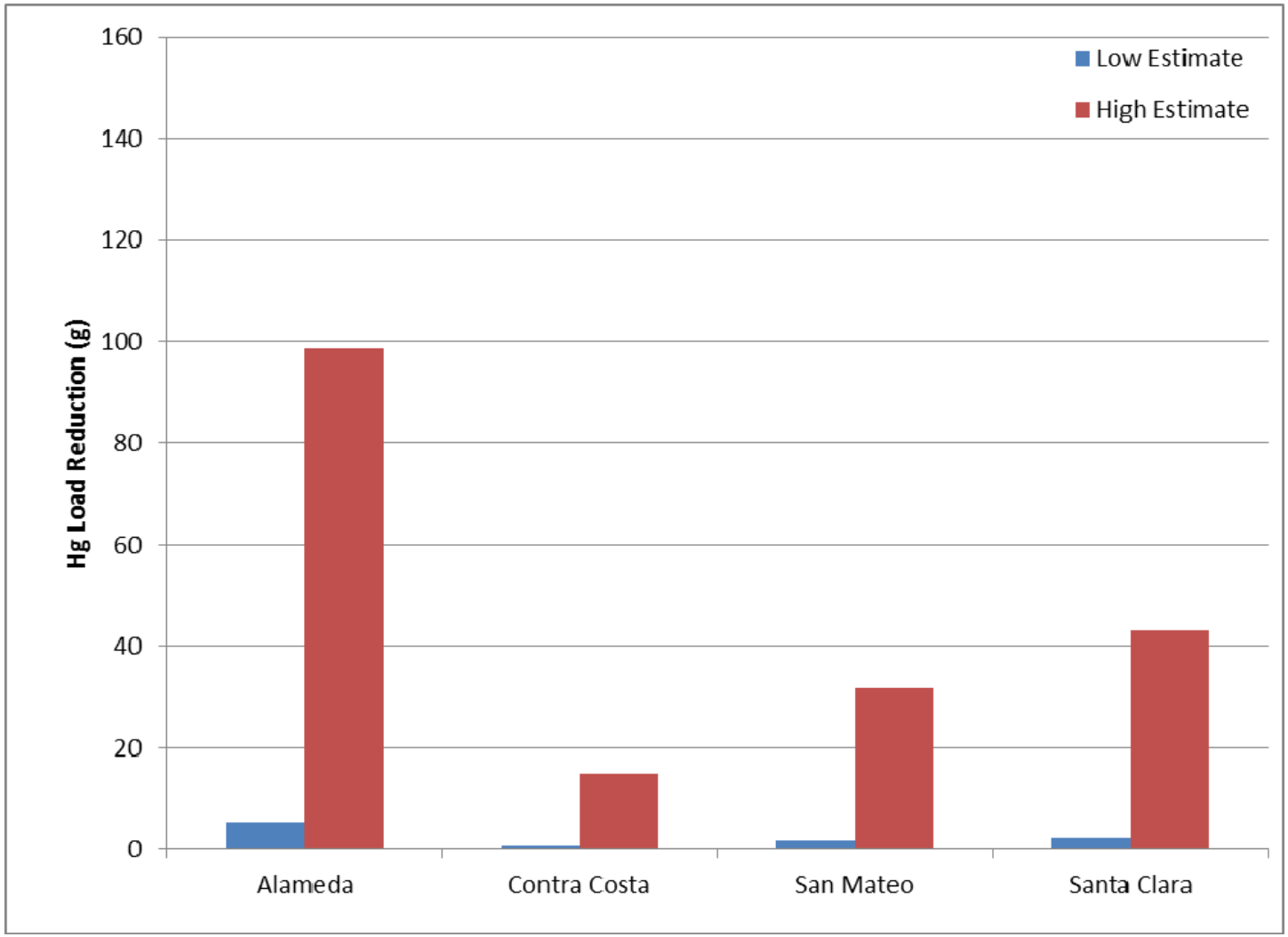
internal info: path, date revised, author



Estimated Average Annual PCB Load Reduction from Pump Station Cleaning Method 1, Normalized Using Tributary Area

Source:	Notes:	Bay Area Stormwater Management Agencies Association	December 2013	Figure B.6.9
Data per Appendix Table B.6.2-1	Estimates only conducted for pump stations with industrial land use or within 200 feet old industrial land	Entity	Date	

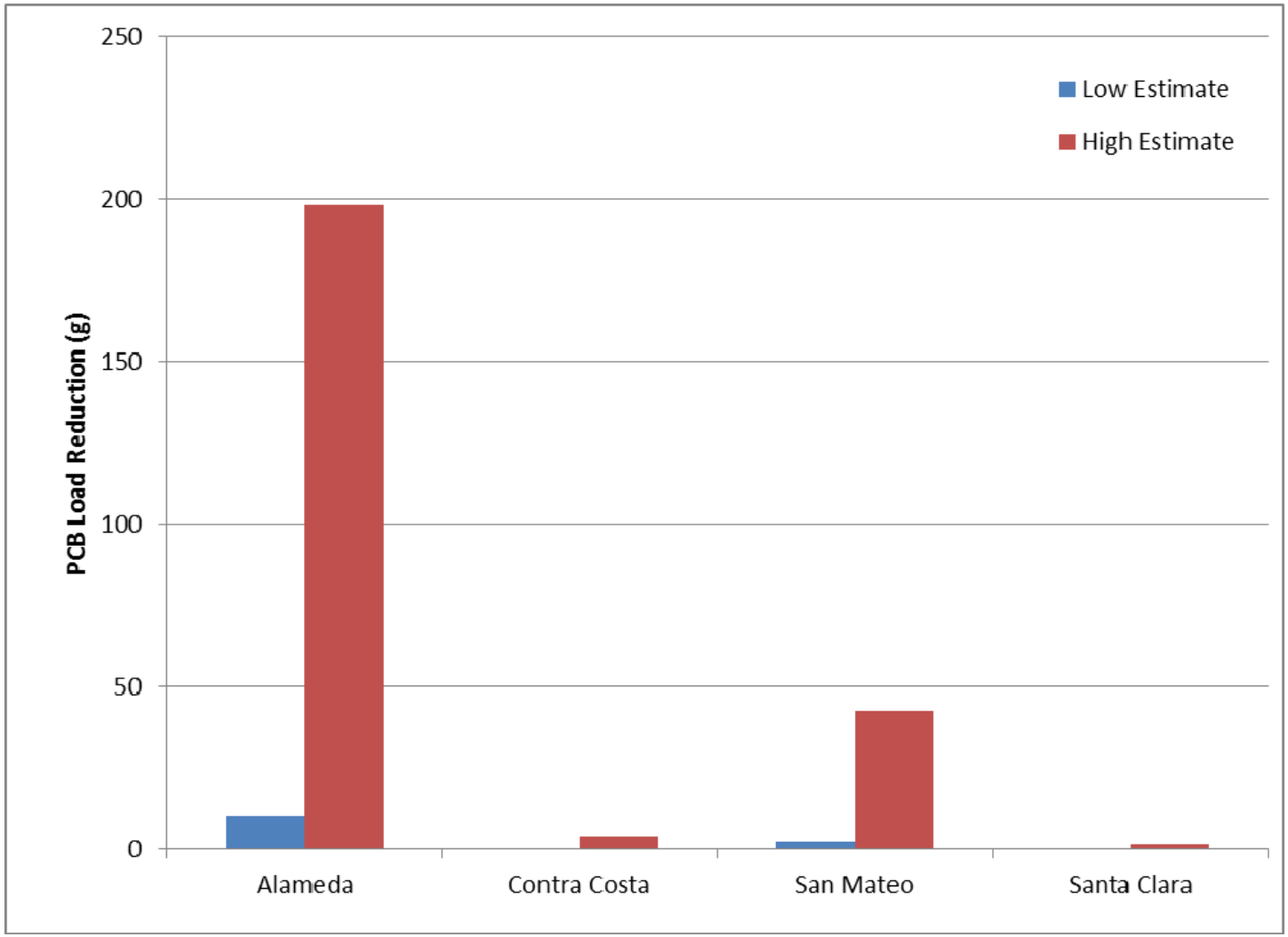
internal info: path, date revised, author



Estimated Average Annual Hg Load Reduction from Pump Station Cleaning Method 1, Normalized Using Tributary Area

Source:	Notes:	Entity	Date	Figure
Data per Appendix Table B.6.2-1	Estimates only conducted for pump stations with industrial land use or within 200 feet old industrial land	Bay Area Stormwater Management Agencies Association	December 2013	B.6.10

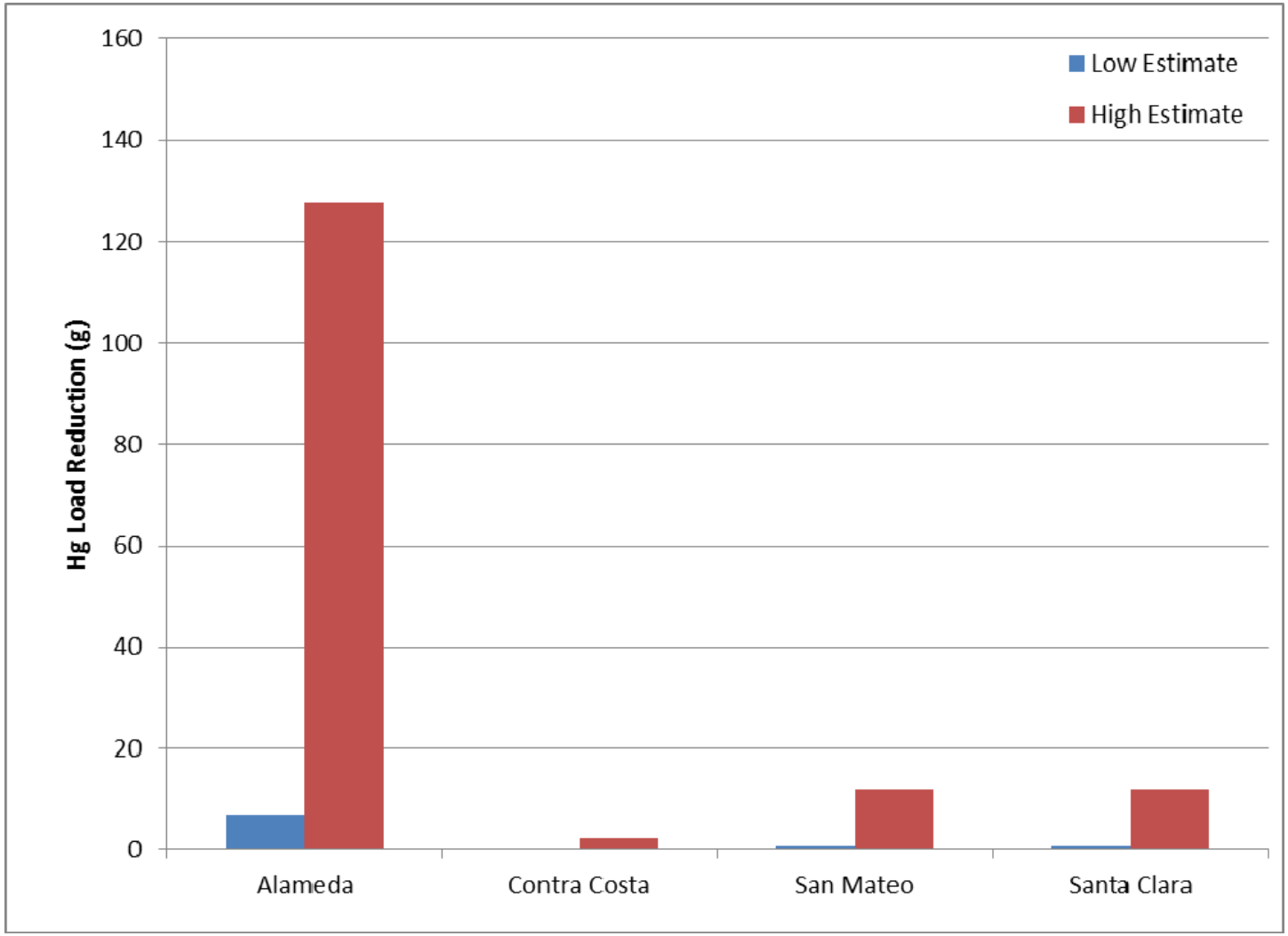
internal info: path, date revised, author



Estimated Average Annual PCB Load Reduction from Pump Station Cleaning Method 2, Normalized Using Max Pumping Capacity

Source:	Notes:	Entity	Date	Figure
Data per Appendix Table B.6.2-2	Estimates only conducted for pump stations with industrial land use or within 200 feet old industrial land	Bay Area Stormwater Management Agencies Association	December 2013	B.6.11

internal info: path, date revised, author



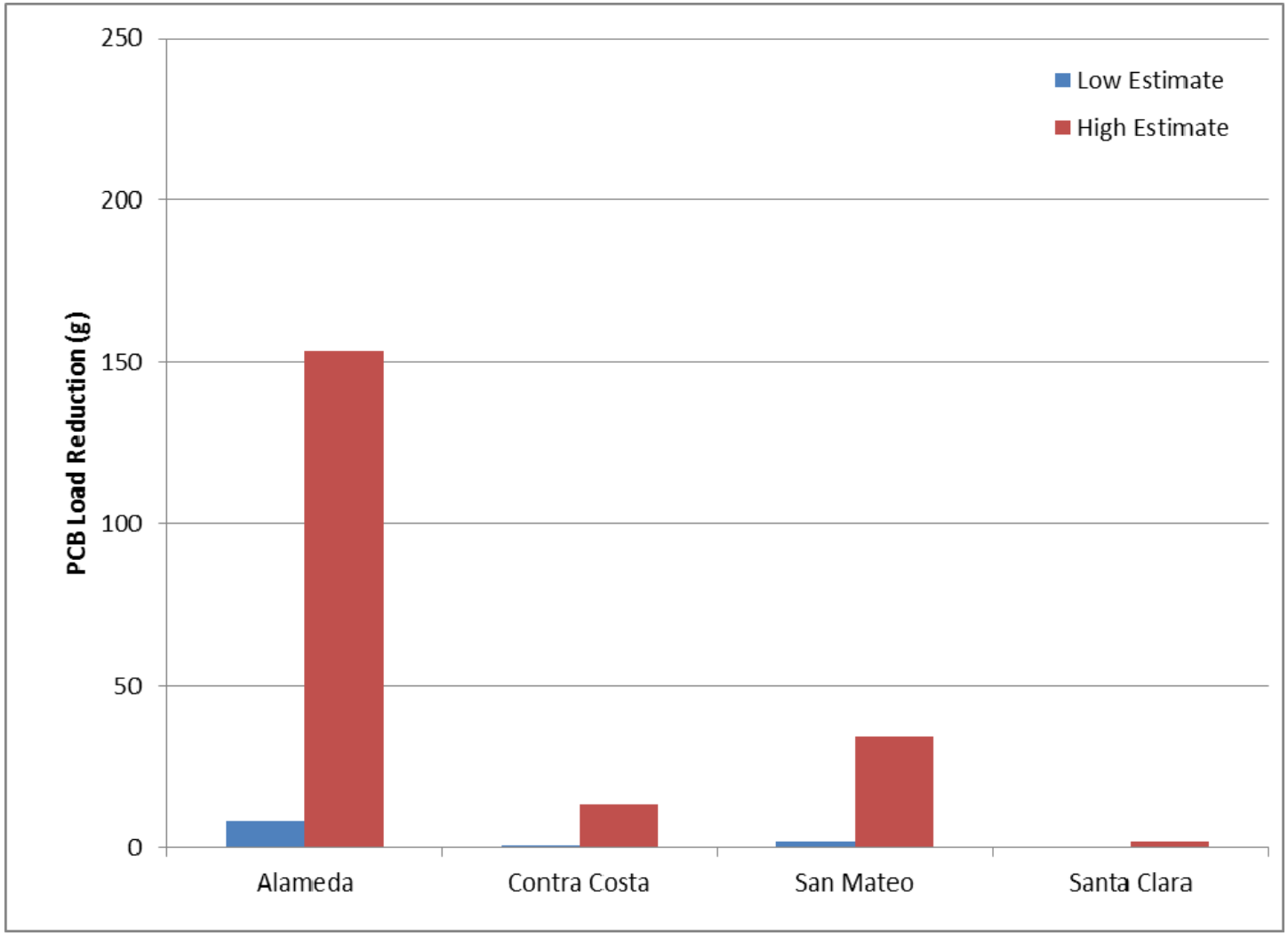
Estimated Average Annual Hg Load Reduction from Pump Station Cleaning Method 2, Normalized Using Max Pumping Capacity

Bay Area Stormwater Management Agencies Association	December 2013	Figure B.6.12
Entity	Date	

Source:
Data per Appendix Table B.6.2-2

Notes:
Estimates only conducted for pump stations with industrial land use or within 200 feet old industrial land

internal info: path, date revised, author

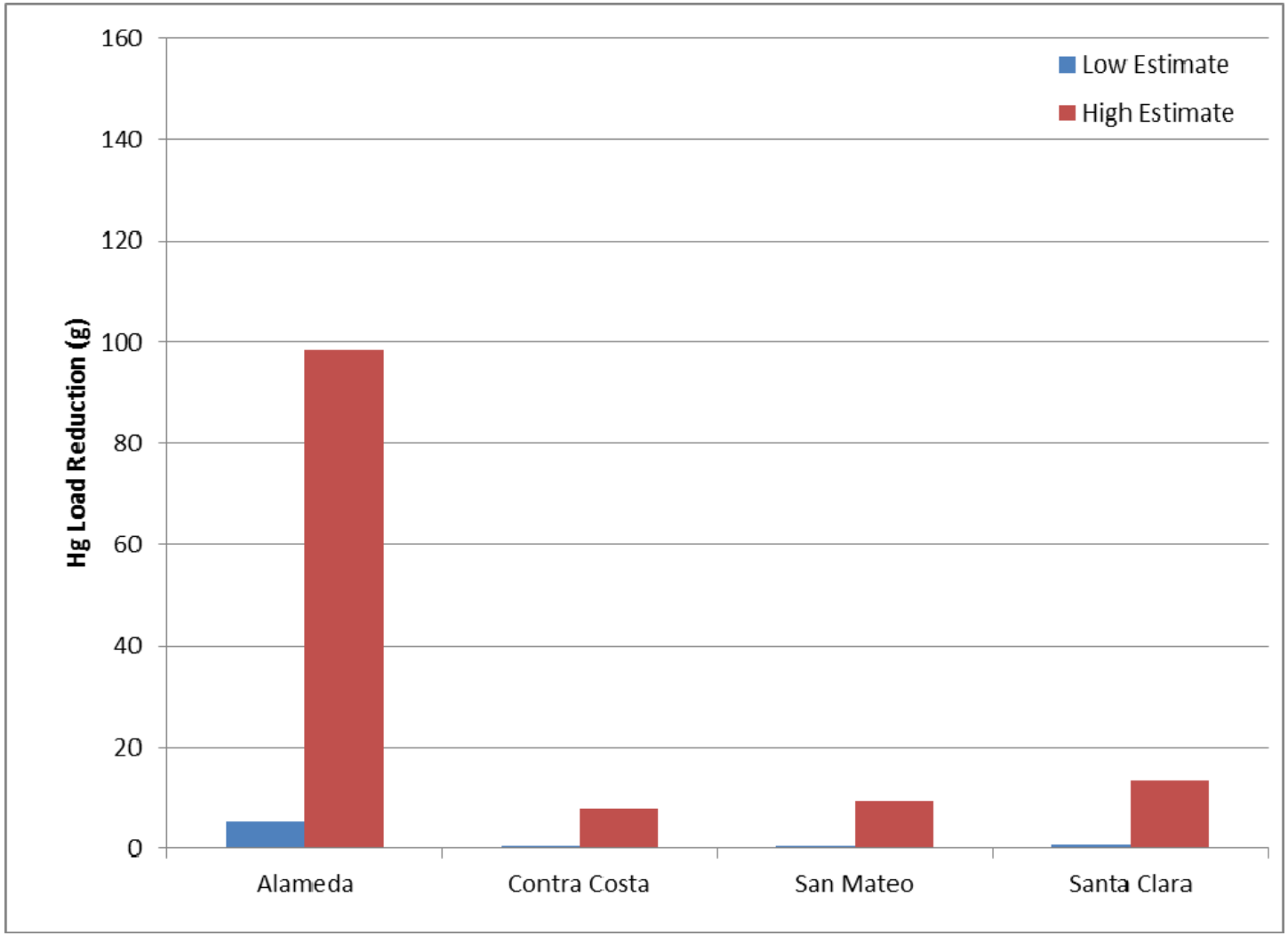


Estimated Average Annual PCB Load Reduction from Pump Station Cleaning Method 2, Normalized Using Tributary Area

Source:	Notes:
Data per Appendix Table B.6.2-2	Estimates only conducted for pump stations with industrial land use or within 200 feet old industrial land

Entity	Date	
Bay Area Stormwater Management Agencies Association	December 2013	Figure B.6.13

internal info: path, date revised, author



Estimated Average Annual Hg Load Reduction from Pump Station Cleaning Method 2, Normalized Using Tributary Area

Source:	Notes:
Data per Appendix Table B.6.2-2	Estimates only conducted for pump stations with industrial land use or within 200 feet old industrial land

Entity	Date	
Bay Area Stormwater Management Agencies Association	December 2013	Figure B.6.14

internal info: path, date revised, author

B.7 STORMWATER TREATMENT MEASURES

B.7.1 Introduction

Stormwater treatment measures fall into two general categories: (1) post-development treatment measures for new development and redevelopment projects constructed in compliance with Municipal Regional Stormwater NPDES Permit (MRP) Provision C.3, and (2) the pilot scale retrofit projects required by MRP Provisions C.3.b.iii. and C.12.e.

The goal of this section of the Integrated Monitoring Report (IMR) is to estimate the load reductions of PCBs and mercury associated with the implementation of these two classes of treatment measures. This section includes a description of the polychlorinated biphenyls (PCB) and mercury control pilot studies, a summary of the status of implementation of the C.3 and pilot measures, and estimates of the loads avoided or reduced for these two classes of treatment control measures.

B.7.2 Summary of PCB and Mercury Control Pilot Studies

B.7.2.1 MRP Requirements

MRP Provision C.3. requires that the Permittees incorporate appropriate source control, site design, and stormwater treatment measures in new development and redevelopment projects to address both soluble and insoluble stormwater runoff pollutant discharges and prevent increases in runoff flows from new development and redevelopment projects. The preferred method of achieving these goals is through the implementation of low impact development (LID) techniques. Provision C.3.b. identifies Regulated Projects, which include special land use categories, new development projects that create 10,000 square feet or more of impervious surfaces, redevelopment projects that create and/or replace 10,000 square feet or more of impervious surface, and a variety of road projects that create 10,000 square feet or more of newly constructed contiguous impervious surface.

Provision C.3.b.iii. requires that the Permittees conduct ten pilot green streets retrofit projects that incorporate LID techniques for site design and treatment in accordance with Provision C.3.c. and provide stormwater treatment sized in accordance with Provision C.3.d. Each county (San Mateo, Contra Costa, Alameda, Santa Clara, and Solano) should have at least two project locations. Additionally, MRP Provision C.3.b.iii.(5) requires that the Permittees conduct appropriate monitoring of these projects to document the water quality benefits achieved. Appropriate monitoring may include modeling using design specifications and site-specific conditions.

Provisions C.11.e. and C.12.e require that the Permittees evaluate and quantify the removal of mercury through treatment measures (e.g., detention basins, bioretention units, sand filters, infiltration basins, treatment wetlands) via retrofits of such measures into existing storm drain

systems. Each county (San Mateo, Contra Costa, Alameda, Santa Clara, and Solano) should have at least one selected location.

B.7.2.2 Implementation Approach

CW4CB Task 5 is anticipated to result in Permittee compliance with MRP Provisions C.11/12.e. The BASMAA Permittees have conducted a systematic process for identifying and prioritizing candidate watersheds, identifying sites within those watersheds that are suitable for retrofitting treatment measures, selecting a cross section of treatment measure types to be tested, and then conducting the implementation process of planning, designing, constructing and monitoring each of the pilot studies. As part of this process, candidate watersheds were screened and prioritized in terms of potential to be an important source of pollutants of concern (POCs). A key element in the process is coordination with the individual agencies to assist in the identification of candidate sites within their jurisdictions and to provide data to assist in the site characterization and the design process. To support the monitoring effort, study designs were developed that included development of management questions, which defined the overall monitoring scope. Sampling and Analysis Plans were then developed to support the pilot tests by defining field and laboratory protocols.

B.7.2.3 Pilot Study Descriptions

This section identifies ten Green Streets pilot projects that were selected in accordance with MRP Provision C.3.b.iii. The project descriptions include the project locations, proposed treatment measures, drainage catchment information, project design information, the status of the project and proposed completion date. The ten selected projects are in various stages of design and construction and will be completed within this MRP term. Figure B.7.1. shows the locations of the ten Green Streets pilot projects.

This section also describes ten retrofit pilot projects that were selected through the Clean Watersheds for a Clean Bay (CW4CB) Task 5 implementation to evaluate the effectiveness of retrofit projects to remove PCBs and other pollutants of concern. The project descriptions include the project locations, proposed treatment measures, drainage catchment information, available project design information, the status of the project and proposed completion date. The El Cerrito Green Streets and Bransten Road projects are also part of the Green Streets Pilot Projects, and are therefore not summarized a second time below. Figure B.7.2. shows the locations of the ten retrofit pilot projects.

In general, constructing the twenty pilot projects within an existing transportation corridor present major challenges. Public right-of-ways generally contain electrical utilities, gas lines, water lines, and other infrastructure. Treatment facilities need adequate space within the right-of-way to operate effectively but cannot conflict with existing utilities and transportation needs, and must be located at a lower elevation than the tributary impervious surface for which treatment is desired. These factors require a comprehensive evaluation of the existing site and its functionality with accurate mapping and information prior to construction. In addition to

technical considerations, factors such as availability of funding, opportunity for integration into other planned projects, and community support are key for the success of the pilot projects.

B.7.2.4 Bioretention Facilities

San Pablo Avenue Green Spine—Richmond (Green Streets)

The City of Richmond's San Pablo Avenue Green Spine Project is located in Contra Costa County in the City of Richmond along the major arterial of San Pablo Avenue between McBryde Avenue and Andrade Avenue. The City of Richmond's San Pablo Avenue Green Spine Project is currently in the preliminary design phase and the city has committed that the design will qualify as a Bay-Friendly landscape. The project is located inside a Priority Development Area as designated by the Association of Bay Area Governments (ABAG) and the Metropolitan Transportation Commission (MTC) FOCUS program. The total drainage area is approximately 2.25 acres. Additional catchment information is unknown at this time.

The proposed treatment measures currently consist of six bioretention areas consisting of one rain garden and five curb extensions. Five of the facilities will be located on the northern portion of San Pablo Avenue to the west of MacDonald Avenue, and one facility will be located on the southern portion of San Pablo Avenue to the east of MacDonald Avenue. Construction will be complete in 2013.

El Cerrito Green Streets Project (Green Streets and CW4CB Task 5)

The El Cerrito Green Streets Project is located in Contra Costa County in the City of El Cerrito. The project includes facilities at two locations along the major arterial of San Pablo Avenue: 1) the Eureka Rain Gardens at 10200 San Pablo Avenue, and 2) the Madison Rain Gardens at 11048 San Pablo Avenue. This project was originally part of the larger San Pablo Avenue Streetscape Project to add LID elements to pedestrian, bicycle, transit, and beautification improvements. The project is located inside the El Cerrito San Pablo Priority Development Area as designated by the ABAG/MTC FOCUS program. The project was completed in August 2010.

The total drainage area to the Project is 1.33 acres, which includes the area within the public right-of-way. The tributary area to the Madison Rain Garden is 0.39 acres and the tributary area to the Eureka Rain Gardens is 0.94 acres. There may be some additional runoff from adjacent properties, but this area was not included in the analysis. The tributary area is classified as 100% commercial, with approximately 99% imperviousness.

The Eureka Rain Garden consists of a series of 12 individual rain gardens and the Madison Rain Gardens consists of a series of seven individual rain gardens. The individual rain gardens are separated from each other to provide access between curbside parking and the sidewalk. The Madison Rain Garden was sized to effectively capture the 0.38 acres of the overall tributary area (0.39 acres) and is therefore, nearly 100% effective. The Eureka Rain Garden was sized to treat 0.64 acres of the overall tributary area (0.94 acres) and is therefore, only 68% effective.

Codornices Creek Restoration Project (Green Streets)

The Codornices Creek Restoration Project is located in Alameda County in the City of Albany and is a joint project between the City of Berkeley, City of Albany, and the University of California to restore lower Codornices Creek between the Union Pacific Railroad Tracks to the west and San Pablo Avenue to the east. As part of the overall restoration project, a series of rain gardens were installed to treat stormwater runoff prior to entering Codornices Creek. The project was completed in 2011. The total drainage area to the project is 1.93 acres of completely impervious area located on clay soils. The area will remain 100% impervious following the restoration, and is commercial and residential in land use with 60% of the area in the public right-of-way.

There are four rain gardens/bioretention areas that are 180 sq. ft., 260 sq. ft., 224 sq. ft., and 425 sq. ft. in size. There are two treatment areas located on either side of the 6th Street, which are separated by a sidewalk providing access to the street. Facility sizing was based on the Alameda Countywide Clean Water Program's C3 Stormwater Technical Guidance, but two of the four basin areas were restricted in size by site conditions, such as driveway access requirements for semi-truck trailers, an existing shallow culvert crossing, and an improved pedestrian crossing.

Park and Hollis Stormwater Curb Extension (Green Streets)

The Park and Hollis Stormwater Curb Extension Project is located in the City of Emeryville in Alameda County at the northeast corner of Park Avenue and Hollis Street. The project is classified as a landscaped curb extension along a collector street that was required by the City of Emeryville as part of an expansion project by Pixar Animation Studios. The project was completed in 2010.

The total drainage area to the Project is 0.19 acres. The Project is located in a commercially developed area and the footprint is entirely in the public right-of-way. Prior to construction, the tributary area was 100% impervious and following the installation of the curb extension, the tributary area will be 93% impervious.

The curb extension is 650 square feet in area and consists of an on-street planted rain garden with an underdrain. The underlying soil is clay, so infiltration was determined to be infeasible. Biofiltration media was added above the impermeable clay layer and an underdrain was installed to convey water to the public storm drain. The Alameda Countywide Clean Water Program's C.3 Stormwater Technical Guidance was used to size the treatment measure, which requires treatment measures to be a minimum of 4% of the tributary area.

Stanley Boulevard Safety and Streetscape Improvement (Green Streets)

The Stanley Boulevard Safety and Streetscape Improvement Project is located in Unincorporated Alameda County along a three mile stretch of Stanley Boulevard between the city limits of Pleasanton and Livermore. The project is currently under construction and the Alameda County

Public Works Agency is converting a four-lane, high volume arterial street, which is currently a primarily industrial corridor, to a rural parkway setting. The overall project will use a variety of sustainable design concepts while improving the safety and aesthetics along Stanley Boulevard.

The total drainage area to the project is approximately 33 acres, 90% of which is in the public right-of-way. The pre-and post- development tributary area imperviousness values are 80% and 78%, respectively. Two treatment measures will be constructed along Stanley Boulevard: 1) an infiltration trench and 2) a bioswale. The infiltration trench is located on the northern side of Stanley Boulevard, approximately 13,895 feet long and 4 feet wide, and is designed to infiltrate all runoff. The bioswale is located on the south side of Stanley Boulevard and is approximately 13,895 linear feet long and 3 feet wide. The bioswale has a raised overflow structure that is 4 inches above grade. The Caltrans standards and Alameda Countywide Clean Water Program's C.3 Stormwater Technical Guidance were used to size the treatment measures.

Sustainable Streets and Parking Lot Demonstration (Green Streets)

The Sustainable Green Streets and Parking Lots Demonstration Project is located in San Mateo County in the City of Burlingame off of Donnelly Avenue and Burlingame Avenue. The project was incorporated into improvements to the Public Parking Lot C Project by the City of Burlingame to improve traffic circulation and add disabled accessible stalls, while maintaining the number of parking stalls. The project was completed in 2011.

The total drainage area to the project is 1.32 acres and consists of an existing parking lot and a building roof. The pre-development imperviousness was 95%. The runoff from this area will be routed into a rain garden, which will add 0.06 acres of landscaped area and result in a post-development imperviousness of 90%.

The proposed treatment measures consist of a 0.06 acre bioretention area (rain garden) and a 0.01 acre planter box (curb extension). The facilities were sized based on flow-based criteria to capture 0.2 inches per hour of rainfall intensity and to be at least 4% of the tributary impervious area in physical extent. The storm drain pipes are sized to handle the 0.2 in/hr rainfall intensity through the two facilities as well. The infiltration rate of the bioretention media is estimated at 10 inches per hour.

Bransten Road Green Streets (Green Streets and CW4CB Task 5)

The Bransten Road Green Streets Project is located in San Mateo County in the City of San Carlos along Bransten Road between Old Country Road and Industrial Road. The project is along a local street, and is in a location where elevated levels of PCBs have been identified through sediment monitoring. Project construction began in late 2013.

The area of impervious roadway surface area draining to the bioretention facilities is about 0.5 acres. This does not include drainage from other sources, such as private properties, adjacent

sidewalks, rooftops, or parking lots. The surrounding area is primarily industrial in land use and the imperviousness in the area prior to construction is approximately 95%.

The treatment measures are seven bioretention areas of varying size that were constructed in newly created curb extensions. The San Mateo Countywide Water Pollution Prevention Program (SMCWPPP) guidelines were used, where feasible, for designing the bioretention areas. The "Simplified Sizing Method" from the SMCWPPP was used to determine whether the bioretention areas satisfy C.3 guidelines. This method requires that the bioretention area is at least four percent of the impervious surface area draining to the individual facility. All of the proposed facilities satisfy this criterion, and some have added capacity to handle additional runoff from other sources besides the roadway areas.

Certain design aspects deviated from the SMCWPPP guidelines due to utility conflicts and site restrictions. The SMCWPPP guidelines state that there should be an underdrain system in place where HSG D soils are present for bioretention areas. However, four of the bioretention areas are designed without underdrains either due to their location along a stretch of Bransten Road with no existing storm drain system (and no feasible addition or extension of the storm drain) or due to the depth of the existing storm drain system being too shallow to connect to the drainage inlet. These four bioretention areas also deviate from the SMCWPPP guidelines of having a minimum soil layer depth of 18 inches due to utility conflicts, and are designed to have soil depths of 12 inches. These areas without underdrains are designed to infiltrate through the biotreatment soil media and into the underlying soils. The three remaining bioretention areas have underdrains with elevated orifices to allow for infiltration of the water that collects in the bottom of the rock layer.

Southgate Neighborhood Green Streets (Green Streets)

The Southgate Neighborhood Green Streets Project is located within the Southgate neighborhood in the City of Palo Alto, which is in the northern part of Santa Clara County. This is a residential neighborhood consisting of single-family homes. The residential streets within this neighborhood, which was subdivided in the 1920's, are very narrow. The existing storm drainage system serving this neighborhood is minimal in scope. Gutter flows from the majority of the streets are directed to a single storm drain inlet at the southeast corner of the neighborhood, at the intersection of Sequoia and Mariposa Avenues. While the surface flow pattern probably worked marginally well when the subdivision was initially laid out, the condition of the street and the curb and gutter has deteriorated over the years, with the damage exacerbated by the growth of shallow tree roots in the planter strips. With the present uneven grades along the curb and gutter, storm runoff is blocked at high points heaved by tree roots and ponds at depressions on its way to the single drain inlet. The key objective of the project is to eliminate severe street ponding through the use of innovative techniques that minimize storm runoff, improve storm water quality, and reduce potable water usage. The goal of the proposed project is to provide improved drainage performance through the use of innovative and environmentally friendly techniques that

reduce storm runoff, eliminate ponding, and enhance neighborhood aesthetics in a way that also encourages bicycle and pedestrian travel.

The total area for the site is approximately 41.4 acres.

The proposed treatment measures include bioretention and biofiltration planters, porous pavement crosswalks, and a porous pavement "paseo" (pedestrian walkway connecting two streets). The bioretention planters will be incorporated into the street right-of-way and existing parkway strips (vegetated areas between the sidewalks and the streets). The project includes installation of 18 bioretention areas. Bioretention facility surface areas will range from 3 to 12 feet in width and from 8 to 50 feet in length, based on site constraints. The total surface area of the bioretention areas is 3,387 square feet.

Porous pavers will be incorporated into crosswalks at four intersections in the neighborhood. The pavers will connect each adjacent corner with a 10-foot-wide crosswalk, creating nearly 6,266 square feet of pervious walkway as a part of the project. The estimates of bioretention and pervious walkways are the maximum potential areas going out for bid, actual numbers may vary.

The project will begin construction in the late spring of 2014.

Packard Foundation Project (Green Streets)

The Packard Foundation Project is located in Santa Clara County in the City of Los Altos on Second Street between Lyell Street and Whitney Street. The project was constructed in 2012.

The total drainage area to the project is 0.5 acres of commercially developed land. The pre-project imperviousness is approximately 80%, which was reduced to approximately 67% following project completion.

The treatment measure is a curbside flow-through rain garden that is 3.5 feet wide and 25 feet long on the north side of Second Street and 6.5 feet wide and 25 feet long on the south side of Second Street. The rain garden was designed based on the Santa Clara County Urban Runoff Pollution Prevention Program (SCVURPPP) C.3 Stormwater Handbook and will operate with a target infiltration rate of 2 inches/hour.

Hacienda Avenue Green Streets (Green Streets)

The Hacienda Avenue Green Street Project is located in Santa Clara County within the City of Campbell on a segment of Hacienda Avenue that connects the San Tomas Area Neighborhood to Winchester Boulevard. The City is redeveloping Hacienda Avenue as a green street with proposed improvements including the installation of new sidewalk, bike lanes, street trees, bioswales and other stormwater treatment facilities; narrowing the existing development area; and encouraging infiltration in open areas or developed permeable surfaces.

The total drainage area to the project is 30.65 acres and has an imperviousness of 70% prior to the green streets improvements. The proposed imperviousness following project completion is 62%, due to the planned reduction in roadway width. The land use of the catchment is primarily residential.

The treatment measures to be implemented along Hacienda Avenue are still in the preliminary design phase, with a completed conceptual design. The proposed components include the installation of bioswales and other stormwater treatment facilities, and the use of permeable paving surfaces when the roadway is resurfaced. The allocation and schedule of additional funding is currently being negotiated, so the construction schedule has not yet been determined.

Nevin Avenue Improvement Project (CW4CB Task 5)

The Nevin Avenue Improvement Project is a planned streetscape project along Nevin Avenue between 19th Street and 27th Street in the City of Richmond. The project catchment contains mixed land uses, including civic, residential, and commercial areas. There are also light industrial and historical industrial land uses areas within close proximity to the project location. The drainage to the treatment measures will be largely street drainage with possible drainage from adjacent parcels.

A portion of the larger Nevin Avenue Improvement Project will be funded by the CW4CB grant. Those stormwater treatment features will be constructed first and will include two bioretention areas/rain gardens at 25th Street and Nevin Avenue on corner curb extensions and Silva Cells between 24th Street and 25th Street. Silva Cells are modular suspended pavement systems that use soil volumes to support tree growth and on-site stormwater management. There will be approximately 2,455 square feet of Silva Cells installed between 24th Street and 25th Street with subterranean drainage.

The project is planned for construction by March 2014.

PG&E Substation Project—1st and Cutting (CW4CB Task 5)

The PG&E Substation Project is located at South 1st Street and Cutting Boulevard in the City of Richmond, Contra Costa County, California. The PG&E substation is bounded by rail and Interstate 580 to the north, a recreational vehicle parking lot to the west, Cutting Boulevard to the south and South 1st Street to the east. The substation is surrounded by a concrete berm that retains most stormwater runoff on-site. Ground cover is largely gravel, along with a parking lot, which consists partially of concrete. There is no landscaping on-site. PCBs have been detected in storm drains directly adjacent to the site as well as in the greater site vicinity.

The treatment measures for the project include one bioretention facility with an underdrain and one bioretention without an underdrain along Cutting Boulevard. The bioretention facilities have been separated into four segments due to the placement of existing light poles that are to remain in place. The facilities were sized in accordance to the Contra Costa Clean Water Program

(CCCWP) C.3 guidance using a multiplying factor of 0.04 for bioretention areas with underlying HSG D soils. The total drainage management area (DMA) for Bioretention Areas #1 and #2 is 51,000 square feet and the total DMA for Bioretention Areas #3 and #4 is 21,500 square feet. Bioretention Areas #1 and #2 are undersized due to a necessary reduction in width to avoid utilities and segmentation to avoid the light poles.

The City of Richmond PG&E Substation Project is planned for completion by October 2013.

West Oakland Industrial Area (CW4CB Task 5)

The West Oakland Industrial Area Project is located in the vicinity of Peralta Street between 24th and 30th Streets in the City of Oakland within the Ettie Street Pump Station Watershed. The blocks adjacent to the six proposed treatment facility locations are highly industrial, and include a metal recycling facility, a concrete batch plant, various mixed light industrial and commercial properties, and some residential land use. The drainage areas for the proposed facilities range from approximately 0.05 acres and 0.33 acres, and largely consist of road land uses with an overall imperviousness of 87%.

The project consists of six Filterra tree well treatment units, with five tree well units, 4 ft by 4 ft, and one tree well unit, 8 ft by 4 ft. The tree wells are sited upstream from existing storm drain inlets, such that the runoff will be intercepted by the tree well curb openings before being routed through a mulch layer and underlying filter media then collected by a 4 inch diameter underdrain. The tree wells were sized based on the rational method using a rainfall intensity of 0.2 inches per hour and a runoff coefficient of 0.95 for their respective delineated tributary areas. The flow through the tree well was based upon the surface area of the facility and an infiltration rate of 100 inches per hour.

Construction is planned for completion by September 2013.

B.7.2.5 Vegetated Swale

Broadway and Redwood Project (CW4CB Task 5)

The Broadway and Redwood Project is located east of Broadway between Redwood and Valle Vista in downtown Vallejo. The project catchment is 0.93 acres and will include drainage from the northbound lanes, sidewalk, and the railroad right-of-way along Broadway Street between Redwood Street just south of Valle Vista Avenue and sheetflow from Valle Vista Avenue between Broadway Street and North Cam Alto. The portion draining from Broadway Street is completely impervious, whereas the area draining between the tracks and Broadway is mostly pervious. The overall land use can be characterized as transportation and lies on HSG D soils, which have very low infiltration rates when wet. The land is owned by Southern Pacific but the Vallejo Sanitation and Flood Control District has an easement on the property that permits construction of a treatment measure within the easement.

The treatment measure for this project consists of a vegetated swale in the existing ditch along Broadway Street. The swale will collect runoff from the sidewalk and northbound lanes of Broadway Street and from Valle Vista Avenue between Broadway Street and North Cam Alto. The swale will be located between the Southern Pacific railroad tracks and the northbound Broadway Street sidewalk. The swale will be designed in accordance with the Fairfield-Suisun Urban Runoff Management Program and will be 100 feet long with a top width of 5 feet and a bottom width of 1 foot. The upper 18 inches of the facility will be amended with biofiltration media to support infiltration. The bottom of the swale and the side slopes will be planted with native bioswale sod (i.e., biofiltration sod, delta native heartland sod, and native preservation mix) and hydroseed for treatment and aesthetic purposes. The plants will require irrigation for the first six to eight weeks during the plant establishment period.

The project is planned for completion by October 2013.

B.7.2.6 Media Filters

Ettie Street Pump Station (CW4CB Task 5)

The Ettie Street Pump Station Project is located in West Oakland at 3465 Ettie Street, adjacent to MacArthur Freeway to the north and Nimitz Freeway to the west. The Ettie Street Pump Station is an Alameda County Flood Control and Water Conservation District (ACFCWCD) facility that collects and pumps stormwater runoff to the San Francisco Bay. The Ettie Street Pump Station drainage catchment is comprised of approximately 954 acres in West Oakland and includes approximately 42% residential, 38% industrial, and 20% commercial land use areas.

The proposed stormwater treatment measure for the project is a media filter system with two parallel filter beds containing different media. The design media filter flow capacity for both filters is limited to approximately 30 gpm. The media filter system would be located at grade outside the pump station building and would include a pump and pretreatment storage tank. The pump would draw water up from one of the two forebays into the pretreatment storage tank, which is designed to settle out the fine and coarse particle sizes. Pumping would be triggered during storm events by elevated turbidity readings from a real-time turbidity sensor in the forebay. The flows would then be evenly split between each media bed using flow control valves. One filter bed would contain rhyolite sand and the second bed would contain a mix of media types, including rhyolite sand, zeolite, and granulated active carbon (GAC). The discharges from the media beds will be combined before returning to the forebay.

The project is planned for construction in the fall of 2013.

PG&E Substation Project—Vallejo (CW4CB Task 5)

The PG&E Substation Project in the City of Vallejo is located at 500 Sutter Street on the corner of Sutter Street and Pennsylvania Avenue. The PG&E substation is bounded by an alleyway (Ford AL) to the north, a truck container lot to the east, Pennsylvania Avenue to the south, and

Sutter Street to the west. Sutter Street is a crowned, two-lane road that has a sidewalk on both sides and is separated from the substation by approximately 12 feet of dense vegetation. The tributary area to the facility is approximately 0.13 acres and the groundcover is primarily compacted gravel.

The treatment measure concept for the PG&E Substation Project is to install a new drainage inlet to the substation driveway to collect sheetflow from the project site. The proposed inlet will be a Contech Catchbasin Stormfilter that provides treatment by capturing pollutants in a replaceable media filter cartridge. The filter media in the cartridge will be determined during the design phase.

The project will be complete by October 2013.

B.7.2.7 Hydrodynamic Separators

Alameda and High Street HDS Unit (CW4CB Task 5)

The City of Oakland Alameda and High Street Hydrodynamic Separator (HDS) Unit Project is located at the intersection of 42nd Avenue and High Street in Oakland. The Alameda and High Street CDS unit is located within a watershed with a high concentration of old industrial land uses, including historic rail lines. The tributary drainage area to the HDS is 35 acres.

The proposed HDS unit is the Contech CDS unit. The unit combines hydrodynamic forces and treatment screens to remove solids from stormwater. Specifications for the unit are not currently available.

The HDS unit was installed as part of Oakland's Trash Load Reduction Plan, with the design completed in December 2011 and construction completed in December 2012.

Leo Avenue HDS Unit Project (CW4CB Task 5)

The Leo Avenue Hydrodynamic Separator (HDS) Unit Project is located on 7th Avenue just southeast of Phelan Avenue in southeast San Jose. The Leo Avenue Watershed has a long history of industrial land uses, including auto repair and salvage yards, metal recyclers, and historic rail lines. This HDS unit was planned for installation as part of San Jose's Trash Load Reduction Plan, but will also serve to test the utility of the device for enhanced sediment removal.

A prefabricated HDS unit designed by Contech is the proposed treatment measure. The Leo Avenue Watershed HDS unit receives runoff from approximately 214 acres of commercial and industrial land uses.

The construction of the Leo Avenue HDS Unit project was completed in October 2012.

B.7.3 Status of Control Measure Implementation

B.7.3.1 Baseline

Stormwater treatment measures were not widely implemented in the baseline years (i.e., before July 1, 2002) since the first C.3 provisions that required implementation of treatment measures for new development and redevelopment projects were adopted in 2001 in the Bay Area county-specific MS4 Permits. Therefore, it is assumed that very few stormwater treatment measures were constructed prior to 2002.

B.7.3.2 Current

An inventory of constructed C.3 Regulated Projects.[20] was conducted by tabulating the stormwater treatment sites that are documented in the Fiscal Year (FY) 09/10, FY 10/11, and FY 11/12 Annual Reports for Alameda County, Contra Costa County, San Mateo County, Santa Clara County, and Solano County. C.3 project data for earlier years was not readily available; therefore this inventory represents a subset (i.e., possible low estimate) of the total number of C.3 treatment measures that have been installed. In total, 1,496 C.3 projects were identified as constructed from the available Annual Reports (Figure B.7.3). These treatment measures are considered as enhanced treatment measures as they were constructed after July 2002.

All of the Green Street and CW4CB pilot retrofit projects are enhanced measures, as they also were constructed or will be constructed after July 2002.

B.7.4 Estimates of Loads Avoided/Reduced

B.7.4.1 Loads Avoided/Reduced Methodology

The estimates of loads avoided/reduced were made using a spreadsheet model to predict mean annual estimates of loads reduced. The model converted rainfall to runoff based on percent imperviousness, and takes into account estimates of bypass (when inflow exceeds capacity of treatment measure) and incidental infiltration. Bypass was assumed to equal approximately 20 percent of inflow for the C.3 projects as the C.3 performance standard is intended to achieve approximately 80 percent capture of the average annual runoff volume. For retrofit projects, bypass was assumed to equal 30 percent, as retrofit treatment measures are often undersized due to space constraints and utility conflicts. Incidental infiltration for those BMPs where such infiltration is feasible was set at 20%, taking into account an analysis of data in the International BMP Database (Geosyntec and Wright Water Engineers 2012b). The water quality component in the model estimates influent and effluent PCBs and mercury as follows.

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[20]MRP Provision C.3.b. states that Permittees shall require all projects fitting the category descriptions listed in Provision C.3.b.ii (i.e. Regulated Projects) to implement LID source control, site design, and stormwater treatment on-site or at a joint stormwater treatment facilities. Regulated Projects include the following special use categories: 1. New development or redevelopment projects, 2. Other development projects, 3. Other redevelopment projects, and 4. Road projects.

The influent concentrations for PCBs and mercury were estimated using land use-based event mean particle concentrations (EMCs), back-calculated from mass emission station data utilizing the Regional Watershed Spreadsheet Model (RSWM) (SFEI 2012). The analysis methodology is referred to as "inverse optimization," a process by which land use runoff particle concentrations are varied to minimize the discrepancy between modeled and measured loads at the mass emission stations. The most appropriate land use categorizations for PCBs were determined to be old urban (pre-1954), new urban, old industrial, and agricultural/open space. For Hg, the inverse optimization methodology could not distinguish between old industrial and old urban runoff concentrations, so in this case, land use Hg concentrations were provided only for old urban, new urban, and agricultural/open space. For modeling purposes, the old urban particle concentration for Hg was used for old industrial. The influent particle concentrations for PCBs, and total mercury presented in Table B.7.4.1 were converted to water column concentrations by multiplying by the mean runoff concentrations of TSS by land use (BASMAA 1996). The concentrations in Table B.7.1 are the mean particle concentrations, because the mean concentration times the volume of runoff equals the load.

Table B.7.4.1. Influent Land Use Mean Particle Concentrations for PCBs and Mercury

Land Use	PCBs[1] (ppb)	Mercury[2] (ppm)
Old Urban	150	0.63
New Urban	0.87	0.16
Old Industrial	2800	0.63
Agri/Open Space	20	0.14

Source: SFEI Technical Memorandum; EMC Data Development for RWSM (SFEI 2012)

[1] For PCBs, the four land use categories used from the RWSM EMC analysis include: 1) old (pre-1954) industrial areas, 2) old urban areas, 3) newer urban areas, and 4) undeveloped land (agriculture/open space).

[2] For HgT, the three land use categories used from the RWSM EMC analysis include: 1) old urban areas, 2) newer urban areas, and 3) undeveloped land (agriculture/open space).

Effluent concentrations of PCBs and total mercury (HgT) were estimated assuming the same particle concentrations as indicated in Table B.7.1. But when converting to water column concentrations the method utilized the mean effluent total suspended sediment (TSS), as provided in the International BMP Database. Thus the method assumes that treatment controls reduce PCB and HgT concentrations in direct proportion to the TSS reduction and that particle concentrations are preserved through the treatment system. The International BMP Database contains effluent TSS data for bioretention facilities, bioswales, manufactured devices, media filters, detention basins, green roofs, and porous pavement (Geosyntec Consultants and Wright Water Engineers 2012).

Table B.7.4.2 summarizes the overall modeling methodology used for estimating influent and effluent PCB and mercury concentrations.

Table B.7.4.2. Modeling Methodology for Influent and Effluent PCB and Mercury Concentrations

Influent PCBs/Mercury	Effluent PCBs/Mercury
Influent PCB and Hg particle concentrations based on inverse optimization analysis of mass emission station data and calibration of RWSM. Particle concentrations converted to water column concentrations by multiplying by land use runoff TSS data as reported by Woodward Clyde (1996).	Effluent PCB and Hg particle concentrations based on inverse optimization analysis of mass emission station data and calibration of RWSM. Particle concentrations converted to water column concentrations by multiplying by BMP-specific mean effluent TSS reported in International BMP Database (Geosyntec Consultants and Wright Water Engineers, 2012).

B.7.4.2 Loads Avoided/Reduced by Practices

Green Streets Pilot Projects Results

Table B.7.4.3 contains the influent, effluent, and total loads reduced for PCBs and mercury for the ten Green Streets Pilot Projects. All of the green streets projects are volume-based treatment facilities. Since these facilities are retrofit projects, a number of the facilities will be smaller, based on current planning and design information, than the MRP requires for new development facilities. Therefore, it is anticipated that these facilities will bypass more than 20% of the inflow, and for the purposes of this analysis, it is assumed that the Green Streets Pilot Projects will bypass 30%, corresponding to a percent capture of 70%.

In addition to bypass, some BMP types could experience incidental infiltration, including bioretention facilities with underdrains (Geosyntec Consultants and Wright Water Engineers 2012c). For the purpose of this analysis, it was assumed that for selected BMPs (i.e., bioretention, bioswales, porous pavement and detention) the incidental infiltration would be 20%.

The land use breakdown for each site was based on draft GIS shapefiles developed by SFEI and EOA (2013), as part of the Regional Watershed Spreadsheet Model development. The shapefiles delineate potential PCB and mercury source areas based on historical land uses and potential PCB and mercury uses. The Green Streets Pilot Projects, which were not included in the C.3 Project locations point shapefile, were assumed to have an equal proportion of all three land uses if they were located within old industrial land use areas as defined by SFEI and EOA (2013) and were assumed to have an equal proportion of Old Urban and New Urban if they were located outside of industrial land use areas.

Table B.7.4.3. Influent and Loads Reduced of PCBs and Mercury for the Green Street Pilot Projects

Project	Average Annual Influent Load (mg)		Average Annual Load Reduction (mg)	
	PCBs (mg)	Hg (mg)	PCBs (mg)	Hg (mg)
Bransten Road Green Streets Project	103	39	66	24
Codornices Creek Restoration Project	488	184	310	114

Project	Average Annual Influent Load (mg)		Average Annual Load Reduction (mg)	
	PCBs (mg)	Hg (mg)	PCBs (mg)	Hg (mg)
El Cerrito Green Streets Project	338	128	215	79
Packard Foundation Project	3.1	16.2	1.8	9.6
Park and Hollis Stormwater Curb Extension	45	17	29	11
Stanley Blvd Safety and Streetscape Improvement Project	303	1588	171	896
Sustainable Streets and Parking Lots Demonstration Project	12	62	7	37
San Pablo Green Spine Project	14	74	8	44
Hacienda Avenue Green Streets	176	920	104	545
Southgate Neighborhood Green Streets Project	**253**	**1323**	**150**	**783**
Total	**1,785**	**4,617**	**1,082**	**2,654**

[1] Insufficient information at time of report. SCVURPPP will provide information.

CW4CB Task 5 Retrofit Pilot Projects Results

Table B.7.4.4 shows the mean annual influent and total loads reduced for PCBs and mercury for the ten CW4CB Task 5 Retrofit Pilot Projects. Imperviousness and/or tributary area was not available for the Ettie Street Pump Station, Alameda and High Street HDS Unit, Nevin Avenue Improvements, PG&E Substation—Vallejo, and the Broadway and Redwood projects, but were estimated from design specifications or aerial images.

Load reductions were estimated for those BMPs where the data in the International Stormwater BMP database indicated a statistically significant difference between the median influent and effluent concentrations. For those BMPs listed in Table B.7.4.4, statistical significance was shown for all but the HDS units (Geosyntec Consultants and Wright Water Engineers 2012c). Data on HDS units from a number of studies contained in the International BMP Database indicate that the median effluent concentration is not significantly different from the median influent concentration. Thus a load reduction estimate based on changes in influent and effluent quality was not made for HDS units. (Some coarse sediments are trapped in HDS units, so there is some load reduction that is achieved, and this will be evaluated as part of the pilot studies.)

Similar to the Green Streets Pilot Projects, it was assumed that the BMPs bypassed 30% of the inflow. The exception to this was the Ettie Street Pump Station where the pilot treatment media filters were estimated, based on runoff and media filter flow capacity, to capture and treat only 0.1% of the influent. For those BMPs that could experience incidental infiltration, the infiltration was set at 20%.

These projects were assumed to have an equal proportion of all three land uses if they were located within old industrial land use areas and were assumed to have an equal proportion of Old Urban and New Urban if they were located outside of industrial land use areas.

C.3 Regulated Projects Results

Of the constructed C.3 Regulated Projects tabulated, 1,022 projects could be geographically located using the information available in Permittee FY 09/10- FY 11/12 Annual Report Operations & Maintenance Tables. The land use breakdown for each site was based on shapefiles developed by overlaying C.3 treatment control locations with land use data layers developed by SFEI and EOA (2013) that delineate "old" and "new" urban and industrial land uses. For each treatment control, a table was generated that indicated the types of land uses in the areas tributary to each project categorized as new urban (constructed post-1974), old urban (constructed pre-1974), and old industrial (constructed pre-1968). Of the 1022 projects, 170 of these are located in old industrial land uses.

Table B.7.4.4. Influent, Effluent, and Loads Reduced (g) of PCBs and Mercury for the Retrofit Pilot Projects

Project	Average Annual Influent Load (mg)		Average Annual Load Reduction (mg)	
	PCBs (mg)	Hg (mg)	PCBs (mg)	Hg (mg)
Alameda and High St. HDS Unit [1]	8,083	3,059	0	0
Bransten Road Curb Extensions	105	40	67	25
Broadway and Redwood	236	89	142	51
El Cerrito Green Streets	16	81	9	48
Ettie St. Pump Station	220,322	83,366	188	68
Leo Avenue HDS System [1]	37,491	14,186	0	0
Nevin Avenue Improvements - Bioretention	23	122	14	72
Nevin Avenue Improvements- Silva Cells	47	244	24	127
PG&E Substation - 1st Ave	426	161	271	100
PG&E Substation - Vallejo	26	10	15	6
West Oakland Industrial Area	195	74	124	46
Total	**266,970**	**101,432**	**854**	**543**

[1] It was assumed that HDS units will not reduce TSS (and therefore PCBs and HgT) loads as the International BMP database does not demonstrate significant difference between influent and effluent TSS. Some load reduction is achieved through settling of coarse sediment, and this will be quantified through the pilot studies.

The POC Loads Monitoring Study completed by SFEI indicates that there is a positive correlation between elevated concentrations of PCBs and mercury and watersheds with older land uses in the San Francisco Bay Area (McKee et. al. 2012). Therefore, the estimated loads avoided/reduced due to C.3 stormwater treatment measures analysis focused on those projects located in old industrial areas as the concentration of PCBs in runoff is projected to be much higher in these areas (Table B.7.4.5).

The stormwater treatment projects identified in the Annual Report O&M tables that contained old industrial development were cross-referenced with older Annual Report Projects-Approved tables to extract the project area, post-project imperviousness, type and number of treatment

measure implemented, and treatment measure sizing criteria used, if available. Of the 170 projects located in old industrial areas, 32 have complete available data. The remaining 138 projects were either in Annual Reports that could not be obtained or did not have data reported in the available Annual Reports.

Of the 32 projects, the type and number of treatment measures were: bioswales (15 facilities), manufactured devices (eight facilities), bioretention (seven facilities), media filters (six facilities), detention basins (two facilities), green roof (one facility), and porous pavement (one facility). Some of the projects reported having multiple treatment measures constructed on-site, so for the purposes of modeling, it was assumed that the catchment area contributing runoff to each treatment measure were equal.

For each BMP type, a separate loads analysis was conducted that generated a load per unit area as indicated in Table B.7.4.6. This then was applied to the total area treated by that type of BMP. In this way, the estimates for the 32 projects were extrapolated to include all 170 projects (Table B.7.7).

Table B.7.4.5. Estimates of Average PCB and Mercury Load Reductions per Treated Acre for 32 C.3 Regulated Projects in Old Industrial Land Use Areas

BMP Type	Number of Facilities[1]	Total Tributary Area (ac)	Sum of Average Annual PCB Load Reduction[2] (mg)	Sum of Average Annual HgT Load Reduction[2] (mg)	Average Annual PCB Reduction (mg/acre)	Average Annual HgT Reduction (mg/acre)
Bioretention	7	13	1691	622	129	47
Bioswale	15	147	19037	6883	130	47
Detention Basin	2	16	1038	363	65	23
Green Roof	1	0.3	64	24	191	71
HDS Unit [3]	8	30	0	0	0	0
Media Filter	6	25	2993	1080	118	43
Porous Pavement	1	2	212	76	97	35
Total	**40**	**234**	**25,035**	**9,048**	**730**	**266**

[1] Some of the thirty two regulated projects reported multiple treatment measures constructed on-site, which totaled to forty facilities.
[2] Determined from summing average annual load reductions from the thirty two individual regulated projects by BMP types listed.
[3] HDS units were not assumed to reduce TSS (and therefore PCBs and HgT) loads as the International BMP database does not demonstrate significant difference between influent and effluent TSS.

Table B.7.4.6. Estimated Load Reduction for 170 C.3 Regulated Projects in Old Industrial Land Use Areas

BMP Type	Total Extrapolated Tributary Area (acre)	Average Annual PCB Load Reduction[1] (g)	Average Annual HgT Load Reduction[1] (g)
Bioretention	74	9.6	3.5

BMP Type	Total Extrapolated Tributary Area (acre)	Average Annual PCB Load Reduction[1] (g)	Average Annual HgT Load Reduction[1] (g)
Bioswale	832	107.9	39.0
Detention Basin	91	5.9	2.1
Green Roof	2	0.4	0.1
HDS Units [2]	168	0.0	0.0
Media Filter	144	17.0	6.1
Porous Pavement	12	1.2	0.4
Total	**1324**	**141.9**	**51.3**

[1] Assumes load reduction per treated acreage values listed in Table B.7.6.
[2] HDS units were not assumed to reduce TSS (and therefore PCBs and HgT) loads as the International BMP database does not demonstrate significant difference between influent and effluent TSS.

B.7.4.3 Summary of Key Uncertainties

Due to the limitations in available project information and local water quality data, there are a number of sources of uncertainty in the loads reduced/avoided estimates.

Modeling Methodology

- The particle concentrations derived from the SFEI "inverse optimization" analysis is based on regional (watershed scale) data and may not reflect site-specific conditions pertinent to small scale pilot or C.3 projects.
- Assumptions regarding bypass and incidental infiltration are based on professional judgment and limited literature and may differ substantially from actual project conditions.
- The assumption that TSS is adequate to characterize solids may be a source of uncertainty as SSC is considered a preferable solids measure, especially where coarse solids are greater than 25% of the total dry solids. However, data from settling tests conducted by SFEI indicate that for PCBs the percent settled in less than 2 minutes (attributed to solids in coarse fraction >75 um) was generally less than 30%.
- The assumption to use equal proportions of land uses (New Urban, Old Urban, and Old Industrial) should be refined once more information on each pilot project catchment is available.
- The assumption that that the HDS units do not achieve any load reduction should be evaluated as monitoring data on the pilot studies becomes evaluated.
- Nationwide data contained in the International BMP Database was used to estimate the effluent TSS for each BMP type since the data for semi-arid areas is limited.

C.3 Projects

- For the C.3 regulated projects, the exact tributary area and characteristics were not available for all of the projects, so assumptions were made based upon available Annual Reports.
- For the C.3 regulated projects, PCB and mercury concentrations were assigned based on the location of the project within new urban, old urban, or old industrial land uses. The watersheds are often large in size and may include land uses different from that determined based on the location of the treatment measure.

B.7.5 References

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FIGURES B.7

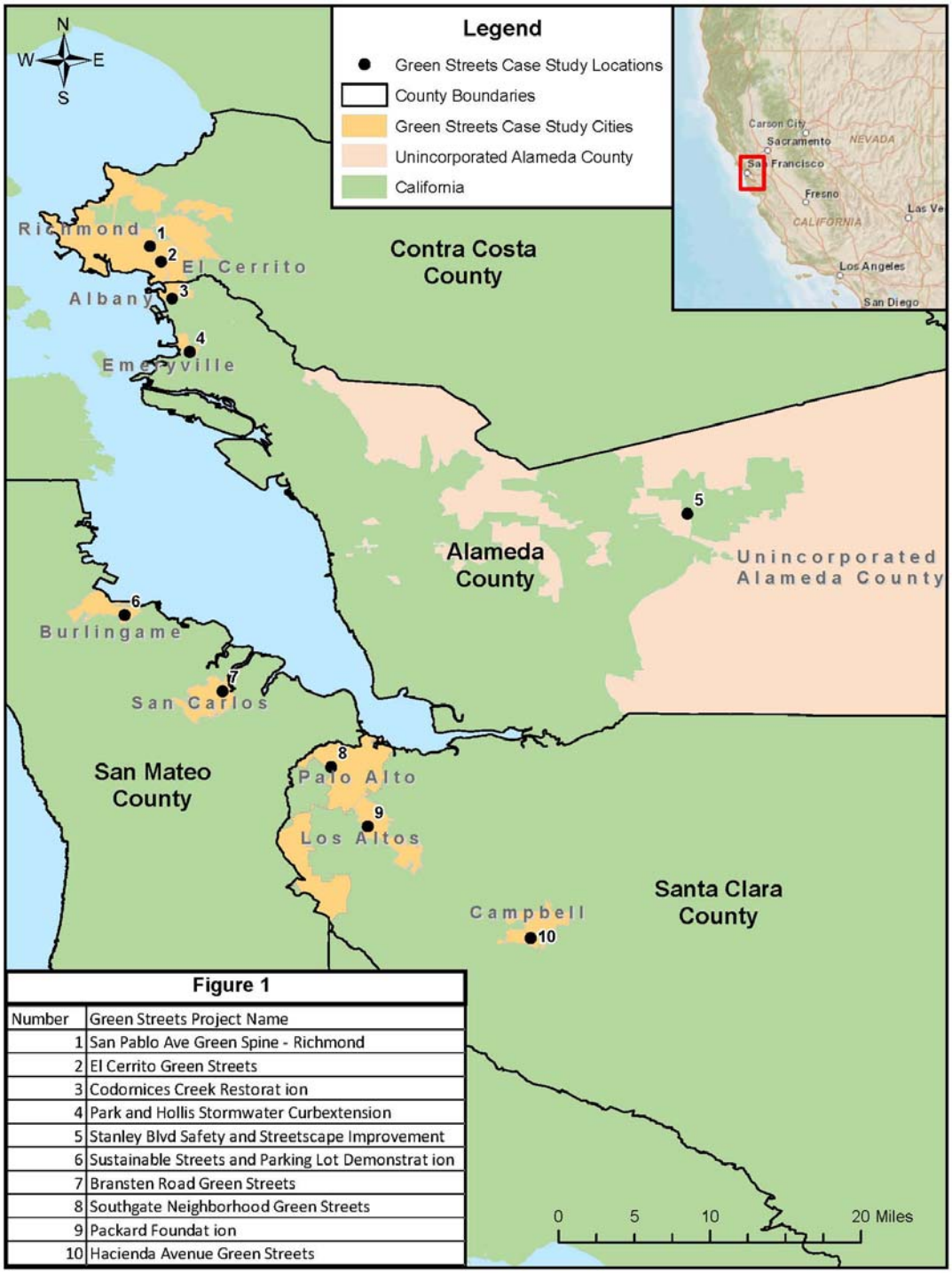

Figure 1

Number	Green Streets Project Name
1	San Pablo Ave Green Spine - Richmond
2	El Cerrito Green Streets
3	Codornices Creek Restorat ion
4	Park and Hollis Stormwater Curbextension
5	Stanley Blvd Safety and Streetscape Improvement
6	Sustainable Streets and Parking Lot Demonstrat ion
7	Bransten Road Green Streets
8	Southgate Neighborhood Green Streets
9	Packard Foundat ion
10	Hacienda Avenue Green Streets

Green Streets Project Locations,

San Francisco Bay Area CA

Source:
Geosyntec Consultants

Bay Area Stormwater Management Agencies Association

May 2013

Figure B.7.1

Entity

Date

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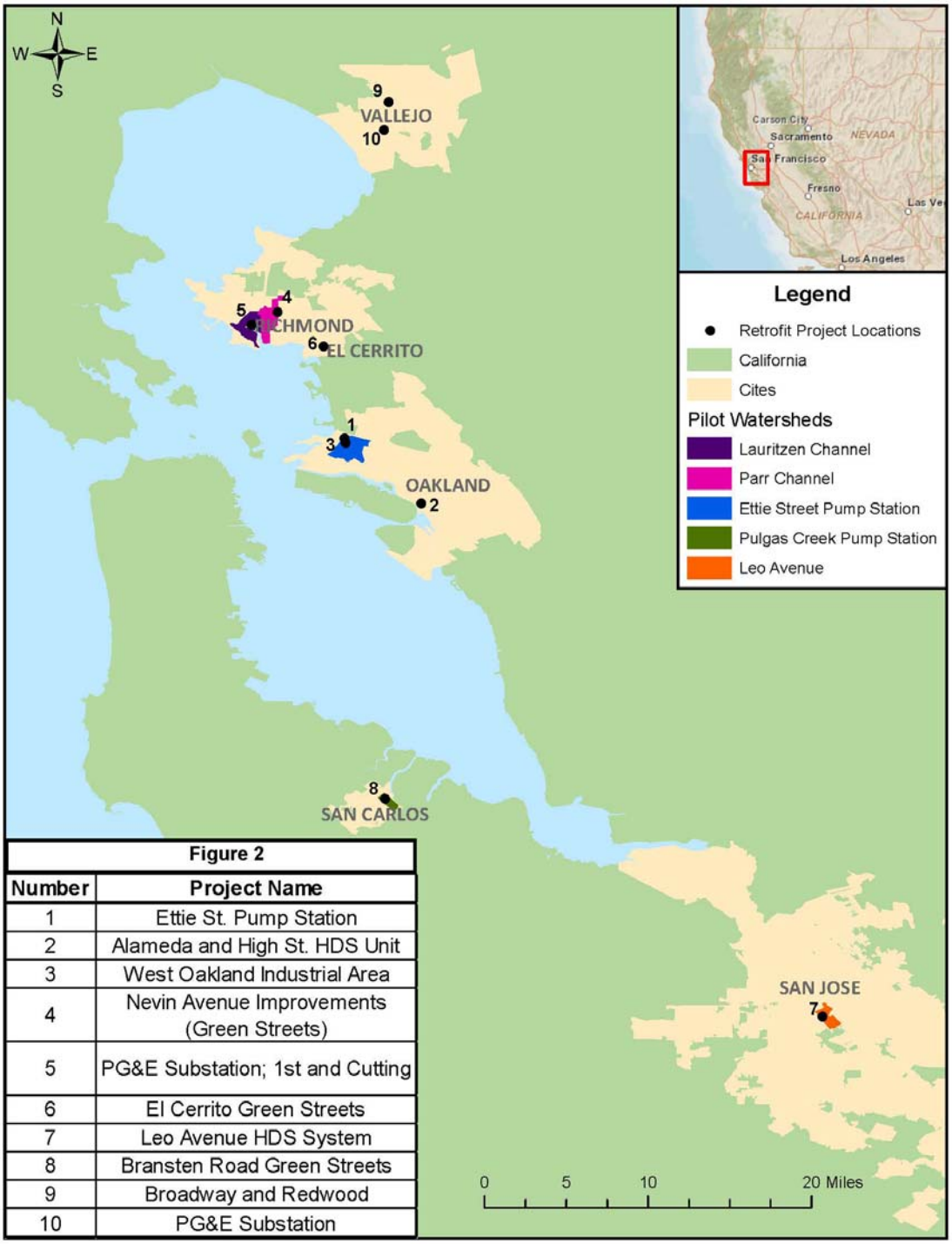

Figure 2

Number	Project Name
1	Ettie St. Pump Station
2	Alameda and High St. HDS Unit
3	West Oakland Industrial Area
4	Nevin Avenue Improvements (Green Streets)
5	PG&E Substation; 1st and Cutting
6	El Cerrito Green Streets
7	Leo Avenue HDS System
8	Bransten Road Green Streets
9	Broadway and Redwood
10	PG&E Substation

CW4CB Task 5 Pilot Retrofit Projects, San Francisco Bay Area CA

Source:
Geosyntec Consultants

Bay Area Stormwater Management Agencies Association

Entity	Date	Figure
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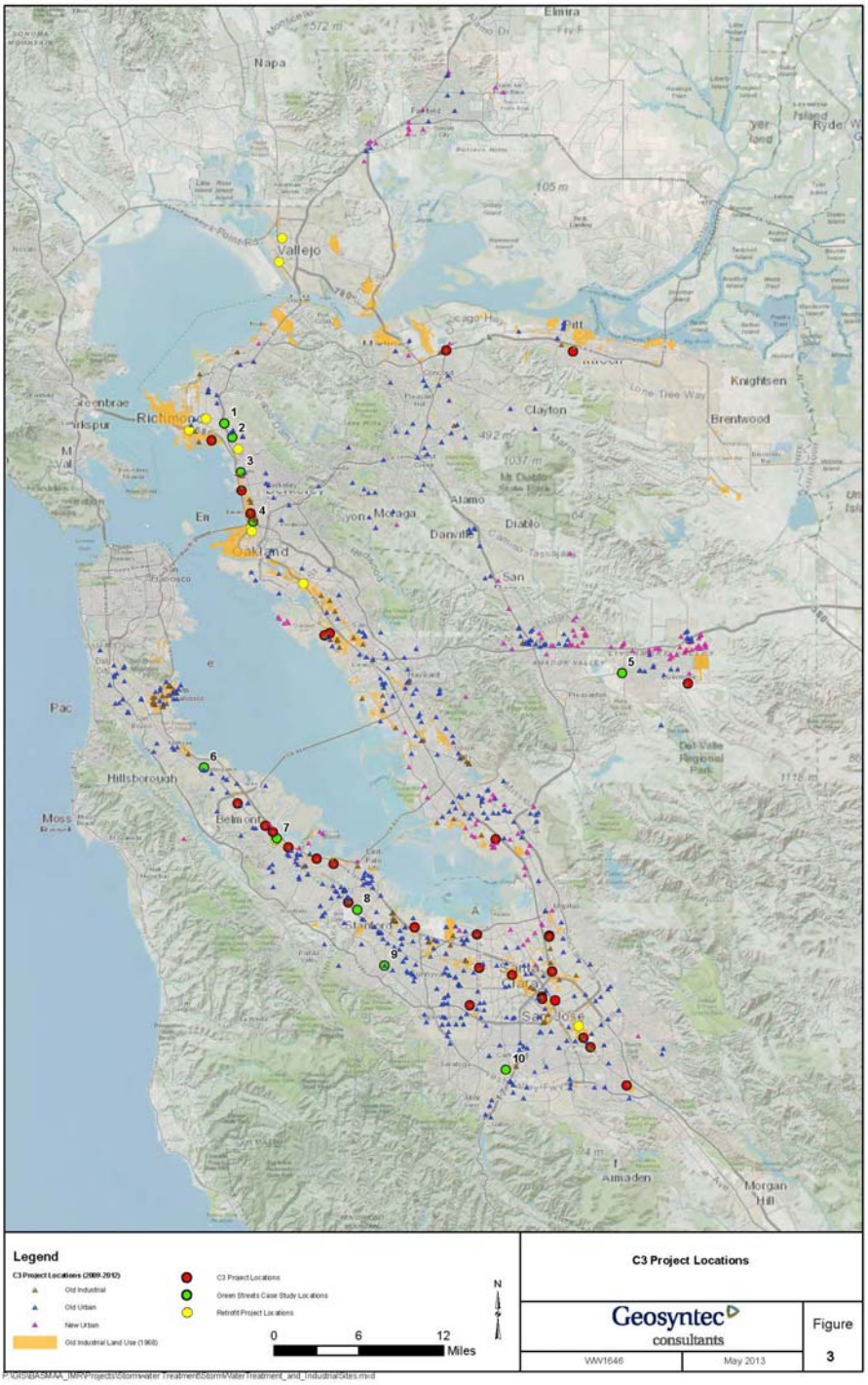

C.3 Project Locations,

San Francisco Bay Area CA

Source:
Geosyntec Consultants

Bay Area Stormwater Management Agencies Association	May 2013	Figure B.7.3
Entity	Date	

internal info: path, date revised, author

B.8 PCBS IN CAULK

B.8.1 Introduction

Prior to the 1979 production ban by the United States Congress, polychlorinated biphenyls (PCBs) were commonly used in various building materials, including sealants that were applied around windows and doors, between concrete and other materials, and around openings for ducts and other conduits. During demolition or renovation of buildings containing PCBs, there is the potential for PCBs to enter the municipal separate storm sewer system (MS4) and ultimately discharge to San Francisco Bay. Thus, building demolition or renovation has been identified as a potential source of PCBs to San Francisco Bay.

Two pilot studies were conducted as part of the PCBs in Caulk Project managed by the San Francisco Estuary Partnership (SFEP) to help inform this issue[21] and address related requirements in the Municipal Regional Stormwater NPDES Permit (MRP). One of the pilot studies was conducted by the San Francisco Estuary Institute (SFEI) and focused on monitoring PCBs in different building types in the Bay Area and developing estimates of regional loads to the Bay. The second pilot study was conducted by Larry Walker Associates, Geosyntec Consultants, and TDC Environmental with the goal of working with the MS4 community to develop tools to assist MS4s in identifying demolition and renovation projects that could potentially release PCBs, and ensuring that the projects follow applicable regulations regarding PCB management.

This purpose of this section is to describe these pilot studies and to present a methodology for estimating the load avoidance or reduction that could be achieved with implementation of the enhanced management practices developed as part of the second pilot study.

B.8.2 Summary of PCB and Mercury Control Pilot Studies

B.8.2.1 MRP Requirements

MRP Provisions

MRP Provision C.12.b requires the Permittees to evaluate the potential presence of PCBs at construction sites, current material handling and disposal regulations/programs, and current level of implementation. Specific implementation requirements include:

[21] This project was originally funded by a Proposition 50 Coastal Nonpoint Source Pollution grant as part of SFEP's Taking Action for Clean Water project; ARRA stimulus funds later replaced state grant funding lost in the 2009 state bond freeze. BASMAA representatives and Regional Water Board staff collaborated in design of the PCBs in Caulk Project and participated in Project Team oversight.

- Develop a sampling and analysis plan to evaluate PCBs at construction sites that involve demolition activities (including research on when, where, and which materials potentially contain PCBs).
- Implement a sampling and analysis plan at a minimum of 10 sites distributed throughout the combined MRP area.
- Develop/select best management practices (BMPs) to reduce or prevent discharges of PCBs during demolition/remodeling. The BMPs should focus on methods to identify, handle, contain, transport and dispose of PCB-containing building materials.
- Develop model ordinances or policies, train and deploy inspectors, and pilot test BMPs at five sites.

PCBs in Caulk Project deliverables[22] were incorporated in the Bay Area Stormwater Management Agencies Association (BASMAA) Regional Pollutants of Concern (POC) Reports describing regionally-implemented activities and submitted on behalf of all MRP Permittees to fulfill Annual Reporting requirements. The 2010 Regional POC Report included the sampling and analysis plan and a status report on sampling and analysis with the available sampling results. The 2011 Regional POC Report included the results of an evaluation of current regulations, level of implementation, and regulatory gaps; the final sampling and analysis report; and a list of appropriate BMPs, BMP training program, and model ordinances and policies to prevent PCB discharges from building demolition and improvement activities.

Part C of the Integrated Monitoring Report (IMR) provides an analysis of the pilot program effectiveness for future implementation opportunities.

Implementation Approach

BASMAA agencies collaborated with SFEP to implement MRP Provision C.12.b. The approaches taken included 1) characterizing via a field monitoring program the concentration of PCBs in different building types in the Bay Area and developing estimates of regional loads to the Bay, and 2) developing and evaluating BMPs which could potentially be applied at appropriate demolition and renovation projects to reduce or prevent the release of PCBs into the MS4. During the planning of these activities, BASMAA representatives made numerous attempts to obtain permission from municipal and private property owners to test building materials for PCBs. It was discovered that obtaining such permission was possible only when a blind sampling program was planned. This was not particularly surprising given that current regulations do not require PCB testing in association with demolition or renovation projects. Furthermore, if testing is conducted voluntarily and PCBs are found at a level exceeding 50 ppm in building materials such as caulks and sealants, the Environmental Protection Agency (EPA)

[22] Available at http://www.sfestuary.org/taking-action-for-clean-water-pcbs-in-caulk-project/

currently requires preparation of a cleanup plan and implementation of that plan, a process that is potentially time-consuming and expensive. When informed of these potential consequences, property owners would only agree to testing building materials for PCBs if a blind sampling program was implemented.

Thus the field monitoring characterization study employed a blind sampling program that kept the exact sampling locations confidential. This allowed for characterization of PCB concentrations found on exterior materials of buildings of various types and ages in the Bay Area without focus on specific locations.

The BMPs and an associated Model Implementation Process (MIP) developed to reduce or prevent discharges of PCBs during demolition/remodeling focused on methods to identify, handle, contain, transport and dispose of PCB-containing building materials. However, performing an implementation trial in the field to evaluate the effectiveness of the BMPs and MIP was problematic without the ability to analyze samples of building materials from specific locations for PCBs. Thus, in lieu of field implementation trials, a training workshop was held on July 26, 2011 to test and refine the MIP before finalization. The workshop targeted municipal staff with responsibility for demolition/renovation permitting.

As a final note, Regional Water Board staff and BASMAA representatives have had many discussions over the course of the permit term regarding implementing the PCB in building materials MRP provision. It was noted that when the MRP was developed it may have been envisioned that PCB BMPs would be applied concomitant to conventional demolition/renovation activities. However, it was later determined that a more plausible process would entail hazardous material inspection, sampling, lab testing, preparing an abatement plan, and abatement, all happening before demolition/renovation, similar to current procedures for asbestos and lead. The construction and demolition industry is becoming aware of the problem with PCBs in building materials but so far the focus has been on human exposure at the site rather than water quality concerns. BASMAA representatives believe the various facets of the "big picture" need to be addressed together (e.g., human exposure at the site, water quality, disposal) rather than trying to apply water quality BMPs outside of this context. BASMAA plans to continue to participate in the stakeholder process as EPA develops related regulations.

B.8.2.2 SFEI PCBs in Caulk Monitoring Study

SFEI prepared the “PCBs in Caulk Project: Estimated Stock in Currently Standing Buildings and Releases to Stormwater during Renovation and Demolition”, or SFEI Monitoring Study, in October 2011[23].

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[23] Available at http://66.147.242.191/~sfestuar/userfiles/PCBsinCaulkFinalReport113011.pdf

The scope of the study, the selection process for the buildings that were monitored, the sampling and analysis methods used, and the collected data and results are summarized below.

Scope of Study

The specific scope and objectives of the SFEI Monitoring Study were to:

- Estimate the mass of PCBs that is associated with caulk in currently standing industrial and commercial buildings in the San Francisco Bay Area that were constructed between 1950 and 1980;
- Estimate the mass of PCBs that is released to urban runoff during the renovation and demolition of these buildings using current practices (i.e., before PCB in Caulk best management practices (BMP) implementation);
- Compare this estimated mass of PCBs released to urban stormwater runoff during renovation and demolition to other PCB sources in the Bay Area; and
- Summarize the information currently available pertaining to the potential effectiveness of BMPs during demolition and renovation of buildings with PCB-containing caulk.

The following sections characterize the types of buildings that were sampled and that contain caulk in the San Francisco Bay Area, the sampling and analysis methods for the testing of caulk concentrations in these buildings, the methodology used for estimating the overall PCB stock in caulk in the San Francisco Bay Area, and the methodology used for estimating the load of PCBs to stormwater during the renovation and demolition of buildings. A supplementary discussion and brief literature review of the potential effectiveness of selected BMPs to address PCB load will be discussed as in a section above.

PCB Concentrations in San Francisco Bay Area Buildings

During 2010 and 2011, samples were collected from the exteriors of 10 currently standing buildings in the San Francisco Bay Area that represented a range of construction types that were constructed during the 1950s, 1960s, 1970s, or 1980s (with the exception of one building that has an unknown construction date). Project partners identified buildings in the region that were candidates for inclusion in the Project based on the building's construction type, date of construction, and the known or suspected use of original caulk. The selected buildings were classified by their construction codes as being either precast/tilt-up concrete shear wall (PC1), pre-cast concrete frame (PC2), concrete shear-wall (C2), light wood-frame residential and commercial smaller than or equal to 5,000 square feet (W1), light wood-frame larger than 5,000 square feet (W2), and reinforced masonry (RM).

Sampling and Analysis Methods

Between 2010 and 2011, 29 caulk samples were collected from ten buildings selected using a blind sampling scheme, which omitted the sampling building locations in order to characterize concentrations found on the exteriors of the targeted buildings as a whole, and not focus on the specific locations. Each of the buildings had between one to seven samples collected from its exterior, with each sample taken from specific caulk types or functions. A maximum of one sample per caulk type or function combination was taken from each building to eliminate duplicates in characterization.

Of the 29 samples collected, 25 were randomly selected and analyzed for PCBs as part of the blind sampling process using a modified EPA method 8270 protocol (semi-volatile organic components by gas chromatography-mass spectroscopy [GC-MS]) by the East Bay Municipal Utility District (SFEI 2011). Method detection limits (MDLs) for the PCB congeners analyzed were based upon 40 CFR 136 Appendix B, and were scaled to reflect the mass and dilution for the samples actually extracted and analyzed. Only three of the 25 samples that were analyzed had PCB concentrations below these detection limits.

Data Analysis and Results

Twenty-two of the 25 caulk samples that were analyzed contained detectable concentrations of PCBs that ranged over six orders of magnitude, from 1 ppm to 220,330 ppm (Table B.8.2.1). Ten of these samples had concentrations that exceeded 50 ppm, which is the concentration at which caulk falls under regulation by the USEPA (USEPA 2012). The median PCB concentration of the entire range of samples was 32 ppm, and the median of only the samples containing concentrations greater than 50 ppm was 9,580 ppm. These sample characteristics are similar to patterns observed in PCBs in Caulk studies conducted in Boston, Toronto, and Switzerland (Herrick et al. 2004; Robson et al. 2010, Kohler et al. 2005).

Table B.8.2.1. PCB Concentrations in Caulk from San Francisco Bay Area Buildings (Klosterhaus et al. 2011)

Building Construction Year	Building Construction Type[1]	Caulk Location on Building	PCB concentration (ppm)
1950s	PC2	Between concrete	220,000
1950s	PC2	Between concrete	198,000
1950s	PC2	Between metal window frame and concrete	146,000
1960s	W2	Between glass and window frame	12,500
1950s	PC2	Between concrete	11,500
1950s	PC2	Around metal window frame	7,630
1950s	PC2	Between glass and metal window frame	3,600
1960s	C2	Between window glass and window frame	89
1980s	RM	Unknown	87
1970s	W2	Between wood and wood	60
1960s	C2	Between window glass and window frame	48

Building Construction Year	Building Construction Type[1]	Caulk Location on Building	PCB concentration (ppm)
1950s	W1	Between glass and metal window frame	15
Unknown	Unknown	Around window frame	15
1970s	W2	Between glass and window frame	11
1970s	W2	Between window frame and wood	10
1970s	W2	Around doorframe	8
1950s	W1	Around doorframe	6
1950s	W1	Around doorframe	5
1950s	W1	Between glass and window frame	3
1950s	W1	Between metal window frame and concrete	2
1960s	PC1	Between concrete	2
1950s	W1	Between wood window frame and wood	1
1950s	W1	Between wood and concrete	0
1950s	W1	Between wood and wood	0
1960s	RM	Between glass and window frame	0

[1] Construction codes: PC1=Precast/tilt-up concrete shear-wall; PC2=Pre-cast concrete frame; C2=Concrete shear-wall; W1=Light wood-frame residential and commercial smaller than or equal to 5,000 square feet; W2=Light wood-frame larger than 5,000 square feet; RM=Reinforced masonry

The distribution of concentrations observed (either less than 100 ppm or greater than 1,000 ppm) in the San Francisco Study area supports one proposed hypothesis: when PCBs were used as plasticizers in caulk, they were added in concentrations of at least 10,000 ppm to maintain the elasticity of the caulking material. Concentrations that are lower than 10,000 ppm are hypothesized to be due to the use of contaminated construction equipment during caulk application or due to secondary contamination via migration of PCBs from adjacent construction materials (Kohler et al. 2005).

The specific PCB congener profiles detected suggest that Aroclor 1254 was the predominant PCB commercial mixture used in typical construction types. This finding is consistent with profiling of contaminants in the Boston, Toronto, and Switzerland case studies. The specific placement/uses of the caulk samples that contained the highest levels of PCBs were located between concrete blocks and around window frames on concrete buildings. In general, buildings with wood frames contained low concentrations of PCBs in caulk (<60 ppm), with one exception. These results also agree with the findings in the previous studies in Boston, Toronto, and Switzerland (Herrick et al. 2004; Robson et al. 2010, Kohler et al. 2005).

The variation of PCB concentration with when the building was constructed is presented in Table B.8.2.2 below, which shows that buildings constructed in the 1950s and 1960s contained the highest PCB concentrations, often greater than 10,000 ppm. There was also PCB detection in a building constructed in the 1980s, which is past the year in which the sale and use of PCBs was banned.

Table B.8.2.2. Temporal Distribution of PCB Concentrations in Caulk Samples in San Francisco Study Area Buildings (Klosterhaus et al. 2011)

Construction Year	Number of Samples	# <MDL	# >MDL-50ppm	# 50-10,000 ppm	# >10,000 ppm	%>50 ppm
1950s	14	2	6	2	4	43
1960s	5	1	2	1	1	40
1970s	4	0	3	1	0	25
1980s	1	0	0	1	0	100
Unknown	1	0	1	0	0	0
Total #	25	3 (12%)	12 (48%)	5 (20%)	5 (20%)	

PCB Stock in Caulk in San Francisco Bay Area Buildings

The second component of the SFEI Monitoring Study was to improve the understanding of the current reservoir of PCBs in caulk in buildings in the San Francisco Bay Area. This characterization was subsequently used in the study to estimate the PCB mass that could potentially be released to stormwater runoff during renovation and demolition of buildings, and to compare caulk in buildings to other characterized sources of PCBs to stormwater in the Bay Area.

Analysis and Calculation Methods

In lieu of an available and accurate inventory of building types in the study area, a geographic information system (GIS)-based approach was used to estimate the number, area, and volume of currently standing buildings that were built during the 1950s -1980s. The GIS analysis was based on historical imagery (USGS Urban Extent 1954 and 1974), current land use data (ABAG 2005), and current aerial imagery (NHAP 1982 and NAIP 2010). The area of interest (AOI) included locations of relevant buildings and land uses. Within this AOI, a set of 100 randomly selected 0.25 square mile grid blocks were digitized to determine the footprints of all applicable currently existing buildings within each respective grid. This information was extrapolated within each MRP county stormwater program area (San Mateo County, Santa Clara County, Alameda County, Contra Costa County, City of Vallejo, and Fairfield-Suisun Cities) to estimate the total building footprint area. A similar approach was used to determine the number of stories within the buildings under consideration in the AOI.

A range of estimates (high, medium, and low) of loadings of PCBs in caulk were developed based on the building characterizations in the study (average footprint, number of stories, number of buildings) and the sampling results (detection frequency and concentration) of this study and those conducted previously in Boston, Toronto, and Switzerland. An approximation of the density of caulk (55 grams /m^3 building) in both the interior and exterior of buildings was used, as it was the most current and reliable estimate available at the time of the study. Table B.8.2.3 summarizes these factors and their respective sources.

Results

The GIS analysis estimated that there are approximately 6,300 currently standing buildings that were built between the 1950s and 1980s in the San Francisco Bay Area. The buildings are heavily concentrated in Santa Clara County (48%), with a remaining 26% in Alameda, 19% in Contra Costa, 6% in San Mateo, and less than 1% in both of the municipalities of Fairfield-Suisun and Vallejo. The density and land use distributions within each of the county and city areas varied, and could be valuable information to consider when making assumptions for management across larger urban areas.

The low, medium, and high estimates for PCB mass in caulk in buildings in the San Francisco Bay Area are 767 kg, 10,500 kg and 46,000 kg, respectively. These values correspond to averages of 0.6, 4.7, and 16 kg of PCBs per building.

Table B.8.2.3. Factors Used to Estimate the PCB Mass in Caulk in San Francisco Study Area Buildings (Klosterhaus et al. 2011)

Factor		Source
Height of one building story (ft)	10.3	Serdar et al. 2011; not standardized
Average # of stories in study area buildings	1.46	This study, Section 3.2.1
Mass caulk per volume building (g/m^3)	55	Robson et al. 2010; estimate from building contractor in Toronto
% of buildings with PCBs >50ppm in caulk (i.e., detection frequency)		Based on detection frequencies in this study, Boston (Herrick et al. 2004), Toronto (Robson et al. 2010), and Switzerland (Kohler et al. 2005).
Low	22	
Medium	36	
High	46	
PCB concentration in caulk (ppm)		25th, 50th, and 75th percentiles of the concentration distribution of this study, Boston (Herrick et al. 2004), and Toronto (Robson et al. 2010). Only samples with PCBs >50ppm collected from buildings built between 1950-1980 were considered
Low	950	
Medium	7,990	
High	27,300	

PCB Mass Loading to Stormwater during Building Renovation or Demolition

A range of estimates of the mass of PCBs that could potentially be released during the renovation or demolition of buildings with PCBs in caulk was determined based on the conceptual understanding of PCB losses to stormwater during these activities (prior to the implementation of BMPs intended to manage PCBs in caulk). The estimate did not account for releases from intact building caulk (i.e., volatilization loss, erosion of in-use caulk, or leaching during precipitation) or residues remaining post-demolition or renovation.

The estimates were based upon a range of average demolitions and renovations per year, the types and time of construction of buildings that were renovated or demolished, the percent of buildings that were assumed to contain PCBs in caulk at concentrations greater than 50 ppm[24], the average stock of PCBs in caulk per building, and the percentage of PCBs in caulk that could be released to stormwater per building. The number of demolitions and renovations in the study area was provided by the Bay Area Air Quality Management District (BAAQMD) "J" numbers, which are required permits for buildings that will be renovated or demolished and that contain greater than 100 square feet of asbestos material. The total number of "J" number permits issued between April 2010 and March 2011 was used as the basis for approximating the low, medium, and high estimates for renovation/demolition activities per year in the area of interest. In order to address the diversity of buildings that were renovated/demolished during that period, a range of high, medium, and low estimates for the percent of buildings potentially containing PCBs were applied (52, 46, and 23%, respectively).

One key assumption for evaluating the PCB loads during building renovation and demolition was quantifying the losses during activities associated with the renovation and demolition processes. A study in Sweden analyzing the PCB emissions during the replacement of PCB-containing caulk was used as a proxy for overall renovation and demolition activities (Jansson et al. 2000). The estimates for losses to the environment consider the PCB mass loss to air and soil, with a safety factor applied to account for releases during the physical transport, grinding, and deposition to soil from washing processes. The low, medium, and high estimates for total PCB mass in building caulk lost to the environment used were 0.0027, 0.0043, and 0.0099%, respectively.

Results

The estimates for the total mass of PCBs released from caulk to stormwater during building renovation and demolition activities ranged from 0.0008 kg/yr for the low estimate, 0.04 kg/yr for the medium estimate, and 0.6 kg/yr for the high estimate (Table B.8.2.4). For the medium estimate, approximately 50% of the total mass was attributed to demolition activities and 50% was attributed to renovation activities. These are likely underestimated values due to the omission of PCB losses from caulk scraps left on-site, in addition to other sources of uncertainty.

Table B.8.2.4. Estimated Annual PCB Mass Released From Caulk to Stormwater During Demolition and Renovation Activities in the San Francisco Bay Study Area (kg/yr) (Klosterhaus et al. 2011)

	PCB mass from demolitions (kg/yr)	PCB mass from renovations (kg/yr)	Total PCB mass (kg/yr)
Low estimate	0.0004	0.0004	0.0008
Medium estimate	0.02	0.02	0.04

[24] This concentration was used because of its significance in existing PCB regulations.

High estimate	0.22	0.39	0.6

When compared to previous studies in the Bay Area, the medium estimate was nearly 10 times lower than the estimate of 0.4 kg/yr calculated in 2010 by Mangarella et al. (low and high estimates were 0.4 and 4 kg/yr, respectively). This is due to an estimate for PCB loss per building in the Mangarella study being ten times higher (0.002 - 0.02 kg/building) than the SFEI Study (medium estimate, 0.0002 kg/building).

It should be emphasized that there are numerous sources of uncertainty in these estimates, and that new information and data should be continually incorporated to refine estimates that were produced for the SFEI Study.

BMP Effectiveness for Demolition and Renovation Practices

There is limited information available that specifically addresses the effectiveness of BMPs for preventing the release of PCBs to the environment during building demolition and renovation. The following sections provide the findings from a brief literature review conducted as part of the SFEI Pilot Study on the effectiveness of abatement and construction material management. Erosion and sediment control BMPs for addressing PCBs in caulk are also addressed.

Abatement BMP Effectiveness

Currently, Sweden and Switzerland have programs in place for the active management of PCB-containing building materials, including caulk. Two studies in Sweden estimated that more than 99% of the PCBs contained in caulk were captured following the implementation of activities that specifically targeted the prevention of PCB release to the environment (Sundahl et al. 1999; Jansson et al. 2000; Astehro et al. 2000). Most of the PCBs were captured via the removal of the caulk from the building through abatement-related activities. These activities included using high power vacuums during the grinding and cutting processes and power washing, which resulted in approximately 0.03% of the total PCB mass in the caulk running off into stormwater. Most of the PCBs that were released to the air resulted from the use of high temperature tools and/or heat generated during demolition or renovation activities.

At the time the SFEI pilot studies were being conducted, a series of reports funded by the USEPA through the National Risk Management Research Laboratory (NRMRL) were underway pertaining to PCBs in caulk. The fourth part, *Laboratory Study of Polychlorinated Biphenyl (PCB) Contamination and Mitigation in Buildings,* addresses the emissions of PCBs in selected primary sources, the migration of PCBs from primary sources to building materials and dust, and evaluates two potential abatement strategies for managing PCBs: encapsulation and chemical destruction.

In terms of effectiveness, encapsulation was demonstrated to be a viable interim option for isolating PCB contamination in buildings when the contaminated materials contain low levels of PCBs (maximum allowed concentration of 430 ppm) (Guo et al. 2012b). This value could be

used as a threshold for the applicability of encapsulation as a mitigation strategy. The Activated Metal Treatment System (AMTS), a chemical destruction technique for PCBs, was also analyzed to screen for effectiveness of removing PCBs from a variety of building materials. AMTS has limited effectiveness as a treatment mechanism on its own due to limitations in effective penetration depth. However, it can be effective for treating contaminated materials after caulking material is removed due to the high thresholds of PCBs that it can treat (Liu et al. 2012).

An additional study was in progress during the time the SFEI pilot studies were being completed that focused on PCBs in school buildings in New York City (Thomas et al. 2012). The main objectives of the study were to characterize sources of PCBs, evaluate contaminant levels, and identify management practices for reducing human exposure. Although the focus was primarily on pathways and exposure in the indoor environment, the sampling results showed that remediation measures can be effective in reducing concentrations from buildings as a whole. Some remedial activities that were completed at the schools during the study included abatement activities, such as caulk patch and repair, fixture removal, HVAC evaluation and repair, encapsulation of exterior caulk, soil removal/replacement, and window removal/replacement. The study showed that even after primary sources of caulks containing PCBs were removed, some secondary reservoirs, such as paint, dust, and masonry, have detectable levels of PCBs remaining.

Construction Material Management Effectiveness

In general, many standard demolition and renovation management codes and regulations emphasize worker safety and hazard minimization. As a consequence, caution is often exercised when hazardous substances are suspected to be present. As noted in above, such precautions have mainly focused on asbestos and lead with limited awareness of PCB concerns. Specific studies on the effectiveness of these precautions to mitigate the deposition of PCBs into water sources have not been conducted. However, the Thomas et al. study on PCBs in schools in New York City successfully implemented some management practices that could be applicable to construction material management during the demolition or renovation of buildings with PCBs in caulk. These include proper ventilation, soil cover and access restriction, routine cleaning, and soil removal/replacement.

Soil and Erosion Control Effectiveness

A study conducted by the San Diego State University Soil Erosion Research Laboratory (SDSU/SERL) analyzed the performance of various mulching BMPs and soil binders for the purpose of soil and erosion control (Caltrans 2000). The BMPs that were included in the analysis include silt fences, compost berms, fiber rolls, hydraulic mulching, compost application, soil binders, hydraulic and bonded fiber matrices and rolled erosion control products. The majority of the BMPs have a relative erosion control effectiveness (when the BMP is compared to a bare soil of similar characteristics) of between 90% to 99%. The study shows that soil and erosion control

BMPs can be an effective management strategy in the detention of soil particles, which PCBs are known to bind to, thus being indirectly managed.

B.8.2.3 PCBs in Caulk Project: BMPs and Planning

The PCBs in Caulk Project aimed to develop tools for municipal agencies to improve the local role in managing potential releases of PCBs to storm drain systems during building demolition or remodeling. The following describes two major components in the project, the development of planning tools and training and the development of BMP guidance.

Model Implementation Process, Outreach, and training

The PCBs in Caulk Project started with a series of outreach workshops to obtain information from various stakeholders to better understand what current practices and policies were being followed in the management of PCB releases from building demolition and renovation projects. The stakeholders included a broad range of interests, including regulatory staff from the Regional Water Board and USEPA Region 9, municipal agency staff, and SFEI staff. Based on input received and additional information on regulatory requirements, an educational fact sheet was produced and distributed to municipal agencies. Project staff then developed a "Model Implementation Process" (MIP) document that provides a stepwise process by which municipal agencies can work with project proponents and the state regulatory agencies to ensure that building demolition and renovation projects comply with existing regulations. The MIP includes a number of templates designed to assist municipalities, including:

- Vendor lists for testing and abatement,
- Structure Type/Age Certification Form,
- PCBs in Caulk Assessment Checklist,
- Outline of PCB Runoff Prevention Plan,
- Building Staff Permit Issuance Checklist,
- PCB Sampling Report,
- Inspection Forms,
- Building Staff Permit Termination Checklist, and
- PCB Clean-up Completion Summary Report.

A training workshop was also conducted with municipal staff to test and refine the MIP before finalization.

BMP Practices

The SFEP Project also published the "Best Management Practices for Reducing PCBs in Runoff Associated with Demolition and Remodeling Projects"[25]. The purpose of the report is to summarize available information on BMPs that can be utilized to control the release of PCBs in caulk to stormwater runoff. Currently, the USEPA has recommended that contractors performing renovation and/or demolition activities implement a series of BMPs aimed at capturing PCB-containing dust that may be mobilized during the removal of caulk. The BMPs focus mainly on the PCB-to-air pathway in order to protect human health[26]. While the goal of the PCBs in Caulk Project is to reduce the exposure of PCBs to water, the BMPs aimed at protecting human health will also likely be effective in reducing the deposition of PCBs to the ground during dry weather periods, which will subsequently reduce the concentrations mobilized by rainfall and runoff. Additional BMPs that are routinely implemented on construction sites for sediment control, erosion control and waste management practices can also reduce the concentrations of PCBs that may be mobilized by wind and rainfall into waterways.

The range of potential BMPs that may be effective for reducing the exposure of PCBs in caulk to stormwater are presented below in three main categories: abatement (or practices implemented prior to demolition/renovation), construction materials management (or the isolation and disposal of materials), and erosion and sediment control practices.

Abatement Practices (Prior to Demolition)

BMPs that can be implemented prior to the start of renovation or demolition activities are considered abatement practices. The main abatement techniques involve the removal of PCB-containing materials, either through physical or chemical extraction from the building. The BMPs that were reviewed as part of the SFEP BMP and Planning Project that can be associated with abatement practices include the following: work area containment, worker training, tools and equipment, and personal protective equipment.

Work Area Containment

The goal of work area containment is to minimize the dispersion of contaminants outside of the specified work zone via wind and/or water mobilization. When used effectively, this BMP is designed to designate and confine the area that contains PCBs so that they may be removed efficiently. Some common practices include:

- Separate areas where work involving PCBs in caulk is planned from non-PCBs in caulk work areas;

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[25] Available at http://www.sfestuary.org/wp-content/uploads/2013/01/4_FinalBMPsNov142011.pdf

[26] Similar practices are required during abatement of asbestos-containing materials, some of which may also contain PCBs. However possible benefits in PCB removal of existing practices are outside the scope of the analyses in this Report.

- Phase work so that activities involving PCBs in caulk are completed, and contaminated materials and equipment are removed, prior to the start of subsequent work;
- Create a containment area where work involving PCBs in caulk is anticipated to isolate the dust and contaminant exposure;
- Take measures to protect nearby water sources, vegetation, buildings, or pathways where humans or the environment may be exposed; and
- Take decontamination precautions after interaction of equipment or personnel to PCBs in caulk.

Worker Training

Worker training emphasizes the proper handling and disposal of materials contaminated with PCBs, which can reduce the potential for PCBs to enter into stormwater. If the site is anticipated to contain soluble concentrations of PCBs above 5 mg/L or total concentrations above 50 mg/kg, it is considered to contain California Hazardous Wastes and the workers must be drained in Hazardous Waste Operations and Emergency Response (HAZWOPER). Specific site-training includes the discussion of the presence of PCBs in caulk and the consequences to human health and the environment from exposure, the identification of personnel responsible for site safety and health, how to identify hazards on site, proper use of Personal Protective Equipment (PPE), work practices that minimize risks from hazards, safe use of engineering controls and equipment, medical requirements, and review of a site-specific health and safety plan. If sites do not contain PCB levels above the thresholds to classify it as containing California Hazardous Wastes, workers are still entitled to receive information and training about PCH hazards and contamination.

Tools and Equipment

Tools and equipment used specifically for the removal of PCBs and those used during the demolition and renovation of buildings containing PCBs in caulk should be selected to minimize the potential for dust generation or mobilization of contaminants. An additional consideration is that tools and processes that generate high temperatures may produce gasses containing PCBs that will be released into the air. These gases may later deposit the PCBs on surfaces or in waters themselves that will contribute to the contamination of stormwater.

Personal Protective Equipment

The use of personal protective equipment (PPE) should be implemented to protect human health during abatement practices, and during actual renovation and demolition activities. When used correctly, PPE can minimize the transport and spread of PCBs from clothing and other materials that may have been unintentionally transported offsite and eventually into stormwater. A site-specific assessment is required prior to the determination of appropriate PPE for sites contaminated with PCBs.

Construction Material Management (Activities Associated with Demolition or Renovation and Engineering Management)

Construction material management BMPs are implemented during and following renovation and demolition projects to isolate and dispose of PCBs and contaminated tools or materials. BMPs that were reviewed as part of the SFEP Pilot Study and relate to construction material management include the following: building occupant notification, demolition BMPs, work area housekeeping and end-of-project activities, and transport and disposal. Many of the BMPs that can be implemented during the abatement phase are also applicable during the actual demolition and renovation process.

Building Occupant Notification

The notification of building occupants when renovation and demolition activities are planned is designed to protect human health, but it can also reduce the unintentional tracking of PCB-laden dust from the project site to water sources through the limitation of unauthorized access. Effective communication among all affected parties (i.e., building occupants, owners, workers, and community members) can help minimize the exposure of PCBs to humans and the environment.

Demolition BMPs

Demolition BMPs are intended to address demolition activities, such as razing of buildings, which occur after hazardous materials like PCBs have already been removed from the building. The BMPs generally involve wetting activities to minimize dust dispersion, and any runoff produced should be managed and contained properly.

Work Area Housekeeping and End-of-Project Activities

Housekeeping and maintenance of work areas is essential for managing PCBs in caulk during demolition and renovation. Daily housekeeping and cleaning activities should be completed to prevent cross-contamination across the project site and to minimize the tracking of PCBs off-site.

Following the completion of the actual building demolition or renovation, contractors should ensure that the trash and debris produced are removed and deposited in the appropriate manner and that the site is cleaned and decontaminated using practices that minimize the potential for dust or contaminant mobilization.

Transport and Disposal

Both the USEPA and the California Department of Toxics Substance Control manage the transport and disposal of materials containing PCBs produced during demolition and renovation projects. Transportation of PCBs must be in accordance with the California Health and Safety code and disposed of under the California Code of Regulations (CCR) Title 22. The disposal of the actual caulk containing PCBs, other contaminated solid wastes, and contaminated liquid wastes should be arranged with the appropriately permitted waste disposal facility and Federal decontamination and disposal regulations should be followed.

Erosion and Sediment Control Practices

Materials containing or exposed to PCBs that are temporarily stored on-site during renovation and demolition projects must be managed to limit exposure to wind and water. Traditional erosion and sediment control BMPs are often applicable when managing the protection of PCB-contaminated materials from erosion and transport. The California Stormwater Quality Association (CASQA) Stormwater Best Management Practice Handbook Portal: Construction (CASQA 2009) contains fact sheets for these BMPs with information pertaining to their purpose, suitable applications, limitations, implementation, costs, and maintenance.

While implementation of specific BMP types will be dependent on site conditions and constraints, the following categories are most applicable to building renovation and demolition where PCBs in caulk are present:

- Wind Erosion Control (WE-1)
- Stabilized Construction Entrance/Exit (TC-1)
- Storm Drain Inlet Protection (SE-10)
- Stockpile Management (WM-3)
- Hazardous Waste Management (WM-6)
- Contaminated Soil Management (WM-7)
- Concrete Waste Management (WM-8)
- Demolition Adjacent to Water (NS-15)
- Paving and Grinding Operations (NS-3)

These BMPs aim to adequately manage construction activities so that stormwater runoff from construction sites does not increase pollutants to levels that impact water quality. Specifically, sediment can be a pollutant and is the primary component of turbidity, total suspended solids (TSS) and suspended sediment concentration (SSC). Sediment can also transport other pollutants, like PCBs that bind to soil particles. Effective soil and erosion control BMPs, from non-structural controls like good-housekeeping, to structural controls like fiber rolls, silt fence, and sedimentation basins, can act to prevent the mobilization of soil and attached pollutants from migrating off-site.

It was the intent of the SFEP Project to test the effectiveness of the various BMPs described above in five case studies where actual demolition or renovation was being conducted by public agencies. After considerable outreach, it was determined that obtaining approval, planning, and implementation for such case studies within the available schedule was infeasible.

B.8.3 Status of Control Measure Implementation

B.8.3.1 Baseline

Table B.8.3.1 below shows the baseline practices governing demolition and renovation in the San Francisco Bay Area. Although monitoring is not required, if monitoring is conducted and concentrations are above 50 mg/kg, EPA regulations require the project or site manager to submit a self-implementing clean-up plan to EPA Region 9.

Table B.8.3.1. Baseline Management Practices for PCBs in Caulk

Practice	Baseline Implementation
Monitoring	Not required
Pre-Demolition Abatement	None
Demolition and Disposal	Standard demolition practices and disposal/ recycling as non-hazardous waste
Erosion and Sediment Control	Required as per the State Water Resources Control Board's Construction General Permit (SWRCB 2009)

B.8.3.2 Current

As no enhanced control practices have been implemented since TMDL adoption, the control measures in Table B.8.3.1 above also represent the current (enhanced) management practices, although there is considerable uncertainty regarding the level of implementation in the San Francisco Bay Area. A key question is the extent to which abatement is conducted for PCB management. As indicated above, the USEPA requires a management plan that includes abatement where monitoring data indicates PCB concentrations in sealants exceeding 50 ppm. But there is no regulatory requirement to monitor PCB concentrations in sealants. So, under the current regulations, abatement of PCBs in sealants may be quite limited. In a similar vein, in lieu of monitoring, the classification of waste is not evaluated and disposal or recycling as a non-hazardous waste could lead to reintroduction of PCBs into the environment.

B.8.4 Estimates of Loads Avoided/Reduced

B.8.4.1 Loads Avoided/Reduced Methodology

PCBs in Buildings and PCB Mobility

As described above, samples collected by SFEI indicate that concentrations of PCBs in caulk in Bay Area buildings fall into two tiers (Kosterhaus et al. 2011). Of the 25 samples analyzed, seven samples exceeded 1,000 ppm (maximum concentration of 220,000 ppm), with the remaining 18 samples less than 100 ppm. Also, 15 of the samples were less than 50 ppm, which is the current trigger for initiating EPA regulatory requirements for a management plan that includes abatement. The buildings with caulk containing the elevated PCB concentrations in excess of 1,000 ppm were all constructed in the 1950s, although there were other buildings with lower PCB concentrations that were also constructed in the 1950s.

Focusing only on those buildings with potential to have PCB-containing materials at concentrations greater than 50 ppm, Klosterhaus et al. conducted a GIS analysis of 1950 to 1980 land use data for areas subject to the MRP and estimated the mass of PCBs contained in caulk in buildings based on the median size of the buildings, the mass of sealant contained in buildings, and the sampling data collected in the San Francisco Bay Area, Boston and Toronto. The medium estimate of PCBs in each building was 4.7 kg of PCBs, with a low estimate of 0.6 kg, and a high estimate of 16 kg per building.

The data on the amount of PCBs from caulk that might be mobilized during demolition/renovation and available for further mobilization by rainfall and runoff is very limited. Kosterhaus et al. conducted a literature review and found only a few pertinent papers, including results from a study of one building in Stockholm, Sweden, where sealant was removed and the percent of mass of PCBs released to the air, soil, and water were reported. Based on their analysis of the data, Kosterhaus et al. estimated a medium value of 0.0043% of the original PCBs mass contained in building sealants entered the surface water runoff system. This study was not necessarily representative of typical demolition/renovation sites, since it required Kosterhaus et al. to make a number of assumptions. The authors indicated that this estimate could be biased low due to the omission of PCBs at concentrations under 50 ppm; and also the potential for PCB release from equipment and other building materials besides caulk and sealants.[27]

The SFEI Study results suggest that PCBs in sealants are not very mobile, and the principal pathway into the environment is via dust and larger sealant fragments released during the pre-demolition abatement process or during the demolition/renovation process itself.

Mass Balance Approach at the Building Scale

This section describes the methodology to be used to estimate the load reduction associated with the management of PCBs that could potentially be released during building demolition or renovation. The methodology is based on a mass balance for the PCBs contained in the sealants of an individual building subject to demolition or renovation.

The overall mass balance used at the building scale is as follows:

$$M_B = M_A + M_D + M_{ESC} + M_{MS4} \qquad \textit{Eq. 1}$$

Where:

$M_B =$ *Mass of PCBs in building,*

[27] While the SFEI Report did comment on other reservoirs of PCBs in existing buildings, discussion of management of non-caulk PCB sources was beyond the scope of the PCBs in Caulk Project and this report.

M_A = *Mass of PCBs removed by abatement prior to demolition,*

M_D = *Mass of PCBs removed by offsite disposal of demolition or renovation material,*

M_{ESC} = *Mass of PCBs removed by capture in erosion and sediment control practice, and*

M_{MS4} = *Mass of PCBs released to the MS4 storm drain system.*

The concept behind the mass balance approach is that the PCB containing materials in an individual building are managed through a sequence of BMPs or steps that can remove a certain portion of the original mass of PCBs. The mass remaining after each individual practice is subsequently available to be removed in the following practice. In this case, the mass of PCBs removed through abatement practices is considered first in the PCB removal hierarchy. Next, the mass remaining following abatement is subject to material management and disposal related controls. Any mass remaining after disposal that may still reside onsite is subject erosion and sedimentation control practices. Stockpile management and disposal and erosion and sediment control practices occur simultaneously, but this does not violate the mass balance.

If the mass removed is expressed as a product of the available mass times a "mass removal effectiveness", or EFF value that varies between 0 and 1, the proportion of the original mass that is removed through the sequence of BMPs or steps can be obtained:

$$(M_B-M_{MS4})/M_B = EFF_A + EFF_D (1-EFF_A) + EFF_{ESC}(1-EFF_A - EFF_D + EFF_A*EFF_D) \quad \text{Eq. 2}$$

Where:

EFF_A = *Mass removal effectiveness of abatement (expressed as fraction between 0 and 1 where 1 is 100% effective),*

EFF_D = *Mass removal effectiveness of offsite disposal, and*

$EFFES_C$ = *Mass removal effectiveness of erosion and sediment controls.*

For example, if abatement is assumed to be 50% effective, disposal is assumed to be 30% effective, and erosion and sediment control is assumed to be 70% effective, the overall percent of mass retained is approximately 90%:

*Fraction of Mass Retained =0.5+0.3(1-0.5) +0.7 (1-0.5-0.3+0.5*0.3) = 0.895*

The remaining 10% of the PCB mass from the building is estimated to enter the MS4 system.

B.8.4.2 Loads Avoided/Reduced by Practices

The purpose of this section is to estimate the load reduction achieved by the implementation of enhanced management practices for the demolition and renovation of buildings containing PCBs in caulk. As no enhanced practices have been implemented at this time, the estimate presented in this section is for loads avoided by baseline management practices.

An estimate of the effectiveness for the baseline management practices was developed for a range (low, medium, high) of management strategy effectiveness levels and a range of mass of PCBs in San Francisco Bay Area buildings. Table B.8.4.1 estimates of the effectiveness for the baseline management practices for the range of management strategy effectiveness levels for the medium estimate of mass of PCBs per building (4.7 kg). The same methodology and assumed effectiveness values were applied for the low and high estimates of PCBs present per building as determined by SFEI (0.6 and 16, respectively) and are presented for comparison in Table B.8.4.2 below.

The estimates of effectiveness provided in Table B.8.4.1. are based on the literature review on effectiveness cited in an earlier section and on professional judgment. The rationale for the selection of effectiveness is summarized below:

- Pre-demolition abatement is assumed not to occur as part of the baseline management practices.
- Offsite disposal effectiveness encompasses practices designed to limit dust generation during demolition and materials stockpiling and removal offsite. Offsite disposal effectiveness also addresses the ultimate disposal of the materials and the extent to which such disposal prevents exposure to the environment. In general, the proper means of conducting these activities are well understood and are routinely implemented by good practitioners. However, the disposal and recycling options differ significantly depending on the classification of the waste. For the baseline management practices, the waste is assumed to be classified as ordinary construction material waste that could be recycled or disposed of in a non-hazardous waste landfill. In this case, there is potential for material to be introduced into the environment resulting in a range of lower effectiveness. Thus the effectiveness of offsite disposal management practices is estimated to range from 70 percent to 90 percent.
- Effective soil and erosion control practices are well known and required by the Construction General Permit. Estimates of effectiveness are supported by an extensive literature base, and although testing does not address PCBs specifically, controls that are effective in managing sediments are likely to be effective in controlling PCBs (which are primarily sediment bound).

Table B.8.4.1. Effectiveness of Baseline Control Measures (Mass per Building = 4.7 kg)

Control Measure Effectiveness	Abatement EFF	Offsite Disposal EFF	ESC EFF	Mass Captured (Fraction)	Mass Captured (kg)	Mass Released (kg)	Mass Released (%)
Low	0	0.7	0.6	0.88	4.14	0.564	12
Medium	0	0.8	0.7	0.94	4.42	0.282	6
High	0	0.9	0.8	0.98	4.61	0.094	2

Table B.8.4.2. Effectiveness of Baseline Control Measures for Low, Medium, and High Estimates of PCB Mass per Building

Control Measure Effectiveness	Mass per Building = 0.6 kg			Mass per Building = 4.7 kg			Mass per Building = 16 kg		
	Mass Captured (kg)	Mass Released (kg)	Mass Released (%)	Mass Captured (kg)	Mass Released (kg)	Mass Released (%)	Mass Captured (kg)	Mass Released (kg)	Mass Released (%)
Low	0.528	0.072	12	4.14	0.564	12	14.1	1.92	12
Medium	0.564	0.036	6	4.42	0.282	6	15.0	0.96	6
High	0.588	0.012	2	4.61	0.094	2	15.7	0.32	2

B.8.4.3 Summary of Key Uncertainties

There are a number of sources of uncertainty to accurately estimating PCB and Hg loads to San Francisco Bay associated with building demolition/renovation. The following describes those sources associated with input to the load estimation methodology, namely:

- Uncertainty in PCB Mass Contained in Buildings, and
- Uncertainty in Effectiveness of Control Measures.

Uncertainty in PCB Mass Contained in Buildings – A key input to the methodology is the amount of PCBs contained in the caulk in buildings subject to demolition or renovation. In one of the pilot studies, Klosterhaus et al. (2011) collected 25 samples from 10 buildings in the Bay Area. The data showed a range from non-detect to 220,000 ppm with generally higher concentration associated with pre-cast concrete structures built in the 1950s and 1960s. The amount of PCBs contained in buildings varied substantially depending on the age and type of buildings. The limited number of buildings sampled is a source of uncertainty in characterizing the Study Area building stock, and the limited number of samples per building also may not sufficiently characterize the variability in PCB concentrations in the caulk within each of the sampled buildings.

Uncertainty in Effectiveness of Control Efforts – The effectiveness of control efforts in mature stormwater program elements (e.g., new development controls) is generally well documented based on monitoring studies, and experience gained in the implementation of various types of measures under a variety of site conditions. In contrast, management of PCBs in caulk during

demolition and renovation for environmental releases to the MS4 system is an emerging issue, and most control measures associated with demolition/renovation focus on worker safety rather than discharge to the MS4 and subsequent environmental effects. Three types of controls are identified in the methodology, pre-demolition abatement controls, demolition and disposal controls, and erosion and sediment transport controls at the site. The literature is very limited in terms of pilot studies that have addressed the effectiveness of abatement and demolition/disposal controls, although one somewhat dated study conducted in Switzerland and cited by Klosterhaus et al. (2011) indicates that abatement can be highly effective. The estimates provided in the methodology illustrate a range based for the most part on best professional judgment.

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B.9 DIVERSION TO POTWS

B.9.1 Introduction

This section of the Integrated Monitoring Report (IMR) addresses the use of diversions of dry weather and/or first flush events from municipal separate storm sewer systems (MS4s) to publically owned treatment works (POTWs) as a method to reduce loads of polychlorinated biphenyls (PCBs) and mercury in urban runoff.

B.9.2 Summary of Stormwater Diversion Pilot Projects

B.9.2.1 MRP Requirements and Implementation Approach

Permittees are currently implementing controls measures to divert stormwater to Publicly Owned Treatment Works (POTWs) at a pilot scale. Municipal Regional Stormwater NPDES Permit (MRP) Provisions C.11.f and C.12.f require the Permittees to pilot test diversions of first flush and dry weather urban runoff to POTWs. These provisions require the Permittees to collectively select five locations and five alternates by evaluating drainage characteristics and the feasibility of diverting flows to the sanitary sewer. In addition:

1. The Permittees should work with the local POTW on a watershed, program, or regional level to evaluate feasibility and to establish cost sharing agreements. The feasibility evaluation shall include, but not be limited to, costs, benefits, and impacts on the stormwater and wastewater agencies and the receiving waters relevant to the diversion and treatment of the dry weather and first flush flows.
2. From this feasibility evaluation, the Permittees shall select five pump stations and five alternates for pilot diversion studies. At least one urban runoff diversion pilot project shall be implemented in each of the five counties (San Mateo, Contra Costa, Alameda, Santa Clara, and Solano). The pilot and alternate locations should be located in industrially dominated catchments where elevated PCB concentrations are documented.
3. The Permittees shall implement flow diversion to the sanitary sewer at the five pilot locations. As part of the pilot studies, they shall monitor and measure PCB load reduction.

Permittees have conducted a systematic process for identifying, prioritizing, and implementing the five required pilot diversion projects. A stormwater diversion feasibility evaluation, coordinated through a Bay Area Stormwater Management Agencies Association (BASMAA) regional project, was conducted in 2009-2010. The evaluation included development of selection criteria for potential diversion projects and identified a range of candidate projects in each of the five counties regulated under the MRP. Based on input from the Regional Water Board, a revised Feasibility Evaluation Report (FER) was submitted in December 2010. This FER submittal fulfilled reporting requirements for Fiscal Year 2009-10 under provisions C.11.f and C.12.f of the MRP.

During FY2010/11, stormwater program representatives (on behalf of Permittees) implemented the screening process developed in the FER to propose five candidate and five alternate pilot diversion projects. Representatives met to refine the list based on expected learning benefits, opportunity areas, and constraints identified in the FER. Staff of the Regional Water Board attended meetings in October 2010, April 2011, and June 2011 to provide their comments on proposed pilot projects.

At that time, stormwater program representatives and Regional Water Board staff concurred that there was likely overlap between evaluations of the proposed diversion pilots and sediment management activities and they could collectively be carried out in fulfillment of Provisions C.11.d and C.12.d of the MRP. Opportunities were subsequently identified to evaluate the benefits of strategic storm drain cleanouts, street sweeping enhancements, street flushing, and other sediment management actions that could augment the planned pilot diversion projects.

Work plans for each of the five diversion projects were provided to the Regional Water Board in May 2012. These work plans identified project objectives, equipment and infrastructure requirements, water quality monitoring (including analytical methods), a general framework for identifying costs, benefits, and operation challenges associated with the diversions, and a time schedule for monitoring, evaluation, and reporting.

Status reports on the diversion projects were submitted with the BASMAA Regional Pollutants of Concern and Monitoring Supplements to the 2011, 2012, and 2013 Annual Reports to meet the MRP's annual reporting requirements. Both planning and implementation activities for the diversion projects were conducted during FY 2012/13 in accordance with May 2012 work plans.

Subsequent sections of this report summarize monitoring results available to-date and describe follow-up monitoring planned for FY 2013/14 as part of the IMR's overall evaluation of the pilot diversion projects and associated schedules for completion. Methodologies that will be used to assess the loads reduced via the pilot diversion projects are also described.

B.9.2.2 Pilot Stormwater Diversion Projects

The pilot diversion feasibility evaluation included costs, impacts on the stormwater and wastewater agencies, and benefits to the receiving waters. Selection criteria were based in part on a review of other programs that had scoped and/or implemented urban runoff diversion projects and on discussions with stormwater program representatives. The selection criteria were intended to inform the selection of sites (i.e., pump stations) for potential diversion and were framed around water quality needs, costs, and acceptability, as summarized in Table B.9.2.1 below.

Maps of PCB concentrations in sediments, pump station locations, and POTW service areas were included in the FER to assist with the needs criteria. Guidance was also provided for addressing the acceptability criteria. Tools for developing cost estimates and estimating potential load reductions of PCBs and Hg from stormwater discharges as a result of pilot diversion projects were also included in the FER.

Table B.9.2.1. Pump Station Diversion Selection Criteria and Information Needed

Criteria		Information Needed
Needs	Will the project likely yield a significant benefit to mercury and / or PCBs in receiving waters?	• PCB concentrations in sediments from the local drainage • Pump station inventories in GIS and tabular formats • Event-mean PCB concentrations in stormwater • TSS and flow measurements • Drainage area assessments
	Will the project provide unique or new information?	• Input from Technical Oversight Committee
	Does a pilot project fit into the broader regional context of pilot-testing a range of pollutant control strategies, including pollution prevention, site remediation, enhanced sediment management, and stormwater treatment retrofitting strategies?	• Input from Technical Oversight Committee
Costs	Are the capital and operation and maintenance costs associated with diversion prohibitive?	• Site investigations • Conceptual designs and drawings • Preliminary site-specific cost estimates • Treatment and connection costs/charges
Acceptability	Is there an accessible POTW willing and able to provide treatment service?	• POTW service area map • Communication with POTW managers
	Can the pilot diversion be sited within acceptable design criteria?	• Pre-design checklist assessment Table 1

The resulting five pilot diversion projects, one for each County regulated by the MRP, are listed in Table B.9.2.2 below and are indicated in Figure B.9.2.1.

Table B.9.2.2. Pilot Diversion Project Descriptions

County	City	Pilot Project
Alameda	Oakland	Dry and wet weather diversion at Ettie Street Pump Station to East Bay Municipal Utility District
Contra Costa	Richmond	Dry and wet weather diversion at North Richmond Pump Station to West County Sanitation District
Santa Clara	Palo Alto	Dry and wet weather collection from existing structure in Palo Alto that diverts urban runoff to the Palo Alto Regional Water Quality Control Plant
Solano	Fairfield	Dry season vactor truck wet well collection at State Street Pump Station and discharge to Fairfield-Suisun Sewer District
San Mateo	San Carlos	Dry and wet weather collection from Pulgas Creek Pump Station and discharge to South Bayside System Authority

A summary matrix identifying the evaluation approach for and characteristics of each of the five pilot diversion projects is included in Appendix B.9.A.

The following sections provide an overview and status of each pilot diversion project as of September 2013. Monitoring at four of the project sites (in Alameda, Santa Clara, San Mateo, and Solano Counties) commenced during the third quarter of 2012. Monitoring for the Contra Costa County project will commence in 1st quarter of 2015, to complement previous characterization monitoring. Agencies will continue to communicate with Regional Water Board staff as the projects progress and may adapt their work plans in response to those discussions and climatic conditions.

Ettie Street Pump Station, Alameda County

Project Overview and Objectives

ACCWP selected for the pilot study the Ettie Street Pump Station (ESPS), located in the City of Oakland. The selection was based on: 1) elevated PCB and mercury concentrations found in previous studies of sediment in the ESPS and its watershed, and 2) geographical proximity to the East Bay Municipal Utilities District (EBMUD) conveyance and wastewater treatment systems (see Figure B.9.2.).

Prior to the development of the Clean Watersheds for a Clean Bay (CW4CB) Pilot Study, the EBMUD investigated the feasibility of a stormwater diversion at ESPS for consideration as a possible PCB and mercury reduction offset program, collecting composite water samples between April 2008 and February 2010 from the pump station forebay during dry weather, first flush, and wet weather events. A pilot constant flow dry weather diversion of 75 gallons per minute (gpm) was implemented by EBMUD in collaboration with the City of Oakland during that same time period using a connection to an existing sanitary sewer line in the ESPS. The EBMUD study found that while the additional treatment volumes from the diversion would not significantly affect EBMUD discharge quality or operations, more "specific" data were needed to address the storm-to-storm variability. In addition, EBMUD would need to evaluate hydraulic capacity, costs, and regulatory implications to clarify the acceptability of a long-term diversion project.

Average PCB concentrations during first flush or other wet weather conditions monitored during the EBMUD project averaged one order of magnitude higher than in dry weather, and were more variable. Thus, the results of the study indicated that the opportunities for reducing PCB loads are much higher for diversions implemented during wet weather. Infiltration in the aging sanitary conveyance system, however, causes capacity problems at the EBMUD plant during peak runoff flows. ACCWP's study therefore focused on diversion scenarios involving pretreatment storage of stormwater runoff followed by post-storm discharge to the sanitary sewer.

Following the EBMUD Study, the ESPS Diversion Pilot Project was planned to further evaluate the potential benefits of diversions. The Pilot Project was also designed to leverage the use of the

ESPS site for one of the retrofit treatment pilot projects included in the CW4CB grant project. The Pilot Project consists of two elements. The initial pilot phase installed a pilot test diversion to evaluate the feasibility of using a continuous turbidity sensor to direct selective pumping of stormwater from the ESPS wet well to a storage tank for detention and pretreatment. Water from the storage tank can be directed either to an existing sanitary sewer line or to a 2-bed media filter treatment system to be installed in fall 2013 as one of the CW4CB retrofit pilot projects described in Section B.7.

To support the overall goals of improving understanding of the cost-effective applications for mercury and PCB controls, the ESPS pilot project has the following objectives:

1. Evaluate potential for PCB and mercury load reductions under scenarios of different diversion pumping regimes;
2. Test use of turbidity thresholds as trigger criteria for diversion;
3. Establish a site-specific relationship between particle size, concentrations of PCBs and mercury, and turbidity to support annual load estimates;
4. Develop scenarios for larger-scale pretreatment and diversion and document additional feasibility considerations involved;
5. Evaluate costs and benefits of the pilot project and larger-scale implementation scenarios; and
6. Coordinate system and monitoring design with planning for the pilot retrofit media filters to maximize data leverage and cost-effectiveness for both pilot projects.

Status of Project

Installation of the turbidity probe and preliminary sampling during one storm event were conducted at the ESPS in spring 2012. Installation of a 500-gallon stainless steel storage tank for the small-scale pilot diversion was completed in summer 2012, followed by a stormwater sampling event in November 2012 that provided particle distribution data requested by CW4CB consultants to inform monitoring plan design for the CW4CB retrofit pilots. However, recurrent data quality problems were observed with the turbidity probe output showing a bias toward lower readings, which were attributed to fouling of the sensor glass and wiper. The probe mount was redesigned to permit regular wet season maintenance without confined space entry, and additional monitoring is planned for FY 2013-14 that will be coordinated with parallel monitoring of the retrofit media filters.

Based on comments by Regional Water Board staff on the May 2012 work plan, the monitoring design was revised to leverage the CW4CB monitoring efforts and increase the ACCWP resources directed to evaluation of costs and benefits associated with a larger scale diversion concept developed during FY12-13. The larger-scale diversion scenario incorporated the following elements:

- Larger pretreatment storage facilities constructed on adjacent land underneath the MacArthur Freeway (see Figure B.9.2.) if feasible through either acquisition of easement rights granted by the State of California to ACFCWCD or a Common Use Agreement between the State and ACFCWCD.
- Permanent diversion conveyance from ESPS to the pretreatment facility.
- Permanent diversion conveyance from pretreatment to sanitary sewer to be implemented by EBMUD and sized to carry typical dry weather flows from the ESPS (approximately 1000 gallons per minute). This conveyance, now in the initial planning stage, will be available in non-peak flow periods for transfer of pretreated stormwater from the ESPS. ACCWP will qualitatively review potential challenges in obtaining easements for a new larger-scale conveyance across existing freeways and railroads, in reference to the alternatives being considered by EBMUD for connection to existing conveyance lines owned by EBMUD or the City of Oakland.
- Wet weather diversion from ESPS to pretreatment that would be triggered by elevated turbidity during storm events. Multiple scenarios of diversion timing and volume will be developed in consideration of alternative turbidity thresholds and the characteristics and constraints of facility capacity and conveyance design.
- Estimated construction and operating costs for facilities and equipment for pumping, controls and monitoring, maintenance, sediment disposal and security for all facilities.
- Outlining terms of agreement with EBMUD for ongoing sharing of costs and TMDL load allocations for PCBs and mercury associated with the amounts transferred through stormwater diversion.

Additional Feasibility Study evaluations will be conducted during September 2013.

North Richmond Stormwater Pump Station, Contra Costa County

Project Overview and Objectives

The Contra Costa Clean Water Program (CCCWP) is facilitating implementation of a stormwater diversion pilot project to divert urban runoff from the North Richmond Stormwater Pump Station (North Richmond Station) to the West County Wastewater District (WCWD). The North Richmond Station is jointly owned by Contra Costa County (61 percent) and the City of Richmond (39 percent) through a Joint Powers Authority (JPA) based on a 1974 agreement. The WCWD is currently under a separate contract with the JPA to maintain and operate the North Richmond Station.

The North Richmond Station is designed to control stormwater flooding conditions for the unincorporated area of North Richmond. The station receives water from a network of stormwater collection sewers which drain into the wet well of the pump station. Stormwater is

then pumped into the discharge channel of the pump station that drains by gravity into a 78-inch discharge pipeline.

As shown on Figure B.9.3, the area draining to the station consists of mainly industrial and residential land uses in the unincorporated area adjacent to the north boundary of the City of Richmond. The storm drainage system delivers stormwater to the North Richmond Station located on the southwest corner of Gertrude Avenue and Richmond Parkway. The station's 78-inch discharge pipeline runs westward from the pump station along an easement on the Chevron Chemical Company's property just south of Gertrude Avenue. At about 950 feet downstream of the pump station, the pipeline enters an 8-foot by 4-foot box culvert which crosses Gertrude Avenue and runs into a trapezoidal earth channel that drains to Wildcat Creek.

Objectives for the North Richmond Station pilot diversion project include:

7. Evaluate PCB and mercury loads avoided through pump station maintenance conducted in conjunction with diversion to a POTW;
8. Design a diversion pilot project that can be permitted for discharge to West County Wastewater District; and
9. Evaluate operating techniques that can treat first flush without adversely impacting POTW capacity.

The Project is being implemented by the County, a Permittee of the CCCWP. The County sought and obtained grant funding administered by the San Francisco Estuary Project through the USEPA San Francisco Bay Area Water Quality Improvement Fund. The Project is one of several in the "Estuary 2100 Phase 2: Building Partnerships for Resilient Watersheds" program. The grant provides $496,649 in USEPA funds, matched by $165,550 from the County to plan, design, construct, and monitor an engineered diversion into WCWD. Details of the diversion concept are discussed in a technical memorandum submitted to the WCWD in November 2012 (CCCWP 2012a).

Baseline water quality monitoring was performed per the scope of the grant between 2010 and 2012. WCWD staff had substantial input on the monitoring parameters for that baseline study. The baseline study was completed and reported in 2012 (Hunt et al. 2012). The water quality characterizations from the North Richmond Station, along with assessments of sediments in the associated drainage area, indicate that mercury and PCB concentrations in sediments are high enough to provide potentially significant benefits for stormwater management in that area. Mercury to suspended sediment ratios are the third highest of twenty-two Bay Areas watersheds characterized by SFEI (Yee and McKee 2012). PCBs to suspended sediment ratios are the fifth highest of Bay Area watersheds assessed in that same study.

Yee and McKee (2012) showed that for the period monitored, 160 million gallons of stormwater passed through the North Richmond Station, conveying an estimated load of approximately 11 grams of PCBs.

Status of Project

A probable construction cost estimate and preliminary schedule for the Project was developed by Brown and Caldwell in December 2012. The estimated construction cost, $764,000, exceeds the original grant assumption. Design costs for the diversion are approximately $100,000, in addition to the construction cost. The construction costs reflect not only the diversion, but also much needed infrastructure rehabilitation at the North Richmond Station. The diversion construction costs represent a moderate (i.e., approximately $50,000 - $100,000) in additional design and construction costs added to the costs of the infrastructure rehabilitation necessary to meet flood control needs.

The current recommended approach is a "hard-piped" diversion, with flows routed into the nearest sanitary sewer collections system. One main pump and one back-up low flow pump (250 gpm, 0.4 mgd) would be installed in the North Richmond Station wet well. The pumps would be connected to and controlled by a supervisory control and data acquisition system (SCADA). Water level sensors in the outlet of the conveyance pipe would allow the pumps to be shut down via the SCADA system if the conveyance was reaching its capacity. In addition, the SCADA system would be connected to continuous water quality probes that could detect petroleum or other spills and trigger pump shut-down.

Some of the more substantial costs of the diversion pilot are related to planning, monitoring, and risk management. The initial pre-diversion monitoring cost was approximately $180,000. Planning support by CCCWP consultants has cost $80,000 to date, and continues to accrue. Although pre-diversion monitoring has been completed (Hunt et al. 2012), concerns raised by WCWD may require additional monitoring. As of June 2013, the need for additional monitoring to support the Project is being discussed by the CCCWP Monitoring Committee.

CCCWP Management Committee Members have been regularly briefed on progress in scoping the diversion pilot. Between January and April 2013, CCCWP staff, along with County and Richmond staff, engaged directly with WCWD staff who were authorized by the WCWD Plans and Programs Committee to discuss pilot diversion concepts with project proponents. In those discussions, the following technical concerns were fleshed out by WCWD:

- Conveyance capacity
- Toxicity to activated sludge microorganisms
- Effluent quality
- Bio-solids quality
- Spills and illicit discharges

CCCWP is developing a technical memorandum addressing the above concerns expressed by WCWD. Concurrently, the County is moving forward with procurement of a design consultant to develop biddable plans, specifications, and cost estimates for the Project. The County continues

to negotiate with WCWD over the terms and conditions of a permit to discharge dry weather urban runoff and first flush into the WCWD collection system. A significant challenge to obtaining that permit is regulatory relief from consequences should the diversion cause a sewage treatment system upset, a sanitary sewer overflow, or exceedance of an effluent limit.

The NPDES permit reissued to West County Agency May 8, 2013 by the Regional Water Board does not provide for explicit regulatory relief. However, it does include a Permit Reopener Provision (VI.C.1.f) that allows for reconsideration of this issue:

> *"If the Dischargers request adjustments in effluent limits due to the implementation of a stormwater diversion pursuant to the Municipal Regional Stormwater Permit (No. CA0038593), for redirecting dry weather and first flush discharges from the storm drain system to the sanitary sewer system as a stormwater pollutant control strategy."*

At present, it is anticipated that construction of the Project would commence in the dry season of 2014, to be ready for a diversion pilot in wet season 2014 – 2015. The proposed approach is for late dry season flows to continue to be diverted to the flood control channel, per normal operations. Weather reports would be monitored, and when there is a significant probability of a storm (e.g., greater than 75 percent chance of at least 0.5 inches of rain in a 24 hour period), the WCWD would be notified and the pump station valving changed to redirect flows to the WCWD. Diversions would continue until level sensors determined that pipeline capacity was less than 0.5 mgd.

The diversion would resume after capacity was restored. This pattern of weather tracking, notification, and diversion would continue for one month. Approximately six months after the first flush diversion was implemented and evaluated, a dry weather diversion would be implemented. The dry weather diversion would be conducted for a summer season (e.g., June through August).

Pulgas Creek Pump Station, San Mateo County

Project Overview and Objectives

The San Mateo Countywide Water Pollution Prevention Program (SMCWPPP) pilot diversion project evaluated the diversion of dry weather runoff and first flush flows of stormwater from near the Pulgas Creek Pump Station to the sanitary sewer collection system served by the South Bayside System Authority's (SBSA) regional wastewater treatment plant. As described in the FY 2010-2011 annual report, SMCWPPP selected the City of San Carlos' Pulgas Creek Pump Station watershed for the pilot diversion project and other CW4CB studies because of the relatively high concentrations of PCBs found in pump station and storm drain sediments. The approximately 330-acre watershed draining to the Pulgas Creek Pump Station is comprised of current and historic industrial land uses.

As part of a stormwater runoff characterization study conducted for the Small Tributaries Loading Strategy (STLS) of the Regional Monitoring Program (RMP), analyses of PCBs and mercury were performed on stormwater samples from the two storm drain lines that flow to the Pulgas Creek Pump Station (McKee et al. 2012). The PCB results in Table B.9.2.3 show that the stormwater contained between about 19,000 and 84,500 picograms per liter (pg/L) of total PCBs. These concentrations are relatively elevated compared to the 886 pg/L Event Mean Concentration (EMC) of total PCBs calculated by SFEI from stormwater runoff sampling with similar methods from a parking lot and recreation area in Daly City (Lent et al. 2011).

The data also show that the concentrations of total PCBs from the north Pulgas Creek storm drain line were generally higher than those found in the south Pulgas Creek storm drain line.

Table B.9.2.3. Total PCBs (pg/L – total of 40 congeners) in Stormwater Runoff to Pulgas Creek Pump Station in San Mateo County

Sampling Date[1]	North Pulgas Creek Storm Drain Line	South Pulgas Creek Storm Drain Line
Feb. 17, 2011	46,896	53,894
	43,339	19,060
March 18, 2011	84,490	31,043
	66,554	21,883
Average	60,320	31,470

[1] Samples collected on the same dates were collected at different times.

One of the essential requirements of the pilot diversion project is to be able to dispose of the diverted dry weather urban runoff and stormwater to the City of San Carlos' sanitary sewer system. The Countywide Program staff worked with SBSA and City of San Carlos staff to obtain a wastewater discharge permit for the City of San Carlos.

In June 2012 SBSA staff distributed a draft permit and based on discussions among City of San Carlos, SBSA, and Countywide Program staff, modifications to the draft were proposed and accepted. The final permit was executed during the first half of July 2012. The permit authorizes the diversion of a limited volume of dry weather urban runoff and stormwater for a one-year period between July 1, 2012 and June 30, 2013. The permit describes discharge, monitoring, and reporting requirements. The discharge permit is subject to revision at any time for the purposes of protecting the sanitary sewerage facilities and workers and to accommodate new regulations and NPDES permit requirements that may be imposed on SBSA.

As outlined in the May 2012 project work plan, the pilot diversion project was to conduct wet and dry weather pilot scale diversions of urban runoff from the north Pulgas Creek storm drain line during FY 2012-2013. A flow meter and turbidity sensor were installed in the north Pulgas Creek storm drain line manhole, located immediately upstream from the pump station. Water was collected for diversion through a small submersible pump that sent water through a flexible

conduit to a 500-gallon storage tank located in the yard adjacent to the pump station. Water from the storage tank was collected and transported by the City of San Carlos' Vactor truck for disposal through a sanitary sewer connection at the City of San Carlos' corporation yard that conveys wastewater for treatment and disposal by the South Bay System Authority (SBSA).

Targeted wet weather diversions were designed to include, to the extent feasible, the first rainfall event of the 2012-2013 wet season, plus up to three additional events. During each of the targeted storm events, discrete water quality samples were to be collected from the north Pulgas Creek storm drain line and tested for PCBs, mercury, and suspended sediment concentrations. In addition, as required by SBSA, testing was also to be conducted during disposal of diverted stormwater collected during two events. Samples would be collected from the Vactor truck discharge to the corporation yard's sanitary sewer connection. These samples would be tested for copper, mercury, and PCBs as the sum of 40 congeners. Sampling was also designed to be conducted in connection with one dry weather diversion event prior to the start of the 2012-2013 rainy season.

The pilot diversion project will also evaluate the projected costs and benefits of a larger scale and more permanent dry and/or wet weather diversion at the Pulgas Creek Pump station in order to have the technical information needed to evaluate the feasibility of diversions as part of future stormwater NPDES permit terms. The evaluation will also include how to coordinate possible plans for a long-term, more permanent sewer diversion with the City of San Carlos' planned upsizing of sewer pipelines along Industrial Road and Brittan Road in the vicinity of the Pulgas Creek Pump Station. One of the major problems with trying to divert stormwater to the sanitary sewer system in the Pulgas Creek Pump Station drainage area is that the sewer system is undersized in this area, and the City of San Carlos is already at its maximum capacity for discharging wastewater to SBSA.

Status of Project

Initial installation of the continuous monitoring equipment (data loggers, flow and turbidity meters, and batteries) in the Pulgas North storm drain line was accomplished in October 2012. A rainfall gauge was installed on the roof of the Pulgas Creek Pump Station. However, at a follow-up maintenance visit in November, technical problems were discovered with the flow/turbidity data logger that prevented logging of continuous turbidity measurements, although continuous flow measurements were being made. The data logger and turbidity sensors were removed and taken to the laboratory for troubleshooting. After several weeks of unsuccessful attempts to resolve the issues, replacement equipment was procured and installed at the site in December 2012.

Thus, prior to December 2012, no turbidity measurements were recorded, and only limited flow measurements (between the initial installation in October and removal of the data logger in November) were recorded. Following the December installation, regular maintenance events were conducted throughout the remainder of the rainy season (approximately every two weeks

through the end of April) in order to download data and assure proper operation of all equipment. From December 2012 through May 2013, continuous flow, turbidity and rainfall data were measured at the site.

One dry weather diversion event was conducted in November 2012. Immediately prior to the diversion, water samples were collected from the North Pulgas storm drain line according to the methods and procedures described in the work plan. Using a portable, submersible pump, approximately 500 gallons of water were pumped out of the North Pulgas storm drain line through flexible conduit into a stainless steel tank. The City of San Carlos maintenance staff removed the water from the tank using their Vactor truck. The water was taken to the City's corporation yard and discharged into the sanitary sewer line, per the SBSA permit.

One storm diversion event was conducted in March 2013. Samples were collected from the Pulgas North storm drain line during the storm event according to the methods and procedures described in the work plan. Stormwater was diverted from the Pulgas North storm drain using the submersible pump/conduit system used for the dry weather diversion into the same stainless steel tank. Following the storm (during dry weather), the City of San Carlos maintenance staff removed the water from the tank using their Vactor truck and discharged the stormwater into the sanitary sewer line, per the SBSA permit. Samples of the water were collected as it was discharged into the sanitary sewer line and analyzed according to the SBSA permit requirements.

Due to the equipment issues[28] at the beginning of the 2012 wet season and the lack of storms during the remainder of the rainy season, only one storm was monitored and only one wet weather diversion was completed. The site was demobilized in May 2013. During the demobilization, water samples were collected from the Pulgas North storm drain line to provide additional data on concentrations of POCs during dry weather, but no water was diverted to the sanitary sewer.

Because only one dry diversion event and one wet weather diversion event has been completed to date, this project will continue through the 2013-2014 rainy season. Weather permitting, three wet weather diversion events will be conducted at this site between October 2013 and April 2014. SMCWPPP is coordinating with SBSA to obtain an extension of the SBSA discharge permit for San Carlos through June 30, 2014. The project schedule included in Appendix B.9.A illustrates the revised timeframe for completion of the project.

[28] Significant communication issues between the data loggers and samplers/probes deployed at the site caused monitoring to be postponed. Communication issues have been subsequently addressed.

Palo Alto Diversion Structure, Santa Clara County

Project Overview and Objectives

The pilot diversion project that is currently being implemented by the Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP), in cooperation with the City of Palo Alto, is an evaluation of an existing dry and wet weather diversion structure located in the City of Palo Alto (Figure 6). The diversion structure was constructed in 1993 to divert a limited volume of urban runoff from the stormwater conveyance system to the Palo Alto Regional Water Quality Control Plant. The area draining to the diversion structure is roughly 50 acres and is bound by Hamilton Avenue, Bryant Street, Channing Avenue and Alma Street. The site was originally selected by the City of Palo Alto because of the land use in the drainage area (commercial, light industrial, multi-family residential), proximity of the 27" sewer trunk line to the storm drain line, and because the sewer trunk line had excess capacity. The structure was designed to divert urban runoff flows into the sanitary sewer at no more than 0.5 million gallons per day (MGD).

The overall goal of this pilot project is to comply with provisions C.11.f/C.12.f of the MRP by better understanding the applicability, costs and benefits associated with the existing Palo Alto urban runoff diversion structure. The Palo Alto pilot diversion project was designed to address the following three objectives:

1. Evaluate pollutant loads to the Bay that are reduced due to current operation of the existing diversion structure.
2. Estimate projected benefits, challenges and costs of constructing and operating a similar diversion structure in other watersheds (e.g., a larger drainage area and/or an area known to have elevated concentrations of PCBs or mercury).
3. Document the knowledge and experience gained from evaluation of the diversion structure to inform planning of urban runoff diversions in the next permit term.

A work plan that describes the methods used to evaluate the effectiveness of the Palo Alto diversion structure and to fulfill the objectives of the project was provided to the Regional Water Board in May 2012. The work plan was designed to guide monitoring and data collection activities over Fiscal Year 2012-13. Work plan tasks included: (1) project planning; (2) water quality monitoring; (3) evaluation of diversion costs and operational challenges; (4) cost and benefit analysis; and (5) reporting.

Monitoring activities outlined in the work plan include continuous monitoring of the volume and turbidity of urban runoff flowing into and through the diversion structure. Water quality sampling includes suspended sediment concentrations, particle size distribution, and mercury and PCB concentrations during two dry weather events and three wet weather events. These data will be used to calculate loads removed from urban runoff due to operation of the diversion structure.

The work plan also defined a framework to evaluate the construction, operation, and costs associated with the diversion structure. This framework guided information gathering activities associated with Work Plan Task 3 (evaluation of diversion costs and operational challenges). Activities conducted during FY 2011-2012 under this task included gathering and reviewing construction documents, and mapping and documentation of the site and the diversion structure. Additional information gathering, including investigation into construction and maintenance costs and operational challenges and constraints to the POTW receiving the diversion were continued during 2012-13.

Targeted storm diversion events included the first rain event of the 2012-2013 wet weather season that generated runoff at the site and additional storm diversion events selected to represent the range of expected flow conditions at the site.

Status of Project

Initial installation of the continuous monitoring equipment (data loggers, flow and turbidity meters, and batteries) at the Bryant/Channing diversion structure in Palo Alto, CA was completed in January 2013. Equipment was installed at two locations: (1) in the storm drain line immediately upstream of the diversion box; and (2) in the manhole immediately downstream of the diversion box, just prior to where the stormwater is discharged into the sanitary sewer line. Following the January installation, regular maintenance events were conducted throughout the remainder of the rainy season (approximately monthly through the end of April) in order to download data and assure proper operation of all equipment. Between January and May 2013, continuous flow was measured at both locations and turbidity was measured at the upstream location only. Rainfall data were collected from nearby existing rain gauges.

Two dry weather urban runoff diversion monitoring events were conducted in FY 2012-13. The first dry weather event was conducted in January 2013 and the second was conducted in May 2013. During both events, samples were collected from both monitoring locations (e.g., from the water as it entered the diversion structure and from the diverted water downstream of the diversion structure). Sand bags were used to temporarily block the diverted water from draining into the sanitary sewer to allow collection of the diverted water. Samples were collected and analyzed according to the methods and procedures described in the May 2012 work plan.

One wet weather monitoring event was conducted in March 2013. Samples were collected from both monitoring locations (upstream and downstream of the diversion box) according to the methods and procedures described in the work plan.

Due to equipment issues (described under the Pulgas Creek Pump Station Diversion project) and the lack of storms during the remainder of the rainy season, only one of the three planned storm monitoring events was completed. The site was demobilized in May 2013, but will be remobilized and continue during the 2013-2014 rainy season in order to collect two additional storm water diversion monitoring events between October 2013 and April 2014. The project

schedule included in Appendix B.9.A illustrates the revised timeframe for completion of the project.

State Street Pump Station, Solano County

Project Overview and Objectives

The Solano County pilot diversion project is being implemented by the Fairfield Suisun Urban Runoff Program (FSURMP) and Fairfield-Suisun Sewer District (FSSD). The project involves changes to the operation of an existing pump station so as to divert stormwater from the station to the FSSD wastewater treatment plant. The State Street pump station is located in the City of Fairfield just upstream of Suisun City. It serves a watershed area of approximately six acres. The contributing area is commercial, of which a significant portion is automotive repair. (See Figures B.9.7. and B.9.8.).

The pump station changes to be evaluated for this project include:

- Shutting off the stormwater pump station during dry weather;
- Removing standing water in the pump station wet well throughout the dry season and before the first flush; and
- Monitoring concentrations of pollutants and pollutant indicators in the diverted water

The following three objectives have been developed for the project:

1. Evaluate pollutant loads to the Bay that are reduced due to stormwater diversion.
2. Estimate projected benefits, challenges and costs of operating a similar diversion in a similar drainage area and/or an area known to have elevated concentrations of PCBs or mercury.
3. Document the knowledge and experience gained from evaluation of the diversion project.

Status of Project

Normal discharges from the State Street Pump Station were terminated in mid-June 2012. The contents of the pump station's wet well (approximately 825 gallons) were subsequently removed by FSSD staff using a Vactor truck. Prior to removal, the discharge pumps were operated to mix the contents and to collect a representative sample. This June 18, 2012 sample was analyzed for PCBs, mercury, total organic carbon, total metals, and suspended sediment concentration. The contents were trucked and discharged to the FSSD treatment plant. As an "in-house" pilot project, there were no formal agreements needed for treatment plant's acceptance of the discharge.

There was minimal subsequent dry weather runoff accumulation in the pump station. FSURMP and FSSD removed approximately 1200 gallons on September 20, 2012, and analyzed a sample for the same suite of constituents as the June 18, 2012 sample. Following collection of this sample, the pump station was returned to normal wet season operation. Flows into the pump station were also monitored during summer 2013. The project schedule included in Appendix B.9.A. illustrates the revised timeframe for completion of the project.

B.9.2.3 Results of Pump Station Diversion Pilot Project Monitoring

As of the writing of this section, analytical results for the five diversion structure pilot projects are not yet available. Once monitoring data become available in FY 2013/14, BASMAA member agencies plan to analyze monitoring results and present data in subsequent reports. The timing of those reports and analyses will be contingent upon the completion of the projects. Current project schedules are included in Appendix B.9.A.

B.9.3 Status of Control Measure Implementation

This section summarizes the baseline and enhanced level of implementation of each of the five pilot stormwater diversion projects. Once monitoring data become available in FY 2013/14, BASMAA member agencies plan to analyze monitoring results and present load reduction benefits in subsequent reports.

B.9.3.1 Baseline

Prior to the TMDL (July 1, 2002) one of the five pilot stormwater diversion projects was operational. The Palo Alto Diversion Structure on Bryant Street was constructed in the mid 1990's and therefore load reductions associated with this structure should be considered baseline, unless the load reduction efficiencies of this structure post July1, 2002 can be enhanced and quantified. No mercury or PCB measurements were made prior to July 1, 2002 to establish baseline load reductions at this site, but could be assumed to be similar to current load reductions for the purposes of calculating the benefits of enhanced implementation in the future at this site.

B.9.3.2 Current

Four of the five pilot projects were active and collected and analyzed samples in FY 2012-13.

Ettie Street Pump Station, Alameda County

In 2013, as part of the C.11.f/C.12.f pilot diversion project, ACCWP began implementation of dry weather and stormwater diversions from the Ettie Street Pump Station (ESPS) in Alameda County to the East Bay Municipal Utilities District (EBMUD). ACCWP monitored turbidity during the FY 2012 – 2013 wet season and sampled stormwater from a November 2012 event, which was analyzed to provide requested particle distribution data. Work continues on evaluation of costs and benefits associated with a larger scale diversion concept similarly based on detention of wet weather diversions.

North Richmond Stormwater Pump Station, Contra Costa County

In 2013, as part of the C.11.f/C.12.f pilot diversion project, planning for the construction of a permanent stormwater diversion at the North Richmond Stormwater Pump Station in Contra Costa County continued. Baseline water quality characterization monitoring was completed during the 2010-2011 wet season. At present, it is anticipated that construction of the Project would commence in the dry season of 2014, to be ready for a diversion pilot in wet season 2014 – 2015.

Pulgas Creek Pump Station, San Mateo County

In FY 2012-13, as part of the C.11.f/C.12.f pilot diversion project, two monitoring events were implemented at the Pulgas Creek Pump Station in San Mateo County, including one diversion of 500 gallons of dry weather runoff and one diversion of 500 gallons of stormwater runoff from the Pulgas Creek Pump Station in San Mateo County to the SBSA. Chemical analysis results from monitoring during these diversion events (currently undergoing QA/QC review) will be used to calculate the total load of mercury and PCBs diverted. Weather permitting, three additional wet weather diversion events are planned for FY 2013-14.

In addition, Program staff continue to work with the City of San Carlos to evaluate the projected costs and benefits of a larger scale and more permanent dry and/or wet weather diversion at the Pulgas Creek Pump station in order to have the technical information needed to evaluate the feasibility of diversions.

Palo Alto Diversion Structure, Santa Clara County

In 2013, as part of the C.11.f/C.12.f pilot diversion project, three diversion monitoring events were conducted at the Bryant Street Diversion Structure in San Mateo County, including two dry weather events and one wet weather event. Monitoring data of flow, turbidity, and water chemistry collected during these events (currently undergoing QA/QC review) will be used to calculate the annual load of mercury and PCBs diverted to the sanitary sewer system at this site. Weather permitting, two additional wet weather diversion monitoring events are planned for FY 2013-14.

In addition, Program staff continues to work with the City of Palo Alto to evaluate the costs and benefits of constructing and maintaining the Bryant Street diversion structure.

State Street Pump Station, Solano County

In 2012, as part of the C.11.f/C.12.f pilot diversion project, the Fairfield Suisun Urban Runoff Program (FSURMP) and Fairfield-Suisun Sewer District (FSSD) began the Solano County pilot diversion project by implementing changes to the operation of the State Street Pump Station in order to divert stormwater from the station to the FSSD wastewater treatment plant.

During two events, dry weather accumulation in the pump station was removed and diverted to the FSSD wastewater treatment plant. Chemical analysis results of samples collected during these events will be used to calculate the load of mercury and PCBs diverted. Flows into the pump station were monitored during summer 2013.

B.9.4 Estimates of Loads Avoided/Reduced

B.9.4.1 Current Loads Avoided/Reduced Methodology

This section presents the conceptual approach that will be used to estimate mercury and PCB stormwater loads avoided/reduced due to pilot stormwater diversion projects.

The Ettie Street Pump Station and Pulgas Creek Pump Station projects each diverted dry season and wet season urban runoff (using differing methodologies) into 500-gallon storage/pretreatment tanks. The pollutant mass diverted is therefore determined by the avarage concentrations measured in the water and sediment in those 500-gallon tanks.

The State Street Pump Station project was shut down June – September 2012 and the volume contained in the wet well was pumped out twice (825 gallons and 1200 gallons) into a vactor truck. The mass diverted is therefore determined by the measured concentrations in the water and sediment diverted.

The Palo Alto Bryant Street Diversion Structure project uses continuous flow measurements recorded during the project to estimate the volume of runoff diverted, and the concentrations measured in the diverted flow (via estimated from turbidity-SSC relationships) to determine the mass diverted.

The basic load reduction calculation method used for each pilot study is shown below:

$$EnhancedReductionDiversion = CurReductionDiversion - BaseReductionDiversion \qquad Eq.\ 1$$

where:

BaseReductionDiversion = *Mass of PCBs or Hg reduced via POTW diversions of urban stormwater in 2002*

CurReductionDiversion = *Mass of PCBs or Hg reduced via POTW diversions of urban stormwater in Year of Interest*

And:

$$Base\ or\ Cur\ ReductionDiversion = ConcDiversion \bullet VolDiversion \qquad Eq.\ 2$$

Where:

ConcDiversion = *Average concentration of PCBs or mercury in sediment and/or water diverted to a POTW*

VolDiversion = *Volume of sediment and/or water diverted to a POTW*

The potential PCB load reduction benefits attainable from pilot diversion projects can be estimated based on either expected average PCB or mercury concentrations in stormwater, or expected average PCB or mercury concentrations in sediments captured by the pilot diversion. This section provides planning tools to assist with this estimation.

The first approach starts by asking "how much water is expected to be diverted to the POTW," and "what is the average PCB concentration in that diverted water?" Water volumes can be estimated from the design storm perspective and the conveyance and treatment capacity perspective. The design storm perspective would multiply the catchment area (acres) by the design storm event (inches of rain) and a runoff coefficient to derive the treatment volume, after unit conversion. However, in most cases, the limiting factor on treatment volume would be storage, conveyance, and treatment capacity. Therefore, it makes most sense, for estimating purposes, to base treatment volume estimates on constraints established by the conveyance system, available storage capacity (if any), and limits on the treated volume that are either set by the POTW or that necessarily result from treatment costs. A similar approach would apply to dry weather diversions. The flow question for a dry weather diversion would be "what is the average expected dry weather flow."

Average PCB and mercury concentrations in dry and wet weather flows can be estimated based on data that will be available via the pilot diversion studies and other recent projects (EBMUD 2010; Hunt et al. 2012; McKee et al. 2012).

B.9.4.2 Baseline and Current Loads Avoided/Reduced

The purpose of this section is to estimate the load reduction expected through pilot diversions of stormwater and dry weather runoff to POTWs. As described in the previous section, estimates of loads reduced and avoided via diversions should account for the mass of PCBs or mercury removed prior to the enhancement of management actions implemented before the adoption of the PCB or Mercury TMDLs for the San Francisco Bay. PCB and mercury load reduction and avoidance estimates should be based on the best available information and the assumptions described in the previous sections.

Prior to the PCB TMDL adoption (July 1, 2002), only one of the five pilot stormwater diversion projects was operational. The Palo Alto Diversion Structure on Bryant Street was constructed in the mid 1990's and therefore load reductions associated with this structure should be considered baseline. Baseline loads avoided/reduced at all other diversion sites are assumed to be zero, given that they were not in place until after July 1, 2002.

Data needed to calculate current loads avoided/reduced are currently being collected by Permittees via the pilot diversion projects. Volumes of water and sediment diverted to POTWs and the average/range of PCB and mercury concentrations in water and sediment diverted are therefore not available at the time. Once data are available, methodologies included in this

previous section will be used to calculate enhanced load reductions attributable to pilot diversions to POTWs.

As an example, Table B.9.4.1 provides estimates of the loads diverted during the limited testing conducted during FY 2012 - 2013 using the volumes diverted during those sampling events and average PCB concentration values from the literature for dry and wet weather events, For the Alameda County Ettie Street Pump Station (ESPS) pilot project there was one 500 gallon stormwater diversion event. If assigned a PCB concentration of 34,515 pg/L based on historic ESPS effluent average wet weather monitoring data (EBMUD 2010), 0.0653 milligrams (mg) would be diverted from ESPS.

The Contra Costa County North Richmond Pump Station Pilot Project was not in operation during 2012 but there are historic dry and wet weather PCB monitoring data available (Hunt et al. 2012).

For the San Mateo County Pulgas Creek Pump Station pilot project, 500-gallons of water/sediment from one dry weather event and 500-gallons of water/sediment for one storm event were diverted. If the latter event was assigned a PCB concentration of 60,300 pg/L based on historic Pulgas Creek North wet weather monitoring data (McKee et al. 2012) 0.1141 mg would be diverted.

For the Santa Clara County Bryant Street Diversion Structure project there were two dry weather and one wet weather monitoring events conducted during which flows were continuously monitored (data being analyzed). There were no historic dry or wet weather PCB monitoring data identified for this site.

For the Fairfield/Suisun State Street Pump Station pilot project, the sump was pumped out twice during the dry weather (825 and 1,200 gallons) for a total of 2,025 gallons. Samples were analyzed to total PCBs (Vista Labs using USEPA Method 1668C) from the first pump out. Two congeners (110 and 138) were reported as detected–not-quantified (DNQ) for a combined concentration of 28.3 pg/L. If these DNQ values were used as actual detected values, 0.0002 mg would have been diverted.

Table B.9.4.1. Municipal Regional Permit – Pilot Stormwater Diversion Projects – Provisions C.11.f and C.12.f – PCB Monitoring and Loads Reduced

Municipal Regional Permit - Pilot Stormwater Diversion Projects - Provisions C.11f and C.12.f - PCB Monitoring and Loads Reduced

30-Aug-13

Project Name & Location	Catchment Size (acres)	Primary Land Uses	Project Characterization (May 2012 Workplan, Updated August 2013): Diversion Type: Gravity	Pumped	Contin.	Batch	Diversion Volume (gals): Dry Weather	Wet Weather	Historic Concentration Based Load Reduced (Average Total PCB Congeners): PCBs (pg/L)	Load Reduced (mg)	PCB Monitoring Results	2012 Events: E1	E2	E3	E4	2013 Events: E1	E2	E3	E4	2014 Events: E1	E2	E3	E4
Alameda	1000	residential		X		X	500		2,927 (dry)	NS	Dry Season: Flow (gals)												
Ettie St. Pump Station		industrial mix						500	34,515 (wet)	**0.0653**	Concentration (pg/L)												
City of Oakland		commercial									Loading (grams)												
											Wet Season: Flow (gals)												
											Concentration (pg/L)												
											Loading (grams)												
Contra Costa	339	Mixed residential		X	TBD	TBD	TBD	TBD	700 (dry)	TBD	Dry Season: Flow (gals)												
North Richmond Pump Station		Light industrial							21,000 (wet)	TBD	Concentration (pg/L)												
City of Richmond		Former nurseries									Loading (grams)												
											Wet Season: Flow (gals)												
											Concentration (pg/L)												
											Loading (grams)												
Fairfield/Suisun	6	Commercial		X		X	2,025		28 (dry)	**0.0002**	Dry Season: Flow (gals)												
State Street Pump Station											Concentration (pg/L)												
											Loading (grams)												
											Wet Season: Flow (gals)												
											Concentration (pg/L)												
											Loading (grams)												
San Mateo	330	Industrial		X		X	500		NA (dry)		Dry Season: Flow (gals)												
Pulgas Creek Pump Station								500	60,300 (wet)	**0.1141**	Concentration (pg/L)												
City of San Carlos											Loading (grams)												
											Wet Season: Flow (gals)												
											Concentration (pg/L)												
											Loading (grams)												
Santa Clara	50	Light Industrial	X		X		Pending		NA		Dry Season: Flow (gals)												
Passive MS4 Diversion		Multi-family Res.						Pending	NA		Concentration (pg/L)												
City of Palo Alto											Loading (grams)												
											Wet Season: Flow (gals)												
											Concentration (pg/L)												
											Loading (grams)												

Table B.9.4.2 shows the results of PCB monitoring conducted by SFEI staff in 17 selected watersheds in the Bay Area during Water Year 2011. With the exception of the Santa Fe Channel site, mean concentrations were below about 60 ng/L with several sites in the low ng/L range. As shown in Table 9.4.2, these relatively low concentrations limit the mass that could potentially be diverted to fractions of a gram even if millions of gallons of stormwater were diverted to a POTW.

Further support for the representativeness of these PCB values is provided by McKee et al. (2012) in their summary of literature values, "*The range of PCB concentrations we observed during the study generally coincide with those reported in the literature for other urban areas (**ND-34 ng/L**, Curren et al., 2011; **2.0-28.9 ng/L**, Foster et al., 2000; **27-179 ng/L**, Marsalek and Ng, 1989; **26.9-1,120 ng/L**, Walker et al., 1999). Except for the Ettie St. Pump Station watershed, a known high leverage area for PCBs, yields reported for the other four watersheds were within similar ranges reported for other SF Bay local watersheds (3.0-5.0 µg/m2/y, Davis et al., 2000; 3.1 µg/m2/y, Gilbreath et al., 2012).*"(emphasis added)

Table B.9.4.2. Total PCB Concentration Minimum, Maximum, Mean (ng/L) and Sample Count in 17 Watersheds Monitored in Water Year 2011 (McKee et al. 2012)

Site	Minimum	Maximum	Mean	N
Belmont Creek	2.83	4.91	3.60	3
Borel Creek	3.41	8.67	6.13	3
Calabazas Creek	5.11	24.8	11.5	5
Ettie Street Pump Station	35.8	69.0	59.00	4
Glen Echo Creek	5.64	85.8	30.00	4
Lower Marsh Creek	0.70	4.14	2.15	6
Lower Penitencia Creek	1.14	1.85	1.48	4
Pulgas Creek South	19.1	53.9	31.5	4
Pulgas Creek North	43.3	84.5	60.3	4
Santa Fe Channel	25.4	468	198	5
San Leandro Creek	4.59	31.3	12.4	7
San Lorenzo Creek	5.70	20.4	12.9	5
Stevens Creek	3.17	17.6	7.53	6
San Tomas Creek	1.62	4.37	2.83	5
Sunnyvale Channel	9.41	67.5	39.2	5
Walnut Creek	3.69	24.4	9.00	6
Zone 5 Line M	16.7	26.3	20.8	4

Table B.9.4.3 below shows the theoretical mass (grams) of PCBs that would be removed for a given volume of stormwater or pump station sump diversion at a given PCB concentration. The above cited monitoring results indicate that average PCB concentrations even in areas with known high concentrations such as Ettie Street, have been found to be less than 100 ng/L. The

table below shows that just under three million gallons of stormwater containing 100 ng/L of PCBs, would be need to be captured to divert about 1 gram of PCBs to a POTW willing and able to accept that amount of flow.

Table B.9.4.3. Mass (grams) of PCBs Diverted for Assumed Flow and Concentration

Gallons Diverted	Total PCB Concentration (ng/L)					
	1	5	10	50	100	200
20,000	0.0001	0.0004	0.0008	0.0038	0.0076	0.0151
50,000	0.0002	0.0009	0.0019	0.0095	0.0189	0.0379
100,000	0.0004	0.0019	0.0038	0.0189	0.0379	0.0757
200,000	0.0008	0.0038	0.0076	0.0379	0.0757	0.1514
400,000	0.0015	0.0076	0.0151	0.0757	0.1514	0.3028
500,000	0.0019	0.0095	0.0189	0.0946	0.1893	0.3785
1,000,000	0.0038	0.0189	0.0379	0.1893	0.3785	0.757
10,000,000	0.0379	0.1893	0.3785	1.8925	3.785	7.57

B.9.4.3 Summary of Key Uncertainties

There are a number of sources of uncertainty in accurately estimating PCB and mercury loads reduced to San Francisco Bay associated with baseline and current diversions of stormwater or dry weather flows to POTWs:

- The appropriate "average" concentrations of PCBs and mercury to use for specific types and locations of stormwater diversions is currently based on limited information on the variability in concentrations within and between diversion events.
- Uncertainties in the estimated volume of water and associated suspended sediments diverted to POTWs remain until data collection efforts via pilot projects are completed.
- The pollutant removal efficiencies of POTWs receiving diverted stormwater or dry weather flows have not been incorporated into the loads reduced/avoided formulas presented and therefore load reduction estimates calculated could be overestimated, although the overestimates are likely minimal.

B.9.5 References

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FIGURES B.9

Locations of Pilot Diversion Projects

Source:
EOA, Inc.

Bay Area Stormwater Management Agencies Association	September 2013	Figure B.9.1
Entity	Date	

internal info: path, date revised, author

Ettie Street Pump Station and Vicinity, Showing Nearby Transportation Facilities and EBMUD Treatment Plant, Oakland CA

Source:
EOA, Inc.

Bay Area Stormwater Management Agencies Association	September 2013	Figure B.9.2
Entity	Date	

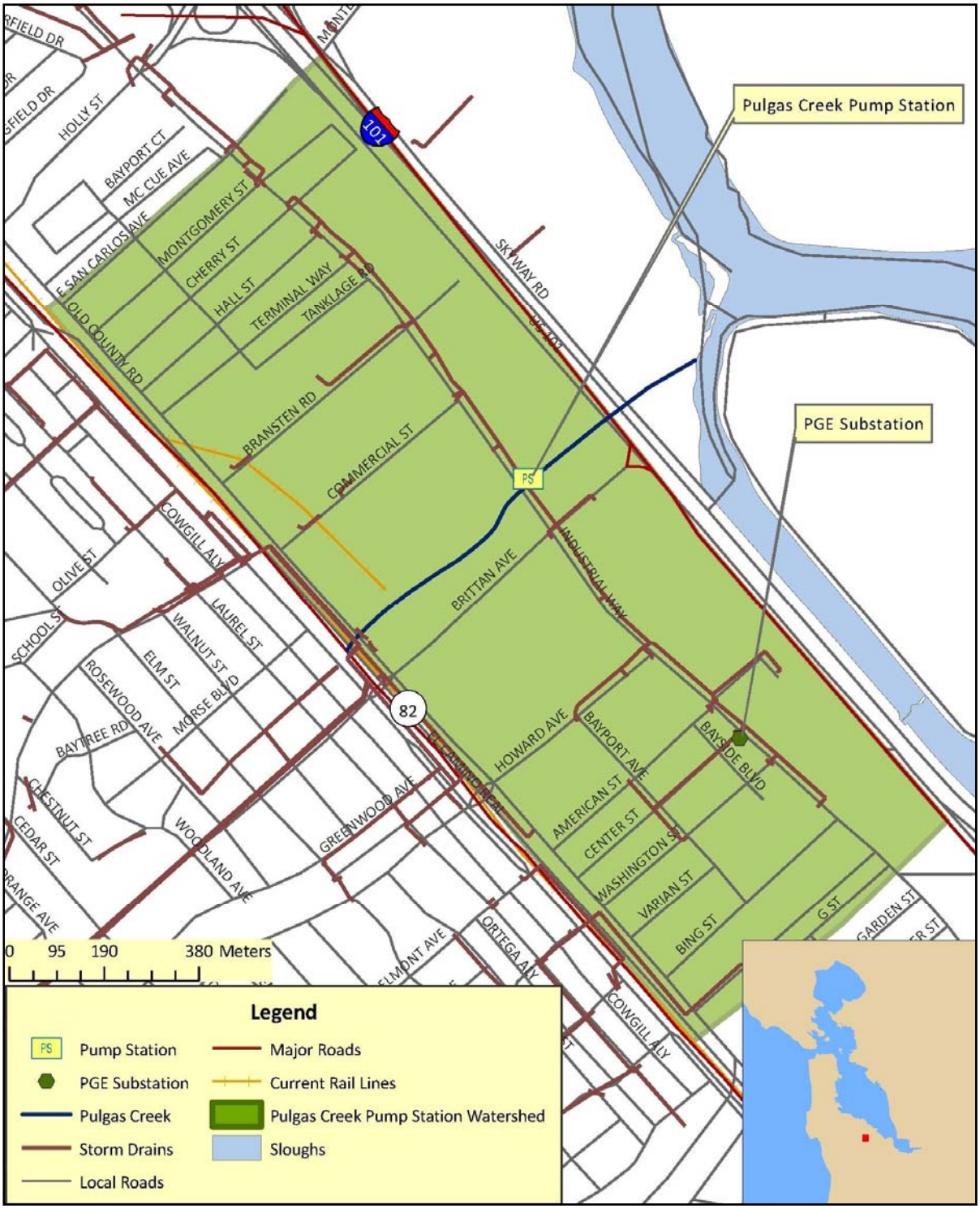
internal info: path, date revised, author

Site Map of North Richmond Stormwater Pump Station Diversion Project, Richmond CA

Source:	Notes:

Bay Area Stormwater Management Agencies Association	September 2013	Figure B9.3
Entity	Date	

internal info: path, date revised, author



Pulgas Creek Pump Station Drainage, City of San Carlos, San Mateo County, CA

Source:
EOA, Inc.

Bay Area Stormwater Management Agencies Association

September 2013

Figure B.9.4

Entity

Date

internal info: path, date revised, author

Legend

- Storm Drain Line
- **A** North Pulgas Storm Drain Manhole
- **B** South Pulgas Storm Drain Manhole

0 15 30 60 Feet

N

Data
Map created: April 30th, 2012
Aerial photo source: Google Maps
Made by: EOA, Inc.
Note: Not drawn to scale, for illustration purposes only.

Pulgas Creek Pump Station Diversion Project, City of San Carlos, San Mateo County, CA

Source:
EOA, Inc.

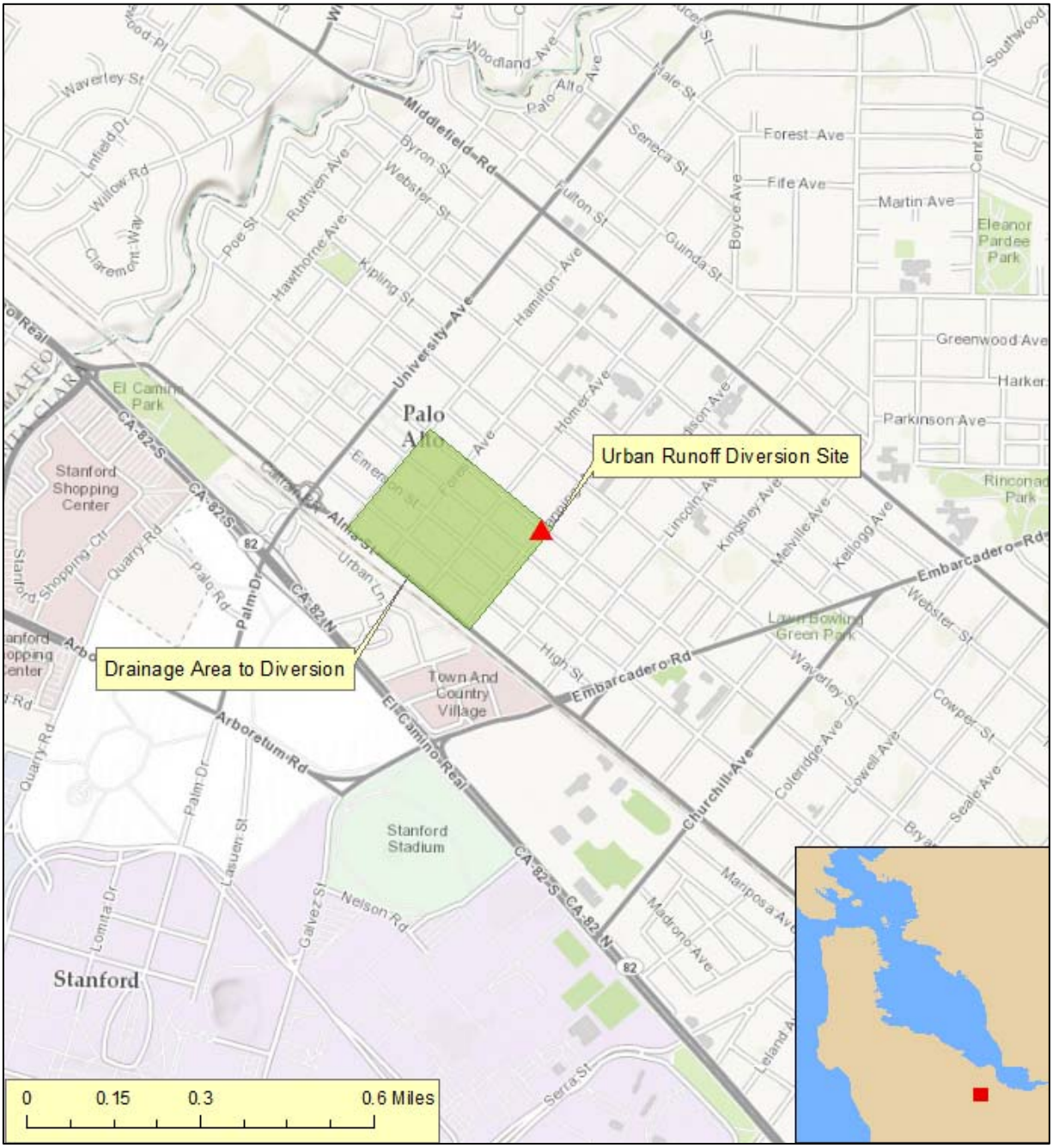
Bay Area Stormwater Management Agencies Association

September 2013

Figure B.9.5

Entity | **Date**

internal info: path, date revised, author



Location of the City of Palo Alto (Bryant Street) Urban Runoff Diversion Structure, Palo Alto, Santa Clara County, CA

Source:
EOA, Inc.

Bay Area Stormwater Management Agencies Association

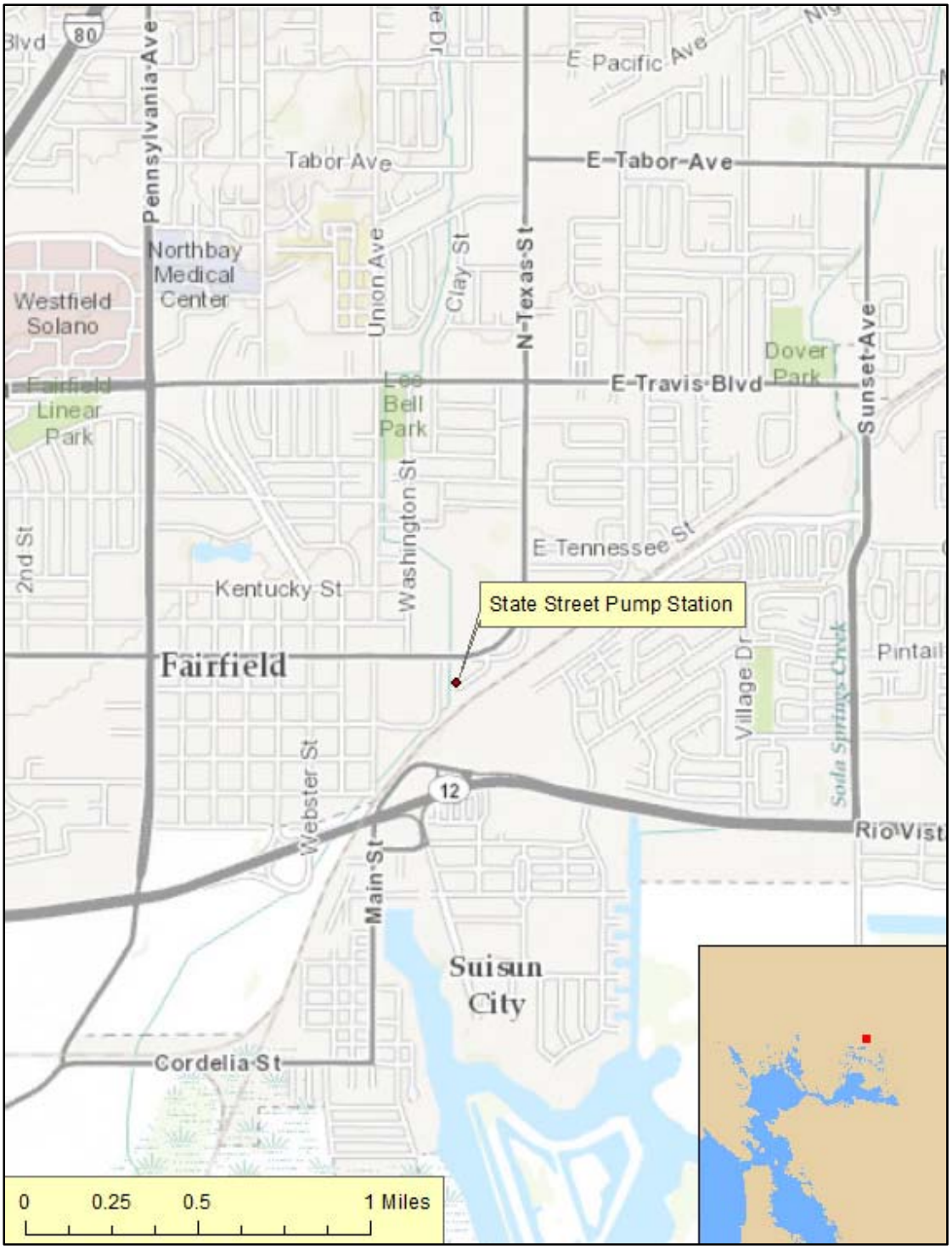
September 2013

Figure B.9.6

Entity

Date

internal info: path, date revised, author



Solano County Diversion Project Location, Fairfield Suisun CA

Source:
EOA, Inc.

Bay Area Stormwater Management Agencies Association

September 2013

Figure B.9.7

Entity

Date

internal info: path, date revised, author

Source:	Notes:

State Street Pump Station Location and Contributing Area, Fairfield CA

Entity	Date	
Bay Area Stormwater Management Agencies Association	September 2013	Figure B.9.8

internal info: path, date revised, author

APPENDICES

APPENDIX B.4.A

CW4CB Task 3 Reconnaissance Survey Form

CW4CB TASK 3 RECONNAISANCE SURVEY FORM

INSPECTED BY: _____ **DATE:** _____ /_____ /_____

SITE/AREA INFORMATION
LOCATION (include address/cross street, if applicable):
NAME OF BUSINESS(ES) (if available):
TYPE OF LAND USE: Commercial ☐ Industrial ☐ Municipal/Agency ☐ Transportation-related ☐ Type: _____ Misc. ☐ Explain: _____
DESCRIPTION OF SURVEYED AREA:

EVIDENCE OF POTENTIAL PCB SOURCE (check all that apply and describe in space given)	
Electrical applications/utilities (transformers, capacitors, appliances, televisions, fluorescent light ballast, motors, etc.)	
Evidence of outdoor hazardous material/waste storage areas (tanks, drums, scrap materials, e-waste). If so, are they labeled?	
Recycling/scrap yards (auto dismantlers)	
Outdoor burning or combustion	
Manufacturing industries with heat transfer systems (e.g., chemicals, high-tech, asphalt, metal products, etc.)	
Building demolition, renovation or window replacement sites/recyclers	
Miscellaneous (rail road lines/yards, coatings, printing inks, pesticides, stressed vegetation, etc.)	
Unidentified puddles or stains	

CW4CB TASK 3 RECONNAISANCE SURVEY FORM

POTENTIAL FOR SEDIMENT EROSION FROM SITE/AREA TO OCCUR (check all that apply and describe in space given)	
Property contains or appears to contain open areas (areas without structures or buildings)	
Street/driveway(s)/parking lot(s) not paved, partially paved or in poor condition	
Sidewalk(s) cracked, in poor condition, or lacking	
Vehicle activity (appears to occur) to/from site on unpaved areas	
Vacant or undeveloped lot(s)	
Site/area has been identified by the city or other party as an illegal dumping location	

ADDITIONAL INFORMATION. Does site/area confirm records review findings? Explain below. Add any additional notes that will inform potential facility inspections. Include names of any identified buildings. Sketch the site to show potential sediment sources and pathways to streets and storm drain inlets. Attach a separate piece of paper, if needed.

APPENDIX B.4.B

Facilities Inspection Form

Facilities Inspection Form

Initial Priority Ranking: H M L
(based on inspection)

INSPECTED BY: _____ DATE: _____/_____/_____

MAP NUMBER/ID: _____ PHOTO ID.#: _____

SITE INFORMATION	
NAME OF CURRENT BUSINESS:	TYPE OF BUSINESS:
NAME OF OWNER:	COVERED UNDER GENERAL INDUSTRIAL PERMIT?
ADDRESS (include cross street, if possible):	
NAME AND TITLE OF OFF-SITE CONTACT:	CONTACT INFORMATION: ADDRESS PH EMAIL
NAME AND TITLE OF ON-SITE CONTACT (if different from above):	CONTACT INFORMATION: ADDRESS PH EMAIL
DESCRIPTION OF SITE (include areas of principal interest and apparent level of housekeeping). ALSO ATTACH A SKETCH OF THE SITE ON A SEPARATE PIECE OF PAPER (include potential sources and pathways to storm drain inlets and on-site and ROW sampling locations).	

TYPE OF POTENTIAL PCB SOURCE (consider current and past use; check all that apply and describe in space given below)	
Electrical applications/utilities (transformers, capacitors, appliances, televisions, fluorescent light ballasts, motors, etc.)	
Hydraulic fluids (lifts, die-casting machinery, etc.)	
Plasticizers (sealants, caulk, PVC, polyurethanes, polycarbonates, etc.)	
Evidence of outdoor hazardous material/waste storage areas (tanks, drums, scrap materials, e-waste) If so, can they be identified?	
Recycling/scrap yards (auto dismantlers)	
Outdoor burning or combustion	
Manufacturing industries with heat transfer systems (e.g., chemicals, high-tech, asphalt, metal products, etc.)	
Building demolition, renovation or window replacement site/recycler	
Gas compressors/stations/pipelines	
Miscellaneous (rail road lines/yards, coatings, printing inks, pesticides, stressed vegetation, etc.)	

Facilities Inspection Form

POTENTIAL FOR SEDIMENT EROSION FROM SITE/AREA TO OCCUR (check all that apply, describe in space given and include in attached sketch)	
Property contains open area(s)/driveway(s)/parking lot(s) not paved, partially paved or in poor condition (circle which applies)	
Vehicle activity to/from site on unpaved areas	
Does the property border streets without curbs, berms or other containment?	
Vacant or undeveloped lot	
If waste (construction/hazardous materials/etc.) is generated on-site, is it kept in a dumpster or other container? If so, describe	

STORMWATER INFRASTRUCTURE AND HYDROLOGY (if any of the below apply to this site, include in attached sketch)	
Are stormwater treatment practices present? If so, describe.	
Are private storm drains or inlets locationed at the facility? If so, describe.	
Has storm drain infrastructure identified in GIS been located on property? Any infrastructure not previously identified?	
Is there sediment accumulation at edges of property, curbs, catch basins, or elsewhere? If so, describe.	

QUESTIONS FOR OWNER/CONTACT (include dates when possible)
1. What type of business(es) did the previous tenant(s)/owner(s) have, and when did they exist?
2. Are PCBs in use now or have they been in the past on this facility? Have there been any spills or leaks? If so, when?
3. Have there been any building fires in the past? Major exterior renovation or window replacement? If so, when?
4. Does the facility have a power substation onsite? In the past? If so, when?
5. What type of business was on the neighboring properties (if applicable)?
6. How are the ground surfaces maintained (hosed, swept)? How is the material disposed of afterwards?
7. Are vehicles used on-site? If so, what type, and is there potential for dirt to be transferred off-site?

APPENDIX B.4.C

AMS/ADH Field Methods Report: Phase 1 Soil/Sediment Testing in the Ettie Street Pump Station, Lauritzen Channel and Parr Channel Watersheds

Field Sampling Report

2012 CW4CB Task 3

Phase I Sampling

November 15, 2012

Submitted to:

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APPLIED marine SCIENCES

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1. Introduction

This report details activities associated with implementation of Clean Watersheds for a Clean Bay (CW4CB) Task 3, Phase I sampling, conducted within the Ettie Street watershed in Oakland and Parr and Lauritzen Channel Watersheds in Richmond, CA. All sampling was conducted between September 27th and October 4th, 2012 by ADH Environmental personnel under the management of Applied Marine Sciences, Inc. (AMS).

2. Field Sampling Report

2.1. Objectives

The objectives of the sampling effort were to collect the following:

1. Sediment samples from up to 42 sites for analysis of PCB congeners, Hg, Total Organic Carbon (TOC), and particle size analysis by ALS Group (ALS).
2. Sediment samples from 10% of the target sites for analysis of field duplicate samples by ALS.
3. Sediment samples from 10% of the target sites for analysis of dioxins, PAHs, PBDEs, and OC pesticides by ALS.
4. Sediment samples from one site for delivery to Kinnetic Laboratories, Inc. (KLI) for analysis of OC pesticide and Hg split samples.

2.2. Personnel

The personnel and work assignments for Phase I sampling are shown in Table 1.

Table 1. Personnel for CW4CB Task 3 Phase I Sampling

Name	Affiliation	Duties
Paul Salop	AMS	Project manager, training for field team personnel
Traci Linder	AMS	Logistics
Lucile Paquette	ADH	Sample collection
Calvin Sandlin	ADH	Sample collection

2.3. Sampling Activities

Sampling activities for Task 3 Phase I sampling conducted within the Ettie watershed are summarized in Table 2. For the four inlet sites sampled within the Ettie Street watershed, City of Oakland personnel supported sampling efforts by providing traffic control and removing and replacing inlet grates. None of the samples collected within the Parr and Lauritzen Channel watersheds were collected from within the drop inlets, and therefore sampling personnel were able to operate independently throughout this sampling.

Table 2. Sampling Activities for CW4CB Task 3 Phase I Sampling

SiteCode	Site Description	Date	Lat	Long	Comments
ETT2	Cole Bros, 1797 12th St, along curb	10/2/12	37.81247	-122.30029	
ETT2a	Nautical Engineering, 1790 11th St	10/2/12	37.81176	-122.30064	

SiteCode	Site Description	Date	Lat	Long	Comments
ETT8a	ISSA Trucking; 1639 18th St	10/2/12	37.81438	-122.29249	
ETT29	Precision Casting; near 32nd and Hannah, on Hannah side	9/28/12	37.82326	-122.28675	
ETT29a	Precision Casting; near 32nd and Hannah, on 32nd side	9/28/12	37.82317	-122.28660	
ETT56	2838 Hannah St, near former driveway	9/28/12	37.82272	-122.28700	
ETT57	2838 Hannah St, adjacent to chain link fence	9/28/12	37.82116	-122.28620	Insufficient soil - no sample taken
ETT58	Vacant lot, directly across street from 2857 Hannah	9/28/12	37.82291	-122.28653	
ETT63	AMG - 3434 Helen St, southern portion of property	10/1/12	37.82639	-122.28638	Insufficient soil - no sample taken
ETT64-65	AMG - 3434 Helen St, northern portion of property	10/1/12	37.82583	-122.28639	Insufficient soil - no sample taken
ETT66	Drop inlet north end of Helen St	10/1/12	37.82640	-122.28662	Inlet
ETT84	CASS West - between 26th and 28th	9/28/12	37.81889	-122.28805	
ETT84b	CASS East Facility, along Union St, between 26th and 28th, at westernmost driveway	9/28/12	37.81985	-122.28493	
ETT84c	CASS north , along Peralta St	9/28/12	37.81987	-122.28490	Insufficient soil - no sample taken
ETT84d	CASS north, along Poplar, east of 28th, adjacent to blue wall	9/28/12	37.82172	-122.28519	
ETT84f	CASS East, along Poplar St	10/2/12	37.82061	-122.28555	Inlet
ETT85	CASS Central, along Poplar St, in front of mural	10/1/12	37.82069	-122.28558	
ETT85a	CASS Central - along Union, SW corner of Peralta & Hannah	10/2/12	37.82090	-122.28643	
ETT85b	NW corner Poplar & 26th, future tree well installation area	10/1/12	37.81938	-122.28612	
ETT121	Granite Expo - NE Corner of Wood St & 34th	9/27/12	37.82465	-122.29043	
ETT121a	CA Waste Solutions - 3300 Wood St, both sides of driveway	9/27/12	37.82418	-122.29042	
ETT121b	Illegal dumping site just south of ETT121a	9/27/12	37.82355	-122.29024	
ETT122	Granite Expo - 3430 Wood St, driveway along Wood St	9/27/12	37.82552	-122.29101	
ETT122a	North of Granite Expo - 3430 Wood St, on abandoned RR ROW	9/27/12	37.82536	-122.29100	
ETT122b	Dumping areas north of Granite Expo - 3430 Wood St	9/27/12	37.82563	-122.29101	
ETT123	Driveway entrance to Dan's Salvage, 3520 Harlan St	10/1/12	37.82696	-122.28209	
ETT123a	Inlet at Dan's Salvage, 3520 Harlan St	10/1/12	37.82663	-122.28201	Inlet
ETT124	Inlet, NW corner Poplar & 26th	10/1/12	37.81951	-122.28607	Inlet
LAU-01	Simms - West (600 South Fourth St)	10/3/12	37.92426	-122.36578	
LAU-02	S. 2nd, 1 block N of Cutting; 427 S 2nd	10/3/12	37.92646	-122.36809	
LAU-03	Rickert property; Cutting & 2nd, on 2nd St side (445 S. 2nd)	10/3/12	37.92559	-122.36807	
LAU-04	Rickert property; Cutting and 2nd, on Cutting side (135 Cutting)	10/3/12	37.92542	-122.36829	
LAU-05	PG&E lot (444 S 1st St; Cutting @ 1st)	10/3/12	37.92557	-122.36907	
LAU-06	PG&E (432 S. 1st St)	10/3/12	37.92664	-122.36912	
PAR-01	Marina North (939 Marina Way South); empty lot; 1st RR crossing south of Wright, across from Kaiser	10/4/12	37.91955	-122.35605	
PAR-02	Marina - South; same empty lot as PAR-01, about 100m south of PAR-01	10/4/12	37.91813	-122.35579	
PAR-03	Ford - North; near south end of Harbour. East side of street, in front of black chain link fence, near entrance to boiler house restaurant	10/4/12	37.91236	-122.35937	
PAR-04	Cal-Oils - North (1145 Harbour Way S); driveway just north of RR tracks	10/4/12	37.91703	-122.36024	
PAR-05	Cal-Oils - South; Large driveway before yellow RR sign on W side of Harbour	10/4/12	37.91750	-122.36045	

SiteCode	Site Description	Date	Lat	Long	Comments
PAR-06	Simms - south (803 Wright Ave), just W of 1st RR tracks on N side of Wright	10/4/12	37.92125	-122.36226	
PAR-07	Simms - south (799 Wright Ave, just W of Gate 6E)	10/4/12	37.92131	-122.36306	
PAR-08	Simms - north (600 Hoffman Blvd); Park at dead end road, 6th St, sampling site directly across Hoffman	10/4/12	37.92397	-122.36330	

Per the programmatic SAP, field duplicates were collected for analysis at a minimum of ten percent of sites sampled. Similarly, samples for analyses of OC pesticides, PAHs, PBDEs, and dioxins were also collected at ten percent of sites. In addition, a split sample from one location, ETT122a, was transferred from AMS to KLI for analysis of mercury and OC pesticides by laboratories employed by the KLI team, SCL and ATL. Samples collected by site are shown in Table 3.

Table 3. Summary of Requested Laboratory Analyses for CW4CB Task 3 Phase I Sampling

SiteCode	PCBs, Hg, TOC, Part. Size	FD, PCBs	FD, Hg, TOC, Part. Size	Dx, OCPs, PAHs, PBDEs	Split (Hg & OCPs)
ETT2	x				
ETT2a	x				
ETT8a	x			x	
ETT29	x				
ETT29a	x				
ETT56	x				
ETT58	x	x		x	
ETT66	x				
ETT84	x				
ETT84b	x				
ETT84d	x				
ETT84f	x				
ETT85	x				
ETT85a	x	x	x		
ETT85b	x				
ETT121	x				
ETT121a	x				
ETT121b	x				
ETT122	x				
ETT122a	x		x	x	x
ETT122b	x				
ETT123	x	x	x		
ETT123a	x				
ETT124	x				
LAU-01	x				
LAU-02	x	x	x		
LAU-03	x				
LAU-04	x				
LAU-05	x				
LAU-06	x				
PAR-01	x				
PAR-02	x				

SiteCode	PCBs, Hg, TOC, Part. Size	FD, PCBs	FD, Hg, TOC, Part. Size	Dx, OCPs, PAHs, PBDEs	Split (Hg & OCPs)
PAR-03	x				
PAR-04	x				
PAR-05	x			x	
PAR-06	x				
PAR-07	x				
PAR-08	x				
Total	38	4	4	4	1

2.4. Sample Handling

All sample containers were supplied by ALS. The containers used and sample handling implemented for Task 3 Phase I are summarized in Table 4.

Table 4. Sample Handling for CW4CB Task 3 Phase I Sampling.

Analysis	Container	Handling Requirements
Particle Size	Ziploc bag	Place on wet ice.
PCBs	8 oz glass	Place on wet ice.
Hg, TOC	8 oz glass	Place on wet ice.
Archive	8 oz glass	Place on wet ice.
PCBs, Dx	8 oz glass	Freeze on dry ice (only for 10% sites where additional analyses performed)
PBDE, OCP, PAH	8 oz glass	Place on wet ice.

2.5. Sample Labeling

The sample ID labeling system used is as follows:

WWW-S-NNN-##

Where:

WWW	=	Watershed
S	=	Media (S for soil)
NNN	=	Site number
##	=	Unique ID number

The photo ID labeling system used is as follows:

WWW-P-NNN-##

Where:

WWW	=	Watershed
P	=	Media (P for photo)
NN	=	Site number, identical to those used for sample ID
##	=	Unique ID number

2.6. Discussion

Representatives from the PMT met with AMS personnel in advance of sampling to review the viability of potential sampling sites and identify specific locations within each identified site for sample collection. On September 24th, Paul Salop of AMS conducted a site visit to proposed Ettie sampling sites with Becky Tuden from the City of Oakland and Adrienne Miller and Matt Freiberg of Geosyntec Consultants. Of those sites targeted for sampling during the reconnaissance, four sites were not sampled due to a lack of a sufficient volume of soil present during subsequent sampling operations, likely due to extensive street and sidewalk cleaning conducting between time of the survey and sampling by respective property owners.

On September 28th, Mr. Salop met with Joanne Le and Lynne Scarpa of the City of Richmond and Khalil Abu-Saba of Brown and Caldwell to perform site visits within the Lauritzen and Parr watersheds. A total of fourteen sites were identified for sampling, six within the Lauritzen watershed and eight within the Parr watershed. All sites were sampled as planned.

APPENDIX B.4.D

QA/QC Summary Report

Laboratory QA Summary

CW4CB Task 3 Phase I

October 20, 2013

Submitted to:

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1. Introduction

The Bay Area Stormwater Agencies Association (BASMAA) contracted with Applied Marine Sciences, Inc. (AMS) to support implementation of CW4CB Task 3. As part of its contract with BASMAA, AMS is providing project quality assurance for all Task 3 activities. Don Yee at SFEI is the Project QA Officer (QAO), and has completed preliminary data review of priority Task 3 analytes Hg and PCBs, which is discussed below.

Task 3 field monitoring was conducted in September and October of 2012. Hg samples were analyzed by two laboratories – (1) Soil Control Lab (SCL) for samples collected by KLI within San Mateo and Santa Clara Counties, and (2) ALS Global / Columbia Analytical Services (ALS) for samples collected by AMS within Alameda and Contra Costa Counties. In the case of PCBs, all samples collected for the Project were analyzed by ALS.

Attached are narrative summaries of reviews of QA/QC samples analyzed with reported field samples for the project. QA/QC samples were evaluated using the procedures and measurement quality objectives (MQOs) described in the project QAPP (BASMAA 2012). QA/QC results generally met project MQOs, with some minor deviations. Some mercury contamination was found in blanks from one lab (SCL), and some congeners in PCB blanks (ALS), likely affecting results for some of the lowest concentration samples reported by the labs, which were censored (not reported) in those samples as a result. PCBs in sediment samples showed moderate to large variation in replicate samples for some of the less abundant congeners; one congener (PCB 20/28) showed very large variation (>100% RPD) and was therefore censored. Details on the individual data submittals by various labs are provided below. All data should be considered preliminary until release of final data submittal by BASMAA.

2. PCBs

PCBs in sediment samples were analyzed by ALS. Samples were collected between September 24 and October 4, 2012, and were analyzed between October 24 and November 25, 2012. The 40 PCB congeners reported by the Regional Monitoring Program for Water Quality in the San Francisco Estuary[1] were reported for 81 field samples (including replicates). Blank and LCS (recovery) samples were also reported.

2.1. Sensitivity

PCB 008 was not detected (ND) in about 1/3 of the samples, but aside from that, most of the analytes were ND in only 2 to 6 of the 81 samples analyzed for PCBs.

2.2. Blanks

About half the analytes (20) were found in the blank at least 2x the MDL in one or more batches (QAPP page 7-5). For 13 of those, blanks were possibly > 10% of the field sample value in 2 or 3 samples - cases with ND results for diluted samples. It is unknown whether the blank signal would constitute a

[1] The RMP 40 list of PCBs has been the historic suite of PCB congeners analyzed by BASMAA agencies.

significant portion of the sample in these cases due to their dilution, so those results were censored with VRIP flag (Data rejected - Analyte detected in field or lab generated blank, flagged by QAO) as a worst-case assumption. Other samples were flagged with VIP (analyte detected in field or lab generated blank, flagged by QAO) as a warning but not censored since the blank contamination was <10% of those field sample concentrations.

2.3. Recovery

Recovery results were only reported for LCSs, with good recovery (within the 70-130% recovery (30% error) QAPP Table 26-2 target for PCBs. Only 3 out of the 29 reported analytes in the LCS were in the RMP 40 target analytes; although a range of PCB homologs were included in the LCS, some interferences are congener specific and would not necessarily be identified in the LCS.

2.4. Precision

Precision was calculated only for sample pairs where an analyte was detected in both samples. Precision results were averaged across batches for analytes, and those with average RPDs > the 25% MQO (QAPP Table 26-2) were flagged as having marginal precision but not censored, and those with RPDs grossly above the MQO (average RPD >50%) were censored (see table below). Only one analyte, PCB 20/28, fell into this latter category.

PARAMETER	avgRPD
PCB 020/28	**100.76%**
PCB 086/87/97/109/119/125	32.80%
PCB 105	44.86%
PCB 110/115	31.82%
PCB 118	26.64%
PCB 132	33.76%
PCB 141	45.14%
PCB 147/149	26.00%
PCB 156/157	27.53%
PCB 158	33.14%

3. Hg - ALS

Mercury in sediment samples collected by AMS/ADH was analyzed by ALS. Samples were collected between September 25 and October 4, 2012, and were analyzed between October 23 and 25, 2012. Total mercury in the <2mm sediment fraction was reported for 47 field samples (including replicates and an intercomparison sample). Blank and LCS (recovery) samples were also reported.

3.1. Sensitivity

Sensitivity was sufficient so no non-detects were reported for total mercury.

3.2. Blanks

No mercury blank contamination was found.

3.3. Recovery

Recovery results were only reported for LCSs, with good recovery (within the QAPP Table 26-4 target 75-125% recovery (25% error) for mercury (actual average 4.6%). The LCS used was ERA D076-540, a metal spiked soil from ERA (external supplier).

3.4. Precision

Precision on lab replicates was good, averaging 6.6% RPD, less than the 25% MQO (QAPP Table 26-4), so no results were flagged for marginal or poor precision. Field replicates were more variable, with individual pairs up to 37% RPD, suggesting field sample heterogeneity, although the average of all replicate pairs was still <25% RPD.

3.5. Intercomparison sample

Results included one sample analyzed for intercomparison to a second lab. The PUL8 result of 0.073 mg/kg dw here, was 51% lower (67% RPD) than the average of SCL results for the same site of 0.22, 0.11 and 0.11 mg/kg dw (for a split sample, a split blind field duplicate, and its lab duplicate, respectively). The intra-lab variation between the split sample and its blind dupe suggest some variation due to sample heterogeneity

4. Hg - SCL

Mercury in sediment samples collected by KLI was analyzed by SCL. Samples were collected between September 24 and October 2, 2012, and were analyzed on October 12, 2012. Total mercury in a <2mm sediment fraction was reported for 36 field samples (including replicates). Blanks, MS/Ds, LCM, and CRM (recovery) samples were also reported.

4.1. Sensitivity

Sensitivity was sufficient so no non-detects were reported for total mercury.

4.2. Blanks

Mercury blank contamination was found slightly over 2x the MDL (QAPP page 7-5), but at concentrations averaging only 0.0057 mg/kg. Four of the lowest concentration samples (all from Pulgas) were < 10x that and flagged VRIP (censored), but the remainder were flagged without censoring (VIP flag).

4.3. Recovery

Recovery samples had good recovery (within the 75-125% recovery (25% error) target (QAPP Table 26-4) for mercury. Recovery errors on the LCM & CRM averaged 6.7%, and on the MS/Ds 4.4%, well within the target, so no recovery qualifiers were needed.

4.4. Precision

Precision on lab replicates was good, averaging 2.2% RPD, less than the 25% MQO (QAPP Table 26-4), so no results were flagged for marginal or poor precision. Field replicates were more variable, with 45% RPD suggesting field sample heterogeneity, but results were not flagged for potentially variable field replicates.

4.5. Intercomparison sample

Results included one sample analyzed for intercomparison to a second lab. The ETT122a result of 0.27 mg/kg dw here, 41% lower (51% RPD) than the average of ALS results for the same site of 0.4 and 0.51 mg/kg dw. Intra-lab variation on sample replicates was 24%, suggesting some sample heterogeneity, which may account for a portion of the total variation.

5. PAHs - ALS

PAHs in sediment samples collected by AMS were analyzed by ALS. Samples were collected between September 27 and October 4, 2012, and were analyzed on October 20-23, 2012. PAHs in a <2mm sediment fraction were reported for 4 field samples. A blank, MS/Ds, and two LCS samples were also reported.

5.1. Sensitivity

Sensitivity was sufficient to have no NDs for most PAHs, but Biphenyl, 2,6-Dimethylnaphthalene, Dibenzothiophene, and Fluorene had 1 ND each, and Acenaphthene had 2.

5.2. Blanks

PAHs were not found in the blank at concentrations over the detection limit.

5.3. Recovery

Matrix spike recovery was never outside the target MQO of 50-150%, but average recovery errors above 35% were seen for Dibenz(a,h)anthracene, 2,6-Dimethylnaphthalene, Indeno(1,2,3-c,d)pyrene, and 2-, Methylnaphthalene.

5.4. Precision

Precision on lab replicates was good for most analytes, with RPDs less than the 25% MQO (QAPP Table 26-2), except for Anthracene, Biphenyl, 2,6-Dimethylnaphthalene, and Fluorene, with RPDs ranging 26-37%.

6. PAHs - ATL

PAHs in sediment samples collected by KLI were analyzed by ATL. Samples were collected between September 24 and October 2, 2012, and were analyzed on October 30 and November 8, 2012. PAHs in a

<2mm sediment fraction were reported for 4 field samples. A blank, MS/Ds, and an LCS sample were also reported.

6.1. Sensitivity

Sensitivity was sufficient to have no NDs for most PAHs, but Acenaphthylene, Anthracene., Fluorene, 2-Methylnaphthalene, and Naphthalene each had one ND result.

6.2. Blanks

Fluorene was found in the blank at a concentration over the detection limit, and greater than or equal to one third the concentration in field samples, so all Fluorene results were censored.

6.3. Recovery

Matrix spike recoveries were never outside the target MQO of 50-150%, and all had <25% error for analytes spiked in a quantitative range (at least 3x MDL).

6.4. Precision

Precision on matrix spike replicates was good for the 3 analytes spiked, with RPDs less than 10%, well within the 25% MQO (QAPP Table 26-2).

7. Pesticides - ALS

Pesticides in sediment samples collected by AMS/ADH were analyzed by ALS. Samples were collected between September 27 and October 4, 2012, and were analyzed on November 6, 2012. 31 pesticides, mostly legacy organochlorine compounds, in a <2mm sediment fraction were reported for 4 field samples. A blank, MS/Ds, and two LCS samples were also reported.

7.1. Sensitivity

Sensitivity was sufficient to have detections of only about half the pesticides, and all but 6 analytes had one or more NDs, despite MDLs mostly <1 ug/kg, meeting the project QAPP targets (most 1 ug/kg or more)

7.2. Blanks

Pesticides were not found in the blank at concentrations over the detection limit.

7.3. Recovery

Matrix spike recovery was outside the target MQO of 50-150% only for Endrin Aldehyde (47%), with Endosulfan I, Endrin, and Hexachlorobenzene approaching those limits with deviations above 35%.

7.4. Precision

Precision on was good for most analytes, with RPDs less than the 25% MQO (QAPP Table 26-2), except for Oxychlordane, Isodrin, Hexachlorobenzene, and Endrin Ketone, with RPDs ranging 28-63%.

8. Pesticides - ATL

Pesticides in sediment samples collected by KLI were analyzed by ATL. Samples were collected between September 24 and October 2, 2012, and were analyzed on October 10 to 15, 2012. 22 pesticides (mainly legacy organochlorines) in a <2mm sediment fraction were reported for 4 field samples and 1 intercomparison sample. A blank, MS/Ds, and an LCS sample were also reported. The analytes reported omitted a number requested in the project QAPP, namely all of the o,p' DDT derivatives, as well as hexachlorobenzene, mirex, cis & trans nonachlor, and oxychlordane.

8.1. Sensitivity

Samples were 100% NDs except for the chlordanes and DDTs. Most of the MDLs were <1ug/kg dw, so met the project requirements

8.2. Blanks

None of the target analytes were detected in blanks.

8.3. Recovery

Recovery was evaluated from matrix spikes and spike dupes, spiked for 6 of the analytes. Recoveries on all the spiked analytes were <70%, always biased low, but within the project target of 50-150%.

8.4. Precision

Precision was measured via matrix spike duplicates, with RPDs within the MQO target of <25% (QAPP Table 26-2) except for p,p' DDT (RPD 32%) which was flagged VIL (not meeting precision target) but not censored

8.5. Intercomparison samples

Results included one sample analyzed by ALS. RPDs between lab results for analytes reported by both ranged from 17 to 90%, with the 90% RPD occurring on an analyte <3xMDL for one of the labs. There were a half dozen or so analytes reported by ALS without results from ATL in the intercomparison sample.

9. PBDEs - ALS

PBDEs in sediment samples collected by AMS/ADH and KLI were analyzed by ALS. Samples were collected between September 24 and October 4, 2012, and were analyzed on November 26 and 27, 2012. 17 PBDE congeners, in a <2mm sediment fraction were reported for 8 field samples. A blank and two LCS samples were also reported.

9.1. Sensitivity

Detection limits ranged 14 to 174 ug/kg dw (highest for PBDEs 206 and 209), about 100x above the project target MRLs of 0.1 to 1 ug/kg. PBDEs were NDs in all samples except for 47, 99, and 209. These are typically among the most abundant PBDEs.

9.2. Blanks

No PBDEs were found in the blank at concentrations over the detection limit.

9.3. Recovery

LCSs were used to evaluate accuracy. Average recoveries had <25% error for all congeners, within the MQO target, so no records needed to be qualified.

9.4. Precision

Replicates of the LCS were used to evaluate precision. The average RPD was <7% for all congeners in the LCS, below the target MQO of 25%. No additional qualifiers were added.

10. Dioxins - ALS

Dioxins in sediment samples collected by AMS/ADH and KLI were analyzed by ALS. Samples were collected between September 24 and October 4, 2012, and were analyzed between October 18 and November 2, 2012. 17 dioxin and furan congeners with 2,3,7,8-TCDD activity, in a <2mm sediment fraction were reported for 8 field samples. Two blanks and 3 LCS samples were also reported.

10.1. Sensitivity

Detection limits ranged 0.07 to 22.5 ng/kg dw (highest for OCDD), slightly above the project target MRLs of 1 to 10 ng/kg for some of the analytes. 1,2,3,7,8,9-HxCDF was ND in all samples, and 2,3,7,8-TCDD, and 1,2,3,7,8-PeCDF were ND in one sample each.

10.2. Blanks

Two lab blanks were reported with 41% (7 out of 17) of the individual analytes having some blank contamination. Most blank contaminations was <10% of field sample concentrations, but one 1,2,3,4,7,8,9- HpCDF result was censored for a higher contribution of the blank.

10.3. Recovery

LCSs were used to evaluate accuracy. Average recoveries had <25% error for all analytes, within the MQO target, so no records needed to be qualified.

10.4. Precision

Replicates of the LCS were used to evaluate precision. The average RPD was below the target MQO of 25% for all congeners in the LCS so no additional qualifiers were added.

11. TOC - ALS

Total organic carbon (TOC) in sediment samples collected by AMS/ADH were analyzed by ALS. Samples were collected between September 27 and October 4, 2012, and were analyzed on October 22 to 23, 2012. TOC in a <2mm sediment fraction were reported for 42 field samples, with 3 lab replicates and one field replicate. Lab blanks, MS/Ds, and LCS samples were also reported.

11.1. Sensitivity

The detection limits were above the project QAPP target of 0.01%, but all TOC results were above the detection limits (TOC MDL 0.05%) with no NDs reported.

11.2. Blanks

TOC was not found in the blanks at concentrations over the detection limit.

11.3. Recovery

MSs were spiked to around 20% TOC, near the high end of field sample concentrations. Recovery errors for the MSs averaged 4%, well within the target MQO of 80-120%. LCSs spiked to only 5x the MDL (0.28% TOC, below any samples) had OK recovery as well, averaging 19% error, so no additional qualifiers were needed.

11.4. Precision

Lab replicates were used to evaluate precision for TOC. The average RPD, around 3.5%, was well within the target MQO of 25% for TOC. A field sample replicate was analyzed, but not used to assess precision, and had a similarly small RSD of 2.5% (analyzed 3x total, paired with a sample with a lab replicate).

12. TOC - ATL

Total organic carbon (TOC) in sediment samples collected by KLI were analyzed by ATL. Samples were collected between September 24 and October 2, 2012, and were analyzed on October 11, 2012. TOC in a <2mm sediment fraction was reported for 31 field samples, along with lab replicates, field blind replicates, lab blanks, and CRMs.

12.1. Sensitivity

All TOC results were above the detection limits (TOC MDL 0.01, meeting the project QAPP target) with no NDs reported.

12.2. Blanks

Some TOC was measured in blanks, but at concentrations (0.02% dw) less than 10% of the lowest field sample (0.28% dw TOC) so no results were censored.

12.3. Recovery

Two certified reference materials (CRMs) were run for TOC and were used to evaluate accuracy. Recovery for the CRMs was 97 to 98%, within the target MQO of 80-120%.

12.4. Precision

The average RPD for lab replicates was within the target MQO of 25% for TOC (individual RPDs of 12.6 and 1.2%). Field sample replicates were not used to flag precision, also met the target with an average RPD of 17.8%.

13. Total Solids - ALS

Total solids in sediment samples collected by AMS/ADH and KLI were analyzed by ALS. Samples were collected between September 24 and October 4, 2012, and were analyzed between October 8 and November 1, 2012. Total solids in a <2mm sediment fraction were reported for 179 samples, including 15 lab replicates and 9 field replicates. No other sample types were reported.

13.1. Sensitivity

Total solids were reported to within 0.1%, with no NDs reported.

13.2. Precision

Lab replicates were used to evaluate precision for total solids, with RPDs <1%, well within the <25% RPD for other sediment conventional analytes.

14. Total Solids - ATL

Total solids were reported in sediment samples analyzed by ATL for intercomparison for chemical analytes. Samples were collected between September 24 and October 2, 2012, and were analyzed on October 8 to 12, 2012. Total solids in a <2mm sediment fraction was reported for 5 field samples, plus 1 lab replicate.

14.1. Sensitivity

Total solids were reported to the nearest 1%, with no NDs reported.

14.2. Precision

The RPD for lab replicates was <1%, within the target MQO of 25% for other sediment conventional analytes.

14.3. Intercomparison samples

The difference in average total solids between the two labs was good, always <3% RPD.

15. Grainsize - ALS

Grainsize in sediment samples collected by AMS/ADH were analyzed by ALS. Samples were collected between September 27 and October 4, 2012, and were analyzed between October 23 and 26, 2012. Grainsize in 9 fractions (from <75 to <0.005 mm) using the ASTM scale were reported in sediment samples for 45 samples, including 3 lab replicates and 4 field replicates. Some of the ASTM sizes are slightly offset from the ranges requested in the project QAPP. No other sample types were reported.

15.1. Sensitivity

Grainsize fractions were reported to within the nearest 0.1% or better, with no NDs reported.

15.2. Precision

Lab replicates were used to evaluate precision for grainsize. The average RPD was below the target MQO of 25% for all size ranges except Medium Gravel (55% RPD), flagged but not censored (CW4CB has no listed censoring threshold). Field sample replicates showed similar variability, with some RPDs higher and others lower than for lab replicates,

16. Grainsize - SCL

Grainsize in sediment samples collected by KLI were analyzed by SCL. Samples were collected between September 24 and October 2, 2012, and were analyzed October 19, 2012. Grainsize in 17 fractions (from <64 to <0.00098 mm) using the Wentworth/Plumb scale were reported in sediment samples for 31 field samples, plus 2 lab replicates and 3 field replicates. No other sample types were reported.

16.1. Sensitivity

Grain sizes were reported to the nearest 0.01% or better, with frequent (sometimes 100%) NDs reported for some of the coarser (pebble) fractions.

16.2. Precision

Lab replicates were used to evaluate precision, except the three pebble fractions which were mostly NDs. Average RPD was above the target MQO (25%) for the majority of analyte/fraction combinations (eight of 14 fractions with detects), and were flagged with a qualifier “VIL” for precision outside the MQO target. Field sample replicates were analyzed, but not used to assess precision, and had similarly large RPDs ranging from 0.02 to 145% (the latter for a pebble fraction, likely to be heterogeneous), with 47% of analyte/fraction combinations having average RPDs>25%. The frequent exceedance of the 25% RPD MQO may in part be due to the numerous fractions; with each fraction representing a smaller portion of the total size range, equivalent shifts in absolute percentages of total mass become amplified when expressed as RPD (a percentage relative to the average of a given fraction).

17. References

BASMAA, 2012. *Quality Assurance Project Plan: Clean Watersheds for a Clean Bay – Implementing the San Francisco Bay's PCBs and Mercury TMDLs with a Focus on Urban Runoff, EPA San Francisco Bay Water Quality Improvement Fund Grant # CFDA 66.202.* Prepared by Applied Marine Sciences, Inc. July 26, 2011.

APPENDIX B.4.E

Kinetic Laboratories, Inc., Field Methods Report: Phase 1 Soil/Sediment Testing in the Leo Avenue and Pulgas Creek Pump Station Watersheds

BASMAA CW4CB – Field Methods Report for Pulgas Creek Pump Station and Leo Avenue Watersheds Phase 1 Sediment Sampling

Prepared by Kinnetic Laboratories Inc.

10 January 2013

1.0 Field Sampling Procedures

Sediment sampling equipment was prepared in the laboratory prior to sampling. Sampling equipment included:

- Stainless steel sampling scoops and spoons
- Stainless steel and Tefzel-coated compositing buckets
- Natural fiber whisk brooms
- Wash bottles and storage containers for deionized water
- Wash bottles for hydrochloric acid and methanol

Prior to sampling, with the exception of new natural fiber whisk brooms, equipment was thoroughly cleaned. Equipment was soaked (fully immersed) for three days in 2% Micro® solution and deionized water. Equipment was then rinsed three times in deionized water and then allowed to dry in a clean place. Equipment was then rinsed with a 1.0% solution of hydrochloric acid, followed by a triple rinse with deionized water to eliminate the acid. A rinse with reagent grade methanol was then followed by another triple rinse with deionized water. Equipment was then allowed to dry in a clean place. Equipment was wrapped in aluminum foil or stored in clean Ziploc bags until used in the field.

Field crews identified areas of sediment accumulation within areas targeted for sampling and analysis. Standardized field data sheets were used to record, at a minimum; date, names of crew members, narrative description of the sampling site (general location), other relevant catchment information such as construction activities, weather conditions, sample matrix, whether soil/sediment is submerged or exposed, method used to collect sample, and sample IDs collected for analysis or archive. A minimum of one set of latitude/longitude per sample site was also recorded at the time of sampling.

In addition to complete field data sheets, a bound logbook was used to record relevant information for each day of sampling. These at a minimum included:

- Team members and their responsibilities
- Time of arrival/entry on the site and time of departure
- Other personnel on site
- Summary of any meetings or discussions with property owner or agency personnel
- Deviations from sampling plans, site safety plans, and QAPP procedures
- Changes in personnel and responsibilities with reasons for the changes.

Photographic documentation was reported on an associated photo log. Photographs were taken documenting sampling sites with each photograph listed in the photo log with time, date,

location, description of the subject photographed, and the name of the person taking the photograph.

Samples were collected directly into compositing buckets which have been covered with aluminum foil when not in use. No sieving of sediments was performed in the field, however, larger debris and cobble were removed from the samples. At the conclusion of sample collection at each site, all sediment was composited in the buckets and then subsampled for distribution to the appropriate laboratories. Disposable powder free nitrile gloves were worn while collecting and compositing samples to mitigate potential contamination. Gloves were changed between each location to reduce the potential for cross-contamination.

Samples were labeled for proper identification in the field and for tracking in the laboratory. The sample labels contained the following information: station location, date of collection, analytical parameter(s), and method of preservation. Every sample, including samples collected from a single location but going to separate laboratories, were assigned a unique sample number. Each sample collected was labeled according to the following naming convention, WWW-NN-MMDDYY where:

WWW	=	Project watershed code (first three letters, i.e., Ett, Lau, Par, Pul, or Leo)
NN	=	Sequential Number (i.e., 01, 02, 03…10, 11…etc.)
MMDDYY	=	Date as month (i.e., 01, 02…12), day (01 through 31), and last two digits of year (i.e., 20**12**)

All sampling equipment used at a particular sampling location was field cleaned prior to use at a different sampling location. The field-cleaning protocol involved 1) removal of sediments using a scrub brush and deionized water; 2) scrubbing of sampling gear and compositing equipment with a 2% Micro® solution and deionized water; 3) rinse with deionized water; 4) rinse with a 1.0% solution of hydrochloric acid; 5) rinse with methanol; and 6) rinse with deionized water.

At the conclusion of sample processing; all samples were be wrapped in protective bubble wrap and stored on ice, or in the case of dioxins dry ice, in the field. At the conclusion of a day's sampling, all samples were either stored overnight on dry ice or removed to a freezer for temporary storage prior to distribution to the analytical laboratories.

2.0 Sample Chain-of-Custody Forms and Custody Seals

All sample shipments for analyses were be accompanied by a Kinnetic Laboratories chain-of-custody record (COC). COCs were completed and sent with samples for each laboratory and each shipment. If multiple coolers were sent to a single laboratory on a single day, multiple forms were completed and set with the samples for each cooler. The COC identified the contents of each shipment and maintained the custodial integrity of the samples. A self-adhesive custody seal was be placed across the lid of each sample at a point of closure. The shipping containers in which samples are stored were sealed with a self-adhesive custody seal any time they were not in someone's possession or view before shipping. All custody seals were signed and dated.

3.0 Pulgas Creek Pump Station Watershed

Sediment sampling for the Pulgas Creek Pump Station watershed was performed over two days (24 – 25 September 2012). The field sampling crew consisted of Jonathan Toal and Amy Howk of Kinnetic Laboratories Inc., Krista McDonald of 2ND Nature LLC, and Nick Zigler of EOA, Inc. Jon Konnan of EOA, Inc. and Jan O'Hara of the Regional Water Quality Control Board (RWQCB) provided additional direction for sampling of sites on the 25th of September. The field crew initially arrived at Bransten Road, San Carlos at 09:00 on 24 September and at Center Street, San Carlos at 09:00 on 25 September.

24 September 2012

3.1 PUL-1-092412 – 37.50618°N; 122.25345°W

The sample was collected by sweeping up a mixture of fines with sand and some gravel with a natural fiber whisk broom and a stainless steel scoop from the gutter in front of the gate of GC Lubricants Company (977 Bransten Road). Larger pieces of gravel and organics (leaves & sticks) where removed during processing. Sample collection was completed at 09:50.

3.2 PUL-2-092412 – 37.50510°N; 122.25538°W

The sample was collected by sweeping up what appeared to be a fine cement dust. This material was collected from the northeast corner of a broken up access driveway next to a green plastic/cyclone fence of the Cemex Concrete Supply plant (1026 Bransten Road). A natural fiber whisk broom and a stainless steel scoop were used to collect the sample. Sample collection was completed at 10:22.

3.3 PUL-10-092412 – 37.50583°N; 122.25432°W

The sample was collected by sweeping up fine sediment from the eastern end of a broken up access driveway at AIM Sheet Metal (1008 Bransten Road). A natural fiber whisk broom and a stainless steel scoop were used to collect the sample. Sample collection was completed at 10:45.

3.4 PUL-15-092412 – 37.50662°N; 122.25301°W

The sample was collected by sweeping up fine sediment from the gutter east of the main AHERN Equipment Rental (941 Bransten Road) access driveway up to the second (low use) access driveway. A natural fiber whisk broom and a stainless steel scoop were used to collect the sample. Sample collection was completed at 11:15.

3.5 PUL-5-092412 – 37.50662°N; 122.25301°W

The sample was collected by scooping sediment from dirt in a low point in the main driveway on Bransten Road, west toward Old County Road of the Garden Supply Company (803 Old County Road). The nearest drop inlet was investigated but there was no sediment in the bottom. A stainless steel scoop was used to collect the sample. Sample collection was completed at 11:55.

3.6 PUL-7-092412 – 37.50662°N; 122.25301°W

The sample was collected from a catch basin on Howard Avenue at the southwest corner of Howard Avenue and Bayport Avenue. Drainage from OK Lumber (1323 Old County Road) was suspected of partially flowing between the two buildings directly south of the catch basin, into the street gutter on Bayport Avenue and then to the catch basin on Howard Avenue. There was a very high organic component to the material from decomposing eucalyptus leaves. A thick layer of leaves was removed to access the bottom of the catch basin. In addition, sediment was also gathered from the gutter just east of the catch basin and following the suspected drainage pattern. A stainless steel scoop was used to collect the sample. Sample collection was completed at 15:30.

<u>25 September 2012</u>

3.7 PUL-13-092512 – 37.49748°N; 122.24727°W

The sample was collected by compositing sediment from four stained areas in the dirt/gravel alley between Center Street and Washington Street. A petroleum odor was noticed after the soil was disturbed. A stainless steel scoop was used to collect the sample. Sample collection was completed at 09:20.

3.8 PUL-14-092512 – 37.49804°N; 122.24707°W

The sample was collected from a dirt/gravel area in front of the gate at 1062A Center Street and included some small stained areas and fines accumulated in the street gutter. A natural fiber whisk broom and a stainless steel scoop were used to collect the sample. Sample collection was completed at 09:45.

3.9 PUL-12-092512 – 37.49697°N; 122.24599°W

The sample was collected in front of the driveway gate at Provence Stone (1040 Varian Street) including a small stained area. A stainless steel scoop was used to collect the sample. Sample collection was completed at 10:10.

3.10 PUL-9-092512 – 37.49940°N; 122.24394°W

The sample was collected from just outside the southwest corner of the PG&E substation just southwest of the corner of Industrial Road and Washington Street. Jon Konnan (EOA, Inc.) and Jan O'Hara (RWQCB) were present to provide insight on the property. A small amount of fine sediment was collected where there was obvious directional flow from the PG&E substation property toward the street gutter. A natural fiber whisk broom and a stainless steel scoop were used to collect the sample. Sample collection was completed at 11:15.

3.11 PUL-8-092512 – 37.49979°N; 122.24445°W

The sample was collected from a dirt area just outside of the northwest corner of the PG&E substation just southwest of the corner of Industrial Road and Center Street. Jon Konnan (EOA, Inc.) and Jan O'Hara (RWQCB) were present to provide insight on the property. It was suspected that stormwater that is contained in the property is pumped out across the ground to the local storm drainage system. A valve was found behind the fence which could possibly be where storm water is pumped out. Any discharge from this valve would flow across the sampling area. A stainless steel scoop was used to collect the sample. Sample collection was completed at 11:35.

3.12 PUL-4-092512 – 37.50024°N; 122.24389°W

The sample was collected from a manhole at 1411 Industrial Road directly across the street from the PG&E substation. This sampling location was previously sampled in 2002 (Sample Identification SMC047) as part of a case study investigating PCB sources for the Pulgas Creek Pump Station. Elevated levels of PCBs were detected from that case study sample. A stainless steel scoop on a pole was used to collect the current sample. Sample collection was completed at 12:20.

<u>Additional Investigated Pulgas Creek Pump Station Watershed Sites Not Sampled</u>

Three other sites were investigated on 24 September but no samples were collected at these sites as no suitable samples were found. These three sites were **1)** Morey Maintenance (781 Old County Road – 37.50539°N; 122.25682°W) at 13:10; **2)** Ramirez Excavation and Demolition (841 Old County Road – 37.50398°N; 122.25519°W) at 13:20; and **3)** L-3 Communications Electron Devices Division (960 Industrial Road – 37.50517°N; 122.24980°W) at 14:15.

4.0 Leo Avenue Watershed

Sediment sampling for the Leo Avenue watershed was performed over two days (1 – 2 October 2012). The field sampling crew consisted of Jonathan Toal and Amy Howk of Kinnetic Laboratories Inc., Krista McDonald of 2ND Nature LLC, and Nick Zigler of EOA, Inc. Lisa Sabin of EOA, Inc., and Eric Dunleavey and Carol Boland of the City of San Jose provided additional direction for sampling of sites on the 1st of October. Carol Boland of the City of San Jose provided additional direction for sampling of sites on the 2nd of October. Don Yee of the San Francisco Estuary Institute observed the sampling for QA review on the 2nd of October. The field crew initially arrived at Leo Avenue, San Jose at 08:40 on 1 October and at the City of San Jose Central Service Yard (1661 Senter Street) at 08:45 on 2 October.

<u>1 October 2012</u>

4.1 LEO-1-100112 – 37.31023°N; 121.86527°W

The sample was collected by compositing sediment from two catch basins at the western end of the cul-de-sac. A blind duplicate sample was generated at this site designated to analytical laboratories as sample identification LEO-28-100112. A stainless steel scoop was used to collect the sample. Sample collection was completed at 09:25.

4.2 LEO-2-100112 – 37.31036°N; 121.86524°W

The sample was collected from the vault of the last manhole at the western end of the cul-de-sac. The sediment collected was taken from the line entering the vault from an unknown source due west of the end of the street and not from the lines from the two catch basins sampled for LEO-1. A stainless steel scoop was used to collect the sample. Sample collection was completed at 09:50.

4.3 LEO-3-100112 – 37.31204°N; 121.86528°W

The sample was collected from sediment in the gutter at the western end of the cul-de-sac between Century Tow and the northern catch basin, and from sediment in the gutter and on the sidewalk between the northern and southern catch basins. A natural fiber whisk broom and a stainless steel scoop were used to collect the sample. Sample collection was completed at 10:20.

4.4 LEO-4-100112 – 37.31117°N; 121.86394°W

The sample was collected from the vault of the manhole in front of the Premiere Recycling gate. This manhole vault is where the original Leo Avenue sample was collected in 2000. A stainless steel scoop was used to collect the sample. Sample collection was completed at 11:10.

4.5 LEO-5-100112 – 37.31126°N; 121.86375°W

The sample was collected from the vault of the next manhole downstream (east) of LEO-4. A stainless steel scoop was used to collect the sample. Sample collection was completed at 11:35.

4.6 LEO-6-100112 – 37.31169°N; 121.86336°W

The sample was collected from driveway cracks and in the gutter between the driveway at the northwest corner of Leo Avenue and 7th Street to the west end of the driveway just east of American Imports. A natural fiber whisk broom and a stainless steel scoop were used to collect the sample. Sample collection was completed at 13:10.

4.7 LEO-7-100112 – 37.31088°N; 121.86436°W

The sample was collected from the vault of the manhole across the street from T&L Autoservices. The owner/manager of nearby Premiere Recycling came out and talked with Nick Zigler, Eric Dunleavy, and Jonathan Toal while sampling was being performed. A stainless steel scoop was used to collect the sample. Sample collection was completed at 13:45.

4.8 LEO-8-100112 – 37.31088°N; 121.86436°W

The sample was collected from sediment from both the east and west driveways/sidewalks of SafeTrans Transportation (505 Burke Street). All sediment sampled was collected prior to where it would reach the street gutter. A natural fiber whisk broom and a stainless steel scoop were used to collect the sample. Sample collection was completed at 14:30.

4.9 LEO-9-100112 – 37.30963°N; 121.85363°W

The sample was collected from the vault of the manhole between the two driveways of 505 Burke Street. A stainless steel scoop was used to collect the sample. Sample collection was completed at 15:00.

4.10 LEO-10-100112 – 37.30619°N; 121.85678°W

The sample was collected near an old railroad right of way where sediment would discharge to a small catch basin near 2070-G South 7th Street. A natural fiber whisk broom and a stainless steel scoop were used to collect the sample. Sample collection was completed at 15:40.

2 October 2012

4.11 LEO-11-100212 – 37.31731°N; 121.86239°W

The sample was collected by compositing sediment from two catch basins at the City of San Jose Central Service Yard (1661 Senter Street). Sediment was collected from inside one catch basin (approximately 40% of the sample) and from sediment accumulated around a sand bagged catch basin (approximately 60% of the sample). A blind duplicate sample was generated at this site designated to analytical laboratories as sample identification LEO-27-100212. A stainless steel scoop was used to collect the sample. Sample collection was completed at 09:23.

4.12 LEO-12-100212 – 37.31701°N; 121.86031°W

The sample was collected by sweeping the driveway just east of 506 Phelan on the south side of the road. A natural fiber whisk broom and a stainless steel scoop were used to collect the sample. Sample collection was completed at 10:25.

4.13 LEO-13-100212 – 37.31490°N; 121.86144°W

The sample was collected by sweeping the driveway in front of Greer Autowreckers at 1750 S. 7th Street. A natural fiber whisk broom and a stainless steel scoop were used to collect the sample. Sample collection was completed at 11:00.

4.14 LEO-14-100212 – 37.31456°N; 121.86135°W

The sample was collected from the vault of the manhole in front of Pacific Auto Parts at 1777 S. 10th Street. A stainless steel scoop was used to collect the sample. Sample collection was completed at 11:30.

4.15 LEO-15-100212 – 37.31766°N; 121.86376°W

The sample was collected by sweeping where sediment had drifted west off an old railroad right of way onto the public sidewalk. This location is just south of the gun club at 1580 S. 10th Street. A natural fiber whisk broom and a stainless steel scoop were used to collect the sample. Sample collection was completed at 12:05.

4.16 LEO-16-100212 – 37.31572°N; 121.86652°W

The sample was collected along the edge of the road where sediment is suspected to have migrated from a nearby old railroad right of way. The owner (Randy) of the property just north of the sampling site stated that he is leasing with an option to buy the old railroad right of way. He stated that he thought a lot of the sediment was blown from across the street (western to eastern side of the road) from the Valley Recycling facility. He seemed very proactive in cleaning up the area and wanted to clean up storm water flow off of the properties. He told us to come talk to him if we needed any help. A stainless steel scoop was used to collect the sample. Sample collection was completed at 13:45.

4.17 LEO-17-100212 – 37.31272°N; 121.86199°W

The sample was collected from the vault of the manhole in front of Straight Line Steering at 1802 Smith Avenue. A stainless steel scoop was used to collect the sample. Sample collection was completed at 14:15.

4.18 LEO-18-100212 – 37.31407°N; 121.86319°W

The sample was collected from the vault of the manhole in front of European Specialty Auto Dismantler at 1731 Smith Avenue. A stainless steel scoop was used to collect the sample. Sample collection was completed at 14:40.

4.19 LEO-19-100212 – 37.31429°N; 121.86341°W

The sample was collected from the vault of the manhole just north of 3M United Auto Parts. A stainless steel scoop was used to collect the sample. Sample collection was completed at 15:10.

APPENDIX B.5.A

Street Sweeping Baseline Level of Implementation and Estimated Load Reductions by Individual Municipality

Table B.5.A.1. Summary of Baseline Level of Implementation for Municipal Street Sweeping

Municipalities	Volume of Material Removed (CY)	Curb Miles Swept	Rate Volume of Material Removed per Curb Mile Swept
Fairfield (FY 93-94 through 01-02)	52,498	193,701	0
Suisun City (FY 93-94 through 01-02)	16,260	42,284	0
San Mateo County Municipalities			
Atherton	--	--	--
Belmont (FY 00-01 through 01-02)	524	11,239	0
Brisbane (FY 01-02)	194	1,537	0
Burlingame (FY 00-01 through 01-02)	7,873	30,597	0
Colma (FY 00-01 through 01-02)	264	701	0
Daly City (FY 00-01 through 01-02)	4,263	39,396	0
East Palo Alto (FY 00-01 through 01-02)	1,123	8,249	0
Foster City (FY 00-01 through 01-02)	1,890	8,180	0
Half Moon Bay (FY 00-01 through 01-02)	650	1,530	0
Hillsborough	--	--	--
Menlo Park (FY 00-01 through 01-02)	5,371	10,189	1
Millbrae (FY 00-01 through 01-02)	2,410	12,406	0
Pacifica (FY 00-01 through 01-02)	3,019	15,771	0
Portola valley (FY 00-01 through 01-02)	316	367	1
Redwood City (FY 00-01 through 01-02)	11,329	31,432	0
San Bruno (FY 00-01 through 01-02)	2,873	5,468	1
San Carlos (FY 00-01 through 01-02)	1,436	11,630	0
San Mateo (FY 00-01 through 01-02)	6,511	33,195	0
San Mateo County (Unicorporated) (FY 00-01 through 01-02)	8,195	22,223	0
South San Francisco (FY 00-01 through 01-02)	5,121	19,714	0
Woodside (FY 00-01 through 01-02)	158	215	1
Santa Clara County Municipalities			
Cupertino	Data Collection Started in 2004		
Los Altos	Data Collection Started in 2004		
Los Altos Hills	Data Collection Started in 2004		
Milpitas	Data Collection Started in 2004		
Mountain View	Data Collection Started in 2004		
Palo Alto	Data Collection Started in 2004		
San Jose	Data Collection Started in 2004		
Santa Clara	Data Collection Started in 2004		
Sunnyvale	Data Collection Started in 2004		
Campbell	Data Collection Started in 2004		

Municipalities	Volume of Material Removed (CY)	Curb Miles Swept	Rate Volume of Material Removed per Curb Mile Swept
Los Gatos	Data Collection Started in 2004		
Monte Sereno	Data Collection Started in 2004		
Saratoga	Data Collection Started in 2004		
Santa Clara County(Unincorporated)	Data Collection Started in 2004		
Alameda County Municipalities			
Alameda County (Unincorporated) (FY 92-93 through 94-95)	7,107	39,239	0
Alameda (FY 92-93 through 96-97)	31,076	76,234	0
Albany (FY 92-93)	74	478	0
Berkeley (FY 92-93 through 96-97)	37,211	130,793	0
Dublin (FY 92-93 through 94-95)	1,021	11,859	0
Emeryville (FY 92-93 through 95-96)	417	2,658	0
Fremont (FY 92-93, 94-95 through 96-97)	31,762	59,707	1
Hayward (FY 92-93 through 96-97)	50,405	179,196	0
Livermore (1992-1994,1995-1997)	10,311	26,246	0
Newark (FY 92-93 through 96-97)	12,618	21,503	1
Oakland (FY 92-93 through 96-97)	155,459	490,518	0
Piedmont	--	--	--
Pleasanton (FY 92-93 through 95-96)	3,276	38,904	0
San Leandro (FY 92-93 through 96-97)	28,913	56,315	1
Union City (FY 92-93 through-93-94, 96-97)	4,578	27,421	0
Contra Costa Municipality			
Antioch (FY 94-95 through 01-02)	14,961	67,134	0
Brentwood (FY 98-99 through 01-02)	16,808	182,160	0
Clayton (FY 94-95 through 01-02)	828	5,202	0
Concord (FY 94-95 through 01-02)	38,424	119,415	0
County (FY 94-95 through 01-02)	11,156	7,825	1
Danville (FY 94-95 through 01-02)	11,773	31,912	0
El Cerrito (FY 94-95 through 01-02)	2,757	5,932	0
Hercules (FY 94-95 through 01-02)	1,783	2,704	1
Lafayette (FY 94-95 through 01-02)	4,300	8,120	1
Martinez (FY 94-95 through 01-02)	11,640	21,794	1
Moraga (FY 94-95 through 01-02)	631	208	3
Oakley (FY 01-02)	1,072	113	9
Orinda (FY 94-95 through 01-02)	708	3,242	0
Pinole (FY 94-95 through 01-02)	3,753	13,432	0
Pittsburg (FY 94-95 through 98-99, 00-01, 01-02)	13,649	64,905	0
Pleasant Hill (FY 94-95 through 01-02)	7,261	34,362	0

Municipalities	Volume of Material Removed (CY)	Curb Miles Swept	Rate Volume of Material Removed per Curb Mile Swept
Richmond (FY 94-95 through 01-02)	19,736	96,880	0
San Pablo (FY 94-95 through 01-02)	5,760	19,588	0
San Ramon (FY 94-95 through 01-02)	19,244	63,864	0
Walnut Creek (FY 94-95 through 01-02)	19,412	61,395	0

Table B.5.A.2. Summary of Current Level of Implementation for Municipal Street Sweeping

Municipalities	Volume of Material Removed (CY)	Curb Miles Swept	Rate (Volume of Material Removed per Curb Mile Swept)
Fairfield (FY 02-03 through 08-09)	42,558	186,616	0.23
Suisun City (FY 02-03 through 08-09)	11,870	40,043	0.30
San Mateo County Municipalities			
Atherton (FY 03-04 through 08-09)	813	3,532	0.23
Belmont (FY 02-03 through 08-09)	7,157	42,438	0.17
Brisbane (FY 02-03 through 08-09)	1,011	6,070	0.17
Burlingame (FY 02-03 through 08-09)	26,406	104,874	0.25
Colma (FY 02-03 through 08-09)	1,037	1,726	0.60
Daly City (FY 02-03 through 08-09)	15,917	145,759	0.11
East Palo Alto (FY 03-04 through 08-09)	10,017	52,914	0.19
Foster City (FY 02-03 through 08-09)	2,342	25,310	0.09
Half Moon Bay (FY 02-03 through 08-09)	2,363	9,989	0.24
Hillsborough	--	--	--
Menlo Park (FY 02-03 through 08-09)	22,528	33,761	0.67
Millbrae (FY 02-03 through 08-09)	6,708	38,549	0.17
Pacifica (FY 02-03 through 08-09)	8,917	62,650	0.14
Portola Valley(FY 02-03 through 08-09)	2,611	7,808	0.33
Redwood City (FY 02-03 through 08-09)	17,441	57,125	0.31
San Bruno (FY 02-03 through 08-09)	11,597	30,131	0.38
San Carlos (FY 02-03 through 08-09)	5,469	41,089	0.13
San Mateo (FY 02-03 through 08-09)	20,218	125,483	0.16
San Mateo County (Unicorporated) (FY 02-03 through 08-09)	24,649	98,910	0.25
South San Francisco (FY 02-03 through 08-09)	20,767	128,521	0.16
Woodside (FY 03-04 through 06-07)	264	1,056	0.25
Santa Clara County Municipalities			

Municipalities	Volume of Material Removed (CY)	Curb Miles Swept	Rate (Volume of Material Removed per Curb Mile Swept)
Cupertino (FY 04-05 through 09-10)	15,113	51,387	0.29
Los Altos (FY 04-05 through 09-10)	7,777	35,069	0.22
Los Altos Hills (FY 06-07 through 09-10)	747	4,535	0.16
Milpitas (FY 04-05 through 09-10)	35,550	73,608	0.48
Mountain View (FY 04-05 through 09-10)	32,979	61,690	0.53
Palo Alto (FY 04-05 through 09-10)	88,282	130,895	0.67
San Jose (FY 04-05 through 09-10)	172,009	373,043	0.46
Santa Clara (FY 04-05 through 09-10)	44,830	171,379	0.26
Sunnyvale (FY 04-05 through 09-10)	48,801	88,608	0.55
Campbell (FY 04-05 through 09-10)	11,120	37,405	0.30
Los Gatos (FY 04-05 through 09-10)	20,370	60,777	0.34
Monte Sereno (FY 04-05 through 09-10)	603	1,407	0.43
Saratoga (FY 04-05 through 09-10)	4,614	19,864	0.23
Santa Clara County (Unincorporated) (FY 04-05 through 09-10)	19,994	70,005	0.29
Alameda County Municipalities			
Alameda County (Unincorporated)	Data Collection Ended in 1997		
Alameda	Data Collection Ended in 1997		
Albany	Data Collection Ended in 1997		
Berkeley	Data Collection Ended in 1997		
Dublin	Data Collection Ended in 1997		
Emeryville	Data Collection Ended in 1997		
Fremont	Data Collection Ended in 1997		
Hayward	Data Collection Ended in 1997		
Livermore	Data Collection Ended in 1997		
Newark	Data Collection Ended in 1997		
Oakland	Data Collection Ended in 1997		
Piedmont	Data Collection Ended in 1997		
Pleasanton	Data Collection Ended in 1997		
San Leandro	Data Collection Ended in 1997		
Union City	Data Collection Ended in 1997		
Contra Costa County Municipalities			
Antioch (FY 02-03 through 08-09)	18,151	75,754	0.24
Brentwood (FY 02-03 through 09-10)	18,176	123,233	0.15
Clayton (FY 02-03 through 09-10)	2,320	12,712	0.18
Concord (FY 02-03 through 08-09)	55,824	146,599	0.38
Contra Costa County (Unincorporated) (FY 02-03 through 08-09)	13,826	3,078	4.49
Danville (FY 02-03 through 09-10)	16,524	37,371	0.44

Municipalities	Volume of Material Removed (CY)	Curb Miles Swept	Rate (Volume of Material Removed per Curb Mile Swept)
El Cerrito (FY 02-03 through 08-09)	6,965	12,516	0.56
Hercules (FY 02-03 through 08-09)	2,213	8,176	0.27
Lafayette (FY 02-03 through 08-09)	6,980	14,672	0.48
Martinez (FY 02-03 through 08-09)	11,090	3,905	2.84
Moraga (FY 02-03 through 08-09)	1,748	6,321	0.28
Oakley (FY 02-03 through 08-09)	3,574	4,982	0.72
Orinda (FY 02-03 through 08-09)	2,694	5,846	0.46
Pinole (FY 02-03 through 08-09)	3,049	4,848	0.63
Pittsburg (FY 02-03 through 09-10)	15,480	86,666	0.18
Pleasant Hill (FY 02-03 through 08-09)	11,625	29,670	0.39
Richmond (FY 02-03 through 08-09)	12,019	105,277	0.11
San Pablo (FY 02-03 through 08-09)	6,120	20,142	0.30
San Ramon (FY 02-03 through 08-09)	16,635	88,036	0.19
Walnut Creek (FY 02-03 through 09-10)	14,143	90,535	0.16

Table B.5.A.3. Estimated PCB and Mercury Loads Reduced for Baseline and Current Municipal Street Sweeping

Municipalities	Total Baseline PCB Load Reduced (g)	Total Current PCB Load Reduced (g)	Total Baseline Mercury Load Reduced (g)	Total Current Mercury Load Reduced (g)	Annual Baseline PCB Load Reduced (g)	Annual Current PCB Load Reduced (g)	Annual Baseline Mercury Load Reduced (g)	Annual Current Mercury Load Reduced (g)
Fairfield	4,269	3,461	5,930	4,807	474	494	659	687
Suisun City	1,322	965	1,837	1,341	147	138	204	192
Atherton	NA	66	NA	92	NA	11	NA	15
Belmont	43	582	59	808	21	83	30	115
Brisbane	3	14	10	50	3	2	10	8
Burlingame	640	2,147	889	2,983	320	307	445	426
Colma	21	84	30	117	11	12	15	17
Daly City	347	1,294	481	1,798	173	185	241	257
East Palo Alto	15	136	25	226	8	23	13	38
Foster City	26	32	43	53	13	5	21	8
Half Moon Bay	9	32	32	117	4	5	16	17
Hillsborough	NA	23	NA	32	NA	23	NA	32
Menlo Park	437	1,832	607	2,545	218	262	303	364
Millbrae	33	91	120	333	16	13	60	48

Municipalities	Total Baseline PCB Load Reduced (g)	Total Current PCB Load Reduced (g)	Total Baseline Mercury Load Reduced (g)	Total Current Mercury Load Reduced (g)	Annual Baseline PCB Load Reduced (g)	Annual Current PCB Load Reduced (g)	Annual Baseline Mercury Load Reduced (g)	Annual Current Mercury Load Reduced (g)
Pacifica	41	121	150	443	20	17	75	63
Portola Valley	4	35	16	130	2	5	8	19
Redwood City	921	1,418	1,280	1,970	461	203	640	281
San Bruno	234	943	325	1,310	117	135	162	187
San Carlos	117	445	162	618	58	64	81	88
San Mateo	530	1,644	735	2,284	265	235	368	326
San Mateo County (unincorporated)	111	334	407	1,225	56	48	204	175
South San Francisco	416	1,689	578	2,346	208	241	289	335
Woodside	2	4	8	13	2	1	8	3
Cupertino	NA	205	NA	751	NA	34	NA	125
Los Altos	NA	105	NA	386	NA	18	NA	64
Los Altos Hills	NA	10	NA	37	NA	3	NA	9
Milpitas	NA	482	NA	1,767	NA	80	NA	294
Mountain View	NA	2,682	NA	3,725	NA	447	NA	621
Palo Alto	NA	7,179	NA	9,971	NA	1,197	NA	1,662
San Jose	NA	13,988	NA	19,428	NA	2,331	NA	3,238
Santa Clara	NA	3,646	NA	5,064	NA	608	NA	844
Sunnyvale	NA	3,969	NA	5,512	NA	661	NA	919
Campbell	NA	151	NA	553	NA	25	NA	92
Los Gatos	NA	1,657	NA	2,301	NA	276	NA	383
Monte Sereno	NA	8	NA	30	NA	1	NA	5
Saratoga	NA	63	NA	229	NA	10	NA	38
Santa Clara County (Unincorporated)	NA	271	NA	994	NA	45	NA	166
Alameda County (Unincorporated)	96	NA	353	NA	32	NA	118	NA
Alameda	2,527	NA	3,510	NA	505	NA	702	NA
Albany	6	NA	8	NA	6	NA	8	NA
Berkeley	3,026	NA	4,203	NA	605	NA	841	NA
Dublin	14	NA	23	NA	5	NA	8	NA
Emeryville	34	NA	47	NA	8	NA	12	NA
Fremont	430	NA	1,578	NA	143	NA	526	NA
Hayward	4,099	NA	5,693	NA	820	NA	1,139	NA
Livermore	140	NA	233	NA	35	NA	58	NA
Newark	171	NA	627	NA	34	NA	125	NA
Oakland	12,642	NA	17,559	NA	2,528	NA	3,512	NA
Piedmont	NA	NA	NA	NA	NA	NA	NA	NA

Municipalities	Total Baseline PCB Load Reduced (g)	Total Current PCB Load Reduced (g)	Total Baseline Mercury Load Reduced (g)	Total Current Mercury Load Reduced (g)	Annual Baseline PCB Load Reduced (g)	Annual Current PCB Load Reduced (g)	Annual Baseline Mercury Load Reduced (g)	Annual Current Mercury Load Reduced (g)
Pleasanton	266	NA	370	NA	67	NA	93	NA
San Leandro	2,351	NA	3,266	NA	470	NA	653	NA
Union City	62	NA	228	NA	21	NA	76	NA
Antioch	635	771	635	771	79	128	79	128
Brentwood	228	246	380	411	57	35	95	59
Clayton	11	31	19	52	2	5	3	9
Concord	521	757	1,910	2,774	74	108	273	396
Contra Costa County (Unincorporated)	151	187	554	687	19	31	69	115
Danville	160	224	266	373	20	32	33	53
El Cerrito	224	566	311	787	32	94	44	131
Hercules	145	180	201	250	18	26	25	36
Lafayette	58	95	97	158	8	16	14	26
Martinez	947	902	1,315	1,253	118	129	164	179
Moraga	9	24	14	39	1	3	2	6
Oakley	46	152	46	152	23	25	23	25
Orinda	10	37	35	134	1	5	4	19
Pinole	51	41	187	152	6	6	23	22
Pittsburg	1,110	1,259	1,542	1,748	139	180	193	250
Pleasant Hill	98	158	361	578	14	23	52	83
Richmond	1,605	977	2,229	1,358	201	163	279	226
San Pablo	78	83	286	304	10	14	36	51
San Ramon	261	225	435	376	33	32	54	54
Walnut Creek	263	192	965	703	33	27	121	100

APPENDIX B.5.B

A Summary of Documented Changes in Municipal Street Sweeping Practices in the North Richmond Pump Station Watershed and Santa Fe Channel Drainages

Appendix B.5.B
Estimation of PCB Loads Avoided / Reduced as a Result of New Street Sweeping Areas in Richmond and North Richmond

As part of MRP implementation, the City of Richmond and unincorporated Contra Costa County made specific changes to their street sweeping programs that have quantifiable benefits for additional PCB loads prevented from entering the MS4 system. There are two examples that can help extrapolate the benefits of enhanced municipal O&M for PCB load reductions: a curb and gutter improvement project in the North Richmond Stormwater Pump Station (NRSPS) watershed, and initiation of high efficiency street sweeping adjacent to a potential source area in the Santa Fe Channel watershed.

The two projects serve as useful bookends for the range of watershed PCB load management scenarios that may be encountered in the rest of Contra Costa County. The NRSPS watershed is an example of a moderately contaminated older industrialized watershed. PCB concentrations in suspended sediments monitored in stormwater at the NRSPS are approximately 220 µg/kg. The watershed as a whole discharged approximately 10 grams of PCBs during the wet season periods monitored in September 2010 – January 2012 (Hunt et al., 2012). For the 2.0 km^2 drainage area, the monitored loads correspond to a production rate of 4.6 $\mu g/m^2/yr$. For context, 4.6 $\mu g/m^2/yr$ is in the upper range of PCB yields for more typical urban Bay Area watersheds, but is below the maximum value of 82 $\mu g/m^2/yr$ noted in the highly contaminated Ettie Street Pump station watershed.

In contrast to the NRSPS, the Santa Fe Channel appears to discharge sediments having approximately 1,000 – 1,400 µg/kg PCBs, about three-fold to five-fold higher than PCB concentrations in sediments discharged from the NRSPS. The sediment production rate of the Santa Fe Channel watershed is unknown at present; however, if the PCB yield in the Santa Fe channel is comparable to that of the Ettie Street watershed (i.e., about 80 $\mu g/m^2/yr$), then the annual PCB load from the Santa Fe Channel watershed would be approximately 260 g per year, as compared to approximately 10 g per year from the 2.0 km^2 NRSPS watershed.

A key question to be addressed for future MRP implementation is whether the majority of required PCB load reduction can be achieved in just a few, highly contaminated watersheds such as Ettie Street or the NRSPS, or whether the majority of load reductions required would have to be spread out over many more moderately contaminated watersheds, such as NRSPS. At present, it does not appear that there are many more “low hanging fruit” examples like the Santa Fe Channel or Ettie Street watersheds; however, that will need to be verified through future reconnaissance monitoring. In the meantime, lessons learned about how enhanced street sweeping translates to load reductions in the NRSPS and Santa Fe Channel helps set expectations for the degree to which enhanced street sweeping can result in aggregate PCB load reductions when applied to other areas of Contra Costa County.

In the summer of 2012, a project was completed to improve the sidewalk, curb and gutter along a section of Market Avenue between 7th street and the Union Pacific Railroad line in the NRSPS watershed (Figure 1). Approximately 300 feet of sidewalk, curb and gutter was installed on the north side of Market Avenue in the Project area where there was formerly soft shoulder. The condition of the north side of Market Avenue before project completion is visible from Google Earth Street View (Figure 2).

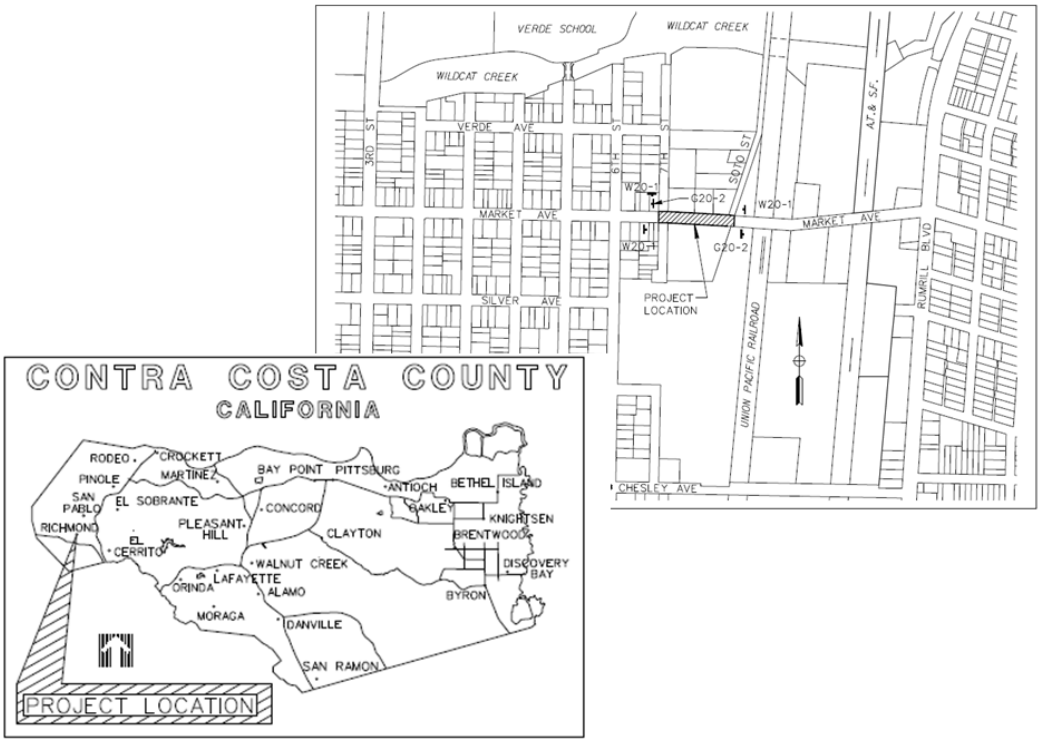

Figure 1. Location of Sidewalk, Curb, and Gutter Improvement Project in the NRSPS Watershed.

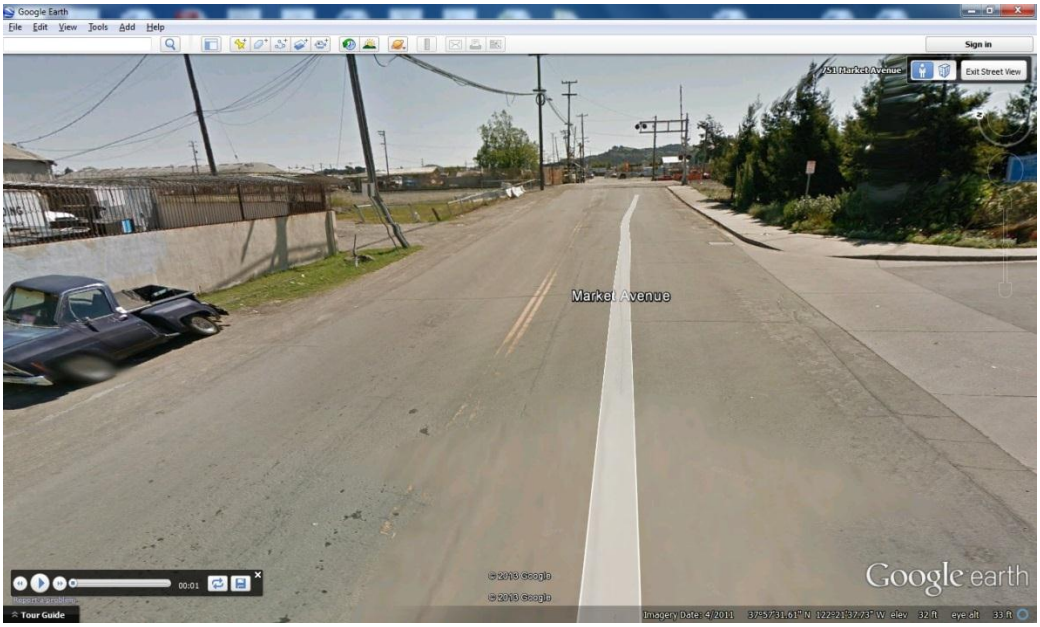

Figure 2. Condition Prior to Improvement of Sidewalk Curb and Gutter Along the North Side of Market Avenue (left side of photo).

Figure 3. Condition After Improvement of Sidewalk Curb and Gutter Along the North Side of Market Avenue (left side of photo).

The condition of Market Avenue following completion of the improvement was photographed in the summer of 2012 (Figure 3). The photograph shown in Figure 3 was taken prior to commencement of street sweeping activities in the project area, which was not previously done because of the soft shoulder. The accumulated sediment in the gutter helps provide an estimate of the sediment and PCB loads avoided as a result of new street sweeping activity in the improved area.

The improved section is approximately 300 linear feet. The accumulated sediment shown in in the photograph in Figure 3 is approximately six inches wide and one inch deep – corresponding to approximately 12.5 cubic feet of sediment, or 938 kg sediment assuming a density of 2.65 g/ml. If the PCB concentration in gutter sediments ranges from 100 to 300 µg/kg, then the PCB mass found in the accumulated sediment shown in Figure 3 would be approximately 0.1 to 0.3 grams. The sediment build-up and track out dynamics of this area are unknown, so the replenishment rate of this 0.1 to 0.3 grams is unknown. For simplicity, it can be assumed that this 12.5 cubic feet of sediment represents the minimum total annual accumulation and wash-off, and that the total could be as much as two or three times greater. In effect, the act of improving sidewalk, curb and gutter along a single city block in North Richmond represents a PCB load reduction of 0.1 gram to as much as 1 gram of PCBs per year as a result of new street sweeping in the improved area.

The proximity of the improved area to bare dirt along rail lines and adjacent dirt lots near Market Avenue suggests that those areas may be the source of sediments. The assumption that sediments from railroad right of ways could be between 100 and 300 µg/kg is reasonable, based on previous assessments in other watersheds (i.e., EOA Inc., 2007). The actual concentration of PCBs in street sediments near the Market Avenue sidewalk improvement will be verified in conjunction with other pilot project monitoring activities conducted in the 2013 – 2014 storm season.

Figure 4. Railroad Right of Way Bisecting Market Avenue and Adjacent Dirt Lots are Suspected Sediment Sources to City Streets

In the Santa Fe Channel, during MRP-required investigations of potential PCB source areas located on private property, sediments were sampled along Hoffman Blvd. adjacent to one such suspect property (Figure 5). The sediment samples collected had approximately 1,400 µg/kg PCBs, consistent with the observed PCB/ suspended sediment ratios observed during the initial watershed reconnaissance of the Santa Fe Channel. On further investigation, it was discovered that the section of Hoffman Boulevard shown in Figure 5 was not on the City of Richmond's logs for regular street sweeping; the section is now being swept weekly as an arterial. The added section of roadway is approximately 1500 feet; the sediment shown in Figure 5 is approximately three inches wide and an inch deep. Therefore, commencement of street sweeping along Hoffman Boulevard would remove approximately 31 cubic feet of sediment, or 2,300 kg, which would otherwise have discharged to the MS4 system. At an estimated PCB concentration of 1,400 µg/kg, this corresponds to a PCB load avoided of approximately 3 grams as a result of adding approximately 1500 linear feet of new street sweeping. As with the NRSPS example, the replenishment rate of the sediments along Hoffman Blvd. is unknown, so the actual annual loads avoided may be substantially more than 3 grams per year.

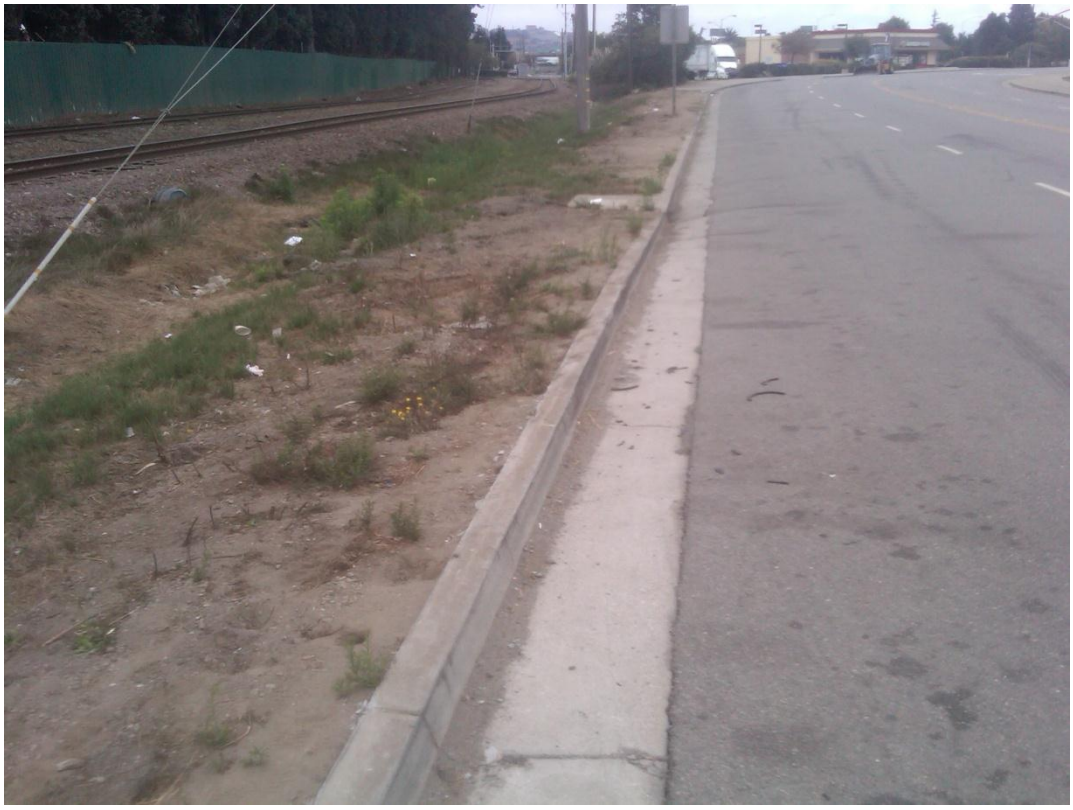

Figure 5. Accumulated Sediments in the Gutter Along Hoffman Blvd., adjacent to a Suspected PCB Source Area

The above estimates of loads avoided by documented changes in municipal street sweeping practices in the NRSPS and Santa Fe Channel drainages can be put into context by comparison with the previously described WinSLAM modeling results. As noted in Table 4-3 above, street sweeping 15 curb miles in the Leo Avenue watershed is modeled to result in an annual load reduction of 48 grams, or 3.2 grams per curb mile annually. Street sweeping in the Sunnyvale East / California Avenue area of 0.94 curb miles results in an annual load reduction of 0.7 grams per curb mile swept. For comparison, the Market Avenue improvement yields from 1.7 to 4.9 grams PCBs annually avoided / reduced per new curb mile swept. New street sweeping activity along a 0.3 mile section of Hoffman Blvd annually avoids at least 3.2 grams of PCBs, or approximately 12 grams PCB per curb mile swept annually.

These practical lessons learned, in combination with modeling results using WinSLAM, help begin to define “rule of thumb” measures of how addition of new street sweeping areas could result in PCB loads reduced. In moderately contaminated areas, such as the NRSPS, curb and gutter improvements would lead to 2 to 5 grams of PCBs reduced annually per curb mile improved, where improvements allow street sweeping in previously un-swept areas. New street sweeping in the less frequently encountered areas that are highly contaminated, such as the Santa Fe Channel drainage near the metal recycler, could yield as much as 10 to 12 grams PCBs annual reduced per curb mile swept. These estimates can help define expectations for the outcome of

watershed improvement and management activities in other areas where there may be opportunities to expand street sweeping through sidewalk, curb and gutter improvements.

APPENDIX B.6.A

Data Summaries for Reported Values and Ranking Method for Drain Inlet Cleaning

Table B.6.A.1. Summary of Reported Values for Baseline and Current, and Enhanced Level of Implementation for Drain Inlet Cleaning.

	Baseline				Current			
Municipality	**Total Number of Inlets**	**Total Number of Inlets Cleaned**	**Total Volume Removed (CY)**	**Average Volume Removed/ Inlet (CY/Inlet)**	**Total Number of Inlets**	**Total Number of Inlets Cleaned**	**Total Volume Removed (CY)**	**Average Volume Removed/Inlet (CY/Inlet)**
Solano County Municipalities								
Fairfield (FY 93-94 through 08-09)	4500	2223	15245.5	6.9	4500	12990	9393.5	0.7
Suisun (FY 93-94 through 08-09)	1500	2558.5	1598.5	0.6	1500	3613	9656.5	2.7
San Mateo County Municipalities								
Atherton (FY 00-01 through 08-09)	198	1628	311.3	0.2	198	2523	597.9	0.2
Belmont (FY 00-01 through 08-09)	1410	1045	372.8	0.4	1410	3918	1815.8	0.5
Brisbane (FY 00-01 through 08-09)	410	551	76.6	0.1	410	8444	1245.2	0.1
Burlingame (FY 00-01 through 08-09)	1100	2293	1222.5	0.5	1100	5738	4884.0	0.9
Colma (FY 00-01 through 08-09)	185	58	8.8	0.2	185	1201	126.8	0.1
Daly City (FY 00-01 through 08-09)	1850	426	298.5	0.7	1850	2267	2172.5	1.0
East Palo Alto (FY 00-01 through 03-04)	437	253	29.1	0.1	437	1466	133.8	0.1
Foster City (FY 00-01 through 08-09)	1275	229	85.5	0.4	1275	2770	399.8	0.1
Half Moon Bay (FY 00-01 through 08-09)	70	408	251.3	0.6	70	1262	249.3	0.2
Hillsborough (FY 00-01 through 08-09)	646	4339	1621.0	0.4	646	12760	2421.0	0.2

	Baseline				Current			
Municipality	**Total Number of Inlets**	**Total Number of Inlets Cleaned**	**Total Volume Removed (CY)**	**Average Volume Removed/ Inlet (CY/Inlet)**	**Total Number of Inlets**	**Total Number of Inlets Cleaned**	**Total Volume Removed (CY)**	**Average Volume Removed/Inlet (CY/Inlet)**
Menlo Park (FY 00-01 through 08-09)	704	487	123.5	0.3	704	1518	1102.4	0.7
Millbrae (FY 00-01 through 08-09)	623	2511	1036.0	0.4	623	11113	2445.8	0.2
Pacifica (FY 00-01 through 08-09)	986	1708	1058.0	0.6	986	11652	4598.0	0.4
Portola Valley (FY 00-01 through 08-09)	264	93	40.0	0.4	264	777	251.4	0.3
Redwood City (FY 00-01 through 08-09)	2685	4455	2143.7	0.5	2685	14676	7181.5	0.5
San Bruno (FY 00-01 through 08-09)	950	2069	243.5	0.1	950	5959	1436.9	0.2
San Carlos (FY 00-01 through 08-09)	701	807	252.3	0.3	701	8679	2733.3	0.3
San Mateo, City (FY 00-01 through 08-09)	5000	9740	424.0	0.0	5000	26812	1333.3	0.0
San Mateo, County (FY 00-01 through 08-09)	1500	5311	352.2	0.1	1500	15951	4695.2	0.3
So. San Francisco (FY 00-01 through 08-09)	1136	6199.5	373.0	0.1	1136	14242	1320.5	0.1
Woodside (FY 00-01 through 08-09)	350	171	314.5	1.8	350	2698	2354.1	0.9
Alameda County Municipalities								
Alameda County (unincorporated (FY 99-00 through 04-05)	3050	4430	31705.5	7.2	3050	1943	33449.6	17.2
Alameda (FY 96-97, 00-01 through 04-05)	2000	1085	434.0	0.4	2000	2705	350.8	0.1
Albany (FY 99-00 through 04-05)	5900	3868	113.3	0.0	5900	3915	224.5	0.1

	Baseline				Current			
Municipality	**Total Number of Inlets**	**Total Number of Inlets Cleaned**	**Total Volume Removed (CY)**	**Average Volume Removed/ Inlet (CY/Inlet)**	**Total Number of Inlets**	**Total Number of Inlets Cleaned**	**Total Volume Removed (CY)**	**Average Volume Removed/Inlet (CY/Inlet)**
Berkeley (FY 96-97, 99-00 through 04-05)	984	13528	1906.2	0.1	984	24030	860.7	0.0
Dublin (FY 96-97, 99-00 through 04-05)	225	2362	138.0	0.1	225	1335	385.6	0.3
Emeryville (FY 96-97, 99-00 through 04-05)	6000	2762	138.0	0.0	6000	3560	193.8	0.1
Fremont (FY 99-00 through 04-05)	3500	9738	1173.7	0.1	3500	10017	736.0	0.1
Hayward (FY 96-97, 99-00 through 04-05)	1823	10983	1075.6	0.1	1823	10976	1629.0	0.1
Livermore (FY 96-97, 99-00 through 04-05)	1249	6459	129.7	0.0	1249	3465	124.8	0.0
Newark (FY 96-97, 99-00 through 04-05)	9471	20410	398.2	0.0	9471	23672	275.8	0.0
Oakland (FY 96-97, 99-00 through 04-05)	150	24927	27472.0	1.1	150	24934	17777.0	0.7
Piedmont (FY 99-00 through 04-05)	4825	691	392.0	0.6	4825	1297	107.8	0.1
Pleasanton (FY 99-00 through 04-05)	2182	1592	1255.0	0.8	2182	1597	297.1	0.2
San Leandro (FY 96-97, 99-00 through 04-05)	3000	8560	204.5	0.0	3000	3181	6255.8	2.0
Union City (FY 96-97, 99-00)	1858	1141	188.0	0.2	1858	452	0.0	0.0
Zone 7 (FY 02-03 through 04-05)	No Data	No data	No data	No data	No data	329	18213.5	55.4
Contra Costa County Municipalities								
Antioch (FY 98-99 through 08-09)	6700	2487	475.6	0.2	6700	6950	963.5	0.1
Brentwood (FY 98-99 through 08-09)	4747	4845	1167.0	0.2	4747	25929	19036.0	0.7

	Baseline				Current			
Municipality	**Total Number of Inlets**	**Total Number of Inlets Cleaned**	**Total Volume Removed (CY)**	**Average Volume Removed/ Inlet (CY/Inlet)**	**Total Number of Inlets**	**Total Number of Inlets Cleaned**	**Total Volume Removed (CY)**	**Average Volume Removed/Inlet (CY/Inlet)**
Clayton (FY 94-95 through 97-98, 01-02 through 08-09)	650	4715	315.0	0.1	650	4550	295.0	0.1
Concord (FY 94-95 through 07-08)	5600	32785	2125.0	0.1	5600	47250	569.0	0.0
Contra Costa County (unincorporated) (FY 97-98 through 08-09)	8130	9464	10527.2	1.1	8130	63200	5123.0	0.1
Danville (FY 98-99 through 08-09)	4694	2566	1339.0	0.5	4694	6913	1285.0	0.2
El Cerrito (FY 98-99 through 08-09)	900	705	378.0	0.5	900	1479	467.0	0.3
Hercules (FY 94-95 through 08-09)	1800	1187	105.6	0.1	1800	2015	127.0	0.1
Lafayette (FY 98-99 through 08-09)	1496	4348	3100.3	0.7	1496	10507	3100.0	0.3
Martinez (FY 98-99 through 08-09)	1320	3945	840.0	0.2	1320	8786	525.0	0.1
Moraga (FY 98-99 through 07-08)	858	3412	17.0	0.0	858	6468	252.0	0.0
Oakley (FY 00-01 through 08-09)	2515	1308	384.7	0.3	2515	10644	140.8	0.0
Orinda (FY 98-99 through 08-09)	1040	550	338.0	0.6	1040	1940	575.1	0.3
Pinole (FY 94-95 through 08-09)	1789	4030	522.1	0.1	1789	10893	1408.5	0.1
Pittsburg (FY 96-97 through 08-09)	2009	7056	10075.0	1.4	2009	7202	3090.5	0.4
Pleasant Hill (FY 98-99 through 08-09)	1294	6024	21.8	0.0	1294	7337	64.3	0.0
Richmond (FY 95-96 through 08-09)	3950	17241	508.0	0.0	3950	18040	12356.3	0.7
San Pablo (FY 98-99 through 08-09)	326	1300	126.2	0.1	326	4599	170.4	0.0

	Baseline				Current			
Municipality	**Total Number of Inlets**	**Total Number of Inlets Cleaned**	**Total Volume Removed (CY)**	**Average Volume Removed/ Inlet (CY/Inlet)**	**Total Number of Inlets**	**Total Number of Inlets Cleaned**	**Total Volume Removed (CY)**	**Average Volume Removed/Inlet (CY/Inlet)**
San Ramon (FY 98-99 through 08-09)	2762	8491	124.8	0.0	2762	19138	428.6	0.0
Walnut Creek (FY 98-99 through 08-09)	3477	11254	690.0	0.1	3477	25860	87.0	0.0

Note: The information in this table is based on already compiled information reported by the Permittees in their Annual Reports.

Table B.6.A.2.Estimated Material Removed per Inlet Calculations for Baseline, Current, and Enhanced Conditions Using the Ranking Method

	Baseline		Current		Enhanced
Municipality	Volume Reduction Ranking	Volume of Material Removed per Inlet Inspected/ Cleaned Estimate (cy)	Volume Reduction Ranking	Volume of Material Removed per Inlet Inspected/ Cleaned Estimate (cy)	Δ Volume Removed/Inlet (Cubic Yards/Inlet)
Solano County Municipalities					
Fairfield (FY 93-94 through 08-09)	High	0.54	High	0.31	-0.22
Suisun (FY 93-94 through 08-09)	High	0.54	High	0.31	-0.22
San Mateo County Municipalities					
Atherton (FY 00-01 through 08-09)	Medium	0.20	Medium	0.11	-0.10
Belmont (FY 00-01 through 08-09)	Medium	0.20	High	0.31	0.11
Brisbane (FY 00-01 through 08-09)	Medium	0.20	Medium	0.11	-0.10
Burlingame (FY 00-01 through 08-09)	Medium	0.20	High	0.31	0.11
Colma (FY 00-01 through 08-09)	Medium	0.20	Medium	0.11	-0.10
Daly City (FY 00-01 through 08-09)	High	0.54	High	0.31	-0.22
East Palo Alto (FY 00-01 through 03-04)	Medium	0.20	Medium	0.11	-0.10
Foster City (FY 00-01 through 08-09)	Medium	0.20	Medium	0.11	-0.10
Half Moon Bay (FY 00-01 through 08-09)	High	0.54	Medium	0.11	-0.43
Hillsborough (FY 00-01 through 08-09)	Medium	0.20	Medium	0.11	-0.10

	Baseline		Current		Enhanced
Municipality	Volume Reduction Ranking	Volume of Material Removed per Inlet Inspected/ Cleaned Estimate (cy)	Volume Reduction Ranking	Volume of Material Removed per Inlet Inspected/ Cleaned Estimate (cy)	Δ Volume Removed/Inlet (Cubic Yards/Inlet)
Menlo Park (FY 00-01 through 08-09)	Medium	0.20	High	0.31	0.11
Millbrae (FY 00-01 through 08-09)	Medium	0.20	Medium	0.11	-0.10
Pacifica (FY 00-01 through 08-09)	High	0.54	High	0.31	-0.22
Portola Valley (FY 00-01 through 08-09)	Medium	0.20	High	0.31	0.11
Redwood City (FY 00-01 through 08-09)	Medium	0.20	High	0.31	0.11
San Bruno (FY 00-01 through 08-09)	Medium	0.20	Medium	0.11	-0.10
San Carlos (FY 00-01 through 08-09)	Medium	0.20	High	0.31	0.11
San Mateo, City (FY 00-01 through 08-09)	Low	0.07	Medium	0.11	0.04
San Mateo, County (FY 00-01 through 08-09)	Low	0.07	Medium	0.11	0.04
So. San Francisco (FY 00-01 through 08-09)	Low	0.07	Medium	0.11	0.04
Woodside (FY 00-01 through 08-09)	High	0.54	High	0.31	-0.22
Alameda County Municipalities					
Alameda County (unincorporated (FY 99-00 through 04-05)	High	0.54	High	0.31	-0.22
Alameda (FY 96-97, 00-01 through 04-05)	Medium	0.20	Medium	0.11	-0.10
Albany (FY 99-00 through 04-05)	Low	0.07	Medium	0.11	0.04

	Baseline		Current		Enhanced
Municipality	Volume Reduction Ranking	Volume of Material Removed per Inlet Inspected/ Cleaned Estimate (cy)	Volume Reduction Ranking	Volume of Material Removed per Inlet Inspected/ Cleaned Estimate (cy)	Δ Volume Removed/Inlet (Cubic Yards/Inlet)
Berkeley (FY 96-97, 99-00 through 04-05)	Medium	0.20	Low	0.04	-0.16
Dublin (FY 96-97, 99-00 through 04-05)	Low	0.07	Medium	0.11	0.04
Emeryville (FY 96-97, 99-00 through 04-05)	Low	0.07	Medium	0.11	0.04
Fremont (FY 99-00 through 04-05)	Medium	0.20	Medium	0.11	-0.10
Hayward (FY 96-97, 99-00 through 04-05)	Medium	0.20	Medium	0.11	-0.10
Livermore (FY 96-97, 99-00 through 04-05)	Low	0.07	Low	0.04	-0.03
Newark (FY 96-97, 99-00 through 04-05)	Low	0.07	Low	0.04	-0.03
Oakland (FY 96-97, 99-00 through 04-05)	High	0.54	High	0.31	-0.22
Piedmont (FY 99-00 through 04-05)	High	0.54	Medium	0.11	-0.43
Pleasanton (FY 99-00 through 04-05)	High	0.54	Medium	0.11	-0.43
San Leandro (FY 96-97, 99-00 through 04-05)	Low	0.07	High	0.31	0.24
Union City (FY 96-97, 99-00)	Medium	0.20	Low	0.04	-0.16
Zone 7 (FY 02-03 through 04-05)	0	0.00	High	0.31	0.31
Contra Costa County Municipalities					
Antioch (FY 98-99 through 08-09)	Medium	0.20	Medium	0.11	-0.10

	Baseline		Current		Enhanced
Municipality	Volume Reduction Ranking	Volume of Material Removed per Inlet Inspected/ Cleaned Estimate (cy)	Volume Reduction Ranking	Volume of Material Removed per Inlet Inspected/ Cleaned Estimate (cy)	Δ Volume Removed/Inlet (Cubic Yards/Inlet)
Brentwood (FY 98-99 through 08-09)	Medium	0.20	High	0.31	0.11
Clayton (FY 94-95 through 97-98, 01-02 through 08-09)	Medium	0.20	Medium	0.11	-0.10
Concord (FY 94-95 through 07-08)	Low	0.07	Low	0.04	-0.03
Contra Costa County (unincorporated) (FY 97-98 through 08-09)	High	0.54	Medium	0.11	-0.43
Danville (FY 98-99 through 08-09)	Medium	0.20	Medium	0.11	-0.10
El Cerrito (FY 98-99 through 08-09)	High	0.54	High	0.31	-0.22
Hercules (FY 94-95 through 08-09)	Medium	0.20	Medium	0.11	-0.10
Lafayette (FY 98-99 through 08-09)	High	0.54	Medium	0.11	-0.43
Martinez (FY 98-99 through 08-09)	Medium	0.20	Medium	0.11	-0.10
Moraga (FY 98-99 through 07-08)	Low	0.07	Medium	0.11	0.04
Oakley (FY 00-01 through 08-09)	Medium	0.20	Low	0.04	-0.16
Orinda (FY 98-99 through 08-09)	High	0.54	Medium	0.11	-0.43
Pinole (FY 94-95 through 08-09)	Medium	0.20	Medium	0.11	-0.10
Pittsburg (FY 96-97 through 08-09)	High	0.54	High	0.31	-0.22
Pleasant Hill (FY 98-99 through 08-09)	Low	0.07	Low	0.04	-0.03

	Baseline		Current		Enhanced
Municipality	Volume Reduction Ranking	Volume of Material Removed per Inlet Inspected/ Cleaned Estimate (cy)	Volume Reduction Ranking	Volume of Material Removed per Inlet Inspected/ Cleaned Estimate (cy)	Δ Volume Removed/Inlet (Cubic Yards/Inlet)
Richmond (FY 95-96 through 08-09)	Low	0.07	High	0.31	0.24
San Pablo (FY 98-99 through 08-09)	Medium	0.20	Low	0.04	-0.16
San Ramon (FY 98-99 through 08-09)	Low	0.07	Low	0.04	-0.03
Walnut Creek (FY 98-99 through 08-09)	Low	0.07	Low	0.04	-0.03

Note: For the basis for the categories "low", "medium" and "high" values, see Section B.6.3. "High" removal rates were considered to be the 75th percentile rate and above; "medium" rates were between the 25th and 75th percentile; and "low" removal rates were values less than the 25th percentile.

Table B.6.A.3. Estimated Baseline, Current and Enhanced Load Reductions from Drain Inlet Cleaning Using Reported Values

Municipality	Average Annual Baseline PCB Load Reduced [g]	Average Annual Current PCB Load Reduced [g]	Average Annual Enhanced PCB Load Reduced [g]	[Average Annual Baseline Mercury Load Reduced [g]	Average Annual Current Mercury Load Reduced [g]	Average Annual Enhanced Mercury Load Reduced [g]
Solano County Municipalities						
Fairfield (FY 93-94 through 08-09)	204.1	161.7	-42.4	426.2	337.6	-88.6
Suisun (FY 93-94 through 08-09)	21.4	166.2	144.8	44.7	347.1	302.4
San Mateo County Municipalities						
Atherton (FY 00-01 through 08-09)	24.4	13.4	-11.0	12.3	6.7	-5.6
Belmont (FY 00-01 through 08-09)	29.2	40.6	11.4	14.7	20.5	5.8
Brisbane (FY 00-01 through 08-09)	6.0	27.9	21.9	3.0	14.1	11.0
Burlingame (FY 00-01 through 08-09)	95.7	109.3	13.5	48.3	55.1	6.8
Colma (FY 00-01 through 08-09)	0.7	2.8	2.2	0.3	1.4	1.1
Daly City (FY 00-01 through 08-09)	23.4	48.6	25.2	11.8	24.5	12.7
East Palo Alto (FY 00-01 through 03-04)	2.3	3.0	0.7	1.1	1.5	0.4
Foster City (FY 00-01 through 08-09)	6.7	8.9	2.2	3.4	4.5	1.1

Municipality	Average Annual Baseline PCB Load Reduced [g]	Average Annual Current PCB Load Reduced [g]	Average Annual Enhanced PCB Load Reduced [g]	[Average Annual Baseline Mercury Load Reduced [g]	Average Annual Current Mercury Load Reduced [g]	Average Annual Enhanced Mercury Load Reduced [g]
Half Moon Bay (FY 00-01 through 08-09)	19.7	5.6	-14.1	9.9	2.8	-7.1
Hillsborough (FY 00-01 through 08-09)	126.9	54.2	-72.8	64.0	27.3	-36.7
Menlo Park (FY 00-01 through 08-09)	9.7	24.7	15.0	4.9	12.4	7.6
Millbrae (FY 00-01 through 08-09)	81.1	54.7	-26.4	40.9	27.6	-13.3
Pacifica (FY 00-01 through 08-09)	82.8	102.9	20.0	41.8	51.9	10.1
Portola Valley (FY 00-01 through 08-09)	3.1	5.6	2.5	1.6	2.8	1.3
Redwood City (FY 00-01 through 08-09)	167.9	160.7	-7.2	84.7	81.1	-3.6
San Bruno (FY 00-01 through 08-09)	19.1	32.1	13.1	9.6	16.2	6.6
San Carlos (FY 00-01 through 08-09)	16.6	51.4	34.8	10.4	32.1	21.7
San Mateo, City (FY 00-01 through 08-09)	33.2	29.8	-3.4	16.7	15.0	-1.7
San Mateo, County (FY 00-01 through 08-09)	27.6	105.0	77.5	13.9	53.0	39.1
So. San Francisco (FY 00-01 through 08-09)	29.2	29.5	0.3	14.7	14.9	0.2
Woodside (FY 00-01 through 08-09)	24.6	52.7	28.0	12.4	26.6	14.1
Alameda County Municipalities						

Municipality	Average Annual Baseline PCB Load Reduced [g]	Average Annual Current PCB Load Reduced [g]	Average Annual Enhanced PCB Load Reduced [g]	[Average Annual Baseline Mercury Load Reduced [g]	Average Annual Current Mercury Load Reduced [g]	Average Annual Enhanced Mercury Load Reduced [g]
Alameda County (unincorporated (FY 99-00 through 04-05)	1531.5	1615.8	84.2	1999.5	2109.5	110.0
Alameda (FY 96-97, 00-01 through 04-05)	15.7	16.9	1.2	20.5	22.1	1.6
Albany (FY 99-00 through 04-05)	4.1	10.8	6.7	5.4	14.2	8.8
Berkeley (FY 96-97, 99-00 through 04-05)	69.1	41.6	-27.5	80.6	48.5	-32.1
Dublin (FY 96-97, 99-00 through 04-05)	5.0	18.6	13.6	6.5	24.3	17.8
Emeryville (FY 96-97, 99-00 through 04-05)	5.0	9.4	4.4	6.5	12.2	5.7
Fremont (FY 99-00 through 04-05)	42.5	35.6	-7.0	55.5	46.4	-9.1
Hayward (FY 96-97, 99-00 through 04-05)	39.0	78.7	39.7	50.9	102.7	51.9
Livermore (FY 96-97, 99-00 through 04-05)	4.7	6.0	1.3	6.1	7.9	1.7
Newark (FY 96-97, 99-00 through 04-05)	14.4	13.3	-1.1	18.8	17.4	-1.4
Oakland (FY 96-97, 99-00 through 04-05)	1361.3	1174.5	-186.8	1822.8	1572.7	-250.1
Piedmont (FY 99-00 through 04-05)	14.2	5.2	-9.0	18.5	6.8	-11.7
Pleasanton (FY 99-00 through 04-05)	45.5	14.4	-31.1	59.4	18.7	-40.6

Municipality	Average Annual Baseline PCB Load Reduced [g]	Average Annual Current PCB Load Reduced [g]	Average Annual Enhanced PCB Load Reduced [g]	[Average Annual Baseline Mercury Load Reduced [g]	Average Annual Current Mercury Load Reduced [g]	Average Annual Enhanced Mercury Load Reduced [g]
San Leandro (FY 96-97, 99-00 through 04-05)	5.5	225.2	219.7	5.8	236.1	230.4
Union City (FY 96-97, 99-00)	6.8	0.0	-6.8	8.9	0.0	-8.9
Zone 7 (FY 02-03 through 04-05)	No data	879.8	--	No data	1.0	--
Contra Costa County Municipalities						
Antioch (FY 98-99 through 08-09)	30.2	35.0	4.8	24.2	28.0	3.8
Brentwood (FY 98-99 through 08-09)	74.1	690.7	616.6	59.4	553.9	494.5
Clayton (FY 94-95 through 97-98, 01-02 through 08-09)	13.3	10.7	-2.6	10.7	8.6	-2.1
Concord (FY 94-95 through 07-08)	67.5	24.1	-43.4	54.1	19.3	-34.8
Contra Costa County (unincorporated) (FY 97-98 through 08-09)	534.7	185.9	-348.9	428.8	149.1	-279.8
Danville (FY 98-99 through 08-09)	42.5	46.6	4.1	34.1	37.4	3.3
El Cerrito (FY 98-99 through 08-09)	24.0	16.9	-7.1	19.2	13.6	-5.7
Hercules (FY 94-95 through 08-09)	3.4	4.6	1.3	2.7	3.7	1.0
Lafayette (FY 98-99 through 08-09)	196.9	112.5	-84.4	157.9	90.2	-67.7

Municipality	Average Annual Baseline PCB Load Reduced [g]	Average Annual Current PCB Load Reduced [g]	Average Annual Enhanced PCB Load Reduced [g]	[Average Annual Baseline Mercury Load Reduced [g]	Average Annual Current Mercury Load Reduced [g]	Average Annual Enhanced Mercury Load Reduced [g]
Martinez (FY 98-99 through 08-09)	53.3	19.0	-34.3	42.8	15.3	-27.5
Moraga (FY 98-99 through 07-08)	1.1	10.7	9.6	0.9	8.6	7.7
Oakley (FY 00-01 through 08-09)	48.8	5.1	-43.7	39.2	4.1	-35.1
Orinda (FY 98-99 through 08-09)	28.6	20.9	-7.8	22.9	16.7	-6.2
Pinole (FY 94-95 through 08-09)	16.6	51.1	34.5	13.3	41.0	27.7
Pittsburg (FY 96-97 through 08-09)	852.9	261.6	-591.3	684.0	209.8	-474.2
Pleasant Hill (FY 98-99 through 08-09)	1.4	2.3	1.0	1.1	1.9	0.8
Richmond (FY 95-96 through 08-09)	26.3	746.6	720.3	16.5	466.9	450.4
San Pablo (FY 98-99 through 08-09)	10.7	6.2	-4.5	8.6	5.0	-3.6
San Ramon (FY 98-99 through 08-09)	7.9	15.6	7.6	6.4	12.5	6.1
Walnut Creek (FY 98-99 through 08-09)	43.8	4.4	-39.4	35.1	3.5	-31.6

Table B.6.A.4. Estimated Baseline, Current and Enhanced Load Reductions from Drain Inlet Cleaning Using the Ranking Method

Municipality	PCBs					Mercury				
	Baseline PCB Load Reduction Ranking	Average Annual Baseline PCB Load Reduction Estimate (g)	Current PCB Load Reduction Ranking	Average Annual Current PCB Load Reduction Estimate (g)	Average Annual Enhanced PCB Load Reduction Estimate (g)	Baseline Hg Load Reduction Ranking	Average Annual Baseline Hg Load Reduction Estimate (g)	Current Hg Load Reduction Ranking	Average Annual Current Hg Load Reduction Estimate (g)	Average Annual Enhanced Hg Load Reduction Estimate (g)
Solano County Municipalities										
Fairfield (FY 93-94 through 08-09)	High	52.2	High	72.7	20.5	High	47.4	High	51.0	3.7
Suisun (FY 93-94 through 08-09)	Medium	24.5	High	72.7	48.2	Medium	16.6	High	51.0	34.4
San Mateo County Municipalities										
Atherton (FY 00-01 through 08-09)	Medium	24.5	Medium	28.7	4.2	Medium	16.6	Low	8.6	-8.0
Belmont (FY 00-01 through 08-09)	Medium	24.5	Medium	28.7	4.2	Medium	16.6	Medium	19.0	2.4
Brisbane (FY 00-01 through 08-09)	Low	8.4	Medium	28.7	20.3	Low	7.0	Medium	19.0	12.0
Burlingame (FY 00-01 through 08-09)	High	52.2	High	72.7	20.5	High	47.4	High	51.0	3.7
Colma (FY 00-01 through 08-09)	Low	8.4	Low	10.7	2.3	Low	7.0	Low	8.6	1.5

Municipality	PCBs					Mercury				
	Baseline PCB Load Reduction Ranking	**Average Annual Baseline PCB Load Reduction Estimate (g)**	**Current PCB Load Reduction Ranking**	**Average Annual Current PCB Load Reduction Estimate (g)**	**Average Annual Enhanced PCB Load Reduction Estimate (g)**	**Baseline Hg Load Reduction Ranking**	**Average Annual Baseline Hg Load Reduction Estimate (g)**	**Current Hg Load Reduction Ranking**	**Average Annual Current Hg Load Reduction Estimate (g)**	**Average Annual Enhanced Hg Load Reduction Estimate (g)**
Daly City (FY 00-01 through 08-09)	Medium	24.5	Medium	28.7	4.2	Medium	16.6	Medium	19.0	2.4
East Palo Alto (FY 00-01 through 03-04)	Low	8.4	Low	10.7	2.3	Low	7.0	Low	8.6	1.5
Foster City (FY 00-01 through 08-09)	Low	8.4	Low	10.7	2.3	Low	7.0	Low	8.6	1.5
Half Moon Bay (FY 00-01 through 08-09)	Medium	24.5	Low	10.7	-13.8	Medium	16.6	Low	8.6	-8.0
Hillsborough (FY 00-01 through 08-09)	High	52.2	Medium	28.7	-23.5	High	47.4	Medium	19.0	-28.4
Menlo Park (FY 00-01 through 08-09)	Medium	24.5	Medium	28.7	4.2	Low	7.0	Medium	19.0	12.0
Millbrae (FY 00-01 through 08-09)	High	52.2	Medium	28.7	-23.5	Medium	16.6	Medium	19.0	2.4
Pacifica (FY 00-01 through 08-09)	High	52.2	High	72.7	20.5	Medium	16.6	High	51.0	34.4

Municipality	PCBs					Mercury				
	Baseline PCB Load Reduction Ranking	**Average Annual Baseline PCB Load Reduction Estimate (g)**	**Current PCB Load Reduction Ranking**	**Average Annual Current PCB Load Reduction Estimate (g)**	**Average Annual Enhanced PCB Load Reduction Estimate (g)**	**Baseline Hg Load Reduction Ranking**	**Average Annual Baseline Hg Load Reduction Estimate (g)**	**Current Hg Load Reduction Ranking**	**Average Annual Current Hg Load Reduction Estimate (g)**	**Average Annual Enhanced Hg Load Reduction Estimate (g)**
Portola Valley (FY 00-01 through 08-09)	Low	8.4	Low	10.7	2.3	Low	7.0	Low	8.6	1.5
Redwood City (FY 00-01 through 08-09)	High	52.2	High	72.7	20.5	High	47.4	High	51.0	3.7
San Bruno (FY 00-01 through 08-09)	Medium	24.5	Medium	28.7	4.2	Medium	16.6	Medium	19.0	2.4
San Carlos (FY 00-01 through 08-09)	Medium	24.5	Medium	28.7	4.2	Medium	16.6	Medium	19.0	2.4
San Mateo, City (FY 00-01 through 08-09)	Medium	24.5	Medium	28.7	4.2	Medium	16.6	Medium	19.0	2.4
San Mateo, County (FY 00-01 through 08-09)	Medium	24.5	High	72.7	48.2	Medium	16.6	High	51.0	34.4
So. San Francisco (FY 00-01 through 08-09)	Medium	24.5	Medium	28.7	4.2	Medium	16.6	Medium	19.0	2.4
Woodside (FY 00-01 through 08-09)	Medium	24.5	Medium	28.7	4.2	Medium	16.6	Medium	19.0	2.4
Alameda County Municipalities										

Municipality	PCBs					Mercury				
	Baseline PCB Load Reduction Ranking	**Average Annual Baseline PCB Load Reduction Estimate (g)**	**Current PCB Load Reduction Ranking**	**Average Annual Current PCB Load Reduction Estimate (g)**	**Average Annual Enhanced PCB Load Reduction Estimate (g)**	**Baseline Hg Load Reduction Ranking**	**Average Annual Baseline Hg Load Reduction Estimate (g)**	**Current Hg Load Reduction Ranking**	**Average Annual Current Hg Load Reduction Estimate (g)**	**Average Annual Enhanced Hg Load Reduction Estimate (g)**
Alameda County (unincorporated (FY 99-00 through 04-05)	High	52.2	High	72.7	20.5	High	47.4	High	51.0	3.7
Alameda (FY 96-97, 00-01 through 04-05)	Medium	24.5	Medium	28.7	4.2	Medium	16.6	Medium	19.0	2.4
Albany (FY 99-00 through 04-05)	Low	8.4	Medium	28.7	20.3	Low	7.0	Medium	19.0	12.0
Berkeley (FY 96-97, 99-00 through 04-05)	High	52.2	Medium	28.7	-23.5	High	47.4	Medium	19.0	-28.4
Dublin (FY 96-97, 99-00 through 04-05)	Low	8.4	Medium	28.7	20.3	Low	7.0	Medium	19.0	12.0
Emeryville (FY 96-97, 99-00 through 04-05)	Low	8.4	Low	10.7	2.3	Low	7.0	Medium	19.0	12.0
Fremont (FY 99-00 through 04-05)	Medium	24.5	Medium	28.7	4.2	High	47.4	Medium	19.0	-28.4
Hayward (FY 96-97, 99-00 through 04-05)	Medium	24.5	High	72.7	48.2	High	47.4	High	51.0	3.7

Municipality	PCBs					Mercury				
	Baseline PCB Load Reduction Ranking	**Average Annual Baseline PCB Load Reduction Estimate (g)**	**Current PCB Load Reduction Ranking**	**Average Annual Current PCB Load Reduction Estimate (g)**	**Average Annual Enhanced PCB Load Reduction Estimate (g)**	**Baseline Hg Load Reduction Ranking**	**Average Annual Baseline Hg Load Reduction Estimate (g)**	**Current Hg Load Reduction Ranking**	**Average Annual Current Hg Load Reduction Estimate (g)**	**Average Annual Enhanced Hg Load Reduction Estimate (g)**
Livermore (FY 96-97, 99-00 through 04-05)	Low	8.4	Low	10.7	2.3	Low	7.0	Low	8.6	1.5
Newark (FY 96-97, 99-00 through 04-05)	Medium	24.5	Medium	28.7	4.2	Medium	16.6	Medium	19.0	2.4
Oakland (FY 96-97, 99-00 through 04-05)	High	52.2	High	72.7	20.5	High	47.4	High	51.0	3.7
Piedmont (FY 99-00 through 04-05)	Medium	24.5	Low	10.7	-13.8	Medium	16.6	Low	8.6	-8.0
Pleasanton (FY 99-00 through 04-05)	Medium	24.5	Medium	28.7	4.2	High	47.4	Medium	19.0	-28.4
San Leandro (FY 96-97, 99-00 through 04-05)	Low	8.4	High	72.7	64.3	Low	7.0	High	51.0	44.0
Union City (FY 96-97, 99-00)	Low	8.4	Low	10.7	2.3	Medium	16.6	Low	8.6	-8.0
Zone 7 (FY 02-03 through 04-05)	No Data	0.0	High	72.7	72.7	No Data	0.0	Low	8.6	8.6
Contra Costa County Municipalities										

Municipality	PCBs					Mercury				
	Baseline PCB Load Reduction Ranking	Average Annual Baseline PCB Load Reduction Estimate (g)	Current PCB Load Reduction Ranking	Average Annual Current PCB Load Reduction Estimate (g)	Average Annual Enhanced PCB Load Reduction Estimate (g)	Baseline Hg Load Reduction Ranking	Average Annual Baseline Hg Load Reduction Estimate (g)	Current Hg Load Reduction Ranking	Average Annual Current Hg Load Reduction Estimate (g)	Average Annual Enhanced Hg Load Reduction Estimate (g)
Antioch (FY 98-99 through 08-09)	Medium	24.5	Medium	28.7	4.2	Medium	16.6	Medium	19.0	2.4
Brentwood (FY 98-99 through 08-09)	High	52.2	High	72.7	20.5	High	47.4	High	51.0	3.7
Clayton (FY 94-95 through 97-98, 01-02 through 08-09)	Medium	24.5	Medium	28.7	4.2	Medium	16.6	Medium	19.0	2.4
Concord (FY 94-95 through 07-08)	High	52.2	Medium	28.7	-23.5	High	47.4	Medium	19.0	-28.4
Contra Costa County (unincorporated) (FY 97-98 through 08-09)	High	52.2	High	72.7	20.5	High	47.4	High	51.0	3.7
Danville (FY 98-99 through 08-09)	Medium	24.5	Medium	28.7	4.2	Medium	16.6	Medium	19.0	2.4
El Cerrito (FY 98-99 through 08-09)	Medium	24.5	Medium	28.7	4.2	Medium	16.6	Medium	19.0	2.4
Hercules (FY 94-95 through 08-09)	Low	8.4	Low	10.7	2.3	Low	7.0	Low	8.6	1.5

Municipality	PCBs					Mercury				
	Baseline PCB Load Reduction Ranking	Average Annual Baseline PCB Load Reduction Estimate (g)	Current PCB Load Reduction Ranking	Average Annual Current PCB Load Reduction Estimate (g)	Average Annual Enhanced PCB Load Reduction Estimate (g)	Baseline Hg Load Reduction Ranking	Average Annual Baseline Hg Load Reduction Estimate (g)	Current Hg Load Reduction Ranking	Average Annual Current Hg Load Reduction Estimate (g)	Average Annual Enhanced Hg Load Reduction Estimate (g)
Lafayette (FY 98-99 through 08-09)	High	52.2	High	72.7	20.5	High	47.4	High	51.0	3.7
Martinez (FY 98-99 through 08-09)	High	52.2	Medium	28.7	-23.5	Medium	16.6	Medium	19.0	2.4
Moraga (FY 98-99 through 07-08)	Low	8.4	Low	10.7	2.3	Low	7.0	Low	8.6	1.5
Oakley (FY 00-01 through 08-09)	Medium	24.5	Low	10.7	-13.8	Medium	16.6	Low	8.6	-8.0
Orinda (FY 98-99 through 08-09)	Medium	24.5	Medium	28.7	4.2	Medium	16.6	Medium	19.0	2.4
Pinole (FY 94-95 through 08-09)	Medium	24.5	Medium	28.7	4.2	Medium	16.6	Medium	19.0	2.4
Pittsburg (FY 96-97 through 08-09)	High	52.2	High	72.7	20.5	High	47.4	High	51.0	3.7
Pleasant Hill (FY 98-99 through 08-09)	Low	8.4	Low	10.7	2.3	Low	7.0	Low	8.6	1.5
Richmond (FY 95-96 through 08-09)	Medium	24.5	High	72.7	48.2	Medium	16.6	High	51.0	34.4

Municipality	PCBs					Mercury				
	Baseline PCB Load Reduction Ranking	**Average Annual Baseline PCB Load Reduction Estimate (g)**	**Current PCB Load Reduction Ranking**	**Average Annual Current PCB Load Reduction Estimate (g)**	**Average Annual Enhanced PCB Load Reduction Estimate (g)**	**Baseline Hg Load Reduction Ranking**	**Average Annual Baseline Hg Load Reduction Estimate (g)**	**Current Hg Load Reduction Ranking**	**Average Annual Current Hg Load Reduction Estimate (g)**	**Average Annual Enhanced Hg Load Reduction Estimate (g)**
San Pablo (FY 98-99 through 08-09)	Medium	24.5	Low	10.7	-13.8	Medium	16.6	Low	8.6	-8.0
San Ramon (FY 98-99 through 08-09)	Low	8.4	Medium	28.7	20.3	Low	7.0	Medium	19.0	12.0
Walnut Creek (FY 98-99 through 08-09)	Medium	24.5	Low	10.7	-13.8	Medium	16.6	Low	8.6	-8.0

APPENDIX B.6.B

Data Summaries Pump Station Load Reduction Estimates

Table B.6.B. Estimates of Annual PCB and Mercury Load Reductions from Pump Station Cleaning using Maximum Pumping Capacity and Tributary Area to Normalize Calculated Load Reductions from the Ettie Street Pump Station

Municipality	Pump Station Location	Maximum Pumping Capacity (gal/min)	Tributary Area (acres)	PCB Low Max Capacity[1] [g]	PCB High Max Capacity [g]	Hg Low Max Capacity [g]	Hg High Max Capacity [g]	PCB Low Tributary Area [g]	PCB High Tributary Area [g]	Hg Low Tributary Area [g]	Hg High Tributary Area [g]
Alameda	Arbor Street at Clement Ave (extension)	30,000.0	0.0	0.16	4.45	0.15	2.86	--	--	--	--
Menlo Park	1221 Chrysler Dr., Menlo Park, CA 94025	619.4	33.5	0.00	0.09	0.00	0.06	0.04	1.16	0.04	0.75
Fremont	South Grimmer/ Osgood	1,500.0	0.0	0.01	0.22	0.01	0.14	--	--	--	--
Hayward	Addison Way	54,000.0	773.0	0.29	8.00	0.28	5.15	0.96	26.81	0.92	17.24
Hayward	Behind Pepsi Plant	190,700.0	322.0	1.01	28.27	0.97	18.17	0.40	11.17	0.38	7.18
Hayward	Eden Landing Rd	82,200.0	306.0	0.44	12.18	0.42	7.83	0.38	10.61	0.37	6.82
Hayward	Crocker/ Santana	365,200.0	847.0	1.94	54.13	1.86	34.81	1.05	29.38	1.01	18.89
Hayward	End of Cabot Rd.	105,300.0	0.0	0.56	15.61	0.54	10.04	--	--	--	--
Oakland	3455 Ettie St.	468,000.0	2000.0	2.49	69.37	2.39	44.60	2.49	69.37	2.39	44.60
Redwood City	Bair Island & E. Bayshore	63,200.0	8.0	0.34	9.37	0.32	6.02	0.01	0.28	0.01	0.18
Redwood City	1180 Broadway	12,800.0	203.0	0.07	1.90	0.07	1.22	0.25	7.04	0.24	4.53
Redwood City	15 Waterside Cr.	32,400.0	43.0	0.17	4.80	0.17	3.09	0.05	1.49	0.05	0.96
Redwood City	1101 Douglas	18,000.0	541.0	0.10	2.67	0.09	1.72	0.67	18.76	0.65	12.06
Redwood City	End of Maple (Eastside)	13,000.0	26.0	0.07	1.93	0.07	1.24	0.03	0.90	0.03	0.58
Redwood City	305 Main St.	42,600.0	88.0	0.23	6.31	0.22	4.06	0.11	3.05	0.11	1.96
Redwood City	195 Seaport Blvd - Across	7,600.0	43.0	0.04	1.13	0.04	0.72	0.05	1.49	0.05	0.96

Municipality	Pump Station Location	Maximum Pumping Capacity (gal/min)	Tributary Area (acres)	PCB Low Max Capacity[1] [g]	PCB High Max Capacity [g]	Hg Low Max Capacity [g]	Hg High Max Capacity [g]	PCB Low Tributary Area [g]	PCB High Tributary Area [g]	Hg Low Tributary Area [g]	Hg High Tributary Area [g]
Redwood City	207 Penobscot Dr.	83,000.0	63.0	0.44	12.30	0.42	7.91	0.08	2.19	0.08	1.40
Redwood City	800 Seaport Blvd.	12,500.0	122.0	0.07	1.85	0.06	1.19	0.15	4.23	0.15	2.72
Redwood City	123 Seaport Blvd., 195-199 Seaport Blvd., 295 Seaport Blvd.	1,000.0	10.4	0.01	0.15	0.01	0.10	0.01	0.36	0.01	0.23
Redwood City		5,200.0	4.0	0.03	0.77	0.03	0.50	0.00	0.14	0.00	0.09
Redwood City	N/End Veterans - 101	35,000.0	164.0	0.19	5.19	0.18	3.34	0.20	5.69	0.20	3.66
Richmond	Richmond Parkway at Gertrude Avenue	45,000.0	666.0	0.24	6.67	0.23	4.29	0.83	23.10	0.80	14.85
San Carlos	Old County & Brittan	2,000.0	1.8	0.01	0.30	0.01	0.19	0.00	0.06	0.00	0.04
San Carlos	1041 Industrial	63,000.0	20.3	0.33	9.34	0.32	6.00	0.03	0.70	0.02	0.45
San Jose	Park Avenue @ Los Gatos Creek	1,740.0	0.0	0.01	0.26	0.01	0.17	--	--	--	--
San Leandro	2048 Farallon Dr.	41,650.0	171.0	0.22	6.17	0.21	3.97	0.21	5.93	0.20	3.81
Santa Clara	2800 Mead (between Chromite & Kifer) Underpass	2,750.0	1.0	0.01	0.41	0.01	0.26	0.00	0.03	0.00	0.02
Santa Clara	1500 Warburton Ave. - Dewatering	0.0	1.0	--	--	--	--	0.00	0.03	0.00	0.02

Municipality	Pump Station Location	Maximum Pumping Capacity (gal/min)	Tributary Area (acres)	PCB Low Max Capacity[1] [g]	PCB High Max Capacity [g]	Hg Low Max Capacity [g]	Hg High Max Capacity [g]	PCB Low Tributary Area [g]	PCB High Tributary Area [g]	Hg Low Tributary Area [g]	Hg High Tributary Area [g]
Santa Clara	1701 De La Cruz Blvd. (South of Reed St.) - Underpass	0.0	5.0	--	--	--	--	0.01	0.17	0.01	0.11
Santa Clara	5611 Lafayette (South of 237)	50,000.0	284.0	0.27	7.41	0.26	4.77	0.35	9.85	0.34	6.33
Santa Clara	3905 Freedome Circle at Mission College Blvd.	35,200.0	200.0	0.19	5.22	0.18	3.35	0.25	6.94	0.24	4.46
Santa Clara	3301 Bassett St (North of Laurelwood Rd.)	2,300.0	1.0	0.01	0.34	0.01	0.22	0.00	0.03	0.00	0.02
Santa Clara	1890 Lafayette St. (south of Reed St.)	200.0	1.0	0.00	0.03	0.00	0.02	0.00	0.03	0.00	0.02
Santa Clara	3298 Lakeside Dr.	30,000.0	170.0	0.16	4.45	0.15	2.86	0.21	5.90	0.20	3.79
Santa Clara	3401 Victor St.	59,150.0	335.0	0.31	8.77	0.30	5.64	0.42	11.62	0.40	7.47
Santa Clara	1990 Walsh Ave. - dewatering	0.0	1.0	--	--	--	--	0.00	0.03	0.00	0.02
Santa Clara	3575 Victor St.	78,150.0	5.0	0.42	11.58	0.40	7.45	0.01	0.17	0.01	0.11
Santa Clara	2501 Stars & Stripes	11,100.0	60.0	0.06	1.65	0.06	1.06	0.07	2.08	0.07	1.34
Santa Clara	5099 Lick Mill Blvd. at Shulman - dewatering	600.0	0.0	0.00	0.09	0.00	0.06	0.00	0.00	0.00	0.00
Santa Clara	2900 Old Mt. View Alviso Rd.	64,500.0	366.0	0.34	9.56	0.33	6.15	0.45	12.69	0.44	8.16

Municipality	Pump Station Location	Maximum Pumping Capacity (gal/min)	Tributary Area (acres)	PCB Low Max Capacity[1] [g]	PCB High Max Capacity [g]	Hg Low Max Capacity [g]	Hg High Max Capacity [g]	PCB Low Tributary Area [g]	PCB High Tributary Area [g]	Hg Low Tributary Area [g]	Hg High Tributary Area [g]
South San Francisco	291 Shaw Road	4,000.0	8.3	0.02	0.59	0.02	0.38	0.01	0.29	0.01	0.19
South San Francisco	Rail Road Right-of-way west of 1335 block of Lowrie Ave.	3,000.0	14.8	0.02	0.44	0.02	0.29	0.02	0.51	0.02	0.33
South San Francisco	Near 270 South Maple Ave.	2,800.0	5.5	0.01	0.42	0.01	0.27	0.01	0.19	0.01	0.12
South San Francisco	Near 270 South Maple Ave.	2,800.0	5.5	0.01	0.42	0.01	0.27	0.01	0.19	0.01	0.12
South San Francisco	Near 270 South Maple Ave.	2,800.0	5.5	0.01	0.42	0.01	0.27	0.01	0.19	0.01	0.12
South San Francisco	South Canal St.	3,000.0	10.2	0.02	0.44	0.02	0.29	0.01	0.35	0.01	0.23
South San Francisco	South Linden	1,500.0	1.3	0.01	0.22	0.01	0.14	0.00	0.05	0.00	0.03
Sunnyvale	Between WPCP at Borregas and Smart Station at Carl Rd.	59,250.0	500.0	0.31	8.78	0.30	5.65	0.62	17.34	0.60	11.15
Sunnyvale	Central Expwy and Fair Oaks	9,000.0	0.0	0.05	1.33	0.05	0.86	--	--	--	--

NOTES:

(1) "High" and "Low" estimates for PCB and mercury load reductions were obtained using the highest and lowest annual load reductions calculated for the ESPS.

(2) --: The pump station maximum pumping capacity or tributary area is not known.

Table B.6.B.2. Estimates of PCB and Mercury Load Reductions from Pumping Station Cleaning Using Maximum Pumping Capacity and Tributary Area to Normalize Sediment Removed from the Ettie Street Pump Station

Municipality	Pump Station Location	Maximum Pumping Capacity (gal/min)	Tributary Area (acres)	PCB Low Max Capacity[1] [g]	PCB High Max Capacity [g]	Hg Low Max Capacity [g]	Hg High Max Capacity [g]	PCB Low Tributary Area [g]	PCB High Tributary Area [g]	Hg Low Tributary Area [g]	Hg High Tributary Area [g]
Alameda	Arbor Street at Clement Ave (extension)	30,000.0	0.0	0.24	4.45	0.15	2.86	--	--	--	--
Menlo Park	1221 Chrysler Dr., Menlo Park, CA 94025	619.4	33.5	0.00	0.06	0.00	0.02	0.04	0.81	0.01	0.23
Fremont	South Grimmer/ Osgood	1,500.0	0.0	0.01	0.22	0.01	0.14	--	--	--	--
Hayward	Addison Way	54,000.0	773.0	0.43	8.00	0.28	5.15	1.44	26.80	0.92	17.24
Hayward	Behind Pepsi Plant	190,700.0	322.0	1.51	28.26	0.97	18.18	0.60	11.17	0.38	7.18
Hayward	Eden Landing Rd	82,200.0	306.0	0.65	12.18	0.42	7.84	0.57	10.61	0.37	6.83
Hayward	Crocker/ Santana	365,200.0	847.0	2.90	54.12	1.87	34.82	1.57	29.37	1.01	18.89
Hayward	End of Cabot Rd.	105,300.0	0.0	0.84	15.60	0.54	10.04	--	--	--	--
Oakland	3455 Ettie St.	468,000.0	2000.0	3.72	69.35	2.39	44.62	3.72	69.35	2.39	44.62
Redwood City	Bair Island & E. Bayshore	63,200.0	8.0	0.35	6.53	0.10	1.83	0.01	0.19	0.00	0.05
Redwood City	1180 Broadway	12,800.0	203.0	0.07	1.32	0.02	0.37	0.26	4.91	0.07	1.38
Redwood City	15 Waterside Cr.	32,400.0	43.0	0.18	3.35	0.05	0.94	0.06	1.04	0.02	0.29
Redwood City	1101 Douglas	18,000.0	541.0	0.10	1.86	0.03	0.52	0.70	13.09	0.20	3.67
Redwood City	End of Maple (Eastside)	13,000.0	26.0	0.07	1.34	0.02	0.38	0.03	0.63	0.01	0.18
Redwood City	305 Main St.	42,600.0	88.0	0.24	4.40	0.07	1.23	0.11	2.13	0.03	0.60

Municipality	Pump Station Location	Maximum Pumping Capacity (gal/min)	Tributary Area (acres)	PCB Low Max Capacity[1] [g]	PCB High Max Capacity [g]	Hg Low Max Capacity [g]	Hg High Max Capacity [g]	PCB Low Tributary Area [g]	PCB High Tributary Area [g]	Hg Low Tributary Area [g]	Hg High Tributary Area [g]
Redwood City	195 Seaport Blvd - Across	7,600.0	43.0	0.04	0.79	0.01	0.22	0.06	1.04	0.02	0.29
Redwood City	207 Penobscot Dr.	83,000.0	63.0	0.46	8.58	0.13	2.41	0.08	1.52	0.02	0.43
Redwood City	800 Seaport Blvd.	12,500.0	122.0	0.07	1.29	0.02	0.36	0.16	2.95	0.04	0.83
Redwood City	123 Seaport Blvd., 195-199 Seaport Blvd., 295 Seaport Blvd.	1,000.0	10.4	0.01	0.10	0.00	0.03	0.01	0.25	0.00	0.07
Redwood City		5,200.0	4.0	0.03	0.54	0.01	0.15	0.01	0.10	0.00	0.03
Redwood City	N/End Veterans - 101	35,000.0	164.0	0.19	3.62	0.05	1.01	0.21	3.97	0.06	1.11
Richmond	Richmond Parkway at Gertrude Avenue	45,000.0	666.0	0.21	3.84	0.12	2.31	0.71	13.29	0.43	7.99
San Carlos	Old County & Brittan	2,000.0	1.8	0.01	0.21	0.00	0.06	0.00	0.04	0.00	0.01
San Carlos	1041 Industrial	63,000.0	20.3	0.35	6.51	0.10	1.83	0.03	0.49	0.01	0.14
San Jose	Park Avenue @ Los Gatos Creek	1,740.0	0.0	0.00	0.01	0.00	0.05	--	--	--	--
San Leandro	2048 Farallon Dr.	41,650.0	171.0	0.33	6.17	0.21	3.97	0.32	5.93	0.20	3.81
Santa Clara	2800 Mead (between Chromite & Kifer) Underpass	2,750.0	1.0	0.00	0.01	0.00	0.08	0.00	0.00	0.00	0.01
Santa Clara	1500 Warburton Ave. - Dewatering	0.0	1.0	--	--	--	--	0.00	0.00	0.00	0.01

Municipality	Pump Station Location	Maximum Pumping Capacity (gal/min)	Tributary Area (acres)	PCB Low Max Capacity[1] [g]	PCB High Max Capacity [g]	Hg Low Max Capacity [g]	Hg High Max Capacity [g]	PCB Low Tributary Area [g]	PCB High Tributary Area [g]	Hg Low Tributary Area [g]	Hg High Tributary Area [g]
Santa Clara	1701 De La Cruz Blvd. (South of Reed St.) - Underpass	0.0	5.0	--	--	--	--	0.00	0.01	0.00	0.03
Santa Clara	5611 Lafayette (South of 237)	50,000.0	284.0	0.01	0.21	0.08	1.47	0.02	0.28	0.10	1.96
Santa Clara	3905 Freedome Circle at Mission College Blvd.	35,200.0	200.0	0.01	0.15	0.06	1.04	0.01	0.20	0.07	1.38
Santa Clara	3301 Bassett St (North of Laurelwood Rd.)	2,300.0	1.0	0.00	0.01	0.00	0.07	0.00	0.00	0.00	0.01
Santa Clara	1890 Lafayette St. (south of Reed St.)	200.0	1.0	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.01
Santa Clara	3298 Lakeside Dr.	30,000.0	170.0	0.01	0.13	0.05	0.88	0.01	0.17	0.06	1.17
Santa Clara	3401 Victor St.	59,150.0	335.0	0.01	0.25	0.09	1.74	0.02	0.34	0.12	2.31
Santa Clara	1990 Walsh Ave. - dewatering	0.0	1.0	--	--	--	--	0.00	0.00	0.00	0.01
Santa Clara	3575 Victor St.	78,150.0	5.0	0.02	0.33	0.12	2.30	0.00	0.01	0.00	0.03
Santa Clara	2501 Stars & Stripes	11,100.0	60.0	0.00	0.05	0.02	0.33	0.00	0.06	0.02	0.41
Santa Clara	5099 Lick Mill Blvd. at Shulman - dewatering	600.0	0.0	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00
Santa Clara	2900 Old Mt. View Alviso Rd.	64,500.0	366.0	0.01	0.28	0.10	1.90	0.02	0.37	0.14	2.52

Municipality	Pump Station Location	Maximum Pumping Capacity (gal/min)	Tributary Area (acres)	PCB Low Max Capacity[(1)] [g]	PCB High Max Capacity [g]	Hg Low Max Capacity [g]	Hg High Max Capacity [g]	PCB Low Tributary Area [g]	PCB High Tributary Area [g]	Hg Low Tributary Area [g]	Hg High Tributary Area [g]
South San Francisco	291 Shaw Road	4,000.0	8.3	0.02	0.41	0.01	0.12	0.01	0.20	0.00	0.06
South San Francisco	Rail Road Right-of-way west of 1335 block of Lowrie Ave.	3,000.0	14.8	0.02	0.31	0.00	0.09	0.02	0.36	0.01	0.10
South San Francisco	Near 270 South Maple Ave.	2,800.0	5.5	0.02	0.29	0.00	0.08	0.01	0.13	0.00	0.04
South San Francisco	Near 270 South Maple Ave.	2,800.0	5.5	0.02	0.29	0.00	0.08	0.01	0.13	0.00	0.04
South San Francisco	Near 270 South Maple Ave.	2,800.0	5.5	0.02	0.29	0.00	0.08	0.01	0.13	0.00	0.04
South San Francisco	South Canal St.	3,000.0	10.2	0.02	0.31	0.00	0.09	0.01	0.25	0.00	0.07
South San Francisco	South Linden	1,500.0	1.3	0.01	0.16	0.00	0.04	0.00	0.03	0.00	0.01
Sunnyvale	Between WPCP at Borregas and Smart Station at Carl Rd.	59,250.0	500.0	0.01	0.25	0.09	1.75	0.03	0.50	0.18	3.45
Sunnyvale	Central Expwy and Fair Oaks	9,000.0	0.0	0.00	0.04	0.01	0.27	--	--	--	--

NOTES:

(1) "High" and "Low" estimates for PCB and mercury load reductions were obtained using the highest and lowest volume of materials removed during cleanouts at the ESPS and sediment concentration data included in Table B.6.9.

(2) --: The pump station maximum pumping capacity or tributary area is not known.

APPENDIX B.7.A

Green Streets Pilot Project Status Table

Appendix B.7.A.1. Project Information for 10 Selected Green Street Pilot Projects

Program	County	No.	Project Name	Owner/ Municipality	Project Location	Project Type (check all that apply)					Project Description	Project Attributes (check all that apply)									Project Status	Project Contact	Estimated Date of Comple-tion	Monitor-ing	Modeling	Project Status
						Arterial	Collector	Local	Parking Lot	Other (*specify*)		Bay-Friendly Landscaping	Stormwater Storage/Use	Stormwater Infiltration	Stormwater Treatment	Enhance Pedestrian and /or bicycle environment	Park-like elements	Connect residential, recreation, schools,	Parking Management	ABAG/MTC- designated Priority Development						
ACCWP	Alameda	1	Park and Hollis Stormwater Curb Extension	Emeryville	Northeast Corner of Park Ave and Hollis Street		X				Planted stormwater curbextension constructed in 2010 as part of new corner plaza area.	X	X			X	X			X	Constructed	Peter Schultze-Allen (Emeryville)	2010	None planned	Yes	Project completed. Pixar Animation Studios responsible, cost information not broken down or available.
		2	Codornices Creek Restoration Project	Berkeley, Albany, University of California	San Pablo Avenue at 6th Street			X			4 Rain Gardens/Bioretention areas with underdrains with discharge to Codornices Creek	X		X	X	X	X	X			Constructed	Jim Scanlin (ACPWA)	2011	Yes 5-Year Plan	Yes	Maintenance of all the improvements made on Codornices Creek is divided among the three agencies (Albany, Berkeley, and UC Berkeley) through a Memorandum of Understanding (MOU). The bioretention facilities were included in this MOU by an amendment before acceptance of construction.The Creek Project requires 5 years of monitoring.
		3	Stanley Boulevard Safety and Streetscape Improvement Project	Unincor-porated Alameda County	Stanley Boulevard Safety and Streetscape Improvement Project	X					Improving 3 miles of roadway, incorporating LID to convert industrial corridor to more rural parkway setting.	98		X	X	X	X	X			Contruction Phase	Justin Laurence (ACCWP)	September 2012	None planned	Yes	Construction is currently in progress. The BMPs have not yet begun construction.
CCCWP	Contra Costa	4	El Cerrito Green Streets	El Cerrito	10200 block of San Pablo Avenue (east side) and 11048 San Pablo Avenue	X					2 Rain Gardens (bioretention with underdrains)	X			X	X	X			X	Constructed	Stephen Pree (El Cerrito)	August 2010	Yes Conducted	Yes	The project was completed in August 2010 and completed water quality monitoring through WY 2012.
		5	San Pablo Avenue Greenspine Project	Richmond	12900 block of San Pablo Ave (west side) between McBryde Ave & Andrade Ave	X					5 Bioretention facilities, including infiltration			X		X	X	X			Preliminary Design Phase	Josh Brandt (SFEP)	Fall 2013	Planned	No	The project is currently in the 30% design phase. Design anticipated to be completed by late summer 2013 and construction to begin in late summer/fall 2013.
SMCWPPP	San Mateo	6	Sustainable Streets and Parking Lots Demonstration Project	Burlingame	1227 Donnelly Avenue, between Primose Road and Bellevue Avenue, Assessor Parcel Number 029-152-300			X	X		Rain Garden (bioretention without underdrain) and curb extention	X		X	X						Constructed	Jane Gomery (Burlingame)	January 2011	No	Yes	The project was completed in January 2011.
		7	Bransten Road Green Street	San Carlos	Bransten Road between Old County Road and Industrial Road			X			Bioretention areas in newly constructed curb extensions				X	X	X		X		100% Design Phase	Ray Chan (San Carlos)	December2014	CW4CB Task 5 Planned	Yes	The project is currently at the 100% design phase phase; construction is anticipated to be completed by the MRP Provision C.3.b.iii due date of December 1, 2014.
SCVURPPP	Santa Clara	8	Packard Foundation Project	Los Altos	343 Second Street, between Whitney and Lyell			X			Flow-through rain gardens in park strip along street and at an intersection; conversion of impervious to pervious area			X	X	X					Constructed	Jill Bicknell (SCVURPPP)	July 2012	None planned	Yes	Construction completed July 2012.
		9	Hacienda Avenue Green Street	Campbell	Hacienda Avenue, between South San Tomas Aquino Rd & Winchester Blvd	X					Improving 1 mile of roadway. Adding bike lanes, sidewalk infill, narrowing roadway width to install bioretention swales and bulbouts	X		X		X	X	X	X		Final Design Phase	Fred Ho (Campbell)	Late 2014/early 2015	Yes (water balance only)	Yes	Conceptual designs approved by City Council. Construction to begin in summer 2014.
		10	Southgate Neighborhood Green Street	Palo Alto	Various streets centered around Miramonte and Castilleja Avenues			X			Adding bioretention and biofiltration planters and pervious pavement throughout a residential neighborhood	X		X	X	X	X	X			Final Design Phase	Jill Bicknell (SCVURPPP)	Early 2014	None planned	Yes	Design received approval from city architectural review design staff. Construction to begin in fall 2013.

Appendix B.7.A.2. Project Information for All Reported Bay Area Green Street Projects

Pro-gram	County	No.	Project Name	Owner/ Municipality	Project Location	Project Type (check all that apply)					Project Description	Project Attributes (check all that apply)									Project Status	Project Contact	Estimated Date of Comple-tion	WQ Monitor-ing	Modelling	Project Schedule, Funding, and Other Information
						Arterial	Collector	Local	Parking Lot	Other (*specify*)		Bay-Friendly Landscaping	Stormwater Storage/Use	Stormwater Infiltration	Stormwater Treatment	Enhance Pedestrian and /or bicycle environment	Park-like elements	Connect residential, recreation, schools,	Parking Management	ABAG/MTC- designated Priority Development						
ACCWP	Alameda	A1	**Park and Hollis Stormwater Curb Extension**	**Emeryville**	Northeast Corner of Park Ave and Hollis Street		X				Planted stormwater curbextension constructed in 2010 as part of new corner plaza area.	X	X			X	X			X	Constructed	Peter Schultze-Allen (Emeryville)	2010	None planned	Yes	Project completed. Pixar Animation Studios responsible, cost information not broken down or available.
		A2	**Codornices Creek Restoration Project**	**Berkeley, Albany, University of California**	San Pablo Avenue at 6th Street			X			4 Rain Gardens/Bioretention areas with underdrains with discharge to Codornices Creek	X		X	X	X	X	X			Constructed	Jim Scanlin (ACPWA)	2011	Yes 5-Year Plan	Yes	Maintenance is divided among 3 agencies (Albany, Berkeley, and UC Berkeley) through a Memorandum of Understanding (MOU) for entire project. The Creek Project requires 5 years of monitoring.
		A3	**Stanley Boulevard Safety and Streetscape Improvement Project**	**Unincor-porated Alameda County**	Stanley Boulevard Safety and Streetscape Improvement Project	X					Improving 3 miles of roadway, incorporating LID to convert industrial corridor to more rural parkway setting.	98		X	X	X	X	X			Contruction Phase	Justin Laurence (ACCWP)	September 2012	None planned	Yes	Construction is currently in progress. The BMPs have not yet begun construction. State Prop 1B & Local funds (64.3%), CEMEX and Vulcan Materials Companies (34.5%), Bay Area Air Quality Management District – Transportation for Clean Air Grant Funds (0.008%), StopWaste.org Bay Friendly Grant Funds (0.002%)
		A4	**San Pablo Avenue Greenspine Project**	**Albany**	San Pablo Ave & Monroe St, Albany 94706	X					3 Stormwater Curb Extensions and Sidewalk Planters	X			X		X				60% Design Phase	Josh Brandt (SFEP)	Fall 2014	Planned	No	Project is funded from USEPA SF Bay Water Quality Improvement Fund and the State's IRWM program. Construction funded by Caltrans. SFEP administers grants.
		A5	**San Pablo Avenue Greenspine Project**	**Berkeley**	San Pablo Ave & Cordornices Creek, Berkeley 94708	X					5 Stormwater Curb Extensions	X			X		X				60% Design Phase	Josh Brandt (SFEP)	Fall 2014	Planned	No	Project is funded from USEPA SF Bay Water Quality Improvement Fund and the State's IRWM program. Construction funded by Caltrans. SFEP administers grants.
		A6	**San Pablo Avenue Greenspine Project**	**Emeryville**	San Pablo Ave & W MacArthur Blvd, Emeryville 94608	X					3 Rain Gardens	X			X	X	X				60% Design Phase	Josh Brandt (SFEP)	Fall 2014	Planned	No	Project is funded from USEPA SF Bay Water Quality Improvement Fund and the State's IRWM program. Construction funded by Caltrans. SFEP administers grants.
		A7	**San Pablo Avenue Greenspine Project**	**Oakland**	San Pablo Ave & 17th Street, Oakland, 94612	X					Stormwater Planters and Street Trees	X		X	X		X		X		60% Design Phase	Josh Brandt (SFEP)	Fall 2014	Planned	No	Project is funded from USEPA SF Bay Water Quality Improvement Fund and the State's IRWM program. Construction funded by Caltrans. SFEP administers grants.
CCCWP	Contra Costa	CC1	**El Cerrito Green Streets**	**El Cerrito**	10200 block of San Pablo Avenue (east side) and 11048 San Pablo Avenue	X					2 Rain Gardens (bioretention with underdrains)	X			X	X	X			X	Constructed	Stephen Pree (El Cerrito)	August 2010	Yes Conducted	Yes	Funded through a federal ARRA Grant and by the El Cerrito Redevelopment Agency and administered through the State Water Resources Control Board via SFEP.
		CC2	**San Pablo Avenue Greenspine Project**	**El Cerrito**	San Pablo Ave & Stockton Ave; San Pablo Ave & Moeser Ave, El Cerrito 94530; El Cerrito 94530	X					Stormwater Curb Extensions, Rain Gardens, and Sidewalk Planters	X		X	X		X				60% Design Phase	Josh Brandt (SFEP)	Fall 2014	Planned	No	Project is funded from USEPA SF Bay Water Quality Improvement Fund and the State's IRWM program. Construction funded by Caltrans. SFEP administers grants.
		CC3	**San Pablo Avenue Greenspine Project**	**Richmond**	12900 block of San Pablo Ave (west side) between McBryde Ave & Andrade Ave	X					5 Bioretention Facilities, including Infiltration	X		X		X	X	X			60% Design Phase	Josh Brandt (SFEP)	Fall 2014	Planned	No	Project is funded from USEPA SF Bay Water Quality Improvement Fund and the State's IRWM program. Construction funded by Caltrans. SFEP administers grants.
		CC4	**San Pablo Avenue Greenspine Project**	**San Pablo**	13613 San Pablo Ave, San Pablo 94806	X					Stormwater Planters	X					X				60% Design Phase	Josh Brandt (SFEP)	Fall 2014	Planned	No	Project is funded from USEPA SF Bay Water Quality Improvement Fund and the State's IRWM program. Construction funded by Caltrans. SFEP administers grants.
		CC5	**Nevine Avenue Improvements Green Streets**	**Richmond**	Nevin Avenue from 19th St to 27th St			X			Rain gardens (bioretention w/underdrain) curb extensions, permeable pavement			X	X	X	X				100% Design Phase	Lynn Scarpa (Richmond)	March 2014	Planned as part of CW4CB Task 5	No	The project is currently at the 100% design phase phase; construction is anticipated to be completed by the MRP Provision C.3.b.iii due date of December 1, 2014.

Appendix B.7.A.2. Project Information for All Reported Bay Area Green Streets Projects

Pro-gram	County	No.	Project Name	Owner/ Municipality	Project Location	Project Type (check all that apply)					Project Description	Project Attributes (check all that apply)									Project Status	Project Contact	Estimated Date of Comple-tion	WQ Monitor-ing	Modelling	Project Status
						Arterial	Collector	Local	Parking Lot	Other (*specify*)		Bay-Friendly Landscaping	Stormwater Storage/Use	Stormwater Infiltration	Stormwater Treatment	Enhance Pedestrian and /or bicycle environment	Park-like elements	Connect residential, recreation, schools, streets,	Parking Management	ABAG/MTC- designated Priority Development Area						
		CC6	**PG&E Substation at 1st & Cutting**	**Richmond**	South 1st Street & Cutting Blvd, Richmond 94804		X				4 Bioretention areas (2 w/underdrains; 2 w/o underdrains)			X	X						100% Design Phase	Lynn Scarpa (Richmond)	October 2013	Planned as part of CW4CB Task 5	No	The project is currently at the 100% design phase phase; construction is anticipated to be completed by the MRP Provision C.3.b.iii due date of December 1, 2014.
SMCW PPP	**San Mateo**	**SM1**	**Sustainable Streets and Parking Lots Demonstration Project**	**Burlingame**	1227 Donnelly Avenue, between Primose Road and Bellevue Avenue, Assessor Parcel Number 029-152-300			X	X		Rain Garden (bioretention without underdrain) and curb extention	X		X	X						Constructed	Jane Gomery (Burlingame)	January 2011	No		Funding for the projects come from a countywide vehicle registration fee under Assembly Bill (AB) 1546, which went into effect on July 1, 2005, and was subsequently extended to 2012 through Senate Bill (SB) 348.
		SM2	**Bransten Road Green Street**	**San Carlos**	Bransten Road between Old County Road and Industrial Road			X			Bioretention areas in newly constructed curb extensions				X	X	X		X		100% Design Phase	Ray Chan (San Carlos)	December2014	Planned as part of CW4CB Task 5	Yes	The project is currently at the 100% design phase phase; construction is anticipated to be completed by the MRP Provision C.3.b.iii due date of December 1, 2014.
SCVUR PPP	**Santa Clara**	**SC1**	**Packard Foundation Project**	**Los Altos**	343 Second Street, between Whitney and Lyell			X			Flow-through rain gardens in park strip along street and at an intersection; conversion of impervious to pervious area			X	X	X					Constructed	Jill Bicknell (SCVURPPP)	July 2012	None planned	Yes	Construction completed July 2012. Funding was provided entirely by the David & Lucile Packard Foundation as part of construction of its headquarters office building.
		SC2	**Hacienda Avenue Green Street**	**Campbell**	Hacienda Avenue, between South San Tomas Aquino Rd & Winchester Blvd	X					Improving 1 mile of roadway. Adding bike lanes, sidewalk infill, narrowing roadway width to install bioretention swales and bulbouts	X		X		X	X	X	X		Final Design Phase	Fred Ho (Campbell)	Late 2014/early 2015	Yes (Water balance only)	Yes	Conceptual designs approved by City Council. Construction to begin in summer 2014. Funding assistance provided by $2 million grant from State's IRWM program (43%) and $0.5 million in Federal funding via Caltrans (11%). City is providing the remainder of the funding (46%).
		SC3	**Southgate Neighborhood Green Street**	**Palo Alto**	Various streets centered around Castilleja &Miramonte Aveunes			X			Adding bioretention and biofiltration planters and pervious pavement throughout a residential neighborhood	X		X	X	X	X	X			Final Design Phase	Jill Bicknell (SCVURPPP)	Early 2014	None planned	Yes	Design received approval from city architectural review design staff. Construction to begin in fall 2013. The project is being funded entirely by the City of Palo Alto.
		SC4	**Martha Gardens Green Alleys Pilot Project**	**San Jose**	Alley between Second and Third Street; Virginia and Martha Strret					x	"Green" concrete sloped to permeable pavers draining to below-grade infiltration galleries.			x	x	x					Project Design Phase	Jill Bicknell (SCVURPPP)	Late 2013	Pre and post-project sediment analysis	No	Project was selected for Prop 84 Stormwater Implementation Grant funding.
		SC5	**Park Avenue: Green Avenue Pilot Project**	**San Jose**	Park Avenue between Meridian Ave. and Sunol St.		x				Bioretention areas constructed at existing curb and at new curb extensions, and permeable paver median.			x	x	x					Preliminary Design Phase	Jill Bicknell (SCVURPPP)	Late 2014	Pre and post project pollutant analysis, flow reduction.	No	Project was selected for Prop 84 Stormwater Implementation Grant funding.

APPENDIX B.7.B

CW4CB Task 5 Pilot Project Status Table

Appendix B.7.B. CW4CB Task 5 Pilot Project Status Table

	Pro-gram	No	Project Name	Project Sponsor	Project Contact	Designer	Schedule											Notes
							10% Designer under BASMAA Contract	100% Designer under BASMAA Contract	Project Sponsor under BASMAA Contract	100% Design Finished	Board or City Council Approves Project	Construction Project Out to Bid	Board or City Council Approves Construction Contractor Selection	CEQA and Building Permits	Construc-tion Begins	Construction Ends	Monitoring Year	
Selected Projects	ACWP	1	Ettie St. Pump Station	ACFCWCD	Arleen Feng	WRECO	N/A	7/13?	10/12	9/13	N/A	10/13?	11/13?	N/A	12/13	12/13	Soonest Jan 1, 2014	100% design completed.
	ACWP	2	Alameda and High St HDS Unit	Oakland	Becky Tuden	Oakland	N/A	N/A		12/11	N/A	3/12	5/12	5/12	10/12	12/12	13/14	Construction complete.
	ACWP	3	West Oakland Industrial Area	Oakland	Becky Tuden	WRECO	N/A	3/16/12	5/1/12	10/12	N/A	1/13	4/16/13	Completed Notice of Exemption	9/13	End of 10/13	Soonest Nov 1, 2013	100% design completed. Construction begins 9/25/13.
	CCCWP	4	Nevin Avenue Improvements (Green Streets)	Richmond	Lynn Scarpa	Richmond /BKF	N/A	N/A	5/15/12	4/13	N/A	11/13	12/13	Done	3/14 - 5/14	7/14	**14/15**	100% design completed. Delay due to Caltrans not submitting comments. Monitoring in 2014/15 instead.
	CCCWP	5	PG&E Substation; 1st and Cutting	Richmond	Lynn Scarpa	WRECO	12/23/11	4/9/12	5/15/12	4/13	N/A	11/13	12/13	N/A	3/14 - 5/14	7/14	**14/15**	100% design completed. Delay due to rejection of first round of bid packages. Monitoring in 2014/15 instead.
	CCCWP	6	El Cerrito Green Streets	El Cerrito	Kahlil Abusaba	Construc-ted	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	13/14	Construction complete.
	SCVU RPPP	7	Leo Avenue HDS System	San Jose	James Downing	San Jose	N/A	N/A	Prior to 5/24/12	1/31/12	N/A	3/22/12	4/6/12	N/A	7/12	10/12	13/14	Construction complete.
	SM CWPPP	8	Bransten Road Curb Extensions	San Carlos	Jon Konnan	WRECO	1/19/12	4/17/12		3/13	4/13	5/13	6/13	Complete Notice of Exemption	9/13	End of 10/13	Soonest Nov 1, 2013	100% design completed. Construction began 9/9/13.
	SC	9	Broadway and Redwood	Vallejo	Sam Kumar	WRECO		2/13/12	6/13	9/13	N/A	10/13	11/13	N/A	12/13	2/14	Soonest April 1, 2014	100% design completed.
	SC	10	PG&E Substation	Vallejo	Sam Kumar	WRECO		2/13/12	6/13	9/13	N/A	10/13	11/13	N/A	12/13	2/14	Soonest April 1, 2014	100% design completed.

Notes:

White – Completed activity

Red – To be completed (Short-term)

Green – To be completed (Long-Term)

Blue – Delayed monitoring year

Bold – Deadline has passed; Need status update

APPENDIX B.7.C

Modeling Methodology

INTEGRATED MONITORING REPORT: SECTION B.7 STORMWATER TREATMENT
APPENDIX B.7.C - MODELING METHODOLOGY

1 Model Overview

A simple spreadsheet model was developed to estimate present and future PCB load reductions for existing and proposed Projects. Existing or proposed Project area, imperviousness, and BMP information were used as site-specific inputs to the model, along with geospatial "Old Industrial" land use information, Bay Area land-use based monitoring data and BMP performance data from the WERF International BMP Database. A summary of the model inputs and potential sources of error is included in the sections below.

2 Model Inputs

2.1 Runoff Calculation

Annual runoff was calculated using the rational method. Two rain gauges were used to calculate annual rainfall depth: Oakland WSO (Station ID # 6335, 1948 – 1986) and San Jose (Station ID # 7821, 1948 – 2001). The Oakland gauge was used for Projects located in Contra Costa and Alameda counties; the San Jose gauge was used for Projects located in Santa Clara and San Mateo counties.

Area and imperviousness is based on project data received by Geosyntec. The runoff coefficient was calculated as 0.9 times the Project imperviousness. This represents a coefficient for roofs from the Santa Clara County C.3 Stormwater Handbook; and also matches LA County and WEF method runoff coefficient values for 100% impervious surfaces.

2.2 Project Land Use

Project land use was assumed to be a mix of Old Urban, New Urban, and Old Industrial land uses to allow for correlation to particle-based PCB concentrations developed by SFEI as part of the Regional Watershed Spreadsheet Model (RWSM) effort (SFEI, 2012). The land use breakdown for each site was based on shapefiles received from EOA on 24 May 2013. The land use information was binary in that it indicated only if a specific land use was in a catchment. Because of this, C.3 Projects, which were included in the "C3 Project locations" (2009-2012) point shapefile (storm_water_treatment_sites_Bay_Area.shp), were assumed to have an equal proportion of each land use listed for each project in the tributary area. Green Streets and CW4CB Task 5 Pilot Projects, which were not included in the C.3 Project locations point shapefile, were assumed to have an equal proportion of all three land uses if they were located within "Old Industrial" land use areas (Bay_Area_Industrial_1968_with_ports.shp); and were assumed to have an equal proportion of Old Urban and New Urban if they were located outside of industrial land use areas. Table 1 shows the assumed proportion of land uses for the C.3 Projects, the Green Streets Pilot Projects, and the CW4CB Task 5 Pilot Projects.

Table 1. Assumed Land Use Breakdown by Project

Project	Assumed Proportion of Land Use Type in Tributary Area		
	Old Industrial	**Old Urban**	**New Urban**
C.3. Projects Modeled			
4040 Campbell	0.33	0.33	0.33
Airgas CP12-0025	0.33	0.33	0.33
ALCO Iron & Metal Co.	0.33	0.33	0.33
Ashby Lumber	0.33	0.33	0.33
Bio-Rad	0.33	0.33	0.33
BRE	0.33	0.33	0.33
Coleman Retail Center (Phase 1 and Phase 2)	0.33	0.33	0.33
Dasco Construction & Drywall	0.33	0.33	0.33
Davis Street Transfer Station / WMI	0.33	0.33	0.33
Dona Spring Animal Shelter	0.33	0.33	0.33
Emerystation Greenway	0.33	0.33	0.33
Extra Space Storage	0.33	0.33	0.33
Fire Prevention Bureau	0.33	0.33	0.33
Fire Station 23	0.33	0.33	0.33
Grocery Outlet	0.33	0.33	0.33
In N Out Burger	0.33	0.33	0.33
Intuitive Surgical Building 103	0.33	0.33	0.33
Lewis & Tibbits	0.33	0.33	0.33
Lowe's	0.33	0.33	0.33
Michael J’s Body Shop	0.33	0.33	0.33
Mil Aspen Associates	0.33	0.33	0.33
Montecito Vista Urban Village -Siena	0.33	0.33	0.33
Mozart Car Museum	0.33	0.33	0.33
Pacific Commons	0.33	0.33	0.33
Palo Alto Medical Foundation	0.33	0.33	0.33
Panasonic	0.33	0.33	0.33
Paragon, PJ3204	0.33	0.33	0.33
Robinson Oil	0.33	0.33	0.33
Stanford Medical	0.33	0.33	0.33
Wente Vineyards	0.33	0.33	0.33
Green Streets Projects Modeled			
Bransten Road Green Street Project	0.33	0.33	0.33
Codornices Creek Restoration Project	0.33	0.33	0.33
El Cerrito Green Streets Project	0.33	0.33	0.33
Green Spine Project		0.50	0.50
Hacienda Avenue Green Streets		0.50	0.50

Project	Assumed Proportion of Land Use Type in Tributary Area		
	Old Industrial	**Old Urban**	**New Urban**
Packard Foundation Project		0.50	0.50
Park and Hollis Stormwater Curb Extension	0.33	0.33	0.33
Southgate Neighborhood Green Streets Project		0.50	0.50
Stanley Blvd Safety and Streetscape Improvement Project		0.50	0.50
Sustainable Streets and Parking Lots Demonstration Project		0.50	0.50
IMR Projects Modeled			
Alameda and High St. HDS Unit	0.33	0.33	0.33
Bransten Road Curb Extensions	0.33	0.33	0.33
Broadway and Redwood	0.33	0.33	0.33
El Cerrito Green Streets		0.50	0.50
Ettie St. Pump Station	0.33	0.33	0.33
Leo Avenue HDS System	0.33	0.33	0.33
Nevin Avenue Improvements (Green Streets)		0.50	0.50
PG&E Substation	0.33	0.33	0.33
West Oakland Industrial Area	0.33	0.33	0.33

2.3 Land Use Based Influent Concentrations

Land use based TSS loads were calculated as the product of the land use based area-weighted TSS concentration and the runoff volume (described above). BASMAA monitoring data from the San Francisco Bay Area Stormwater Runoff Monitoring Data Analysis 1988-1995 (BASMAA, 1996) was used to develop land use based TSS concentrations for the three designated land use types (Table2).

Table 2. Land Use Based TSS Concentration Data

Modified TSS Influent Data	
Land Use	**TSS (mg/L)**
Old Urban[1]	92
New Urban[1]	92
Old Industrial	157

[1] Assumed to be the average of BASMAA Residential and Commercial as urban redevelopment projects are typically a mix of these two land uses.

Influent PCB and total mercury (HgT) concentrations and loads were calculated using particle-based concentrations calculated from the RWSM analysis (SFEI, 2012). These particle-based concentrations were multiplied by the TSS concentrations included in Table 2 above to obtain the land-use based PCB and HgT concentrations shown in Table 3.

Table 3. PCB and HgT Particle and Water Concentration Data

Land Use	Particle Concentrations		Resulting Water Concentrations	
	PCBs (µg/kg)	HgT (mg/kg) [1]	PCBs (µg/L)	HgT (µg/L)
Old Urban	150	0.63	0.0138	0.05796
New Urban	0.87	0.16	0.00008004	0.01472
Old Industrial	2800	0.63	0.4396	0.09891

[1] SFEI could not distinguish old industrial from old urban for HgT, so old industrial was assumed to equal old urban in model.

These water concentrations were multiplied by the average annual runoff from the project to obtain influent PCB and HgT loads.

2.4 BMP Performance

The reduction in PCB and HgT load was determined based on the BMPs present in the existing or proposed Projects. For the Green Streets and CW4CB Task 5 Pilot projects, the number and types of BMPs were determined based on Project information that was available at the time of modeling as provided by individual project leads. For the constructed C.3 Regulated Projects, the number and types of BMPs were determined using the information available in Permittees' FY 09/10- FY 11/12 Annual Report Operations & Maintenance Tables. In the case of multiple BMPs per catchment, the individual tributary area for each BMP is assumed to be the total area divided by the number of BMPs.

2.4.1 Capture and Volume Reduction

BMPs were assumed to capture a specified proportion of the influent volume. Eighty percent of average annual runoff for C.3 Projects and 70% of average annual runoff for Green Streets and CW4CB Task 5 Pilot Projects was assumed to be captured in the BMPs. Additionally, for bioretention facilities, bioswales, detention basins, and porous pavement BMPs, 20% of the captured volume was assumed to be infiltrated in the BMP, with the associated pollutant loads removed via infiltration.

2.4.2 Treated Effluent Concentrations

The treated, un-infiltrated volume was assumed to have the effluent concentrations listed in Table 4. Effluent PCB data was calculated to be the combination of effluent TSS concentration and land use based, particle-based PCB concentration. This assumes that the particle-based concentration is the same in the influent and the effluent.

Table 4: BMP Effluent Concentrations and Capture Efficiency

BMP Type	Effluent Concentration (mg/L)	% Capture (C.3 Projects)	% Capture (IRM and Green Streets Projects)	% Infiltration of Captured Volume
Bioretention	17.70	80	70	20
Bioswale	27.00	80	70	20
HDS Units	--[1]	80	70	0
Media Filter	22.4	80	70	0
Detention Basin	42.3	80	70	20

Green Roof	10.5	80	70	0
Porous Pavement	29.4	80	70	20

[1] HDS units were not assumed to reduce TSS (and therefore PCBs and HgT) loads as the International BMP database does not demonstrate significant difference between influent and effluent TSS.

2.4.3 Discharged Load

The discharged load was calculated as the sum of the BMP effluent load, determined as described above, and the bypass load, calculated as the influent concentration times the proportion of the average annual runoff volume which is not treated by the BMP. The difference between the discharged load and the inflow load is assumed to represent the total load reduction.

APPENDIX B.9.A

Pilot Stormwater Diversion Project Summary Table and Schedules

Appendix B.9.A. Pilot Stormwater Diversion Project Summmary Table and Schedules

Project Name & Location	Project Objectives	Catchment Size (acres)	Primary Land Uses	Diversion Type				Expected Diversion Flow (gpm)		Monitoring		Tasks	2012				2013				2014			
				Gravity	Pumped	Contin.	Batch	Wet weather	Dry weather	Pollutants	Other		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Alameda Ettie St. Pump Station City of Oakland	1. Evaluate load reductions 2. Pilot turbidity trigger for diversion 3. Establish particle size-POC concentration relationships 4. Project cost/benefits and challenges of larger-scale project scenarios 5. Coordinate with pilot retrofit to leverage data collection	1000	residential industrial mix commercial		X		X	25 max	25 max	Mercury, PCBs	SSC, DOC (potential), particle size, turbidity (forebay), station pumping volume, pretreatment volume, diversion volume, rainfall	1. Pre-project wet and/or dry season monitoring and analysis		■	■								
												2. Detailed planning and work plan development	■	■										
												3. Equipment installation/construction and implementation	■	■	■			■						
												3.a Large scale scenario development				■	■	■	■					
												4. Post installation/construction monitoring and analysis			■	■	■	■		■	■			
												5. Data analysis and interpretation and project reporting			■	■		■	■	■	■			
Contra Costa North Richmond Pump Station City of Richmond	1. Evaluate PCB and mercury loads avoided through pump station maintenance conducted in conjunction with diversion to a POTW. 2. Design a diversion pilot project that can be permitted for discharge to West County Wastewater District 3. Evaluate operating techniques that can treat first flush without adversely impacting POTW capacity	339	Mixed residential, light industrial; formerly used for nurseries		X	TBD	TBD	TBD	TBD	PCBs, mercury, metals	Mass sediment removed	1. Pre-project wet and/or dry season monitoring and analysis	■											
												2. Detailed planning and work plan development		■	■	■	■	■						
												3. Equipment installation/construction and implementation							■	■				
												4. Post installation/construction monitoring and analysis									■			
												5. Data analysis and interpretation and project reporting										■		

Project Name & Location	Project Objectives	Catchment Size (acres)	Primary Land Uses	Diversion Type				Expected Diversion Flow (gpm)		Monitoring		Tasks	2012				2013				2014			
				Gravity	Pumped	Contin.	Batch	Wet weather	Dry weather	Pollutants	Other		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Fairfield/Suisun State Street Pump Station	1. Evaluate pollutant loads to the Bay that are reduced due to stormwater diversion. 2. Estimate projected benefits, challenges and costs of operating a similar diversion in a similar drainage area and/or an area known to have elevated concentrations of PCBs or mercury. 3. Document the knowledge and experience gained from evaluation of the diversion project.	6	Commercial				**X**	NA	10000 gallons	Mercury, PCBs	SSC	1. Pre-project wet and/or dry season monitoring and analysis	■											
												2. Detailed planning and work plan development	■	■										
												3. Equipment installation/construction and implementation			■									
												4. Post installation/construction monitoring and analysis			■	■	■	■	■					
												5. Data analysis and interpretation and project reporting						■	■	■				
San Mateo Pulgas Creek Pump Station	1. Characterize PCB and Hg concentrations in dry & wet weather flows into the pump station and establish relationships as feasible among turbidity, SSC, and pollutant concentrations. 2. Pilot-test the practicability of using a turbidity threshold trigger to selectively divert flows with elevated turbidity and associated particle-bound pollutants and thereby optimize pollutant loads diverted.	330	Industrial		**X**		**X**	25 max	25 max	Mercury, PCBs	SSC, TOC, particle size, turbidity	1. Pre-project wet and/or dry season monitoring and analysis	NA											
											diversion and stormwater runoff volumes, rainfall	2. Detailed planning and work plan development	■	■										

Integrated Monitoring Report

Part C: PCB and Mercury Load Reduction Planning

Prepared for

Alameda Countywide Clean Water Program

Prepared by

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PREFACE

This Part C of the Integrated Monitoring Report (IMR) is submitted by the Alameda Countywide Clean Water Program (Program or ACCWP), on behalf of all the towns, cities, counties, and flood control agencies represented by the Program[1] (i.e., Permittees) subject to the Municipal Regional Stormwater National Pollutant Discharge Elimination System (NPDES) Permit (MRP, Order R2009-0074) issued by the California Regional Water Quality Control Board, San Francisco Bay Region (Regional Water Board) on October 14, 2009. This report (including all appendices and attachments), together with Part B of the IMR, fulfills the requirements of MRP provisions C.11 and C.12 to report plans for implementing control measures for reducing mercury and polychlorinated biphenyls (PCBs) to address Total Maximum Daily Load (TMDL) reductions[2] for urban runoff. These plans, which are under continuing development, are based on background information regarding individual control measures presented in IMR Part B.

Each of the sections of IMR Part B pertains to a specific type of control measure applicable to reducing urban runoff loads of PCBs and mercury, and incorporates available information on the effectiveness of each control measure to provide the following:

- Summary of MRP requirements associated with the control measure type;
- Status of control measure implementation, including baseline (pre-TMDL), current (Post-TMDL), and enhanced implementation;
- Descriptions of loads avoided/reduced calculation methodology;
- Estimates of baseline and current loads avoided/reduced; and
- A summary of uncertainties associated with control measure effectiveness and loads avoided/reduced calculations.

Table P-1 below shows the locations of reporting information in IMR Parts B and C.

[1]Cities of Alameda, Albany, Berkeley, Dublin, Emeryville, Fremont, Hayward, Livermore, Newark, Oakland, Piedmont, Pleasanton, San Leandro, and Union City; Alameda County; Alameda County Flood Control and Water Conservation District; and Zone 7 Water Agency

[2] California Regional Water Quality Control Board San Francisco Bay Region. San Francisco Bay Basin (Region 2) Water Quality Control Plan (Basin Plan), Chapter 7: Water Quality Attainment Strategies Including Total Maximum Daily Loads. June 29, 2013.

Table P-1: Municipal Regional Permit Provisions Addressed by Integrated Monitoring Report Parts B and C

Provision	Provision Topic	IMR Part B Sections	IMR Part C
C.11.a	Collection and Recycling of Mercury-containing Devices(a)	Section B.2	N/A
C.12.a	Identification of POCs During Industrial Inspections [1]	Section B.3	N/A
C.11.b	Monitoring Methylmercury [2]	N/A	N/A
C.12.b	Evaluations of BMPs for Building Demolition and Renovation	Section B.8	N/A
C.11/12.c	Investigations and Abatement of Sources in Drainages	Section B.4	Section C.3.2
C.11/12.d	Enhanced Municipal Operation and Maintenance Practices	SectionsB.5 & B.6	Section C.3.2
C.11/12.e	On-Site Stormwater Treatment via Retrofits	Section B.7	Section C.3.2
C.11/12.f	Diversions to Publicly Owned Treatment Works	Section B.9	Section C.3.2
C.11/12.g	Stormwater Loads and Loads Reduced	Incorporated in all sections	Section C.3.2
C.11/12.h	Fate and Transport Studies [3]	N/A	Section C.4.1
C.11/12.i	Regional Risk Reduction	N/A	Section C.4.2
C/11.j	Mercury Allocation Sharing	N/A	Section C.4.3

Notes:
1 MRP reporting primarily addressed in Permittee Annual Reports.
2 Design, methods, and results of methylmercury monitoring are reported in IMR Part A.
3 Primarily conducted through the Regional Monitoring Program for Water Quality in San Francisco Bay (RMP)
N/A – Not addressed.

The most current information available on POC sources to MS4s in the Bay area, the cost and effectiveness of stormwater control measures, and uncertainties associated with sources and control measure benefits was used in the development of this report. That said, information regarding sources, loads, costs, and benefits remains limited. Therefore, the results and conclusions presented in this report should be considered preliminary and as additional information becomes available, Permittees may choose to incorporate new information in this IMR Part C through revision or by addenda.

ACKNOWLEDGEMENTS

The Bay Area Stormwater Management Agencies Association (BASMAA) collaboratively developed a three-part outline for preparation of the IMR to coordinate IMR preparation on a countywide basis as prescribed in MRP provision C.8.g.v. Part A of the IMR fulfills reporting for Water Quality Monitoring conducted in accordance with the requirements of MRP provision C.8.

IMR Part B was prepared jointly by all MRP Permittees as a BASMAA project with the following objectives:

- Report on the effectiveness of PCB and mercury control measures implemented in compliance with the MRP, including estimates of loads reduced; and,
- Identify the chosen monitoring/measurement approach concerning PCB and mercury loads assessment and estimations of loads reduced.

The source mapping portion of this IMR Part C was developed in collaboration with EOA, Inc. as a collaborative project with the San Mateo Countywide Water Pollution Prevention Program (SMCWPPP) and the Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP). The conceptual framework for implementation plans was developed through discussions among representatives of ACCWP, SMCWPPP, SCVURPPP and other stormwater programs.

C.1 Introduction and Objectives

Background

Concentrations of polychlorinated biphenyls (PCBs), mercury, and other pollutants (collectively referred to as Pollutants of Concern or POCs) in San Francisco Bay (Bay) sport fish are believed to pose a health risk to those consuming these fish. Municipal separate storm sewer systems (MS4s) are one of the sources/pathways of POCs identified in Total Maximum Daily Load (TMDL) water quality restoration programs developed by the California Regional Water Quality Control Board, San Francisco Bay Region (Regional Water Board).[3] Local public agencies (i.e., Permittees) subject to requirements in National Pollutant Discharge Elimination System (NPDES) permits for MS4 discharges are required to implement control measures in an attempt to reduce POCs from entering stormwater runoff and the Bay. Reductions from MS4s are anticipated to assist with restoring water quality in the Bay and reducing the levels of POCs in Bay fish. These control measures, also referred to as best management practices (BMPs), are the tools that Permittees can use to assist in restoring water quality in the Bay.

NPDES permit requirements associated with Phase I Permittees in the Bay area are included in the Municipal Regional Permit (MRP), which was issued to 76 cities, counties, and flood control districts in 2009. Consistent with the TMDL plans, provisions C.11 and C.12 of the MRP require the implementation of control measures to reduce POCs in urban stormwater runoff. The results and findings of control measure implementation and effectiveness evaluations conducted to-date are presented in Integrated Monitoring Report (IMR) Part B.

Objectives and Management Questions

This report, IMR Part C, builds upon the information presented in Part B and is intended to achieve the following objectives:

- Demonstrate full compliance (in combination with IMR Part B) with the March 15, 2014 MRP reporting requirements associated with C.11 (mercury) and C.12 (PCB) provisions;
- Provide an initial analysis of watershed areas that may have high, moderate, and low/no opportunity for POC load reduction from MS4s, based on the water quality monitoring data collected during the term of the MRP;
- Evaluate the costs and benefits of implementing different control measure implementation scenarios intended to significantly reduce POCs in MS4 discharges to the Bay;
- Develop preliminary cost estimates for implementing POC control measures described in IMR Part B; and

[3]See IMR Part B for additional information on POC sources and pathways.

- Provide preliminary guidance for future POC control measure implementation, including further information/data collection necessary to cost-effectively reduce POCs in Bay fish tissue and achieve water quality standards in the Bay.

Consistent with these objectives, IMR Part C is intended to provide preliminary answers to the following core management questions:

- Which watershed characteristics correlate well with watershed areas that have high, moderate, and low/no opportunity for POC load reduction?
- What proportion of POC loads from MS4s is attributable to high, moderate, and low/no opportunity areas?
- What are the costs and benefits of implementing various control measure strategies in high and moderate opportunity areas?
- What additional information is needed to verify the location of high and moderate opportunity areas where control measures should be considered?
- What is the recommended process for collecting such information and identifying the most cost effective control measure strategies for specific high and moderate opportunity areas?

Organization of IMR Part C

The organization of Part C is based on the objectives and associated management questions listed above. Section 2 includes the results of an analysis of water quality monitoring data, land use information, and other Bay area data/information designed to identify areas within each Permittee's jurisdiction that may have elevated sources of POCs and contribute disproportionately to POC loads to the Bay via MS4s. Estimated average annual PCB and total mercury loading rates (mg/acre/yr) and loads (grams/yr) associated with MS4s are provided in this section and related appendices.

Section 3, provides an implementation planning framework and approach for the ACCWP Permittees. This section also includes an analysis of costs and water quality benefits for MS4 control measure implementation scenarios for the three implementation tiers established by the implementation planning framework, which include various source and treatment controls.

Section 4fulfills MRP reporting requirements associated with POC fate and transport studies (C.11.h/C.12.h), risk reduction program implementation (C.11.i/C.12.i), and the allocation sharing scheme with Caltrans for mercury urban runoff loads (C.11.j).

C.2 Identification of Areas with Elevated Sources and Loads

In this section, water quality monitoring, land use, and other recently collected or compiled Bay area data are used to provide an initial identification of areas within each Permittee's jurisdiction that may have elevated sources of POCs and contribute disproportionate loads to the Bay via MS4s. The data were analyzed to develop relationships between POC yield (e.g., grams/acre/year) and land use characteristics. Based on this preliminary analysis, results are provided for the projected mean annual PCB and total mercury (HgT) loads (i.e., grams/year) associated with runoff from areas located within each Permittee's geographical boundary. Assumptions used to conduct this analysis and sources of uncertainties are also discussed. This analysis was conducted using the most recent information on POC loading rates from Bay area watersheds (Davis et al., 2013) and knowledge of POC sources located within these land areas.

C.2.1 Methodology

The methodology presented in this section was developed to assist Permittees in identifying which watershed characteristics correlate well with areas that have high, moderate, and low rates of POC loading to receiving waters via stormwater. The methodology was based on the collective understanding of Bay area Permittees and scientists on the types of land areas, facilities, and activities that generate POCs, with a focus on PCBs. The ultimate goal of the analysis was to assist Permittees in identifying high opportunity areas for POC load reduction in the future and to provide first order estimates of POC loading rates from high, moderate, and low opportunity areas.

C.2.1.1 <u>Source Area Mapping</u>

Based on the uses and sources of PCBs and mercury in the urban environment, and the results of PCB source identification and abatement studies described in IMR Part B, PCB sources (and to a lesser extent mercury) are generally associated with watershed areas where equipment containing POCs were transported or used and facilities that recycle POCs or POC-containing devices and equipment. These sources include current and historic metal, automotive, and hazardous waste recycling and transfer stations; electrical properties and power plants; and rail lines. These sources are typically located in land use areas that were industrialized between the late 1920's and the late 1970's, the timeframe when PCB and mercury production were the greatest in the U.S.

To assist Permittees in identifying potential POC sources and source areas, a number of preliminary GIS data layers were developed using existing and historical information on land use and facility types that were located in the Bay area during the early to mid 20th century. GIS data layers include a revised "old industrial" land use layer that attempts to depict industrial areas present in 1968; an "old urban" land use layer that depicts urban areas developed by 1974, other than those depicted as "old industrial"; points depicting current facilities that have the potential

to have or have had PCBs on site; and historical and current rail lines where PCBs may have been transported.

Old Industrial Land Areas

Three sets of data layers were acquired and served as the primary sources of information used to create the old industrial data layer: 1) the 2005 version of the Association of Bay Area Governments (ABAG) land use data layers for the five Bay area counties, which depicts current industrial land use areas; 2) 1968 aerial photographs for the Bay area at 30,000 scale acquired from the United States Geological Survey's (USGS) Earth Explorer website; and 3) the most currently available County Assessor parcel data layers for Bay area counties. Through the development of the "old industrial" layer, two data layers were created. The first depicts industrial land areas in 1968 that are not currently characterized as industrial by ABAG. This data layer was created by panning through 1968 aerial photography and identifying industrial land areas outside of the areas characterized as industrial land use in roughly 2005 by ABAG. The purpose of this layer was to identify potential industrial facilities that were present in 1968, but possibly redeveloped or incorrectly identified within the ABAG land use data. The second data layer that was created depicts areas characterized by ABAG in 2005 as industrial land uses that were clearly not industrial in the 1968 aerial photographs. Most of these areas were developed into industrial land uses after 1968 and are most commonly agricultural in the aerial photographs. All parcels that were identified as at least partially industrial in 1968 were visually checked in the data layer to provide greater confidence in its accuracy. Minor edits were then made based on this quality assurance check. If there was uncertainty as to whether a parcel in the 1968 photographs was industrial, then the parcel was classified based on the ABAG land use data. As a final check, the 1968 aerial photographs were also compared to current aerial photographs and each parcel that had been redeveloped was attributed with the current land use, even if that land use remained industrial.

Old and New Urban Land Areas

"Old Urban" and "New Urban" land use data layers that depict areas urbanized prior to and after 1974, respectively, were developed using an urban extents data layer from 1974, the closest year to 1968 that the data were available. All areas that were within the urban extent in 1974 were defined as old urban; those areas that fell outside of this definition were classified as new urban.

Identification of Potential POC Associated Facilities

Point data were collected for a number of facility types that may be associated with either PCBs or mercury. These facility types include those associated with electrical generation, known mercury emitters, metal manufacturing, drum recycling, metal recycling, shipping, automotive recycling, general recycling, and those known to have or historically have had PCBs in use. This information was primarily gathered by the San Francisco Estuary Institute (SFEI) as part of the Urban Stormwater BMPs Proposition 13 Grant project and contains data from a variety of

sources, including the California Air Resources Board, Envirostar, Superfund, Department of Toxic Substances Control, and the State Water Resource Control Board.

Certain facility types for which point data were developed were mapped in greater detail to develop polygons to allow area calculations to be performed. Of particular interest for PCBs were the several hundred electrical substations in the Bay area. Areas for these facilities were delineated using current and 1968 aerial photographs to attribute whether each facility was built prior to or after 1968. Additionally, military, port, and railroad land uses areas were developed using ABAG 2005 land use data and the latest assessor's parcel data. Military parcels were further edited to only include developed areas.

Land use and facility data layers created as part of this effort were then combined to create one contiguous data layer. This data layer was attributed with additional information such as city, county, and watershed. Table 2.1 lists the acreage within each municipality's boundary within old industrial, old urban, new urban, open space, and other land use categories. Definitions of each land use category are provided within the footnotes to the table.

Table 2-1: Land Use Area (Acres) for Each Municipality in Alameda County

	Land Use Category					
	1	2	3	4	5	
Agency	Old Industrial	Old Urban	New Urban	Open Space	Other	Total
Alameda	197.3	3224.5	964.5	604.2	1627.2	6617.7
Alameda County	575.6	10155.2	1015.9	126668.8		138415.6
Albany	42.3	1016.9	6.5	63.3		1128.9
Berkeley	379.8	6118.0	147.3	70.0		6715.1
Dublin	9.8	2057.7	2290.7	3792.5	1199.7	9350.4
Emeryville	418.3	292.2	54.2	21.3		786.0
Fremont	1003.1	12054.3	7831.2	17949.2		38837.8
Hayward	1247.4	8692.1	2959.8	6054.1	462.3	19415.7
Livermore	929.7	5302.5	5503.2	4886.5	333.1	16954.9
Newark	479.9	2795.0	1268.0	1077.0		5620.0
Oakland	3899.9	21086.1	1073.8	5094.8	2100.8	33255.4
Piedmont		1079.5		6.9		1086.4
Pleasanton	72.5	3945.2	8245.2	2929.6		15192.6
San Leandro	1382.0	5434.7	664.5	582.4		8063.6
Union City	491.8	3309.8	1475.3	7003.3		12280.2
Total	11129.5	86563.5	33500.2	176803.8	5723.2	313720.1

Notes:
Land use categories are defined as follows:

1 Electrical Property – Old, Industrial – Old, Industrial - Old - Now Open Space/Vacant, Industrial - Old - Now Redeveloped, Port, Railroad
2 Freeway, Urban Old – Commercial, Urban Old – HDR, Urban Old – LDR, Urban Old - Other
3 Electrical Property – New, Industrial – New, Urban New – Commercial, Urban New – HDR, Urban New – LDR, Urban New – Other
4 Agriculture, Open Space
5 Airport, Military

C.2.1.2 PCB and Mercury Yield and Loads Analysis

The analysis consisted of the following steps:

- Review watershed yield data,
- Characterize watersheds in terms of yield,
- Develop regression equations linking yields to watershed attributes, and
- Apply regression equations to estimate loads at the municipal scale.

C.2.2 Results

C.2.2.1 Review of SFEI Watershed Yield Data

The San Francisco Estuary Institute (SFEI) recently released the draft *PCB Synthesis Report* (Davis et al., 2013) that summarizes what has been learned from monitoring PCBs in San Francisco Bay and in the watersheds that discharge to the Bay. Data are presented for various media including fish tissue, sediment, and water. Watershed monitoring results are also provided where yield estimates are made for monitored watersheds (Figure 2-1).

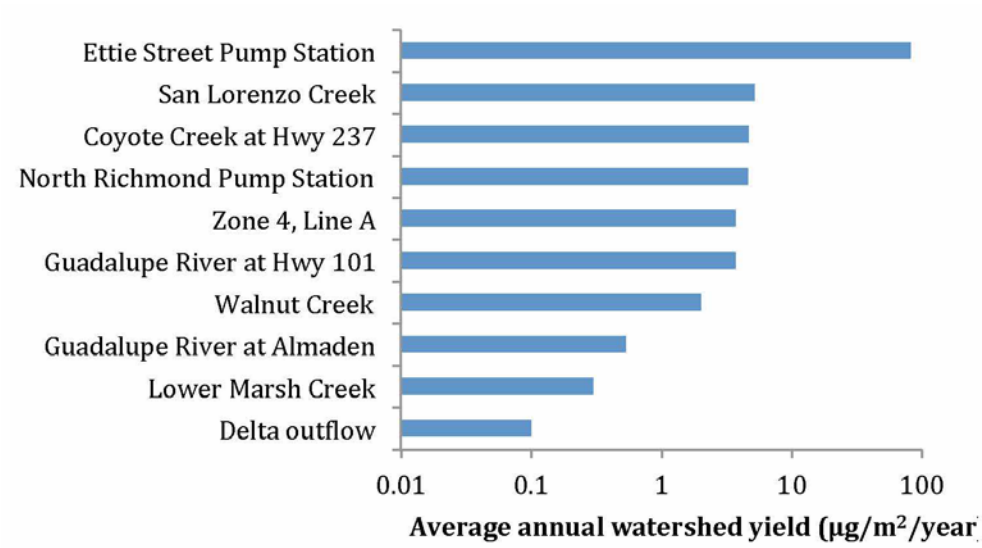

Figure 2-1: Average Annual Watershed Yield

SFEI also reported yield estimates for Lower Marsh Creek, San Lorenzo Creek, Walnut Creek, Sunnyvale East Channel, and the Ettie Street Pump Station (ESPS) in the *POC Loads Monitoring Data, Water Year 2011 Report* (Table 13; McKee et al., 2012). The estimates of yield from these sources (ranked by yield) are provided in Table 2-1 below. These yield estimates cover a range from approximately 0.1 to 80 µg/m^2/yr. The lowest yield is associated with the Delta outflow and the highest yield is associated with the ESPS.

Table 2-2: Mean Annual PCB Yield Estimates

Watershed	PCB Yield [µg/m^2/yr]	PCB Yield [µg/acre/yr]	Watershed Cluster No.[1]
Ettie Street Pump Station	82	320,000	1
Sunnyvale East Channel (H)	8.8	34,000	2
Sunnyvale East Channel (L)	4.8	19,000	2
Coyote Creek at Hwy 237	4.8	19,000	6
North Richmond Pump Station	4.7	19,000	NA
Zone 4, Line A	3.8	15,000	1
Guadalupe River at Hwy 101	3.8	15,000	6
San Lorenzo Creek	2.6	10,000	6
Walnut Creek	2.0	8,100	6
Guadalupe River at Almaden	0.54	2,200	6
Lower Marsh Creek	0.30	1,200	NA
Delta Outflow	0.10	400	NA

Notes:
Sources: PCB Synthesis Report (Davis et al., 2013) and POC Loads Monitoring Report WY 2011 (McKee et al., 2012).
NA – not identified in list of watersheds in *Exploratory Categorization of Watersheds for Potential Stormwater Monitoring in San Francisco Bay* (Greenfield et al., 2010).
1 From *Exploratory Categorization of Watersheds for Potential Stormwater Monitoring in San Francisco Bay* (Greenfield et al., 2010). Clusters are a function of land cover, imperviousness, historic industrial land use, and other features.

Yield estimates for HgT provided in the *POC Loads Monitoring Report, WY 2011* (Table 13, McKee et al., 2012) are summarized in Table 2-2 below.

Table 2-3: Mean Annual Total Mercury Yield Estimates

Watershed	HgT Yield (µg/m2/year)	HgT Yield (µg/acre/yr)	Watershed Cluster No.
Ettie Street Pump Station	79	300,000	1
Walnut Creek	29	110,000	6
Sunnyvale East Channel (H)	23	88,000	2
Sunnyvale East Channel (L)	13	50,000	2
Lower Marsh Creek	9	35,000	NA
San Lorenzo Creek	8	31,000	6

Notes:
Source: *POC Loads Monitoring Data WY 2011* (Table 13, McKee et al., 2012)
NA – not identified in list of watersheds in *Exploratory Categorization of Watersheds for Potential Stormwater Monitoring in San Francisco Bay* (Greenfield et al., 2010).

C.2.2.2 Watershed Characterization

The yield data summarized above indicates that yields vary between watersheds. Therefore, an analysis was conducted to look for trends between yield and watershed characteristics.

SFEI has conducted a watershed characterization study where they categorized 185 watersheds in the Bay Area into eight "clusters" depending on land cover, imperviousness, historical industrial land use, and other features (Greenfield et al., 2010). As indicated in Tables 2-1 and 2-2 above, the watersheds for which yield estimates are available fall into cluster numbers 1, 2 or 6, where the clusters (and the number of watersheds classified within each cluster) are defined as:

- Cluster No. 1: high commercial and residential land cover and imperviousness, high historic industry and railroads, no PG&E facilities, moderate area (41 watersheds)
- Cluster No. 2: High commercial and residential land cover and imperviousness, high historic industry and railroads, one to four PG&E facilities, large area (43 watersheds)
- Cluster No. 6: largest watersheds, with moderate population density, high open land cover, and low imperviousness (22 watersheds)

This analysis indicates that generally the highest yielding watersheds tend to be in clusters 1 and 2, which are the smaller, more developed and impervious watersheds.

A further analysis was conducted by Geosyntec to examine if the watersheds could be classified based on observed water quality, rather than watershed characteristics alone. For this purpose, data collected as part of the reconnaissance study conducted by McKee et al. (2012) were examined[4]. Figure 2-2 below shows mean particle ratio[5] and mean total PCB concentrations measured at various locations in the reconnaissance study (total of 17 watersheds). The bars represent the range of observations. The data clearly distinguish two categories of watersheds, a set of watersheds (black circles) in contrast to elevated watersheds (red squares) where concentrations are significantly higher. (A similar distinction was found by McKee et al. (2012) in their analysis of particle ratio data.)

The elevated watersheds consist of ESPS, Santa Fe Channel, Pulgas Creek North, and Pulgas Creek South, of which the latter three watersheds are in Cluster No. 2. Those watersheds near the origin of Figure 2-2 have moderate discharge quality in contrast to the elevated watersheds, and are referred to herein as "baseline watersheds." The concept being that, unless data indicate that a watershed is elevated, the best estimate of loads would be derived from data describing the baseline watersheds.

A similar analysis for HgT indicated that most of the watersheds that were higher in PCB concentrations were also higher in HgT concentrations, but the data exhibited more of a continuum (see Figure 4, McKee et al., 2012). So the decision was made to not distinguish watersheds for HgT as was done with PCBs, but rather to assume that all the watersheds were in the same population. This decision was also driven in part by the more limited data set that is available for HgT yield.

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[4]Source of Data: California Environmental Data Exchange Network (CEDEN), SFEI River Loading Study Program, http://www.ceden.us/AdvancedQueryTool

[5] The particle ratio is the ratio of the pollutant of concern concentration (e.g., PCB concentration) to the suspended sediment concentration, for a water sample.

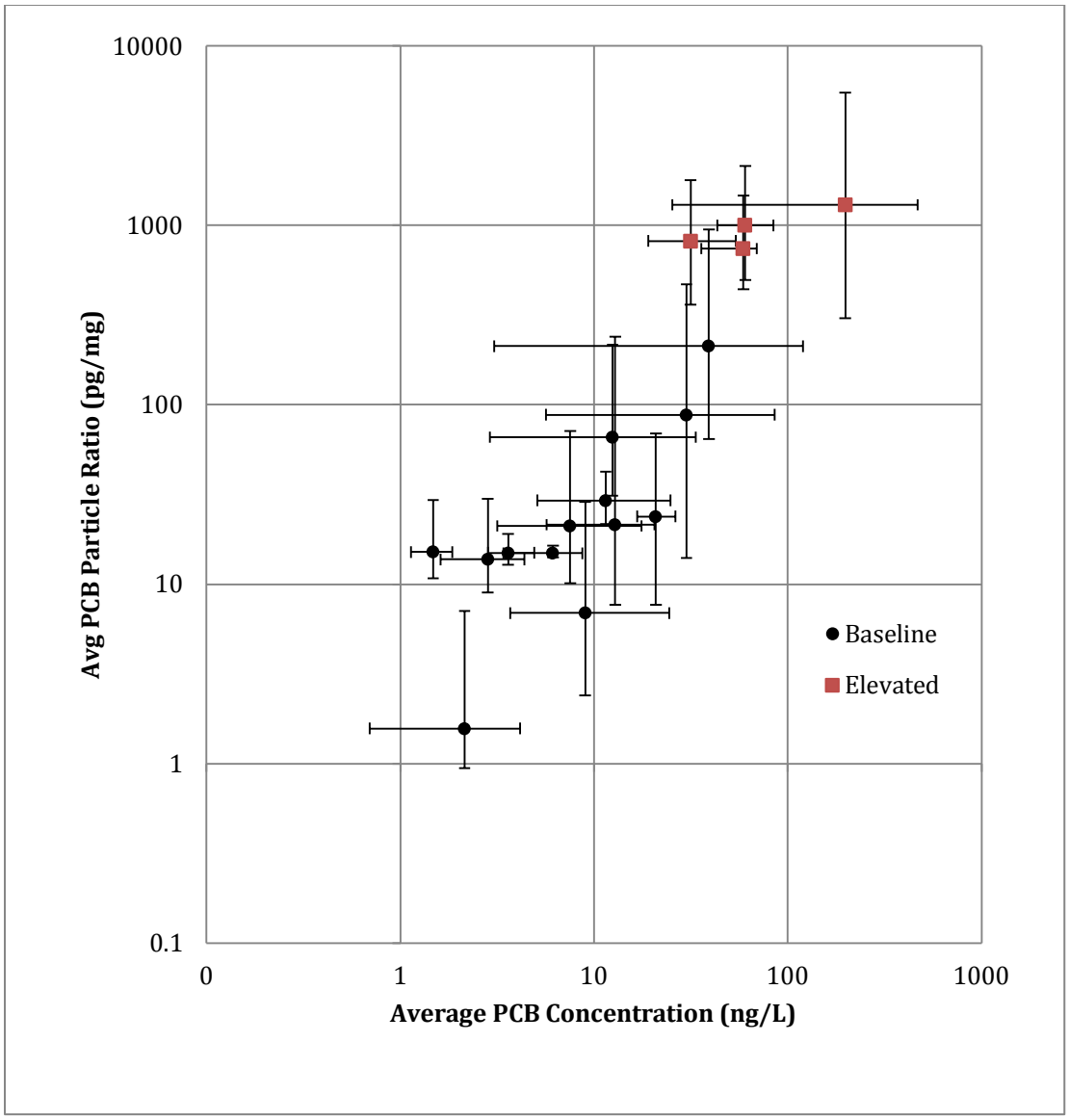

Figure 2-2: Mean and Range of PCB Concentrations in Various Watersheds

C.2.2.3 <u>Regression Analysis</u>

A regression analysis was conducted using data collected by McKee et al. (2012) for selected baseline watersheds where measured yields were available (from Davis et al., 2013). The selected watersheds were San Lorenzo Creek, North Richmond Pump Station, Zone 4 Line A, Guadalupe River at 101, Marsh Creek and Walnut Creek. Coyote Creek at 237 was not considered representative in that most development in the watershed is relatively new; that is, the sum of old industrial and old urban land uses represents 22 percent of the watershed compared to 37 percent for the Walnut Creek watershed and 70 percent for the Guadalupe River at 101 watershed.

To simplify the regression, land use categorizations from the basemap described in Section C.2.1 above were aggregated into five categories (Table 2-3).

Table 2-4: Land Use Categories for Regression Analysis

Specific Category	General Category
Electrical Property - Old	1 – Old Industrial
Industrial - Old	1 – Old Industrial
Industrial - Old - Now Open Space/Vacant	1 – Old Industrial
Industrial - Old - Now Redeveloped	1 – Old Industrial
Port	1 – Old Industrial
Railroad	1 – Old Industrial
Freeway	2 – Old Urban
Urban Old - Commercial	2 – Old Urban
Urban Old - HDR	2 – Old Urban
Urban Old - LDR	2 – Old Urban
Urban Old - Other	2 – Old Urban
Electrical Property - New	3 – New Urban
Industrial - New	3 – New Urban
Urban New - Commercial	3 – New Urban
Urban New - HDR	3 – New Urban
Urban New - LDR	3 – New Urban
Urban New - Other	3 – New Urban
Agriculture	4 – Open Space
Open Space	4 – Open Space
Airport	5 – Other
Military (Developed Areas Only)	5 – Other

The form of the linear regression equation is:

Yield (mg/acre/yr) = [(A x area (old industrial) + B x area (old urban) + C x area (new urban) + D x area (open) + E x area (other)]/Total Area

Where the coefficients are:

A = 50 mg/acre/year (old industrial)

B = 17.5 mg/acre/year (old urban)

C = 2 mg/acre/year (new urban)

D = 2.5 mg/acre/year (open space)

E = 2 mg/acre/year (other)

The regression analysis results show the importance of land use type on yield, with old industrial having the highest yield. This is consistent with the analysis conducted by McKee et al. (2012), which showed a positive correlation between PCB concentrations and historic industrialization. Old urban also has a modest effect, and the effects of other land uses are negligible. Figure 2-3 below shows how the predicted yields using the regression equation compare to the reported yields from SFEI based on measurements. An R^2 of 0.87 indicates that approximately 87 percent of the variability in PCB yields could be explained by land use.

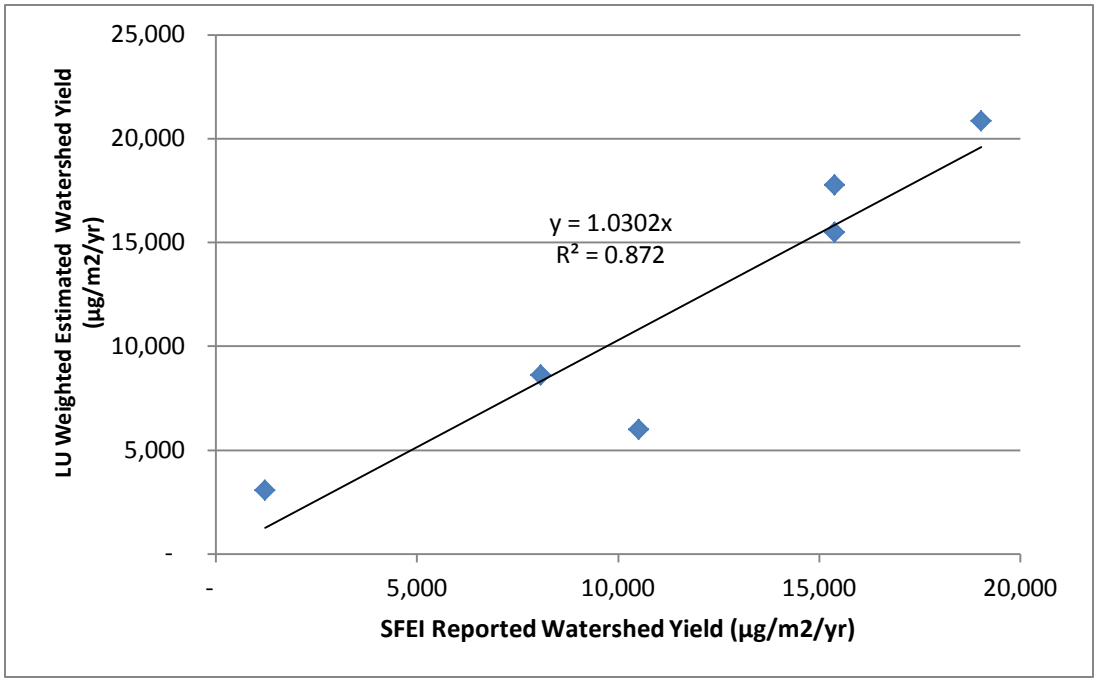

Figure 2-3: PCB Yields Using Linear Regression versus Estimated Yields Based on Monitoring Data

A linear regression analysis was also conducted for HgT which resulted in the following regression coefficients.

A = 1,000 mg/acre/year	(old industrial)
B = 165 mg/acre/year	(old urban)
C = 25 mg/acre/year	(new urban)
D = 25 mg/acre/year	(open space)
E = 20 mg/acre/year	(other)

Figure 2-4 below shows how well the linear regression replicated the SFEI reported data. The R^2 of 0.76 indicates that land use explains about 76 percent of the variability in estimated yields. The importance of old industrial, and to a lesser extent old urban land use, similar to that with PCBs, is illustrated by the magnitude of the coefficients for these land uses.

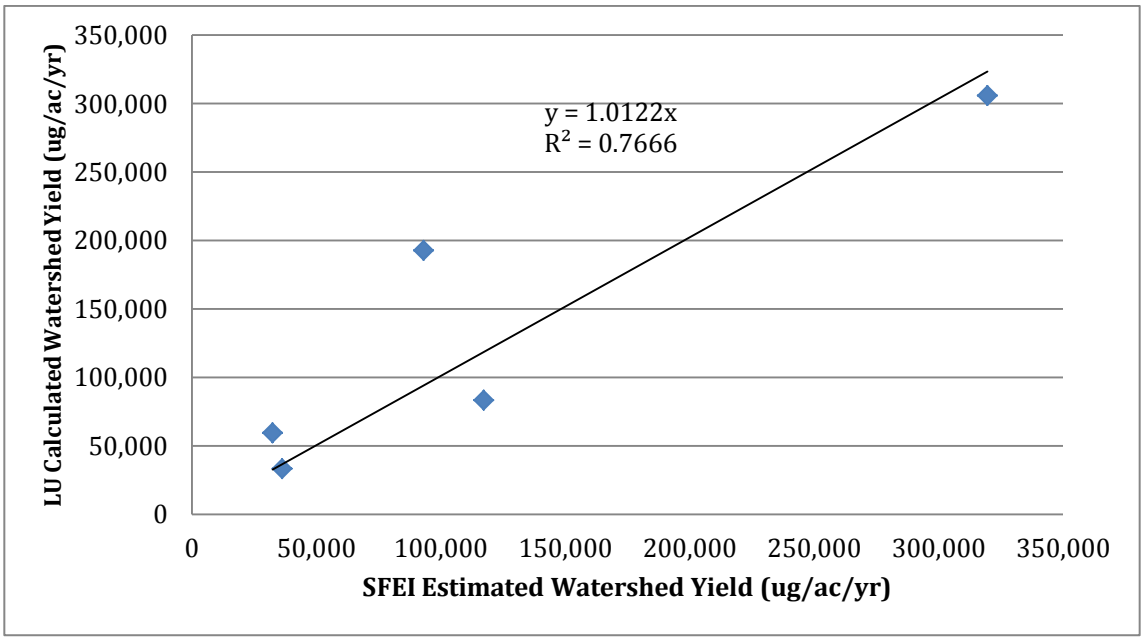

Figure 2-4: Total Mercury Yields Using Linear Regression versus Estimated Yields Based on Monitoring Data

C.2.2.4 <u>Load Projections</u>

The regression equations were applied to the aggregated land uses (old industrial, old urban, new urban, open, and other(see Table 2-3)) to estimate the mean annual PCB and HgT loads for each municipality in Alameda County, except for the PCB load from the ESPS watershed. For the ESPS watershed, the SFEI estimated PCB yield shown in Figure 2-1was applied to estimate PCB load rather than the regression equation developed for the baseline watersheds.

Maps that display the spatial distribution of the five land use categories listed in Table 2-3 for each municipality in Alameda County are provided in Appendix A. Loading estimates based on the regression analysis for PCBs and HgT are provided for each municipality in Alameda County in Appendix B.

C.2.3 Limitations and Uncertainty

There are a variety of sources of uncertainty in the load projections including:

- Elevated Watersheds – The data, especially for PCBs, indicate that there are some watersheds where concentrations are elevated relative to other monitored watersheds, and that these elevated watersheds have high PCB yields and therefore contribute disproportionately to loads. There may be additional elevated watersheds that have not been identified because of the limitations in monitoring.
- Land Use Database Accuracy– Land use is the basis for the regression analysis, and not only is the type of land important, but in the case of PCBs the age of the land use also is critical. The land use data therefore is attempting to characterize the historical evolution of land use based on available sources and aerial photo interpretation. The land use maps have not been "ground truthed" at this time and therefore pose an important limitation in the analysis.
- Data Limitations– Limitations in the monitoring data used to estimate yields include the limited number of watersheds, the limited number of storm events sampled, and limited grab sample collection.
- Land Use as a Surrogate– Land use is used as a surrogate for actual PCB and mercury sources, and although the types of potential sources have been identified, the actual locations and sizes of sources are difficult to determine at this level of analysis. So the same land use type in different locations and municipalities may have very different sources and thus distinctly different PCB and mercury concentrations in runoff.

In summary, it is difficult to assess the quantitative implications of these limitations on the magnitude of the projected loads, especially as one moves from regional to smaller spatial scales. Experience with the difficulty in making loading estimates suggests that readers consider the projected loads as first order estimates only.

C.3 Implementation of Enhanced Control Measures

C.3.1 Implementation Planning Framework and Approach

C.3.1.1 Planning Framework

BASMAA and the Regional Water Board staff have identified a framework for PCB TMDL implementation planning which incorporates three tiers of source areas with different potential PCB yield and load reduction opportunities, described below as they apply to the ACCWP Permittees:

- High Opportunity (Tier 1) – The PCB yield in these areas is known to be high with enough certainty to begin evaluating implementation options. The Ettie Street Pump Station (ESPS) watershed is confirmed as a High Opportunity area. This report describes a menu of enhanced control measures to be considered by the City of Oakland and the Alameda County Flood Control and Water Conservation District (ACFCWCD) for early implementation during the next permit term in the ESPS watershed.
- Potential High Opportunity (Tier 2) – The PCB yield in these areas are moderate as an overall average; the available PCB screening data are limited but show that localized areas vary from low to high PCB yield. A preliminary estimate of the total acreage of these areas is provided below based on an analysis of available screening data. The location and extent of these areas will be identified by the relevant Permittees working with the ACCWP beginning in 2014. The planned work will involve gathering information at the municipal scale to identify High Opportunity areas and to rank or prioritize them for further analyses of feasibility/opportunity for implementing enhanced control measures during the next or subsequent permit terms.
- Moderate Opportunity (Tier 3) – The PCB yield in these areas is moderate as an overall average, although the total load from this area is significant due to the large area. As the planning process progresses, Moderate Opportunity areas will include areas initially classified as Potential High Opportunity that future information/analyses indicate would not be High Opportunity areas for enhanced control measures. Permittees will include these areas, along with the areas currently classified as “Other Old Urban,” in long-term master planning efforts to identify potential opportunities and funding sources for enhanced control measures. These planning efforts are likely to be related to redevelopment areas, green street infrastructure projects, and trash control retrofits.

The remaining land use areas, classified as New Urban and Open Space on the maps provided in Appendix A, are low/no opportunity areas that will not be carried forward in the implementation planning efforts.

Section C.3.2 below discusses the preliminary analysis and results associated with characterizing each of these three tiers and the development of control measure scenarios and associated load

reduction estimates. A cost effectiveness analysis of control measure implementation scenarios is also provided.

C.3.1.2 ACCWP Planning Approach

A PCB Reduction Strategy Workgroup (Workgroup) was formed consisting of ACCWP staff and key Permittees to develop the PCB enhanced control measure implementation planning approach and preliminary schedule summarized in Table 3-1 below. The planning approach consists of the following four steps:

- Step 1: Identify High Priority Areas. In this step, the preliminary maps presented in this report will be refined using a desktop analysis and input from the Permittees. Data will be collected on the Potential High Opportunity areas to resolve characterization questions, so that these areas can be reclassified as either High Opportunity or Moderate Opportunity. Final GIS maps will then be prepared to illustrate the High Opportunity and Moderate Opportunity areas within each jurisdiction.
- Step 2: Identify PCB Load Reduction Opportunities. This step includes identifying existing enhanced control measures that have been implemented since 2002, selecting early implementation enhanced control measures for the ESPS watershed, selecting enhanced control measures for the newly identified High Opportunity areas, and coordinating with municipal planning processes to identify potential opportunities and funding sources in the Moderate Opportunity areas.
- Step 3: Assess Candidate Control Measures. In this step, the effectiveness, cost, ease of implementation, and other benefits for candidate enhanced control measures for High Opportunity and Moderate Opportunity areas will be evaluated. Concept designs, cost estimates, and construction schedules will be prepared for early implementation enhanced control measures in the ESPS watershed.
- Step 4: Compile Plan Identifying Activities and Schedule. The final step is to prepare the implementation plans, including this IMR, a supplement to the IMR to incorporate the results of the activities conducted in 2014 to help inform the MRP renewal process, a Focused Implementation Plan, and a Long Term Implementation Plan.

As shown in the schedule portion of Table 3-1, some activities in the planning process have been implemented as part of developing this report. The Workgroup may modify or adapt portions of the schedule in response to new information or to coordinate with ongoing discussions with BASMAA and Regional Water Board staff.

Table 3-1: ACCWP PCB Implementation Planning Approach Activities and Schedule

Step	Implementation Planning Activity	Timeframe
1A	Develop preliminary source area maps for each municipality	IMR
1B	Revise preliminary maps by identifying known redeveloped parcels and major PCB remediation sites that have completed cleanup in the Potential High Opportunity areas and moving them into the Moderate Opportunity category [go to: 2B]	2014
1C	Revise preliminary maps through desktop analysis to identify other parcels that are incorrectly categorized as Old Industrial - move them to Moderate Opportunity	2014
1D	Collect information for screening the Potential High Opportunity areas (to identify them as either High Opportunity or Moderate Opportunity)– review history and records, windshield surveys, sample sediment or water to resolve characterization questions	2014
1E	Revise maps to re-categorize parcels from Potential High Opportunity into either High Opportunity or Moderate Opportunity [go to: 2D or 2E]	2014 - 2015
2A	Preliminary identification of enhanced control measures implemented since July 2002 [go to: 4A, 1D]	2014
2B	Estimate reductions achieved from redevelopment and site cleanups since July 2002 [go to: 4A, 1D]	2014
2C	Identify opportunities for known High Opportunity areas (i.e., Ettie Street Watershed) [3A, 1D]	2014
2D	Identify opportunities for newly identified High Opportunity Areas [go to: 3D]	2014 - 2015
2E	Coordinate with municipal planning processes to identify potential opportunities and funding sources in Moderate Opportunity areas [go to: 4C]	2015 - 2016
3A	Evaluate potential suite of enhanced control measures with municipality input [go to: 3B, 3D]	IMR
3B	Evaluate the effectiveness, cost, ease of implementation, and other benefits for candidate control measures for early implementation in ESPS and watershed [go to: 3C]	2014
3C	Prepare concept design, cost estimate, and construction schedule for selected early implementation control measure in ESPS watershed [go to: 4C]	2014
3D	Evaluate the effectiveness, cost, ease of implementation, and other benefits for candidate control measures for newly identified High Opportunity areas [go to: 3E]	Q1/Q2 2015
3E	Conduct site-specific feasibility assessment to select control measures for newly identified High Opportunity areas [go to: 4C]	Q3/Q4 2015
3F	Evaluate the effectiveness, cost, ease of implementation, and other benefits for candidate control measures in Moderate Opportunity areas [go to: 4D]	2015
4A	Prepare IMR Part C showing preliminary maps/lists of PCB control areas, early implementation actions, and discuss planning process for developing the focused and long term implementation plans	IMR
4B	Prepare IMR supplement incorporating updates to 4A, especially focused planning	2014
4C	Develop Focused Implementation Plan (focused on High Opportunity areas)	2015
4D	Develop first version Long Term Implementation Plan (including timeline for adaptive updates)	2015

C.3.2 Load Reduction Analysis for Enhanced Control Measures

C.3.2.1 High Opportunity Area (Tier 1)

Estimated Area

The total area of the ESPS watershed is approximately 1,180[6] acres and the watershed contains about 215 acres of Old Industrial land use. To estimate the amount of High Opportunity area within the ESPS watershed, the locations within Old Industrial (or similar to Old Industrial) land use where sediment samples exceeded 1 mg/kg (about the 75th percentile PCB concentration) were identified.[7] The area of Old Industrial parcels found adjacent to these sampling locations, about 38 acres, was designated as High Opportunity (shown in blue on Figure 3-1). The results of this estimation method suggest that the High Opportunity area within the ESPS watershed represents roughly 18% of the total Old Industrial land use area within the ESPS watershed (Table 3-2).

Table 3-2: Fraction of High Opportunity Land Area in ESPS Watershed

ESPS Watershed	Acres	% of Total Acres	% Old Industrial
Total Acres	1,180	-	-
Total Old Industrial	216	18%	-
High Opportunity	38	3%	18%

The ESPS watershed is known to have elevated PCB concentrations relative to the rest of the County, so the percent of Old Industrial area within this watershed that is deemed High Opportunity is likely to be higher than for Old Industrial areas in other areas in the County.

Enhanced Control Measures

This High Opportunity area in the ESPS watershed was part of the CW4CB Task 3 effort to conduct additional screening and to identify and interview private land owners whose parcels could potentially be PCB sources. The ultimate goal of this effort was to develop a list of sites for referral to the Regional Water Board for potential actions, including remediation. Based on this relative familiarity with the High Opportunity area, the City of Oakland developed a preliminary list of enhanced control measures for consideration for early implementation in the ESPS watershed (provided in Appendix D).

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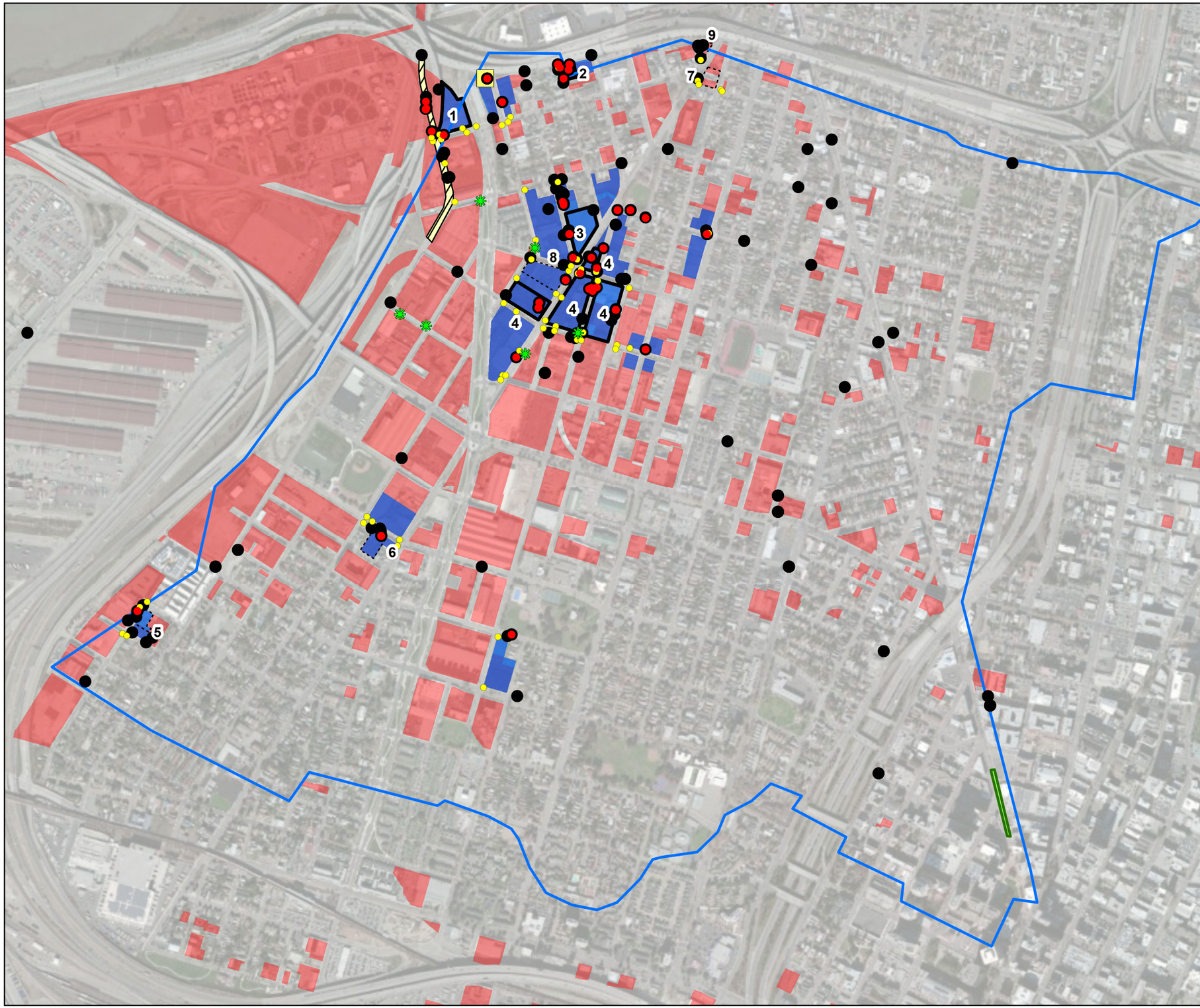
[6] Adapted from Salop, et al. Analysis of 2001-01 Source Investigations in Ettie Street Pump Station and Glen Echo Creek Watersheds, Oakland, California. August 28, 2002.

[7] The data analyses presented herein are preliminary and will be updated as part of the implementation planning conducted in 2014.



Legend

- PCB Conc. >1 mg/kg
- PCB Conc. <1 mg/kg
- Pump Station
- ESPS Watershed
- High Opportunity Area
- Industrial - Old

Control Measure

- High Priority Inlet Cleanout Location - O&M Control
- Tree Wells - Treatment Control
- Green Street - Treatment Control
- Referral Site - Source Control
- Potential PCB Source Site - Source Control
- Illegal Dumping - Source Control

Number	Name	Site Type
1	Granite Expo	Referral Site
2	AMG Facility	Referral Site
3	Former Giampolini Facility	Referral Site
4	Cass West	Referral Site
5	Cole Brothers	Potential PCB Source
6	Former Martinez Brothers	Potential PCB Source
7	Alliance Metals	Potential PCB Source
8	Cypress Auto Salvage	Potential PCB Source
9	Dan's Auto Salvage	Potential PCB Source

N

Notes: The Referral Sites and Potential PCB Sources shown on the map will have both street sweeping and inlet cleanout control measures in place.

Feet

0 1,200 2,400 3,600

Ettie Street Pump Station Control Measures Map

Geosyntec consultants

WW1646 | January 2014

Figure 3-1

P:\GIS\BASMAA_IMR\Projects\2013Nov\ESPS Control Measures Map.mxd

Load Reduction Estimate

Table 3-3 below shows the load reduction estimates for PCBs for the enhanced control measures listed in Appendix D. As shown in Table 3-3, the scenario consists of a mix of control measures that vary depending on source type, which in this case have been identified as remediation sites and recycling facilities.[8] Table 3-3 also includes measures planned for implementation at the ESPS (whose drainage catchment is the entire 1,180 acre watershed). The projected load reduction achieved by all measures is estimated to be 18,030 mg/yr (18 grams/yr). Of that load reduction, approximately 9.6 grams would be achieved by the enhanced measures conducted by the ACFCWCD at the ESPS and the remaining 8.4 grams/yr would be achieved by distributed enhanced control measures implemented by the City of Oakland or property owners within the 38 acre High Opportunity area. The total yield in the High Opportunity area is estimated to be 990 mg/acre/yr[9], so for the 38 acre High Opportunity area in this preliminary scenario, the total load is approximately 37,620 mg/yr (37.6 grams/yr) and the projected reduction of 8.4 grams/yr associated with the distributed enhanced control measures would be a 22 percent load reduction.

The overall yield from the ESPS watershed as a whole is estimated to be approximately 330 mg/acre/yr, so the total runoff load from the 1,180 acre ESPS watershed is projected to be approximately 390,400 mg/yr (390 grams/yr). Thus the load reduction of 18,030 mg/yr (18.0 grams/yr) for the preliminary scenario shown in Table 3-3 represents approximately a five percent reduction in the total watershed PCB annual load.

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[8]Source types may also include PCBs associated with PG&E sub-stations or rail road rights-of-way, but these source areas appeared to be limited in the ESPS High Opportunity area.

[9] The yield for High Opportunity areas was calculated by assuming that the ratio of the baseline yields determined in the regression analysis outside of the ESPS watershed applied within the ESPS watershed for the non-High Opportunity areas, while keeping the estimated annual PCB load constant.

Table 3-4 shows the load reduction for HgT for these same control measures. The estimates are based on the corresponding yield analysis for HgT that was used in projecting loads, HgT concentrations in water from the EBMUD Diversion Study (EBMUD, 2010), HgT sediment data contained in the SFEI sediment database, and HgT sediment data collected at the ESPS during the partial cleanout that was conducted in May 2013.

Potential controls listed in Appendix D also include treatment by diversion of dry weather and selected wet weather flows from the ESPS to the East Bay Municipal Utility District wastewater treatment plant, but estimates of load reductions are too provisional for inclusion in Tables 3-3 and 3-4 at this time. These estimates will be updated in 2014 after clarification of proposed diversion pipe sizing and potential wet weather storage.

Table 3-3: Projected PCB Load Reduction for Tier 1 (ESPS Watershed High Opportunity Area)

Source Area Type[1]	Approx. Number	Area (acres)	Projected Annual PCB Load Reduction							
			Source Control	Operation and Maintenance			Treatment			
			Property ID & Abatement (mg/yr)	Street Sweeping[5] (mg/yr)	Drop Inlet Cleaning (mg/yr)	Pump Station Cleanout[6] (mg/yr)	ESPS Media Filter (mg/yr)	Tree Well Retrofits[7] (mg/yr)	Redev. (C.3)[8] (mg/yr)	Total (mg/yr)
PCB Remediation Sites[2]	4	12	7,680							7,680
Recycling Facilities[3]	5	4		150	70					220
Other High Priority[4]	14	22						120	420	540
ESPS Watershed		1,180				9,530	60			9,590
Total			7,680	150	70	9,530	60	120	420	18,030

Notes:

1 Potential source area types may also include Railroad ROW and Old Electrical properties (e.g., sub-stations), but these source types do not occur or are very limited in the ESPS watershed.

2 Former Giampolini Site, AMG facility, CASS, and Granite Expo (Geosyntec CW4CB Task 3 Project with City of Oakland).

3 Cole Brothers, Former Martinez Brothers, Alliance Metals, Cypress Auto Salvage, Dan's Auto Salvage (Geosyntec CW4CB Task 3 Project with City of Oakland).

4 Defined as parcels in proximity to sampling locations where one of more sediment samples had PCB concentration > 1 mg/kg.

5 Assumes advanced sweeper (vacuum assisted or regenerative air) and curb and gutter and parkway pavement in good condition. Primarily sweeping to minimize offsite tracking at entrances and exits of recycling facilities.

6 Assumes annual cleanout of all 4 wet wells in ESPS.

7 Analysis reflects proposed installation of 6 tree wells, 2 of which are located in High Priority area within ESPS watershed. Sum of catchment areas equals 0.8 acres.

8 Assumes average redevelopment rate of 2% (or approximately 0.5 acre) per year with resulting reduction in yield from 990 mg/acre/yr (High Opportunity yield) to 350 mg/acre/yr (Old Urban yield).

Table 3-4: Projected HgT Load Reduction for Tier 1 (ESPS Watershed High Opportunity Area)

Source Area Type[1]	Approx. Number	Area (acres)	Projected Annual HgT Load Reduction							
			Source Control	Operation and Maintenance			Treatment			Total
			Property ID & Abatement (mg/yr)	Street Sweeping[5] (mg/yr)	Drop Inlet Cleaning (mg/yr)	Pump Station Cleanout[6] (mg/yr)	ESPS Media Filter (mg/yr)	Tree Well Retrofits[7] (mg/yr)	Redevelopment (C.3)[8] (mg/yr)	(mg/yr)
PCB Remediation Sites[2]	4	12	10,020							10,020
Recycling Facilities[3]	5	4		460	110					570
Other High Priority[4]	14	22						50	420	470
ESPS Watershed		1,180				17,300	150			17,450
Total			10,020	460	110	17,300	150	50	420	28,510

Notes:

1 Potential source area types may also include Railroad ROW and Old Electrical properties (e.g., sub-stations), but these source types do not occur or are very limited in the ESPS watershed.

2 Former Giampolini Site, AMG facility, CASS, and Granite Expo (Geosyntec CW4CB Task 3 Project with City of Oakland).

3 Cole Brothers, Former Martinez Brothers, Alliance Metals, Cypress Auto Salvage, Dan's Auto Salvage (Geosyntec CW4CB Task 3 Project with City of Oakland).

4 Defined as parcels in proximity to sampling locations where one of more sediment samples had PCB concentration > 1 mg/kg.

5 Assumes advanced sweeper (vacuum assisted or regenerative air) and curb and gutter and parkway pavement in good condition. Primarily sweeping to minimize offsite tracking at entrances and exits of recycling facilities.

6 Assumes annual cleanout of all 4 wet wells in ESPS.

7 Analysis reflects proposed installation of 6 tree wells, 2 of which are located in High Priority area within ESPS watershed. Sum of catchment areas equals 0.8 acres.

8 Assumes average redevelopment rate of 2% (or approximately 0.5 acre) per year with resulting reduction in yield

C.3.2.2 Potential High Opportunity Areas (Tier 2)

Estimated Area

In evaluating Potential High Opportunity areas outside of the ESPS watershed, candidate land use categories considered included Old Industrial, Railroad, Old Electrical Property, and Remediation land uses. Table 3-5 summarizes the areas of each of these land uses within Alameda County (exclusive of the ESPS watershed), for a total of 8,051 acres[10].

Table 3-5: Candidate Land Uses and Projected Potential High Opportunity Area in Alameda County Outside of the ESPS Watershed

Candidate Land Use	Area (Acres)	Potential High Opportunity Area (Acres) [1]
Old Industrial	6,039	302[2]
Railroad	1,630	82
Old Electrical Property	65	3
PCB Remediation Sites	317[3]	16
Total	8,051	403

Notes:
1 5% of the candidate land use area was assumed to calculate the Potential High Opportunity area, except for PCB Remediation Sites.
2 Includes 35 acres of recycling facilities, 12 PCB remediation sites for a total of 150 acres, the remainder is general Old Industrial land use area.
3 Represents the area of 26 PCB remediation sites located outside of the Old Industrial land use area (see Table 3-9).

As with the ESPS watershed, sediment PCB data was used to guide the selection of what portion of the area might be High Opportunity. Tale 3-6 below shows that 187 sediment samples were available. If it is assumed that each sample reflects a contributing area of one acre, the 187 samples represented only about two percent of the total area. Five of the 187 samples exceeded the 75th percentile concentration of 1 mg/kg, which represents about 2.7 percent of the previously screened area.

The question is – how much of the candidate land use area outside of the ESPS watershed that has not been screened (~98 percent of the total area) may also be found to be High Opportunity upon investigation? For the purposes of the analyses in this section, an assumption of five percent was used to account for the low density of sampling and any bias in the sampling station selection. With this assumption, there are approximately 403 acres of Potential High Opportunity areas outside of the ESPS watershed in Alameda County as a whole (Table 3-5).

[10]In this table the old industrial area also includes some source types, but these are not included separately in the table to avoid double counting.

Table 3-6: PCB Sediment Concentrations and Associated Areas

	No. of Samples	Assumed Area per Sample (ac)	Area (ac)	Percent of PHO Area (Excluding ESPS)	Percent of Previously Screened Area
High (>1 mg/kg)	5	1	5	0.1%	2.7%
Med (1>x>0.3)	14	1	14	0.2%	7.5%
Known Low (<0.3)	168	1	168	2.1%	89.8%
Total Area Sampled	187	1	187	2.3%	100.0%
Unknown (Not Sampled)			7,876	97.7%	

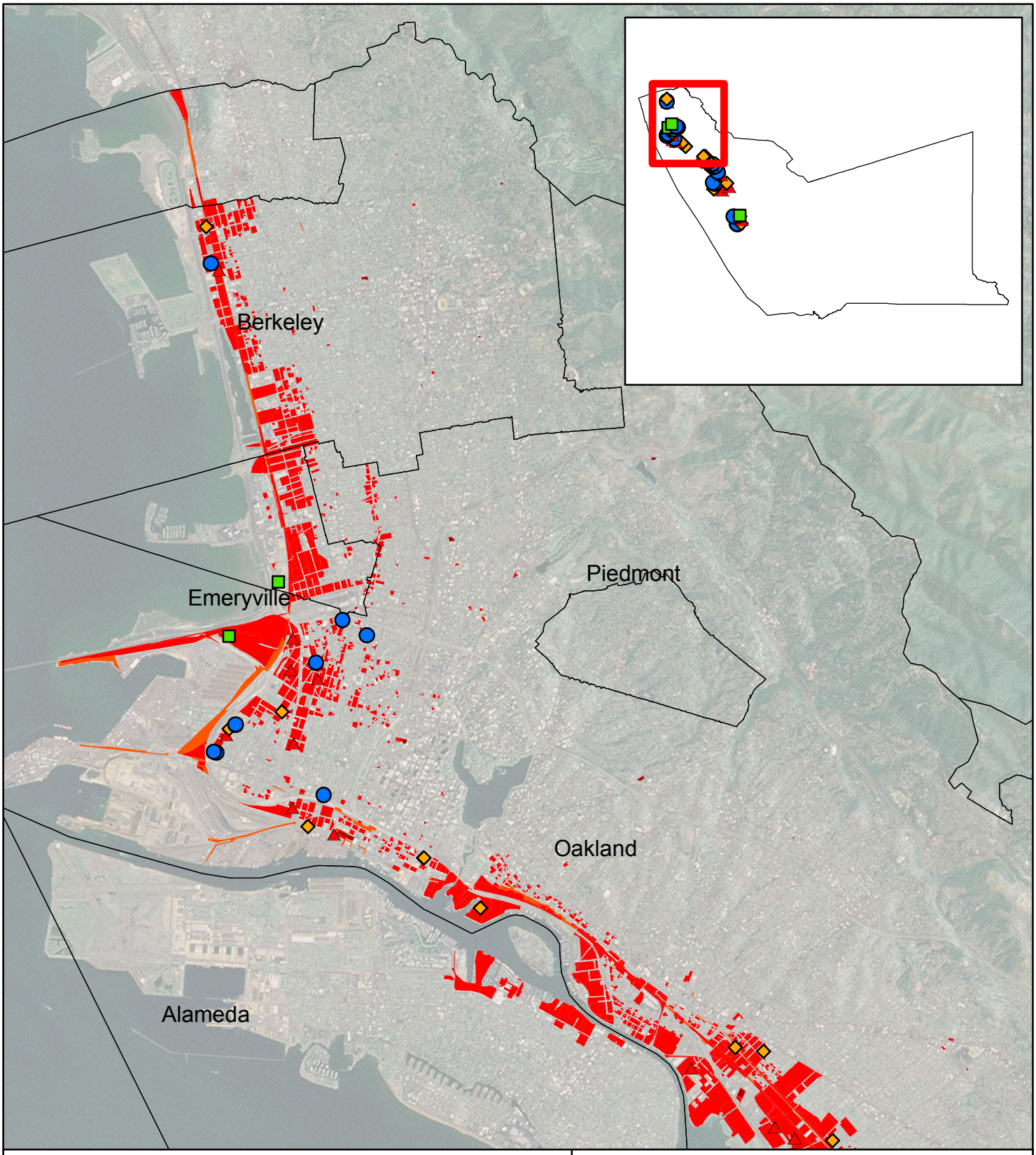
Notes:
*Area determined from IMR Part C.2 source area maps.

Enhanced Control Measures for Specific Source Areas

Recycling Facilities

Recycling facilities vary depending on the type of materials being recycled, and may include auto recycling, wastes of various sorts (e.g., paper recycling), electronics recycling, building materials recycling and bottle/glass recycling. The recycling types of interest are those which receive materials that contain unlabeled PCBs as a result of past uses or trace contamination. A literature review of historical PCB uses in the urban environment include capacitors, hydraulic fluids and lubricants, plasticizers, paints, inks, and flame retardants (McKee and Mangarella et. al., 2006). Based on this analysis, vehicle recycling, electronics recycling, and metal recycling are the higher risk types of recycling facilities where PCBs could inadvertently be part of the material train.

According to the GIS database developed by SFEI and EOA for this project, there are approximately 47 active recycling facilities in the Potential High Opportunity areas within Alameda County outside of the ESPS watershed (see Table 3-7). If we assume approximately one acre per facility, the total area of active recycling facilities is 47 acres, and the higher risk facilities account for approximately 35 acres (Table 3-7). Figures 3-2 and 3-3 show the locations of the recycling facilities (including those located within the ESPS watershed).



Legend

Recycling Facilities

- AUTO
- DRUMS
- METALS
- WASTE

Land Use

- Railroad
- Industrial - Old
- Electrical Property - old
- Municipal Boundary

N

0 4,900 9,800 14,700 19,600 Feet

Recycling Facilities in Northern Alameda County

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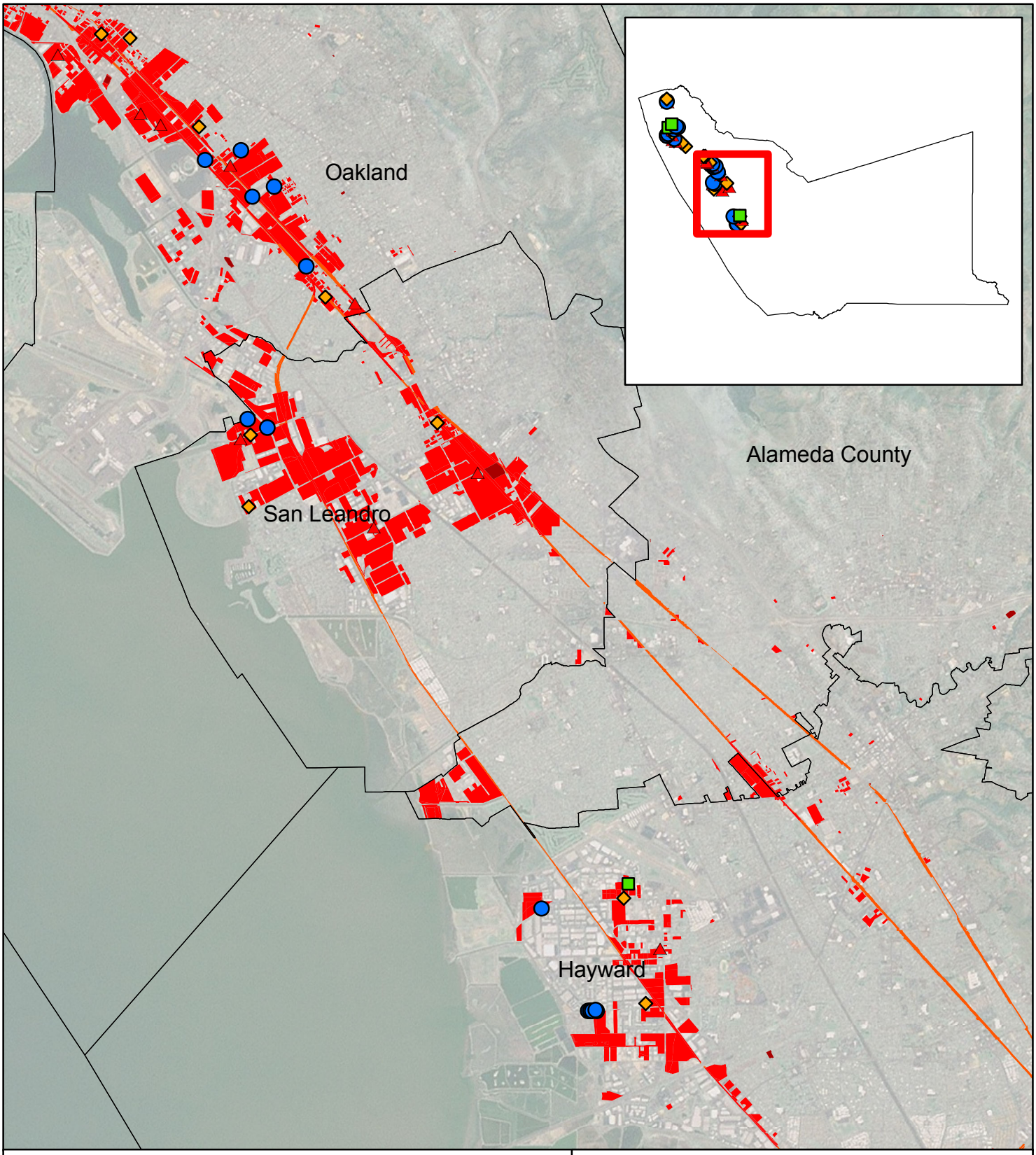
Figure 3-2

P:\GIS\BASMAA_IMR\Projects\2013Nov\RecyclingLocations_1.mxd



Legend

Recycling Facilities

- AUTO
- DRUMS
- METALS
- WASTE

Land Use

- Railroad
- Industrial - Old
- Electrical Property - old
- Municipal Boundary

N

0 4,900 9,800 14,700 19,600 Feet

Recycling Facilities in Central Alameda County

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Figure 3-3

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Table 3-7: Predicted Number and Extent of Low and High Risk Recycling Facilities in Potential High Opportunity Areas in Alameda County

Facility Type	Number	Classification *	
		Lower Risk Facilities (acres)	Higher Risk Facilities (acres)
Auto-Related Recycling	18		18
Drum Recycling	3		3
Metals Recycling	14		14
Waste Recycling	12	12	
Total	**47**	**12**	**35**

Notes:
* Assumes an average area of facilities is 1 acre based on preliminary GIS analysis.
Source: EOA/SFEI GIS analysis

PCBs are commonly in a solid form, either contained within a given material (e.g., as plasticizer) or adsorbed to sediment. During storm events, sediments and materials containing PCBs may mobilize and migrate into the MS4. Factors that facilitate migration off-site can include off-site tracking by vehicles, exposure of materials to rainfall and uncontrolled runoff, and erosion of sediments. Given these mechanisms, larger storm events may disproportionately mobilize PCBs into the MS4.

Given the distributed nature of the recycling facilities of interest, integrated source control may be an appropriate strategy. Control measures could be taken at both the site level and in the municipally-managed facilities, including the street right-of-way and the MS4. Facility managers could be encouraged to implement control measures on-site through existing industrial inspection activities by Permittees, or referral to regulatory agencies for enforcement follow-up. Permittee or facility owners' actions could include targeted sweeping of roads adjacent to such facilities, with special focus on entry and egress points; more intense inspection and cleaning of drop inlets in those portions of the storm drain system that carry runoff from the recycling facility; and, where lacking, the installation of curbs and gutters to reduce erosion and facilitate sweeping.

An example of enforcement action taken by the Regional Water Board is the August 27, 2012 Cleanup and Abatement Order (CAO) issued to Schnitzer Steel Products Facility located at 1101 Embarcadero West in Oakland. The facility is a metal shredder/recycler located on a bulkhead wharf adjacent to the Oakland Estuary. Although there are limited PCB data in the vicinity of this facility, PCB sediment concentrations in the vicinity of a metal shredding facility in the Santa Fe Channel area in Richmond are elevated.

The above measures address minimizing the accumulation of sediment and associated PCBs in the storm drain system between storm events. During storm events, treatment comes into play and may be considered as part of an overall strategy or as an alternative strategy to integrated source control. Distributed treatment may be feasible in the form of retrofitting drop inlets or

where land availability affords, installing bioretention units or tree well systems in the right-of-way (ROW).

Substations

Although no longer produced in the United States, PCBs may be present in products and materials produced before the 1979 ban, including electric transformers. PG&E is the major user of PCBs in transformers, although PG&E has an active program of phasing out the use of PCBs over time as equipment is replaced. Sources can include transformers containing PCBs that are located on utility poles, in vaults where below-ground utilities are located, or at power substations. PCBs can be released into the environment from leaks and spills associated with failure of containment vessels, vandalism, or fires.[11] SFEI conducted an analysis of potential releases from facilities in the Bay Area and estimated that approximately 0.02-0.09 kg/year of PCBs could be released from transformers and 0.16-0.88 kg/year from large capacitors (McKee and Mangarella et. al., 2006).

An example of a spill occurred on April 16, 2013 at the PG&E Metcalf Substation in San Jose where vandalism (shooting) of 13 large transformer vessels released approximately 50,000 gallons of mineral oil containing a maximum PCB concentration estimated at 12 mg/L.[12]

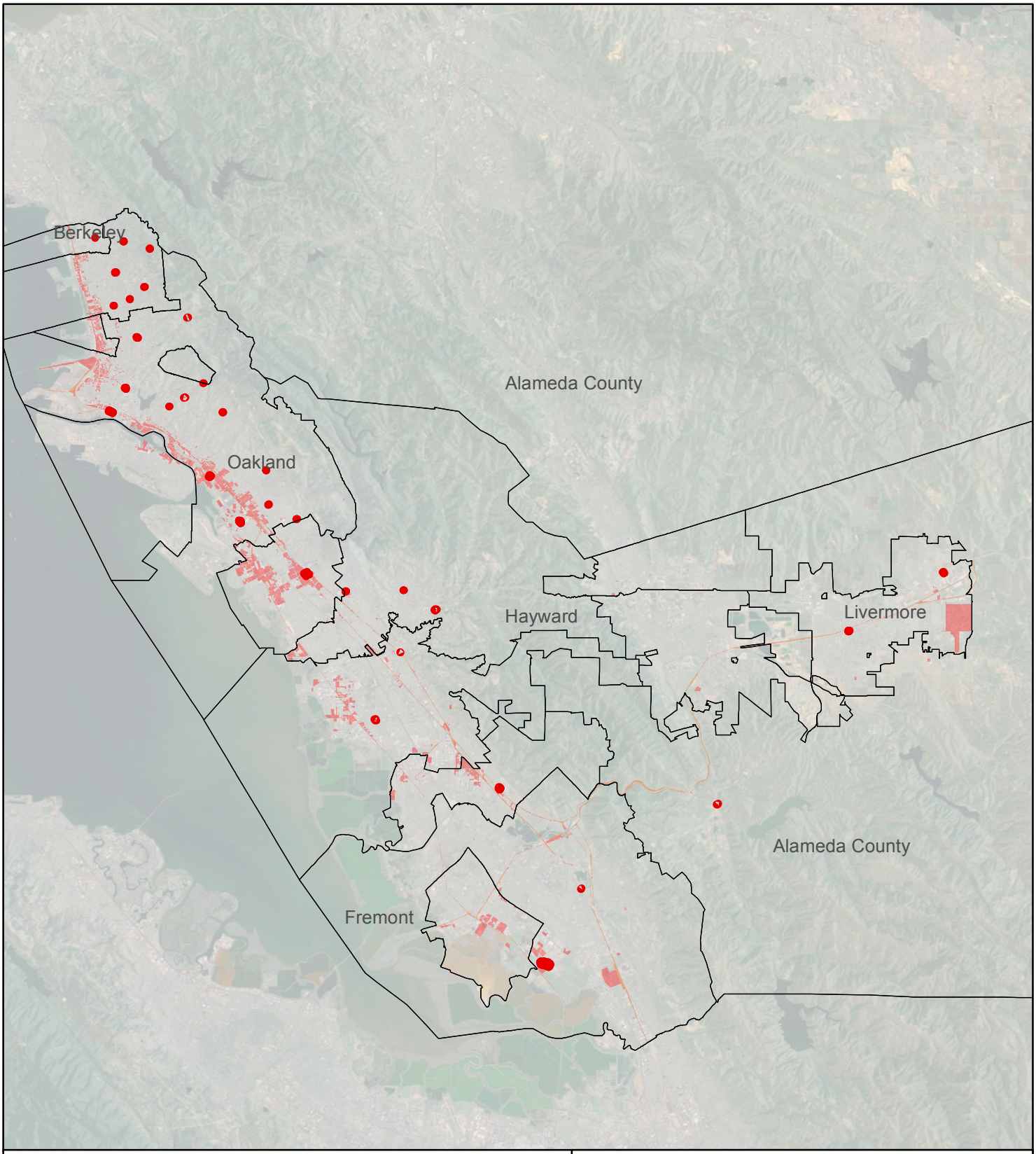
According to a GIS analysis of the data provided by EOA[13], there are approximately 32PG&E substations in Alameda County. If we assume 5% of these sites will have High Opportunity, that would account for approximately three acres. Figure 3-4 shows the locations of the PG&E substations.

---

[11] Past spills from pole-mounted and vault-located transformers that contain PCBs are not sufficiently traceable or quantifiable for enhanced control measures. PCBs also can be released from vaults where cables may contain lubricants with PCBs, an example of which was documented in a San Leandro incident in 2013 involving a cable PCB lubrication leak.

[12] http://www.pge.com/nots/rates/tariffs/tm2/pdf/GAS_3398-G.pdf.

[13] These sites are called "Electrical Properties" in the database and the numbers presented are for sites that existed before 1968.



Legend

Land Use

- Railroad
- Industrial - Old
- Electrical Property - old
- Municipal Boundary
- ESPS Watershed

N

0 19,000 38,000 57,000 76,000 Feet

Old Electrical Facilities in Alameda County

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Figure 3-4

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The major focus for control is on on-site equipment maintenance and spill control, which would be the responsibility of the site owner and operator. Permittee control measure options consist of drainage system source control and/or treatment. These measures would be most feasible at larger PG&E substations that can be documented to contain PCBs and where there is significant risk of breaching secondary containment on the substation. Source control could entail inspection and cleanout of drop inlets in the vicinity of the substation. Treatment could include retrofitting the drop inlet, given available space in the public ROW, with a treewell, linear bioretention unit, or filtration.

Transportation Facilities

Transportation facilities include railway rights-of-way and historical trolley routes. Railway ROW are a potential source of PCBs, as PCBs were historically used in switching equipment and other electrical uses, as well as for dust suppression. Transportation of fluids containing PCBs could also be released to the environment thought leaks and spills. SFEI has conducted a GIS analysis of historical railroad ROW in the Bay Area that indicates that the total area of railroad ROW was approximately 40 km^2 (~10,000 acres) accounting for about 11% of the Old Industrial land use (McKee and Mangarella et. al., 2006).PCBs in railroad ROW are most likely associated with sediments, which can be eroded during intense storm events and carried into the MS4 and ultimately to the Bay.

There are approximately 1,630 acres of railroad ROW included in Alameda County outside of the ESPS watershed. Figure 3-5 shows the location of the railroad ROW. Kleinfelder (2005) measured a PCB concentration of 0.61 mg/kg in soils near the Southern Pacific Railroad in the ESPS watershed, which is elevated, but not in the upper quartile of concentrations defined as >1 mg/kg. Thus it is not clear, pending further data, that railway ROWs are all High Opportunity areas. For purposes of this report, five percent (82 acres) of the railroad ROW were assumed to be Potential High Opportunity area. In addition, urban areas in the East Bay were served by an extensive electric streetcar system into the 1950's (Figure 3-6). These historical facilities were located throughout the East Bay, including the Moderate Opportunity areas that will be addressed as part of the Permittee's long-term master planning process.

The most effective control measure would be erosion and sediment control conducted within the railroad ROW by the property owner. Permittee control measures could include O&M measures by which sediments that originate from the railroad ROW are removed from gutters by street sweeping or cleaning out drop inlets. Also, there may be areas where erosion into the MS4 could be limited by the construction of curbs and gutters to contain sediments on-site and to facilitate street sweeping.

Legend

Land Use

- Electrical Property - old
- Industrial - Old
- Railroad
- Municipal Boundary
- ESPS Watershed

N

0 19,000 38,000 57,000 76,000 Feet

Railroad Properties in Alameda County

Geosyntec consultants

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Figure 3-5

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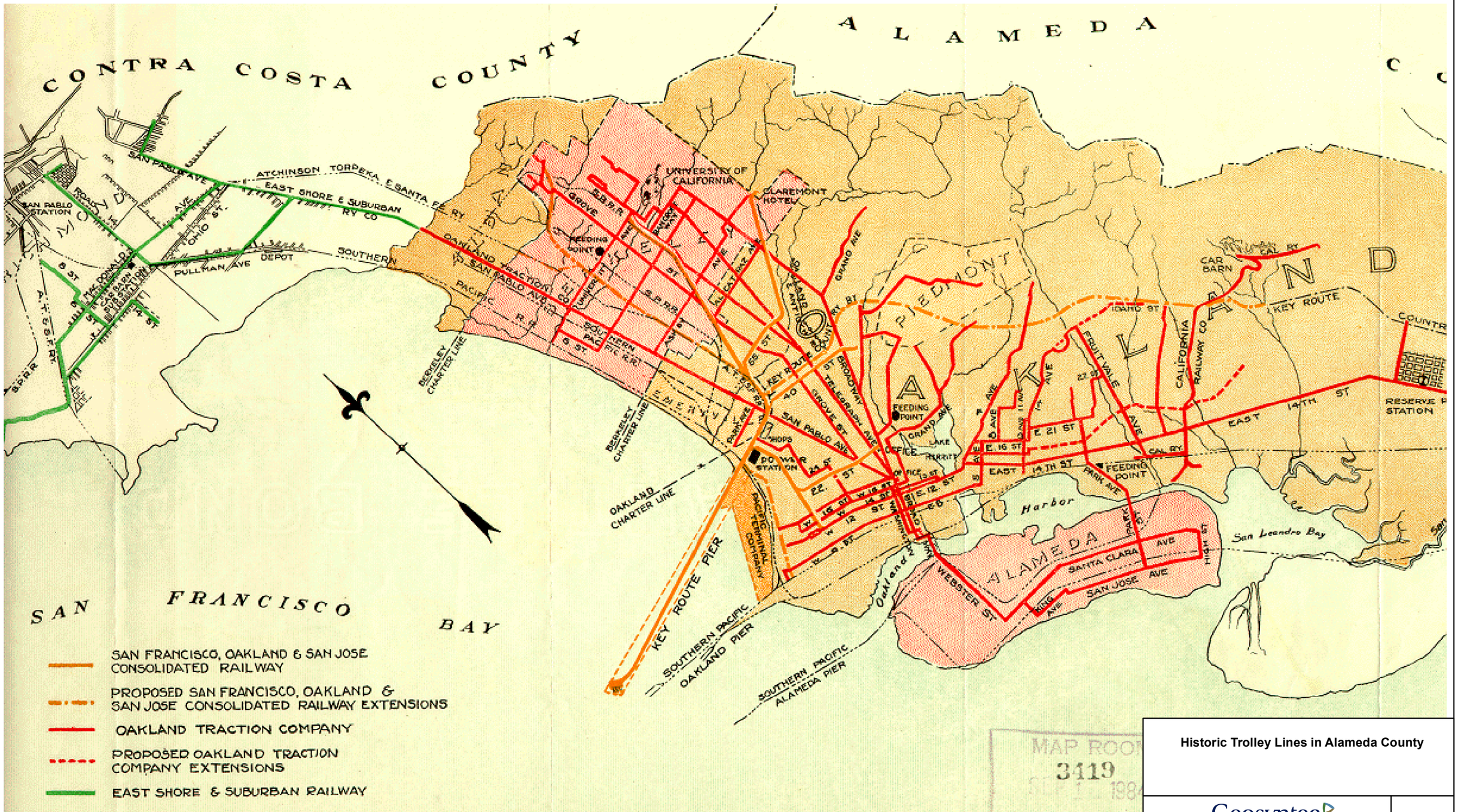

Source: http://www.bayarearailfan.org/photogal/displayimage.php?album=topn&cat=0&pid=91#top_display_media

Historic Trolley Lines in Alameda County

Geosyntec consultants

WW1646	January 2014	Figure 3-6

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Remediation Sites

Remediation sites are sites where past industrial, military, or other use of PCBs resulted in releases to the environment leading to soil and/or groundwater contamination. Table 3-8lists and Figures 3-7 and 3-8 show the location of potential remediation sites based on the State Water Resources Control Board Envirostar database and additional sites identified in the Source Area Maps. Table 3-8 is not a comprehensive list of all remediation sites in Alameda County; it is a preliminary list based on publicly-available information collected to-date. Table 3-8lists 35 sites contained within the Envirostar database and seven additional sites identified by the GIS analysis where PCBs are one of the constituents of concern.

Table 3-8: Potential Remediation Sites in Alameda County Outside ESPS Watershed

Facility Name	Area[1]	Located In Old Industrial Land Use?	Type	Status	City	Source
A. Bercovich 2nd Street	NC	N	State Response	Certified O&M - Land Use Restrictions Only - Land Use Restrictions	Oakland	Envirostor
Applied Biosystems	NC	N	Voluntary Cleanup	Certified / Operation & Maintenance - Land Use Restrictions	Pleasanton	Envirostor
Aspire School Site/66th Avenue Charter School	NC	Y	School Cleanup	Inactive - Action Required	Oakland	Envirostor
Bay Area Rapid Transit District	NC	N	Historical	Refer: Other Agency	Hayward	Envirostor
Bedford Property Site	NC	N	Historical	Refer: RWQCB	Oakland	Envirostor
Berkeley Industrial Court	NC	Y	State Response	Refer: RWQCB	Berkeley	Envirostor
Burbank E.S./Hayward Joint Use Park	NC	N	School Cleanup	Certified / Operation & Maintenance	Hayward	Envirostor
City Of Oakland - Subaru Lot	NC	Y	State Response	Certified O&M - Land Use Restrictions Only - Land Use Restrictions	Oakland	Envirostor
Cypress Freeway-3rd Street Soundwall	NC	N	Voluntary Cleanup	Certified	Oakland	Envirostor
Downtown Education Complex	NC	N	School Cleanup	Active	Oakland	Envirostor
Emeryville Mound Parcel	NC	N	Voluntary Cleanup	Active	Emeryville	Envirostor
Former Montgomery Ward Building	NC	N	School Cleanup	Certified	Oakland	Envirostor
General Electric - Oakland	**23**	Y	State Response	Active - Land Use Restrictions	Oakland	Envirostor
General Electric Company	NC	N	Corrective Action	Refer: SMBRP	Union City	Envirostor
Habitat For Humanity Project	NC	N	State Response	Certified	Oakland	Envirostor
Heinz/Grayson Plume	NC	Y	State Response	Refer: RWQCB	Berkeley	Envirostor
Heroic War Dead EBMUD	NC	Y	State Response	Certified O&M - Land Use Restrictions Only - Land Use Restrictions	Oakland	Envirostor
Horton Landing Park	NC	Y	Voluntary Cleanup	Refer: Other Agency	Emeryville	Envirostor
Ikea (Former Barbary Coast)	NC	N	State Response	Certified / Operation & Maintenance - Land Use Restrictions	Emeryville	Envirostor
ITT Grinnell Property	NC	Y	Historical	Refer: Other Agency	Emeryville	Envirostor
Lawrence Berkeley National Laboratory	NC	N	Corrective Action	Active	Berkeley	Envirostor

Facility Name	Area[1]	Located In Old Industrial Land Use?	Type	Status	City	Source
Lawrence Livermore National Lab (USDOE)	NC	Y	Federal Superfund - Listed	Active	Livermore	Envirostor
Montgomery Street Project	NC	N	Evaluation	Inactive - Needs Evaluation	Hayward	Envirostor
Myers Drum - Emeryville	NC	N	State Response	Certified / Operation & Maintenance - Land Use Restrictions	Emeryville	Envirostor
Myers Drum - Oakland	NC	N	State Response	Certified / Operation & Maintenance - Land Use Restrictions	Oakland	Envirostor
Oakland Army Base	NC	N	State Response	Active - Land Use Restrictions	Oakland	Envirostor
Oakland Gateway Development Area	NC	N	State Response	Active	Oakland	Envirostor
Pacific States Steel - Phase Iii	NC	Y	State Response	Certified / Operation & Maintenance - Land Use Restrictions	Union City	Envirostor
Pennzoil Company	NC	Y	Historical	Refer: RWQCB	Alameda	Envirostor
PG&E - Decoto Pipeyard	NC	N	Voluntary Cleanup	Certified	Union City	Envirostor
Port Of Oakland - Embarcadero Cove	NC	N	State Response	Certified / Operation & Maintenance - Land Use Restrictions	Oakland	Envirostor
Shellmound Venture Project	NC	N	Voluntary Cleanup	Certified O&M - Land Use Restrictions Only - Land Use Restrictions	Emeryville	Envirostor
Smith's Wrecking Yard	NC	N	Voluntary Cleanup	Certified	Oakland	Envirostor
Sobex Incorporated	NC	N	Historical	Refer: RWQCB	Fremont	Envirostor
Union Pacific Oakland Coliseum Site	**0.88**	N	State Response	Active	Oakland	Envirostor
McCaulay Foundry	**7.7**	N	No Data	No Data	Berkeley	EOA/SFEIGIS Analysis
PG&E	**10.79**	Y	No Data	No Data	Emeryville	EOA/SFEIGIS Analysis
USPS	**20.1**	N	No Data	No Data	Oakland	EOA/SFEIGIS Analysis
Alameda Navy Base[2]	1,420	N	No Data	No Data	Alameda	EOA/SFEIGIS Analysis
DRMO, US Navy Supply Center[2]	103.5	N	No Data	No Data	Alameda	EOA/SFEIGIS Analysis
Oakland Airport[2]	571.5	N	No Data	No Data	Oakland	EOA/SFEI GIS Analysis
Port Of Oakland[2]	1,632	N	No Data	No Data	Oakland	EOA/SFEI GIS Analysis

Facility Name	Area[1]	Located In Old Industrial Land Use?	Type	Status	City	Source
Average Remediation Site Area	12.5					
Total Potential High Opportunity Remediation Area	475[3]					
Total Potential High Opportunity Remediation Area Outside Old Industrial	317					

Notes:
Envirostor sites with status indicating "No Further Action Required" or equivalent were removed from the table. For this analysis, most site areas are unknown (indicated as Not Calculated (NC) in the table).

1 Areas in bold were used to formulate Average Remediation Site Area (12.5 ac); these areas were calculated by GIS analysis using aerial photography

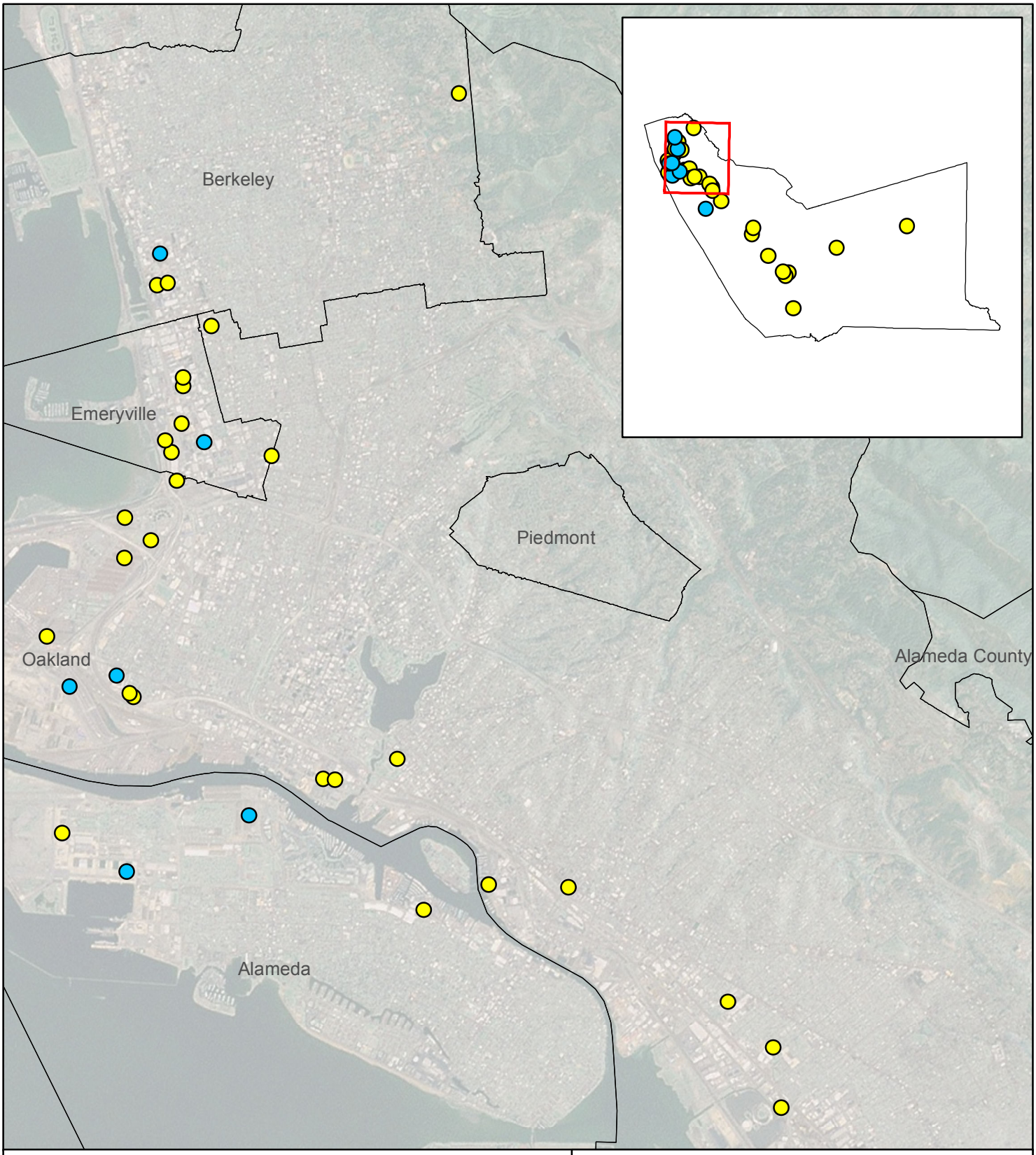
2 Large sites were not included in the Total Potential High Opportunity Remediation Area. These sites will be further analyzed for inclusion in the Potential High Opportunity Remediation Area. A portion of these sites will likely be reclassified for inclusion in IMR Part C or in the 2014 planning process.

3 Totals assume that NC areas are equal to the average remediation site area (12.5 ac).

The actual number and net area of potential future remediation sites will be assessed as part of the future implementation planning efforts. An approximate analysis of potential remediation sites based on Table 3-8 follows.

The average area for the remediation sites, not including the larger sites (Alameda Navy Base, DRMO US Navy Supply Center, the Oakland Airport, and the Port of Oakland parcels) was estimated as 12.5 acres. As shown in Table 3-8 above, the estimated area for remediation sites outside of the Old Industrial land use area is 317 acres. Assuming that five percent of this area has elevated PCB concentrations, a total of 16 acres would be Potential High Opportunity. In addition, 12 sites with a total of 150 acres within the Old Industrial area are assumed to have elevated PCB concentrations.

In order to locate additional areas available for remediation, each Permittee would develop a program to screen, identify, and refer sites to DTSC and the Regional Water Board for potential remediation, based on the model initially developed by the City of Oakland and refined through the CW4CB Task 3 Pilot Projects. The process could include drawing upon the knowledge of the municipal industrial inspectors, review of regulatory lists that have been developed by the DTSC, conducting site surveys, and sampling on-site or in the public ROW. The City of Oakland will also coordinate their efforts with a joint initiative by the Regional Water Board and USEPA to identify and clean up potential PCB sources in selected portions of east Oakland that drain to San Leandro Bay.



Legend

- Envirostor
- EOA/SFEI Sources
- Municipal Boundary
- ESPS Watershed

N

0 4,500 9,000 13,500 18,000 Feet

Potential Remediation Sites in Northern Alameda County

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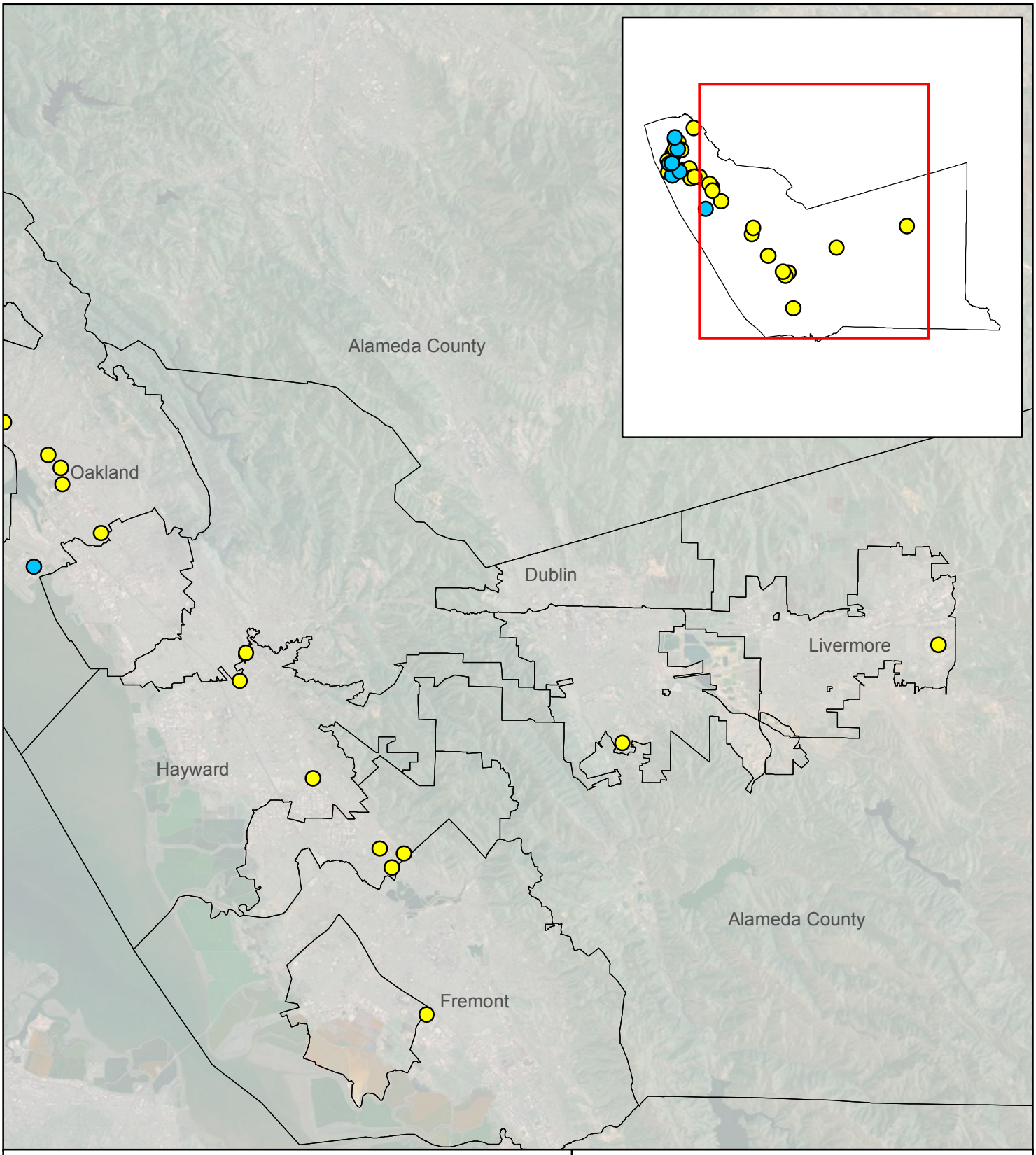
Figure 3-7

P:\GIS\BASMAA_IMR\Projects\2013Nov\Remediation Sites.mxd



Legend

- Envirostor
- EOA/SFEI Sources
- Municipal Boundary
- ESPS Watershed

N

0 12,500 25,000 37,500 50,000 Feet

Potential Remediation Sites in Southern Alameda County

Geosyntec consultants

WW1646	January 2014

Figure 3-8

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Control measures that can be undertaken to reduce the PCB yield at these remediation sites fall into two categories: on-site remediation and/or maintenance or treatment in the public ROW. Typical stormwater management associated with on-site remediation may include: erosion and sediment control, installation of on-site retention, installation of curb and gutters, and off-site tracking control. The remediation process is lengthy and uncertain, and the Permittees may consider implementing control measures in the surrounding public ROW as an interim strategy. Public ROW control measures may include enhanced street sweeping, drop-inlet cleaning, and treatment (e.g., green streets or tree wells).

Pump Stations

Areas close to the Bay are often at elevations that are below the higher tidal elevations. These areas are often served by pump stations that convey stormwater runoff and incidental dry weather flows to the Bay. These areas, being along the margin of the Bay, often drain historical industrial areas where PCBs were more likely to be used. Other pump stations operate in very flat areas to convey stormwater across elevated roadways or bridges.

A review of the GIS database found four pump stations within the planning area that appeared to contain some Old Industrial land use area within their drainage catchment, all owned and operated by ACFCWCD. Table 3-9 lists the pump stations in the GIS database within Alameda County; the pump stations outside of the ESPS watershed that may be considered for enhanced control measures (either diversion or enhanced O&M) are shown in grey. See Figures 3-9 through 3-12 for the pump station locations.

There are a variety of potential control measures at pump stations, including source control and treatment options for dry and weather flows. One source control is removal of sediments that accumulate over time in the pump stations themselves. Diversion of flows to nearby wastewater treatment plans is one treatment option, as is diversion to a stormwater treatment unit constructed near the pump station.

Cost effectiveness will be addressed based on information available at the ESPS, with the qualification that the ESPS is much larger than other pump stations in Alameda County and extrapolation of results must take this into account.

Sediment removal is a common maintenance practice at pump stations, and may be conducted, depending on accumulation, on an annual basis. Pump stations are not designed to collect sediments, so the amount that accumulates is small compared to the amount that is discharged. Moreover results from a cleanout conducted in May 2013 at the ESPS indicated that the material is relatively coarse and concentrations of PCBs are relatively low (~0.13 mg/kg). The total mass of PCBs removed from this partial cleanout (~13 yd^3) was estimated to be about 2 grams.

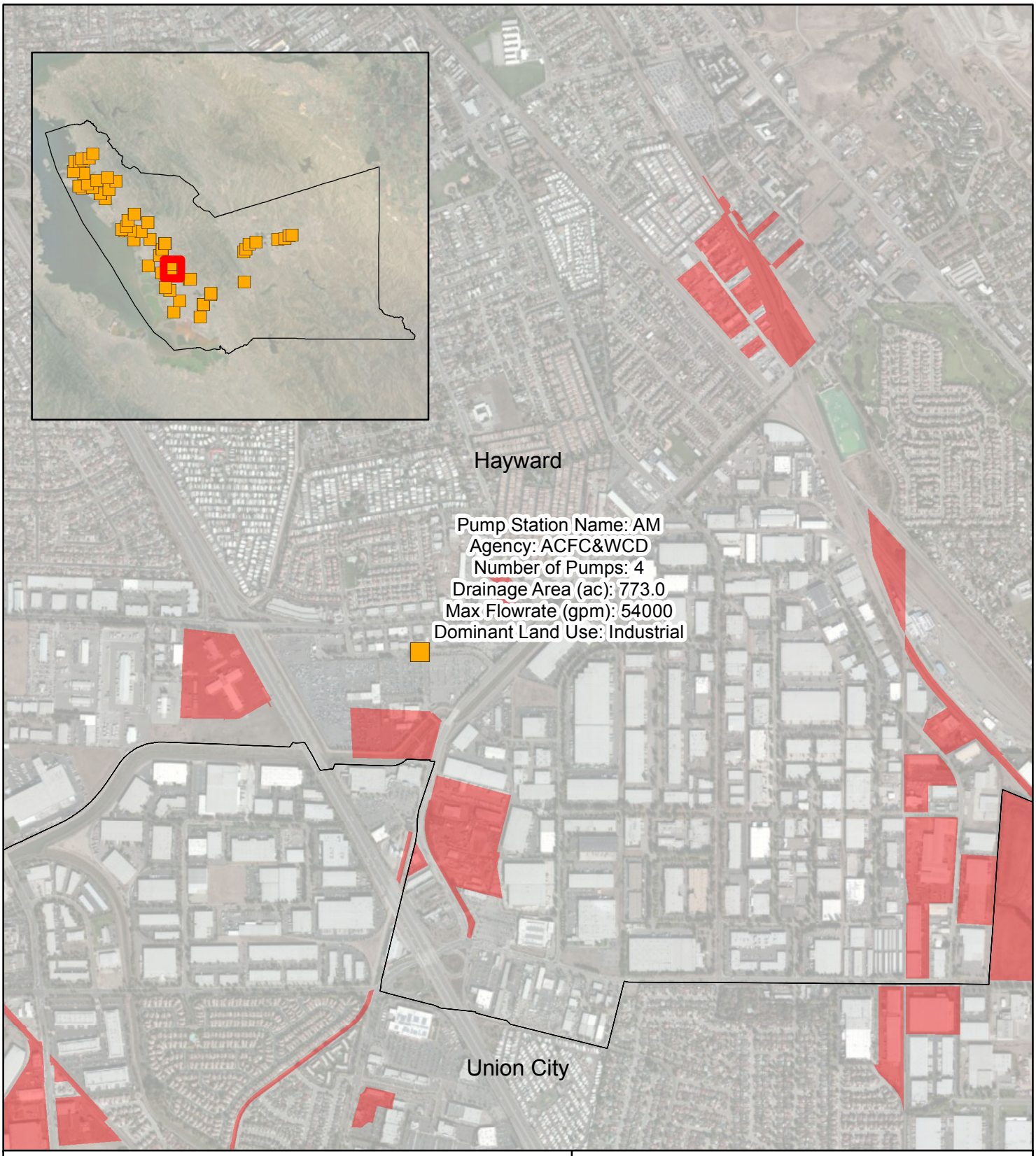
Table 3-9: Alameda County Pump Station Inventory

Pump Station Name	Agency	Number of Pumps	Drainage Area (ac)	Dominant Land Use	Address	Max Flow rate (gpm)
AL	ACFC&WCD	4	725	Residential	31269 Veasy St. Hay.	105,350
AM	ACFC&WCD	4	773	Industrial	1990 Indust. Prk.W Hay.	54,000
BS	ACFC&WCD	7	322	Industrial	29950 Hesperian Blvd. Ha	190,700
BV	ACFC&WCD	3	219	Residential	2480 Belvedere Dr.	48,760
D-1	ACFC&WCD	3	171	Industrial	2048 Farallon Dr.	41,650
EL	ACFC&WCD	4	306	Industrial	3599 Arden rd. Hay	82,200
ES	ACFC&WCD	8	92.6	Residential	2690 Eden Park Pl.	104,000
ET	ACFC&WCD	6	1,180	Residential, Industrial	3455 Ettie St.	468,000
F	ACFC&WCD	3	239	Residential	2603 Fairway Dr.	38,000
H	ACFC&WCD	2	91	Residential	13203 Monarch Bay	6,000
ID	ACFC&WCD	4	847	Industrial	1200 Industrial Prk. West	365,200
J-2	ACFC&WCD	5	370	Residential	4588 Delores Dr.	164,500
J-3	ACFC&WCD	6	343	Residential	32000 Union City Bl	57,500
LM	ACFC&WCD	4	4,670	Residential	7th Street	412,976
MC	ACFC&WCD	2	4	Residential	East Mckillop	200
RL	ACFC&WCD	4	84	Residential	15670 Anchorage	25,600
RU	ACFC&WCD	4	770	Residential	29560 Ruus Rd. Hay	30,550
SC	ACFC&WCD	3	92	Industrial	19105 Barrington Ct.	105,300
ST	ACFC&WCD	3	39.4	Residential	1898 Pecheco Wy. Hay	12,030
TE	ACFC&WCD	1	Unknown	Residential	Hardy Park	230
WV	ACFC&WCD	3	84	Residential	32110AlvaradoNiles	32,880
Bayport	City of Alameda	4	Unknown	Urban	5th @ Tinker Ave	46,650
Eastshore	City of Alameda	2	Unknown	Urban	Eastshore Drive at Central Ave	0
Golf Course Slough	City of Alameda	2	Unknown	Open, Residential	Golf course slough at Doolittle Drive	0
Main Street	City of Alameda	2	Unknown	Urban	Main Street (west of Ferry Terminal)	4,500
Marina Village	City of Alameda	3	Unknown	Urban	Marina Village Parkway	51,000
Northside (Arbor Street)	City of Alameda	4	Unknown	Urban	Arbor Street at Clement Ave (extension)	30,000
Third Street	City of Alameda	1	10.3	Urban	Appezzato Parkway & 3rd St.	0
Webster Street	City of Alameda	3	Unknown	Urban	North end of Mariner Square Drive	0
1	City of Fremont	2	Unknown	Commercial	Sullivan Underpass - Niles	1,500
2	City of Fremont	2	Unknown	Residential	Pickering/Mission	1,000
3	City of Fremont	2	Unknown	Industrial	South Grimmer/Osgood	1,500
	City of Livermore	3	34.9	Roadway	Isabel/Stanley	12,009
	City of Livermore	2	0.7	Roadway	Murietta/Stanley	2,396
	City of Livermore	2	2.3	Roadway	P/Railroad	2,396
	City of Livermore	2	1.7	Roadway	N.Livermore/Railroad	1,202
	City of Newark	2	<1	Residential	Crystal Springs Dr.*	1,754

Pump Station Name	Agency	Number of Pumps	Drainage Area (ac)	Dominant Land Use	Address	Max Flow rate (gpm)
SD1	City of Pleasanton	2	3	Underpass	4950 Bernal Avenue	1,200
SD2	City of Pleasanton	2	4	Underpass	4000 Del Valle Parkway	1,600
SD3	City of Pleasanton	2	15	Underpass	3090 Valley Avenue	8,000
SD4	City of Pleasanton	2	9	Underpass	1040 Valley Avenue	1,600
	Hayward		Unknown		Old Harder Road Underpass (East)	2,000
	Hayward		Unknown		New Harder Road Underpass (West)	2,000
	Hayward		Unknown		Tennyson Road Underpass	2,000
	Hayward		Unknown		D Street Underpass	2,000
	Hayward		Unknown		Orchard Road Underpass	2,000
SL1	San Leandro		Unknown			0
SL2	San Leandro		Unknown			0

Notes:

1 The highlighted pump stations are shown in Figures 3-9 through 3-12.



Legend

Pump Station

Municipal Boundary

Land Use

Industrial - Old

N

0 1,000 2,000 3,000 4,000 Feet

Pump Station AM

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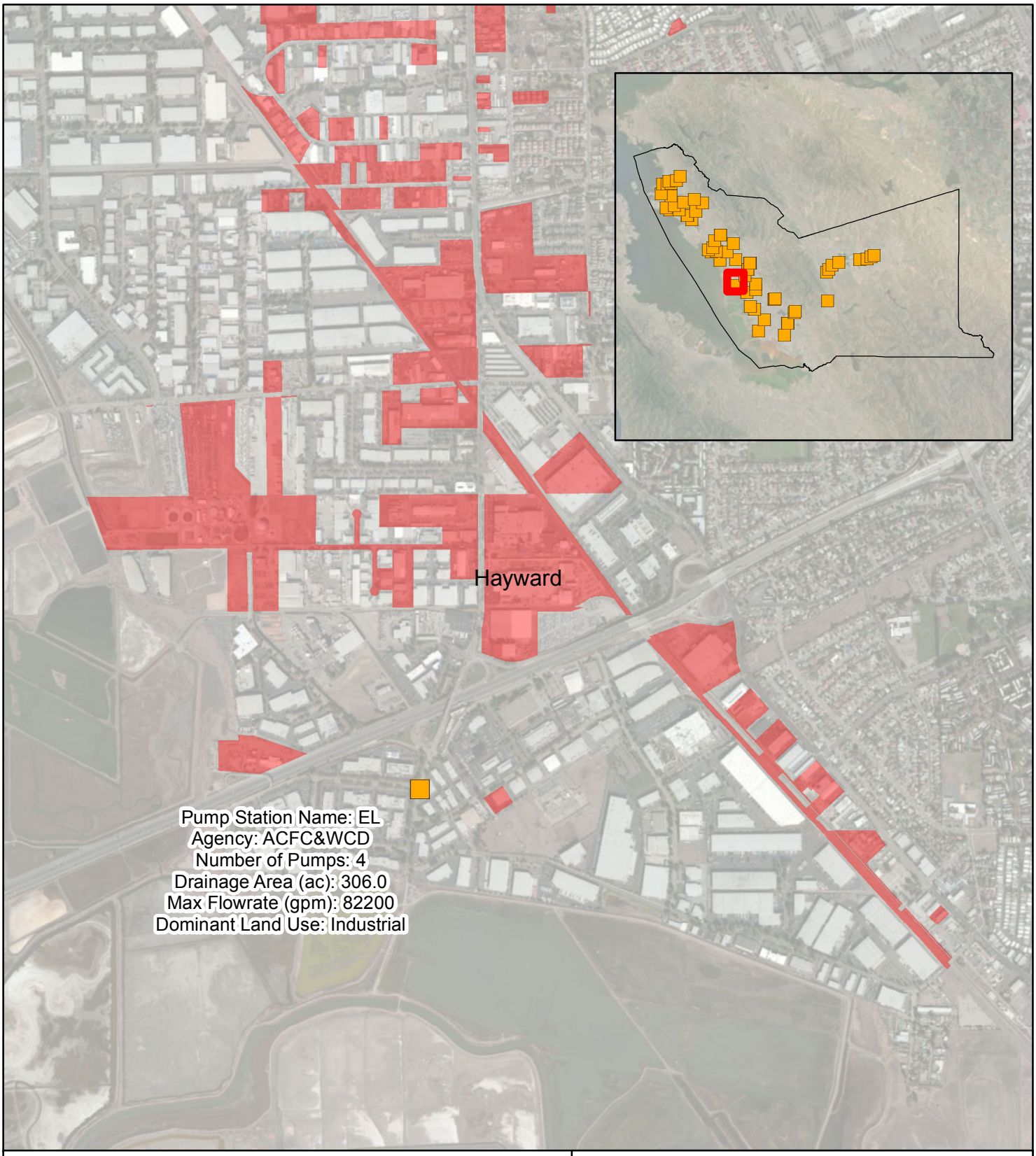
Figure 3-9

P:\GIS\BASMAA_IMR\Projects\2013Nov\Pump Station AM.mxd



Legend

Pump Station

Municipal Boundary

Land Use

Industrial - Old

N

0 1,000 2,000 3,000 4,000 Feet

Pump Station EL

Geosyntec consultants

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Figure 3-10

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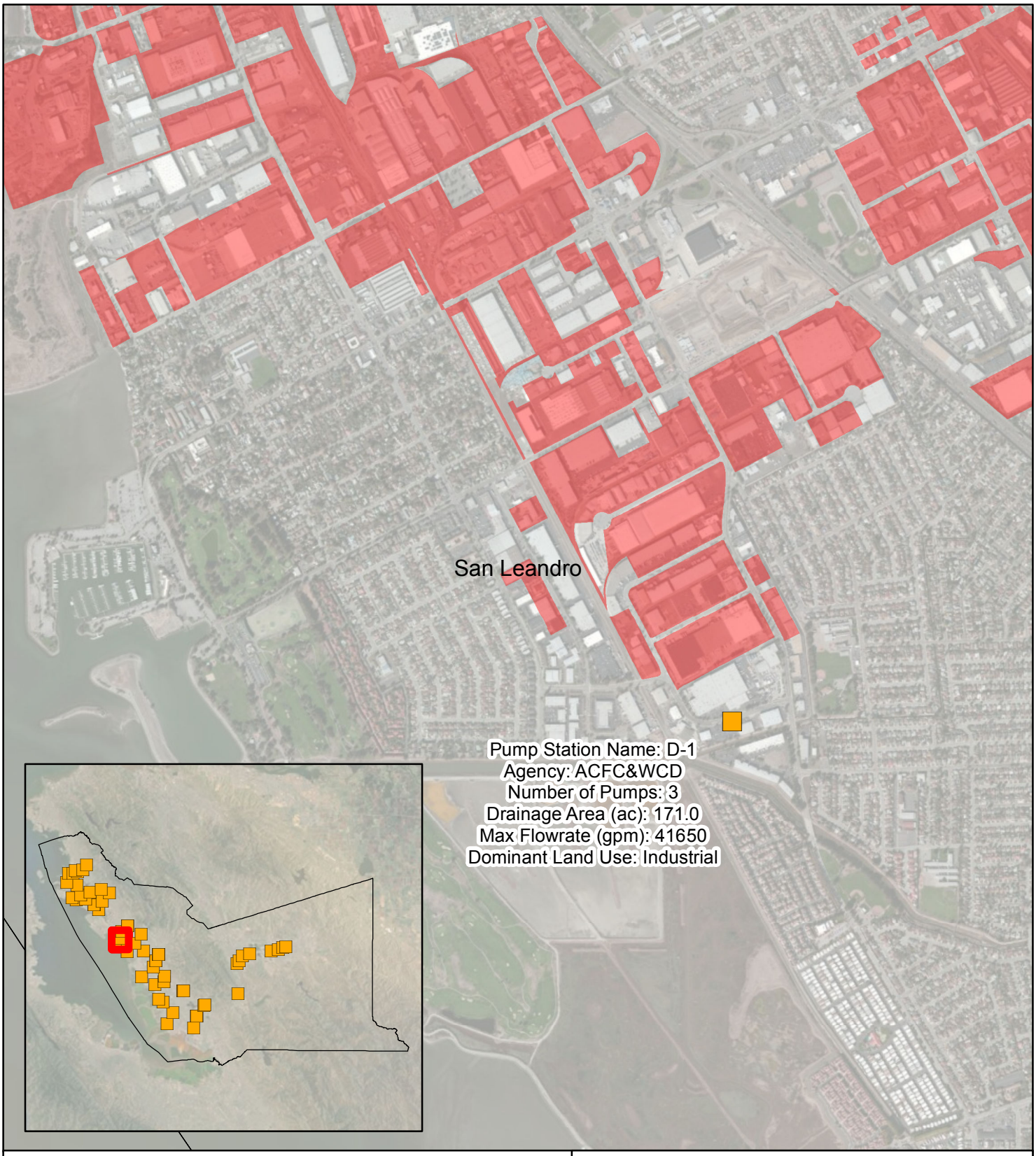

Legend

Pump Station

Municipal Boundary

Land Use

Industrial - Old

N

0 1,000 2,000 3,000 4,000 Feet

Pump Station D-1

Geosyntec consultants

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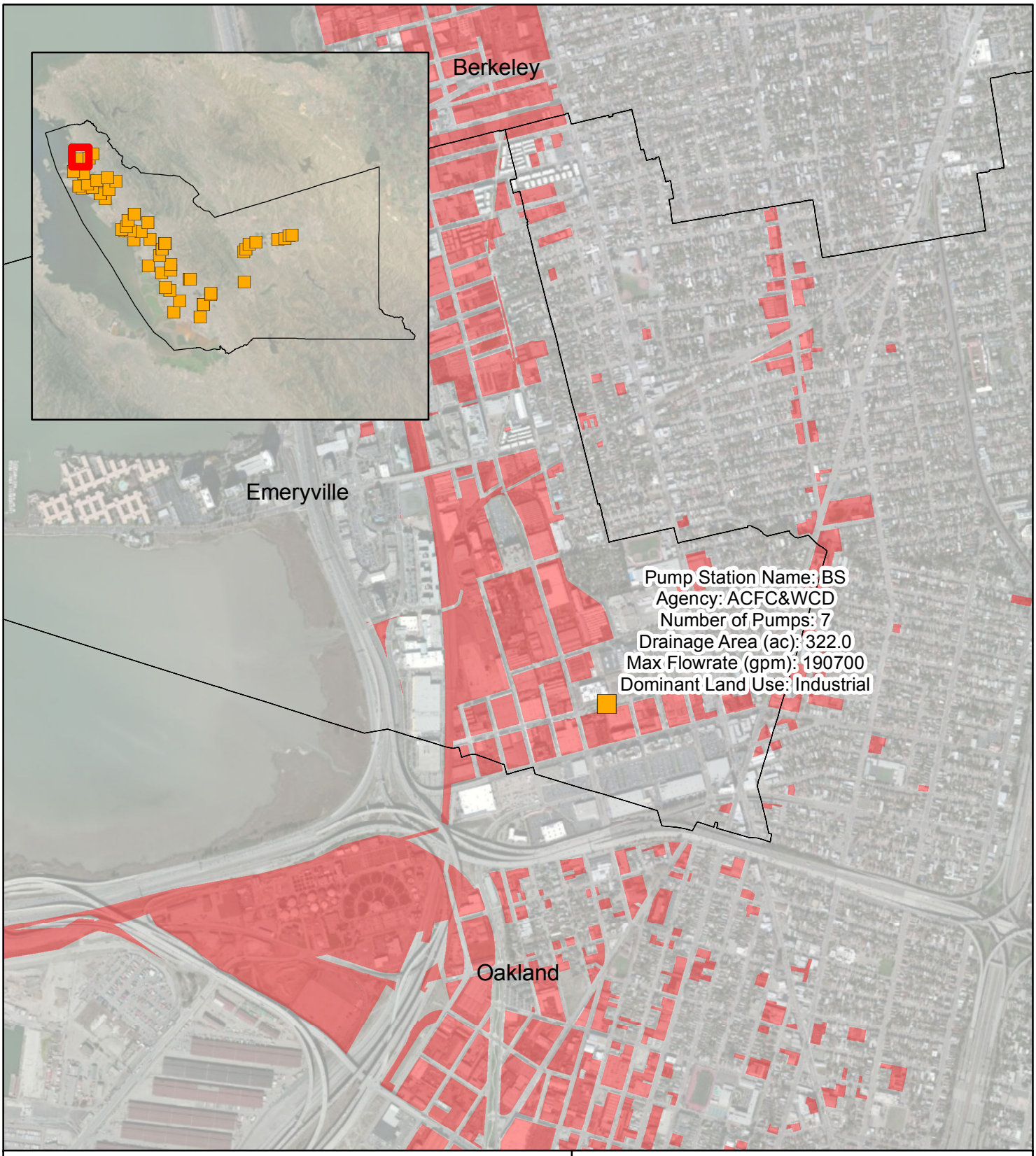
Figure 3-11

P:\GIS\BASMAA_IMR\Projects\2013Nov\Pump Station D-1.mxd



Legend

Pump Station

Municipal Boundary

Land Use

Industrial - Old

N

0 1,000 2,000 3,000 4,000 Feet

Pump Station BS

Geosyntec consultants

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Figure 3-12

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Estimated Load Reduction

Given the preliminary nature of the estimate of the Potential High Opportunity area and the current approximate assessment of source types (Table 3-5), the load reduction analysis for this preliminary scenario was extrapolated from the load reduction analysis conducted for the 38 acre High Opportunity area in the ESPS watershed. As discussed above, the load reduction effectiveness estimated for the distributed enhanced control measures for the 38 acre High Opportunity area is approximately 22 percent. Applying that effectiveness to the Potential High Opportunity Area yields the load reduction estimates shown in Table 3-10 below. The yield for PCBs and HgT are estimated to be relative similar, so the projected load reduction is assumed to be similar.

Table 3-10: Projected PCB and Mercury Load Reduction Estimates for Potential High Opportunity Area (Tier 2)

Constituent	Area (acres)	Runoff Load[1] (grams/yr)	Load reduction effectiveness[2] (%)	Load Reduction (grams/yr)
PCBs	403	400	22%	90
HgT	403	400	22%	90

Notes:

1 Based on estimated PCB yield of 990 mg/acre/yr, consistent with ESPS High Opportunity area analysis, and HgT yield of 1,000 mg/acre/yr consistent with regression equation for HgT.

2 Based on control measure scenario used for ESPS High Opportunity area analysis

The 403 acres are a preliminary estimate of the Potential High Opportunity Area that will be further refined in 2014 as per the implementation planning approach outlined in Table 3-1. Local municipal staff are the most competent to identify potential source types in their jurisdictions, given their knowledge and experience through industrial inspections and other activities. Moreover, control measure selection and implementation will be tailored to the source type and other local conditions.

C.3.2.3 Moderate Opportunity Area (Tier 3)

Tier 3 consists of the Old Urban areas shown on the preliminary base maps plus those Potential High Opportunity areas that are found not to have elevated PCB yields through the implementation planning to be conducted in 2014. Certain land uses within the Old Urban areas may redevelop over the long term, including industrial, commercial, retail, and multi-family residential land uses. [Single family residential is considered less likely to undergo wholesale redevelopment, except in an extreme case such as eminent domain.] Also included in Tier 3 are arterial roads in old urban areas (including single family residential areas) that could be potentially be subject to the C.3 standards or could be amenable to treatment with Green Streets via retrofit.

Table 3-11 shows the current estimates of these areas in Alameda County based on a GIS parcel analysis. Load reduction estimates assume that the entire area would be redeveloped over time

and that redevelopment or treatment retrofit would reduce the PCB and HgT yields from the Old Urban yield to New Urban yield. Table 3-11 below shows the results for PCBs and Table 3-12 shows the estimates for total mercury. The tables indicate that implementation of this maximum scenario is somewhat more effective for total mercury than PCBs, as the yield for total mercury is higher than that for PCBs in the Old Urban land use.

Table 3-11: PCB Load Reduction Estimates for Tier 3

Land Use	Area (acres)	Old Urban Yield (mg/acre/yr)	New Urban Yield (mg/acre/yr)	Load Reduction (grams/yr)
Old Urban[1]	33,310			
Arterials[2]	4,174			
Total	37,484	17.5	2	580

Notes:

1 Parcels that potentially could be redeveloped consisting of commercial, multifamily residential, schools, and retail – located in Old Urban and Old Industrial land uses not included in Tier 1or Tier 2.

2 Arterial roads in Old Urban that could potentially be retrofitted with Green Streets or equivalent treatment

Table 3-12: HgT Load Reduction Estimates for Tier 3

Land use	Area (acres)	Old Urban Yield (mg/acre/yr)	New Urban Yield (mg/acre/yr)	Load Reduction (grams/yr)
Old Urban[1]	33,310			
Arterials[2]	4,174			
Total	37,484	165	25	5,250

Notes:

1 Parcels that potentially could be redeveloped consisting of commercial, multifamily residential, schools, and retail – located in Old Urban and Old Industrial land uses not included in Tier 1or Tier 2.

2 Arterial roads in Old Urban that could potentially be retrofitted with Green Streets or equivalent treatment

C.3.3 Cost Analysis

Costs were estimated to implement the control measures associated with each of the three tier scenarios presented in Section C.3.2 above. The costs are planning level cost estimates that take into account, depending on the control measure, administrative, planning, design, construction, and operation and maintenance costs.

Table 3-13 presents estimated costs for the Tier 1 enhanced control measures presented in Appendix D. For structural measures, capital costs include planning, design, construction and a 25 percent contingency. Source information for cost estimates for structural measures rely on budgets associated with the CW4CB Task 5 retrofit pilot projects, and therefore reflects actual Bay Area costs. Life cycle estimates of costs assume a 20 year service life and fixed annual amortization. Potential controls listed in Appendix D also include treatment by diversion of dry weather and selected wet weather flows from the ESPS to the East Bay Municipal Utility District wastewater treatment plant, but costs are not known at this time. These estimates will be developed in 2014 after clarification of proposed diversion pipe sizing and potential wet weather storage.

For non-structural measures, various sources were used including literature sources and outreach to municipal agencies. In some cases, cost estimates were derived from discussions with the members of the Work Group. Operation and Maintenance Costs for structural measures were assumed to equal 20% of the annual amortization cost.

Table 3-13: Cost Estimate for Tier 1 Control Measure Implementation

Type of Control Measure	Capital Cost ($)	Amortized Capital Cost ($/year)	O&M ($/year)	Life Cycle Cost ($/year)
Private Property Abatement and Remediation[1]	0	0	$40,000	$40,000
Street Sweeping[2]	0	0	$1,000	$1,000
Drop Inlet Cleaning [3]	0	0	$5,000	$5,000
Tree Well retrofits[4]	$345,000	$17,250	$3,450.0	$20,700
Redevelopment [5]	0	$0	$9,000	$9,000
Pump Station Cleanout [6]	0	$0	$52,000	$52,000
ESPS Media filters [7]	$140,000	$7,000	$1,400	$8,400
Total	$485,000	$24,250	$111,850	$136,100

Notes:
Capital cost amortized over 20 year period assuming straight line amortization assumed to equal 20% of amortized capital cost.

1 MS4 administrative costs of $10,000 per year per facility (professional judgment)
2 $80 per curb mile (Sediment Management Practices Literature Review)
3 $200 to clean out one drop inlet (professional judgment)
4 Capital cost is CW4CB Task 5 Budget estimate
5 MS4 administrative costs $20,000/acre/yr (professional judgment)
6 Unit rates provided by Pump Station Supervisor
7 Capital cost is CW4CB Task 5 Budget estimate

Tier 2 High Priority areas have been estimated in a preliminary way in terms of overall number of acres, but the final area and locations will be evaluated and selected by the Permittees through the implementation planning process. So the types of source areas and the appropriate control measures for those source areas have yet to be determined. Thus for the purposes of this report, costs have been extrapolated, based on area, from the life cycle costs for the ESPS High Priority area. The life cycle cost estimate for the 38 acre High Priority area in the ESPS watershed has been estimated at approximately $140,000 per year (Table 3-13). Linearly extrapolating to the 403 acre Potential High Priority area, the total life cycle cost would be approximately $1.5M per year. This estimate assumes that remediation and redevelopment costs are born by the site owner and developer, respectively.

As discussed above, the Tier 3 Old Urban areas have been estimated based on a GIS parcel analysis of those land uses in Old Urban and that portion of Old Industrial which was not selected as High Priority. The control measure scenario primarily relies on redevelopment and retrofitting with Green Streets-type controls or equivalent. In the case of redevelopment, the

majority of costs would be borne by the developer. In the case of green streets retrofitting or redevelopment of arterial streets, where the catchment is limited to the roadway, the cost would be borne by the municipality. Where a green streets installation treats runoff from a development project, some funding could come from the developer and some from the municipality. This scenario is primarily qualitative at this point, and cost estimates for implementation would be subject to significant uncertainty.

C.4 Other Reporting Requirements

This section fulfills MRP reporting requirements associated with POC fate and transport studies (C.11.h/C.12.h), risk reduction program implementation (C.11.i/C.12.i), and the allocation sharing scheme with Caltrans (C.11.j).

C.4.1 POC Fate and Transport

MRP provisions C.11.j and C.12.j require Permittees to "conduct or cause to be conducted studies aimed at better understanding the fate, transport, and biological uptake of mercury and PCBs discharged in urban runoff to San Francisco Bay and tidal areas." Working through BASMAA, the Permittees used previous annual reports to describe the specific manner for meeting these information needs through their participation in the Regional Monitoring Program for Water Quality in San Francisco Bay (RMP) and to provide updates on the status of these studies.

The RMP Multi-Year Plan[14] describes activities in the two main program elements, Status and Trends Monitoring and Special Studies. Special Studies are developed through the RMP's structure of Work Groups and pollutant-specific Strategies which have coordinated information needs for mercury, PCBs and other Pollutants of Concern. As described in IMR Part A, staff from ACCWP and other BASMAA programs actively represented all MRP Permittees on the RMP Steering Committee, Technical Review Committee and several Work Groups and Strategy Teams to oversee the implementation of studies, review results, and comment on draft reports.

Major findings from RMP mercury studies were reported in Davis et al. (2012), which synthesized results from recent RMP studies on food web uptake and methods to identify high leverage pathways that introduce mercury to Bay food webs. A more extended Mercury Synthesis report for RMP stakeholders will incorporate additional data from a study of mercury food web uptake in small fish (e.g., Grenier et al., 2013), and more detailed recommendations on filling information needs for San Francisco Bay in the following areas:

- Data on mercury content for additional popular sport fish species;
- Improved spatial understanding of biotic exposure to mercury uptake, particularly in tidal marshes, managed ponds, reservoirs, and streams;
- Information to promote understanding of the potential benefits of management actions at local and regional scales;
- Evaluation of the effectiveness of management actions at local and regional scales; and

[14] The January 2014 update to the RMP Multi-Year Plan is available at http://www.sfei.org/sites/default/files/Item8_RMP%20Multi-Year%20Plan%2001-23-14%20clean.pdf

- The overall potential for reduction of net methylmercury production at a regional scale.

The RMP's PCB Strategy activities during the MRP permit term included:

- Monitoring of mercury, PCBs, and other pollutants in biota, both ongoing (Status & Trends) and in a special 3-year study of Small Fish living along the Bay margins that are an important link in the Bay food web (Greenfield and Allen, 2012).
- Preparation of a draft report outlining a conceptual model of transport and food web uptake for mercury and PCBs in Bay Margin areas to help inform future data collection in these areas (Jones et al. 2012). The RMP originally intended to incorporate these recommendations plans for more detailed fate and transport modeling of the Bay and its margin areas; however in 2013the RMP Steering Committee approved shifting the Multi-Year Plan forecasting/modeling priorities toward other modeling objectives and away from a focus on PCBs and other sediment-associated bioaccumulative pollutants.
- A review of current knowledge and information needs to support modeling of food web bioaccumulation for multiple Pollutants of Concern (Melwani et al. 2012).

A draft PCB Synthesis document was reviewed by RMP stakeholders in 2013 (Davis et al. 2013). It incorporates significant new information generated by the RMP and others since the preparation of the 2008 PCB TMDL Staff Report, including Bay sediment data using more accurate analytical methods (high resolution mass spectrometry) and the randomized sampling design; additional trend data from sport fish, bivalves, and bird eggs; data on the magnitude and spatial distribution of PCBs in small fish that are important for understanding food web pathways; and information on the entire suite of 209 congeners for sediment, water and biota. draft recommendations regarding priorities for future information needs have not been integrated among different sections of the synthesis or finalized to incorporate review comments but may include:

- Continuing RMP monitoring of sport fish and small fish, with consideration of additional sampling locations or time series to support multiple objectives.
- Assessment of sediment trends data and the potential value of continuing to track dry season trends.
- Assessment of PCBs in the Bay margins using indicator species and sediment.
- Identification of high-leverage watersheds or groups of watersheds contributing high PCBs in marginal areas.
- Identification of source areas for cleanup, with more emphasis on source control.
- The importance of determining the role of loading from in-Bay contaminated sites in segment-scale recovery of the Bay.

BASMAA representatives will continue participation in RMP Work Groups, Strategy Teams, and Committees to promote future implementation of studies to address priority information needs for mercury and PCBs outlined in the recent synthesis documents.

C.4.2 Regional Risk Reduction Activities

Provisions C.11i and C.12.i require that Permittees "develop and implement or participate in effective programs to reduce mercury-related risks to humans and quantify the resulting risk reductions from these activities." Working through BASMAA, ACCWP Permittees addressed this requirement through participation in the San Francisco Bay Fish Project (SFBFP) coordinated by the California Department of Public Health (CDPH) to raise public awareness of fish contamination issues in San Francisco Bay and to encourage fish-consuming populations to reduce their exposure to pollutants in contaminated fish. Representatives from BASMAA and the Alameda County Environmental Health Department joined representatives of wastewater dischargers and regulatory agencies in the SFBFP Stakeholder Advisory Group (SAG) to implement four main tasks:

- Conduct needs assessments,
- Create and convene the SAG to solicit feedback on project activities,
- Conduct risk communication and exposure reduction activities, and
- Program evaluation and coordination.

BASMAA's Clean Watersheds for a Clean Bay project also contributed funding for these tasks, which were contracted to CDPH via the Aquatic Science Center. CDPH's final project report[15] for the SFBFP described successful outcomes for all tasks including:

- Development of educational materials including a "Safe Eating Guidelines" advisory brochure for use by anglers and in community workshops and clinics[16]. The brochures were translated from English into 10 additional languages and printed copies were made available to funded groups. Advisory information was provided as a kiosk flyer and also adapted into a coloring book for children.
- Development of a new "Fish Smart" warning sign and posting of signs at fishing sites around the Bay. In addition to the OEHHA phone number, signs contain a "QR code" which, when scanned by a smart phone, links to a CDPH website where the Safe Eating

[15]http://www.sfei.org/sites/default/files/users/antonytran/SFB%20Fish%20Project%20Final%20Report-CDPH%2010-29-12.pdf

[16] Brochures and other materials are available as pdf files along with order forms for print versions at http://www.sfei.org/content/educational-materials

brochures are available in all languages[17]. As of December 2012 CDPH reported signs had been posted at a total of 60 sites around the Bay, including 13 in Alameda County, which was roughly about 40% of all sites identified. In July and August 2012 CDPH interviewed 37 anglers at 10 fishing sites where signs had been posted for at least one week. CDPH found that, in general, most anglers noticed the signs and understood the main messages. However, only one in three anglers reported that the signs were likely to influence their future decisions.

- Implementation of a grant program in which four community groups were awarded a total of $100,000 to conduct risk reduction activities in vulnerable communities. CDPH provided support and worked with each of the groups to conduct evaluations of their projects in two areas: a) process evaluation documenting implementation of the core activities; and b) outcome evaluation to measure changes in awareness, knowledge or intent to change behavior among participants in the funded projects. All groups successfully implemented their projects and met or exceeded their goals for the numbers of participants, totaling over 8,000 of which 5,726 were consumers of Bay fish and 4,741 were considered to be at risk. The participants also identified over 17,000 other members of their households who ate Bay fish; the actual number of potential indirect contacts is likely to be larger because some of the funded groups did not obtain this information from all of their participants.
- Evaluation: the outcome evaluation results for the funded groups demonstrated positive changes in terms of increases in knowledge and access to information after participation in the funded group activities. However despite providing standard evaluation tools CDPH could not aggregate outcome evaluation data across the funded groups because all made some modifications to the tools or the way they collected, aggregated, and presented their outcome evaluation data. Participants generally demonstrated a willingness to share the information with others and an intention to change behavior in ways that reduce exposure to chemicals from Bay fish. The groups planned to continue incorporating the educational materials in future work with their target communities.

CDPH staff identified several challenges to completing the effective posting of fishing sites and Alameda County Environmental Health has continued working with them to post signs and track posting activities. The final project report lists other recommended improvements to the SFBFP components if continued.

C.4.3 Mercury Allocation Sharing

Provision C.11.j.i of the MRP requires Permittees to "develop an equitable mercury allocation-sharing scheme in consultation with Caltrans to address the Caltrans facilities in the program area, and report the details to the Water Board. Alternatively, Caltrans may choose to implement

[17]www.sfbayfish.org

mercury load reduction actions on a watershed or region-wide basis in lieu of sharing a portion of an urban runoff management agencies' mercury allocation." Provision C.11.j.ii of the MRP also requires that Permittees "submit in their March 15, 2014 Integrated Monitoring Report the manner in which the urban runoff mercury TMDL allocation will be shared between the Permittees and Caltrans." (Emphasis added.)

Working through BASMAA, Permittee representatives and Caltrans met several times to review provision C.11.j and to discuss approaches to addressing it. Those discussions led to a letter from Caltrans (provided in Appendix F) in which Caltrans states the manner will be to take the alternative approach provided in provision C.11.j of implementing mercury load reduction actions on a watershed or region-wide basis, consistent with TMDL implementation requirements in Caltrans' MS4 Permit, and including developing an equitable sharing scheme with Permittees. The State Water Board is scheduled on May 20, 2014 to consider the addition of Caltrans' TMDL implementation requirements in an Amendment to the Caltrans Permit. Permittees intend to work with Caltrans to identify load reduction actions that can be implemented on a watershed or region-wide basis.

C.5 References

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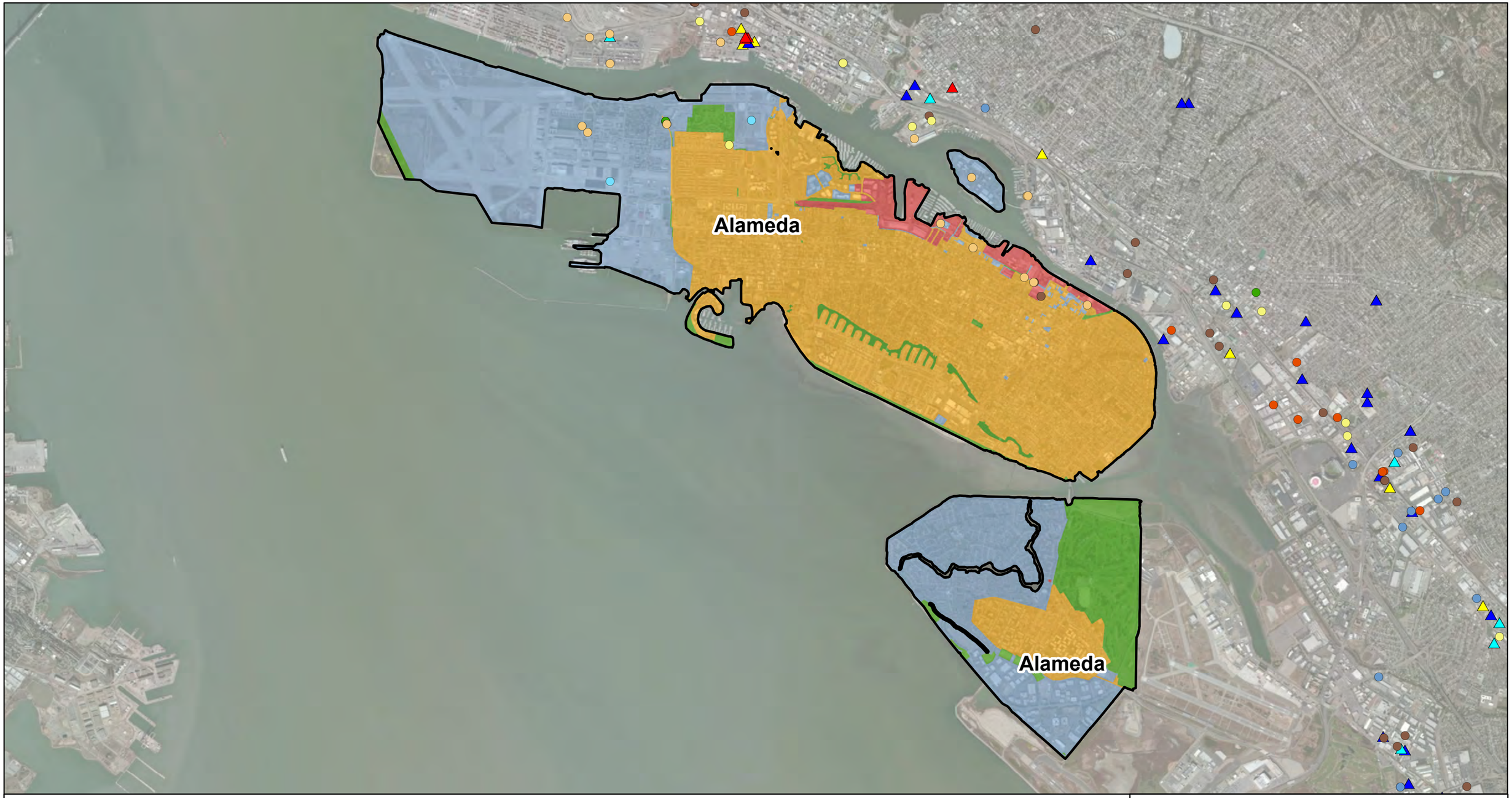
ACCWP IMR PART C

APPENDIX A

Land Use PCB Yield Maps by Municipality



Legend

Pollutant Source Areas
- Transportation/Shipping
- Metals Recycling
- Recycling Drums
- Automotive Recycling
- General Waste Recycling
- Metals Manufacturing
- Cremation Facility
- Self Reported PCB Source
- Municipal Boundary

Sampling Site PCB Concentration (mg/kg)
- < 0.1 (1-25th Percentile)
- 0.1 - 0.3 (25-50th Percentile)
- 0.3 - 1.0 (50-75th Percentile)
- >1 (75-99th Percentile)

Land Use (Category)
- Old Industrial (1)
- Old Urban (2)
- New Urban (3) & Other (5)
- Open Space (4)

0 3,600 7,200 10,800
Feet

N

City of Alameda
Land Use Categories
ACCWP IMR

Geosyntec consultants

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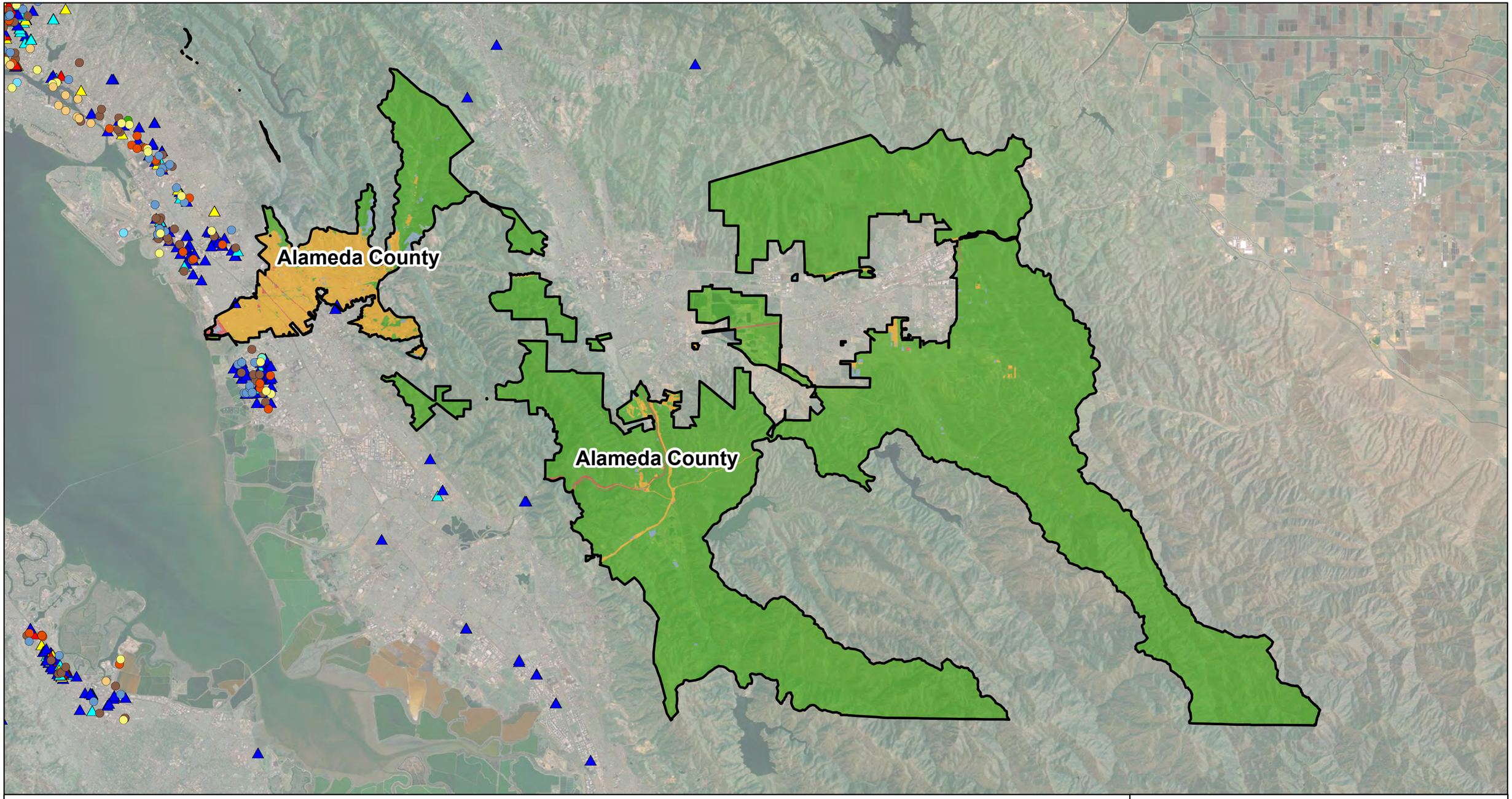
Figure A-1

P:\GIS\BASMAA_IMR\Projects\2014Jan\Alameda_Weighted_PCBs_AlamedaCity_Appendix_1.mxd



Legend

Pollutant Source Areas
- Transportation/Shipping
- Metals Recycling
- Recycling Drums
- Automotive Recycling
- General Waste Recycling
- Metals Manufacturing
- Cremation Facility
- Self Reported PCB Source
- Municipal Boundary

Sampling Site PCB Concentration (mg/kg)
- < 0.1 (1-25th Percentile)
- 0.1 - 0.3 (25-50th Percentile)
- 0.3 - 1.0 (50-75th Percentile)
- >1 (75-99th Percentile)

Land Use (Category)
- Old Industrial (1)
- Old Urban (2)
- New Urban (3) & Other (5)
- Open Space (4)

N

0 16,000 32,000 48,000
Feet

Unincorporated Alameda County
Land Use Categories
ACCWP IMR

Geosyntec consultants

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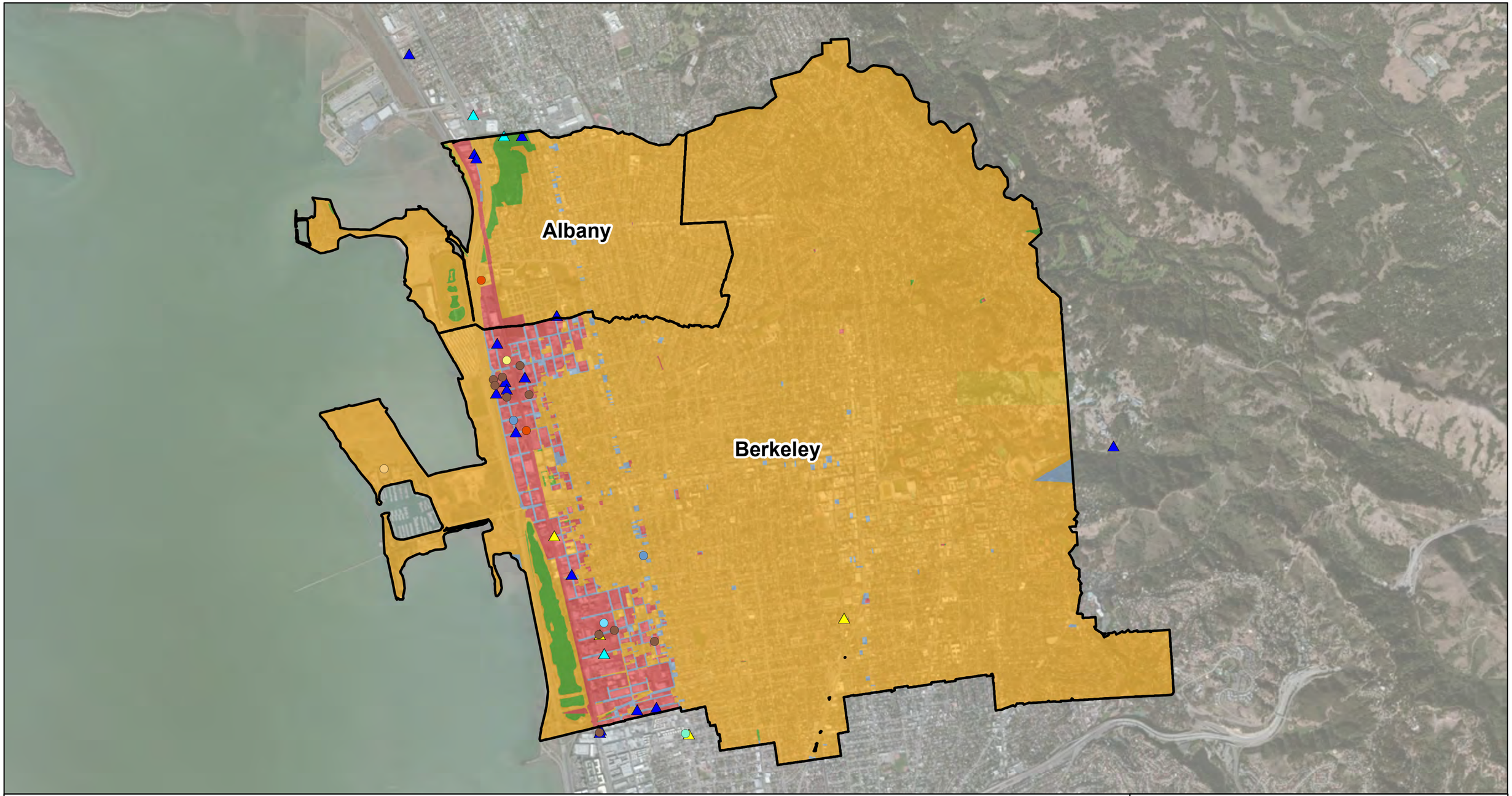
Figure A-2

P:\GIS\BASMAA_IMR\Projects\2014Jan\Alameda_Weighted_PCBs_AlamedaCounty_Appendix_2.mxd



Legend

Pollutant Source Areas
- Transportation/Shipping
- Metals Recycling
- Recycling Drums
- Automotive Recycling
- General Waste Recycling
- Metals Manufacturing
- Cremation Facility
- Self Reported PCB Source
- Municipal Boundary

Sampling Site PCB Concentration (mg/kg)
- < 0.1 (1-25th Percentile)
- 0.1 - 0.3 (25-50th Percentile)
- 0.3 - 1.0 (50-75th Percentile)
- >1 (75-99th Percentile)

Land Use (Category)
- Old Industrial (1)
- Old Urban (2)
- New Urban (3) & Other (5)
- Open Space (4)

N

0 2,800 5,600 8,400
Feet

Albany and Berkeley
Land Use Categories
ACCWP IMR

Geosyntec consultants

WW1646 | January 2014

Figure A-3

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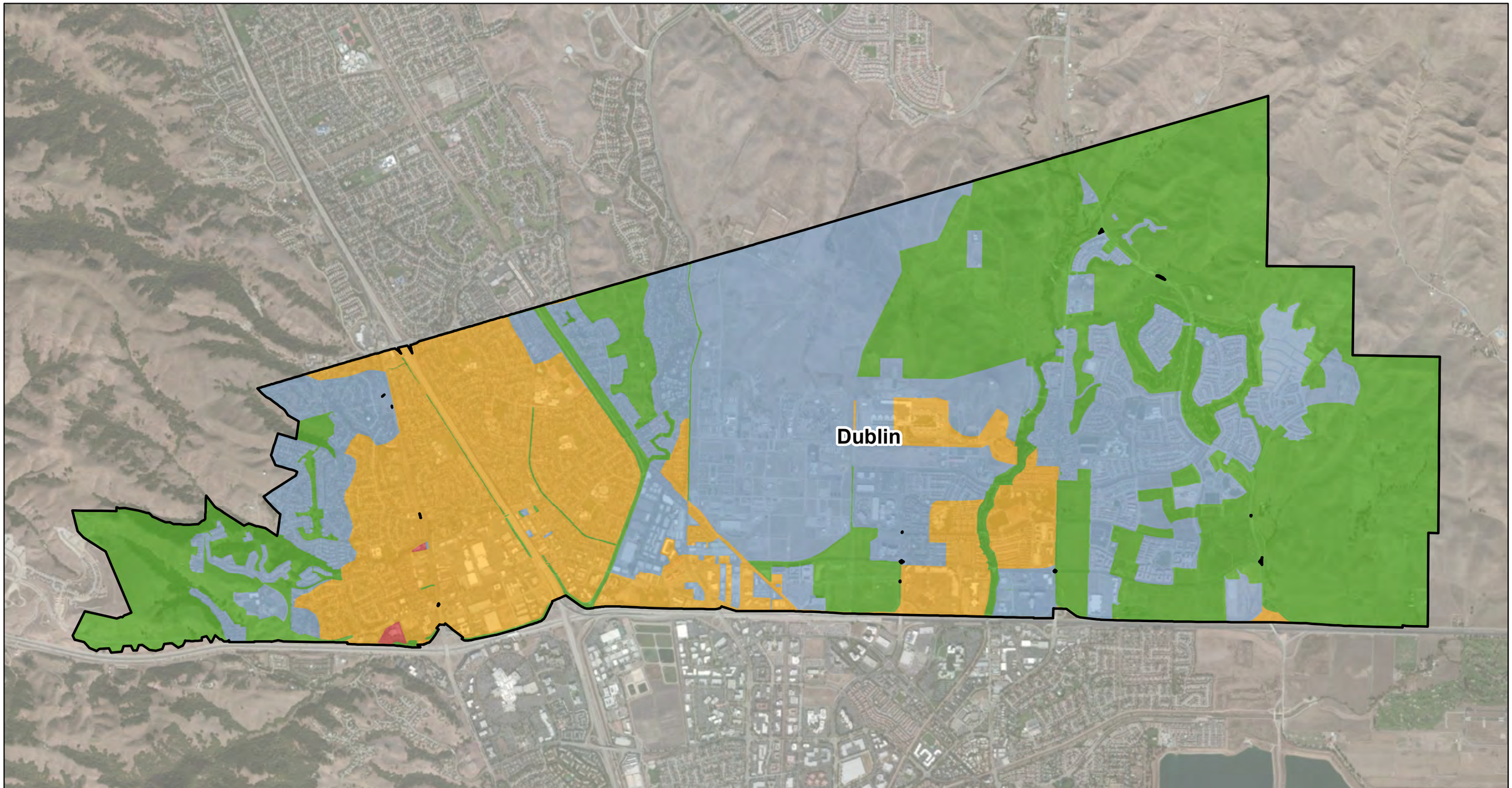

Legend

Pollutant Source Areas
- Transportation/Shipping
- Metals Recycling
- Recycling Drums
- Automotive Recycling
- General Waste Recycling
- Metals Manufacturing
- Cremation Facility
- Self Reported PCB Source
- Municipal Boundary

Sampling Site PCB Concentration (mg/kg)
- < 0.1 (1-25th Percentile)
- 0.1 - 0.3 (25-50th Percentile)
- 0.3 - 1.0 (50-75th Percentile)
- >1 (75-99th Percentile)

Land Use (Category)
- Old Industrial (1)
- Old Urban (2)
- New Urban (3) & Other (5)
- Open Space (4)

N

0 2,800 5,600 8,400
Feet

Dublin
Land Use Categories
ACCWP IMR

Geosyntec consultants

WW1646 | January 2014

Figure A-4

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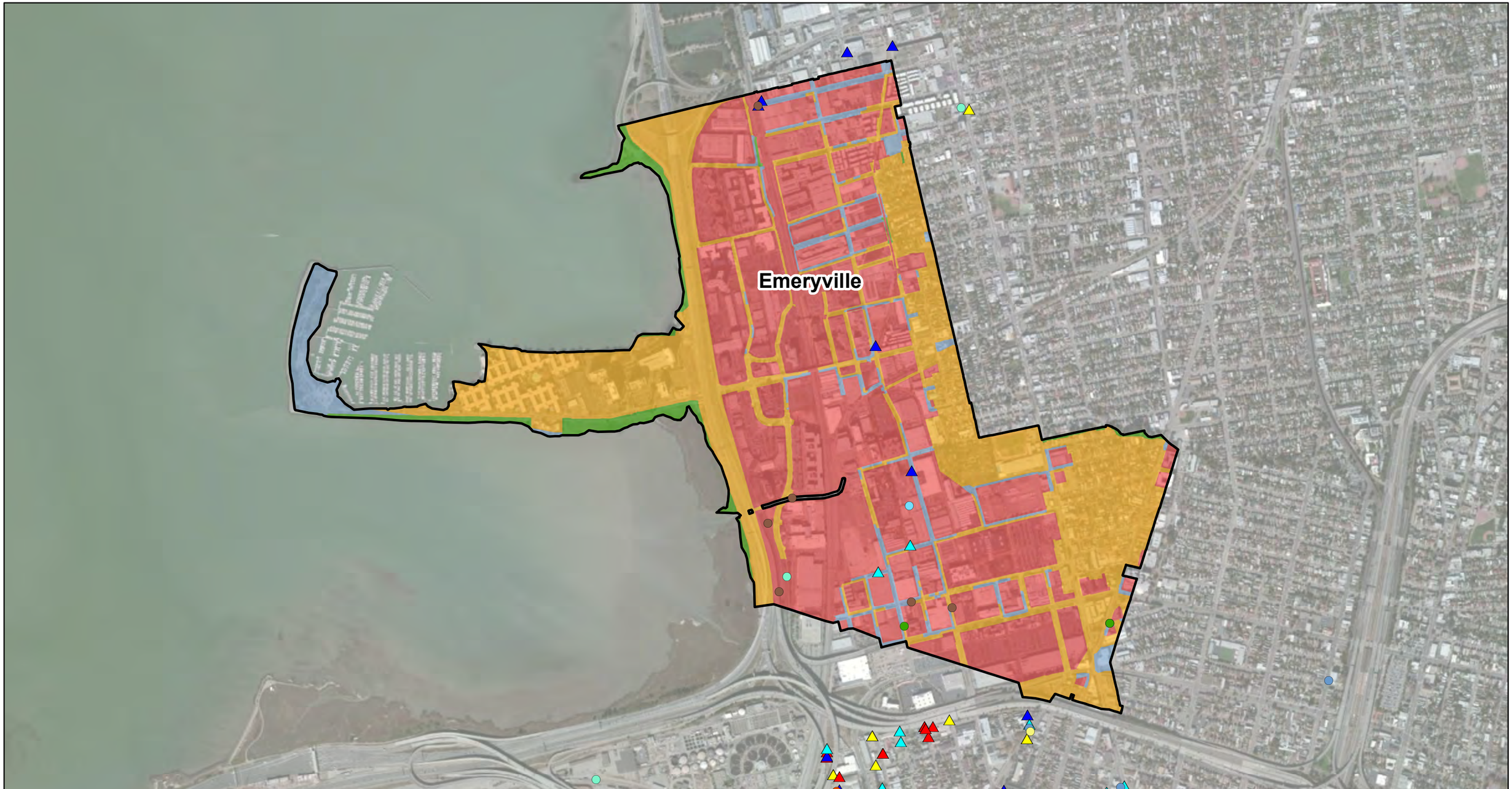

Legend

Pollutant Source Areas
- Transportation/Shipping
- Metals Recycling
- Recycling Drums
- Automotive Recycling
- General Waste Recycling
- Metals Manufacturing
- Cremation Facility
- Self Reported PCB Source
- Municipal Boundary

Sampling Site PCB Concentration (mg/kg)
- < 0.1 (1-25th Percentile)
- 0.1 - 0.3 (25-50th Percentile)
- 0.3 - 1.0 (50-75th Percentile)
- >1 (75-99th Percentile)

Land Use (Category)
- Old Industrial (1)
- Old Urban (2)
- New Urban (3) & Other (5)
- Open Space (4)

N

0 1,200 2,400 3,600
Feet

Emeryville
Land Use Categories
ACCWP IMR

Geosyntec consultants

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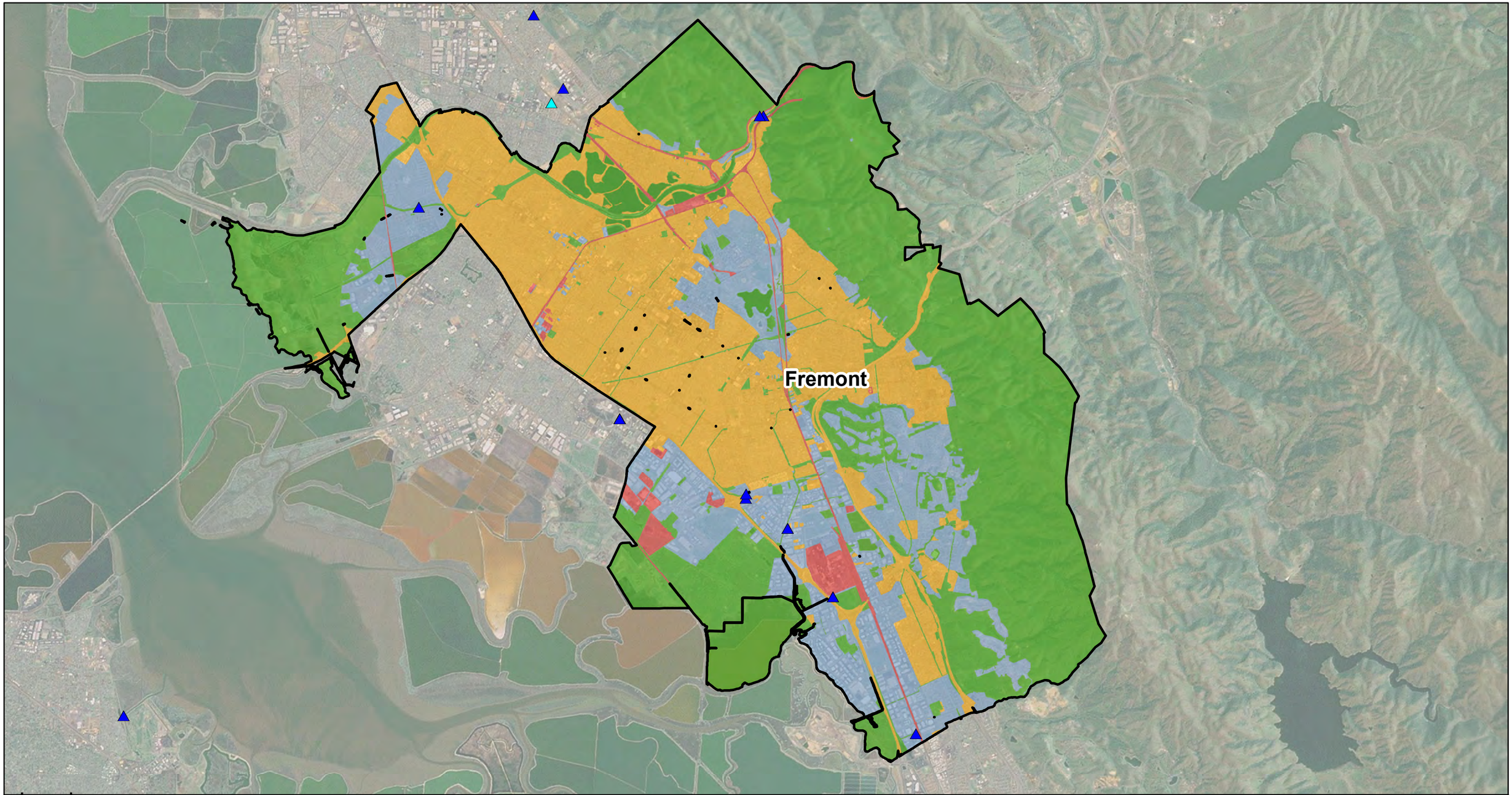
Figure A-5

P:\GIS\BASMAA_IMR\Projects\2014Jan\Alameda_Weighted_PCBs_Emeryville_Appendix_5.mxd



Legend

Pollutant Source Areas
- Transportation/Shipping
- Metals Recycling
- Recycling Drums
- Automotive Recycling
- General Waste Recycling
- Metals Manufacturing
- Cremation Facility
- Self Reported PCB Source
- Municipal Boundary

Sampling Site PCB Concentration (mg/kg)
- < 0.1 (1-25th Percentile)
- 0.1 - 0.3 (25-50th Percentile)
- 0.3 - 1.0 (50-75th Percentile)
- >1 (75-99th Percentile)

Land Use (Category)

General
- Old Industrial (1)
- Old Urban (2)
- New Urban (3) & Other (5)
- Open Space (4)

0 6,900 13,800 20,700
Feet

N

Fremont
Land Use Categories
ACCWP IMR

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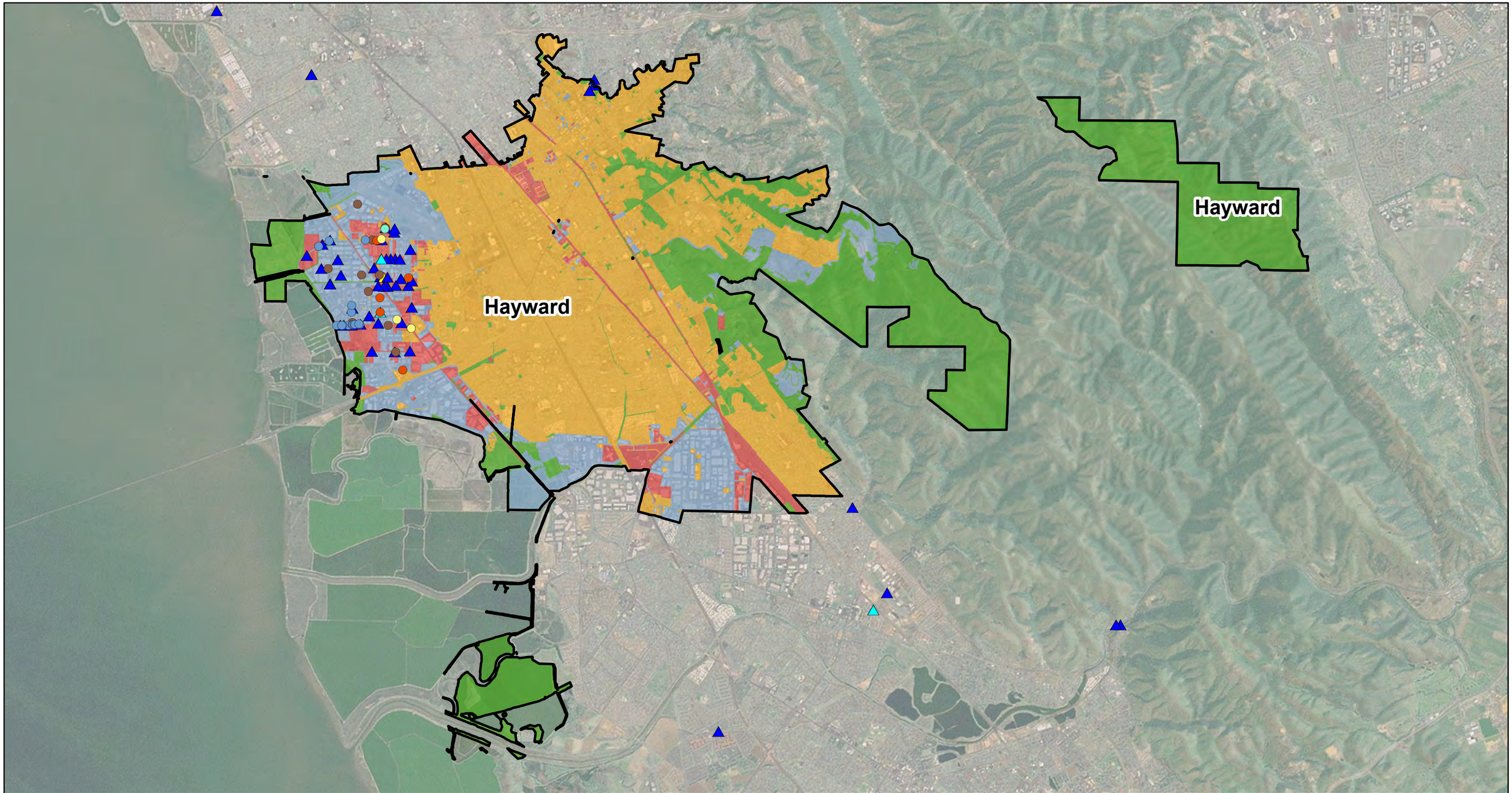
Figure A-6

P:\GIS\BASMAA_IMR\Projects\2014Jan\Alameda_Weighted_PCBs_Fremont_Appendix_6.mxd



Legend

Pollutant Source Areas
- Transportation/Shipping
- Metals Recycling
- Recycling Drums
- Automotive Recycling
- General Waste Recycling
- Metals Manufacturing
- Cremation Facility
- Self Reported PCB Source
- Municipal Boundary

Sampling Site PCB Concentration (mg/kg)
- < 0.1 (1-25th Percentile)
- 0.1 - 0.3 (25-50th Percentile)
- 0.3 - 1.0 (50-75th Percentile)
- >1 (75-99th Percentile)

Land Use (Category)
- Old Industrial (1)
- Old Urban (2)
- New Urban (3) & Other (5)
- Open Space (4)

0 5,900 11,800 17,700
Feet

N

Hayward
Land Use Categories
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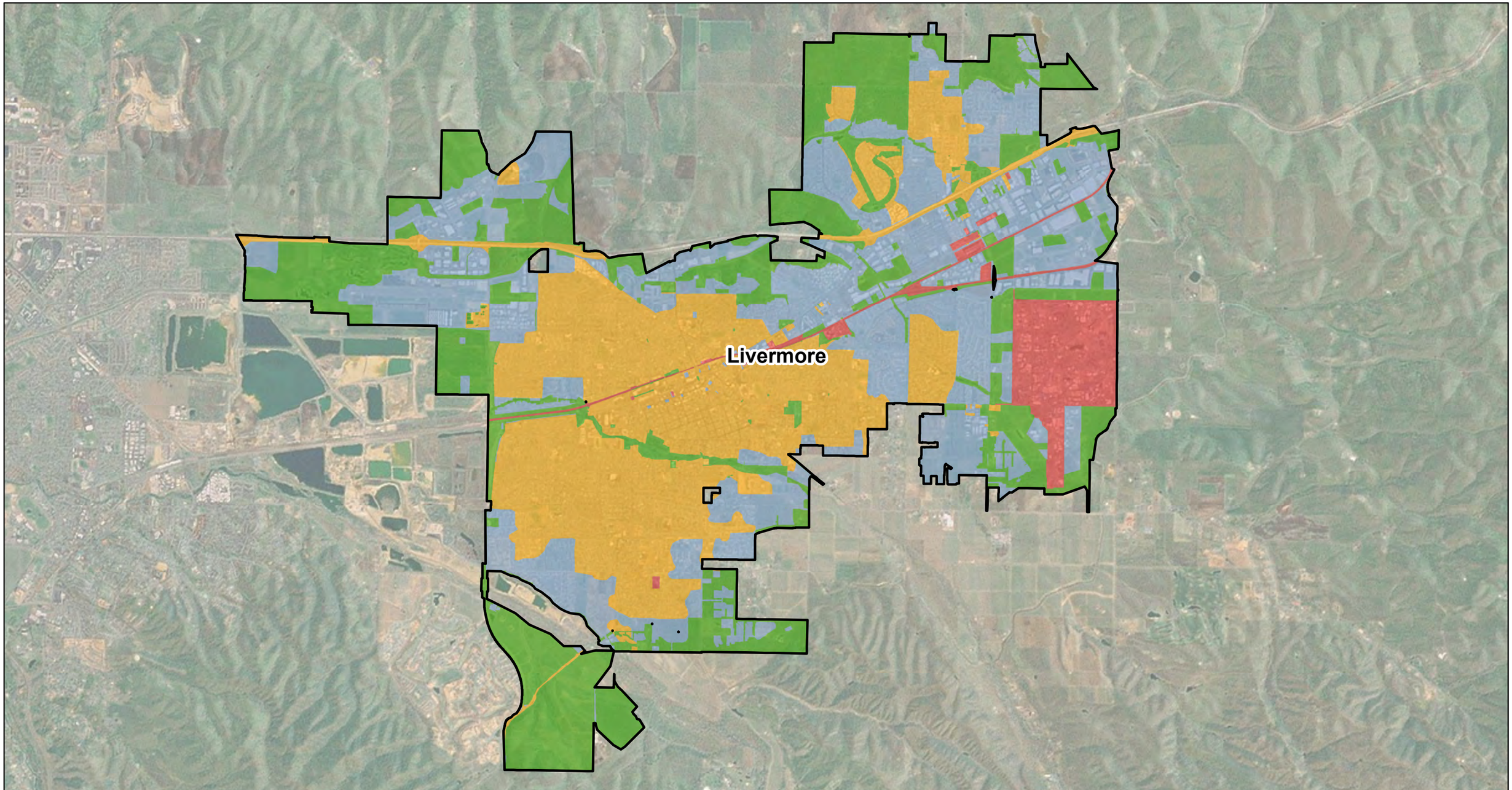
Figure A-7

P:\GIS\BASMAA_IMR\Projects\2014Jan\Alameda_Weighted_PCBs_Hayward_Appendix_7.mxd



Legend

Pollutant Source Areas
- Transportation/Shipping
- Metals Recycling
- Recycling Drums
- Automotive Recycling
- General Waste Recycling
- Metals Manufacturing
- Cremation Facility
- Self Reported PCB Source
- Municipal Boundary

Sampling Site PCB Concentration (mg/kg)
- < 0.1 (1-25th Percentile)
- 0.1 - 0.3 (25-50th Percentile)
- 0.3 - 1.0 (50-75th Percentile)
- >1 (75-99th Percentile)

Land Use (Category)
- Old Industrial (1)
- Old Urban (2)
- New Urban (3) & Other (5)
- Open Space (4)

N

0 4,600 9,200 13,800
Feet

Livermore
Land Use Categories
ACCWP IMR

Geosyntec consultants

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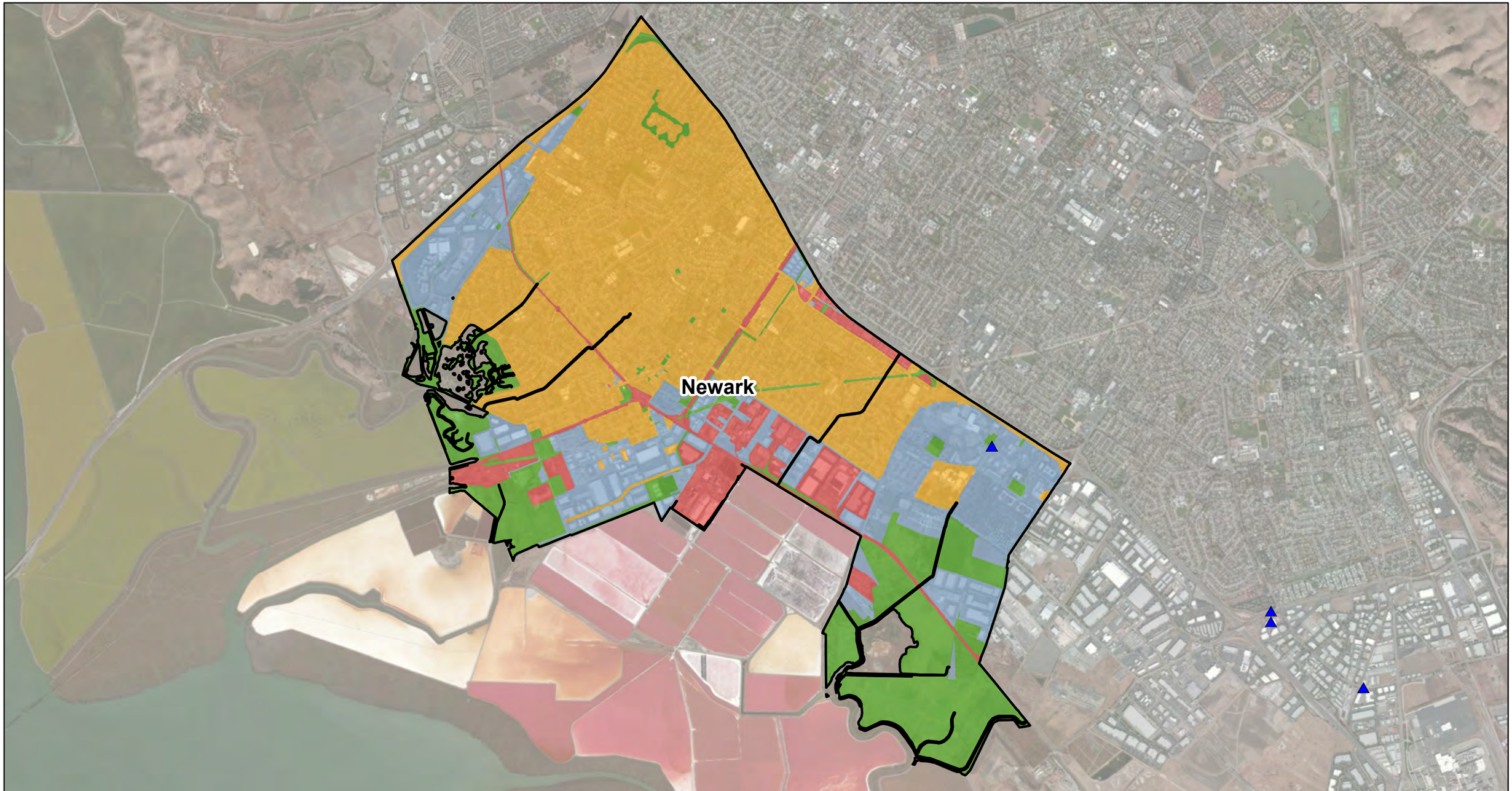
Figure A-8

P:\GIS\BASMAA_IMR\Projects\2014Jan\Alameda_Weighted_PCBs_Livermore_Appendix_8.mxd



Legend

Pollutant Source Areas
- Transportation/Shipping
- Metals Recycling
- Recycling Drums
- Automotive Recycling
- General Waste Recycling
- Metals Manufacturing
- Cremation Facility
- Self Reported PCB Source
- Municipal Boundary

Sampling Site PCB Concentration (mg/kg)
- < 0.1 (1-25th Percentile)
- 0.1 - 0.3 (25-50th Percentile)
- 0.3 - 1.0 (50-75th Percentile)
- >1 (75-99th Percentile)

Land Use (Category)
- Old Industrial (1)
- Old Urban (2)
- New Urban (3) & Other (5)
- Open Space (4)

N

0 3,200 6,400 9,600
Feet

Newark
Land Use Categories
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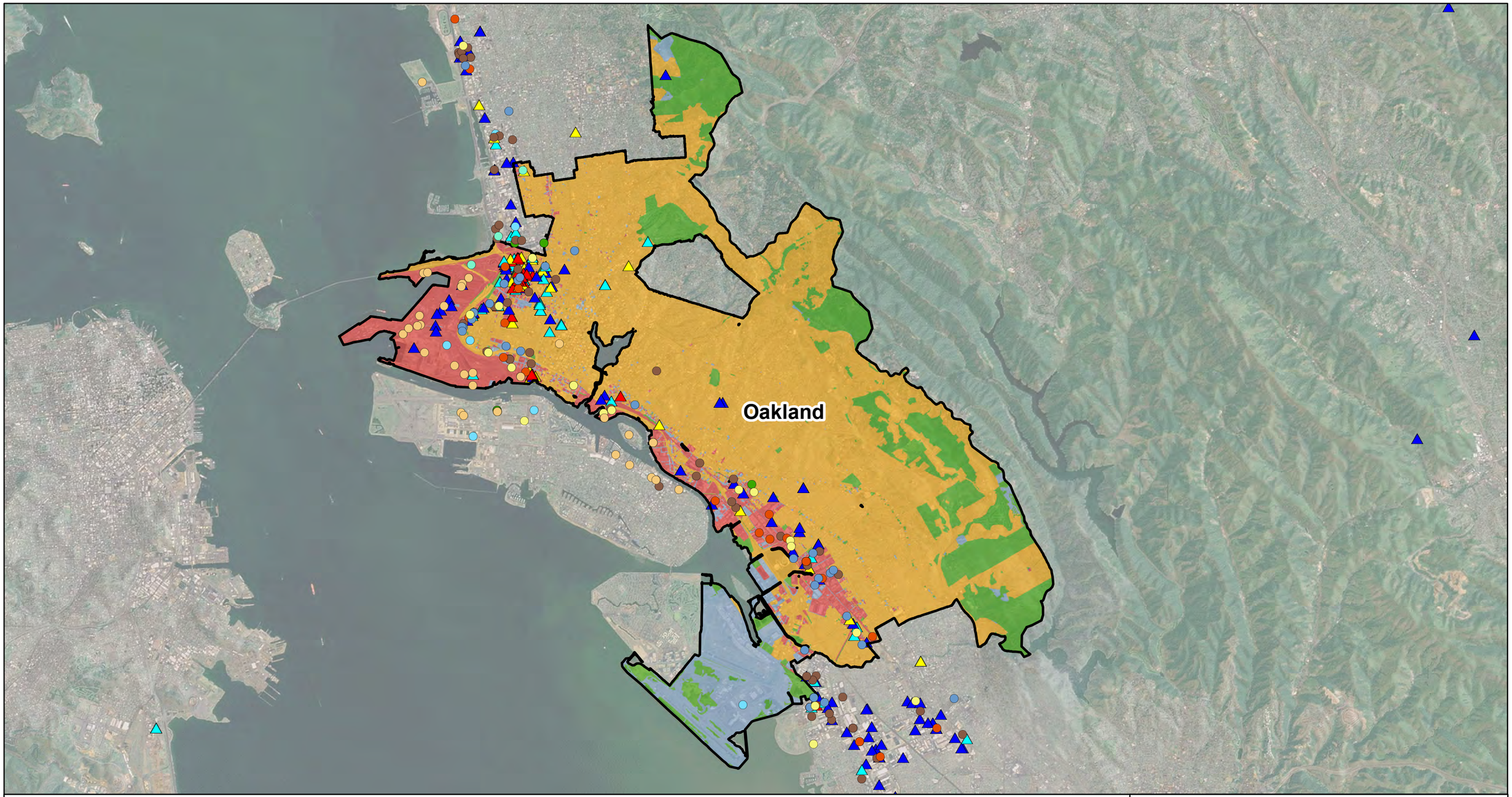
Figure A-9

P:\GIS\BASMAA_IMR\Projects\2014Jan\Alameda_Weighted_PCBs_Newark_Appendix_9.mxd



Legend

Pollutant Source Areas
- Transportation/Shipping
- Metals Recycling
- Recycling Drums
- Automotive Recycling
- General Waste Recycling
- Metals Manufacturing
- Cremation Facility
- Self Reported PCB Source
- Municipal Boundary

Sampling Site PCB Concentration (mg/kg)
- < 0.1 (1-25th Percentile)
- 0.1 - 0.3 (25-50th Percentile)
- 0.3 - 1.0 (50-75th Percentile)
- >1 (75-99th Percentile)

Land Use (Category)
- Old Industrial (1)
- Old Urban (2)
- New Urban (3) & Other (5)
- Open Space (4)

N

0 8,400 16,800 25,200
Feet

Oakland
Land Use Categories
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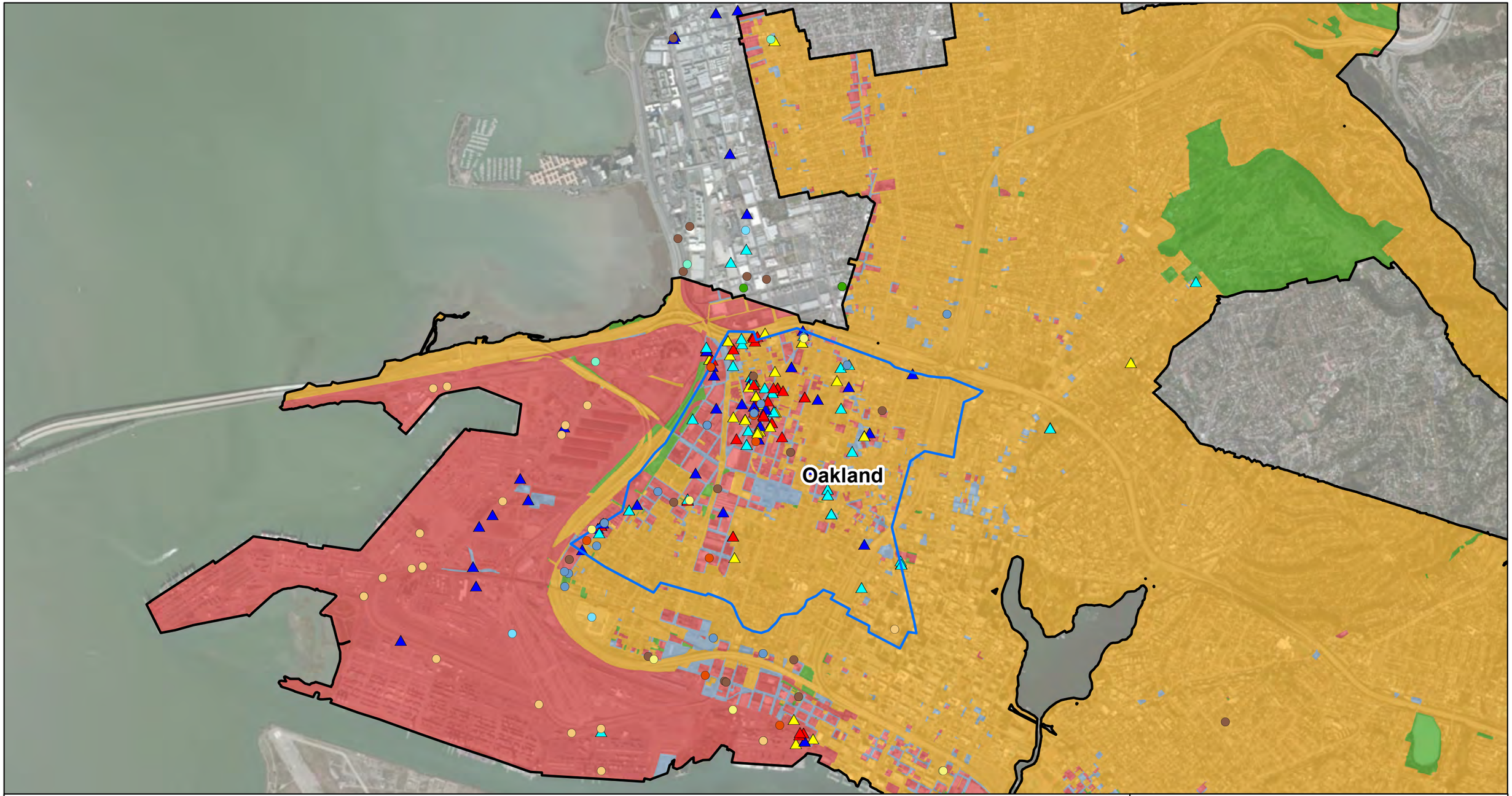
Figure A-10

P:\GIS\BASMAA_IMR\Projects\2014Jan\Alameda_Weighted_PCBs_Oakland1_Appendix_10.mxd



Legend

Pollutant Source Areas
- Transportation/Shipping
- Metals Recycling
- Recycling Drums
- Automotive Recycling
- General Waste Recycling
- Metals Manufacturing
- Cremation Facility
- Self Reported PCB Source
- Municipal Boundary

Sampling Site PCB Concentration (mg/kg)
- < 0.1 (1-25th Percentile)
- 0.1 - 0.3 (25-50th Percentile)
- 0.3 - 1.0 (50-75th Percentile)
- >1 (75-99th Percentile)

Land Use (Category)
- Old Industrial (1)
- Old Urban (2)
- New Urban (3) & Other (5)
- Open Space (4)
- ESPS Watershed

0 2,500 5,000 7,500
Feet

N

Oakland, Ettie St. Detail
Land Use Categories
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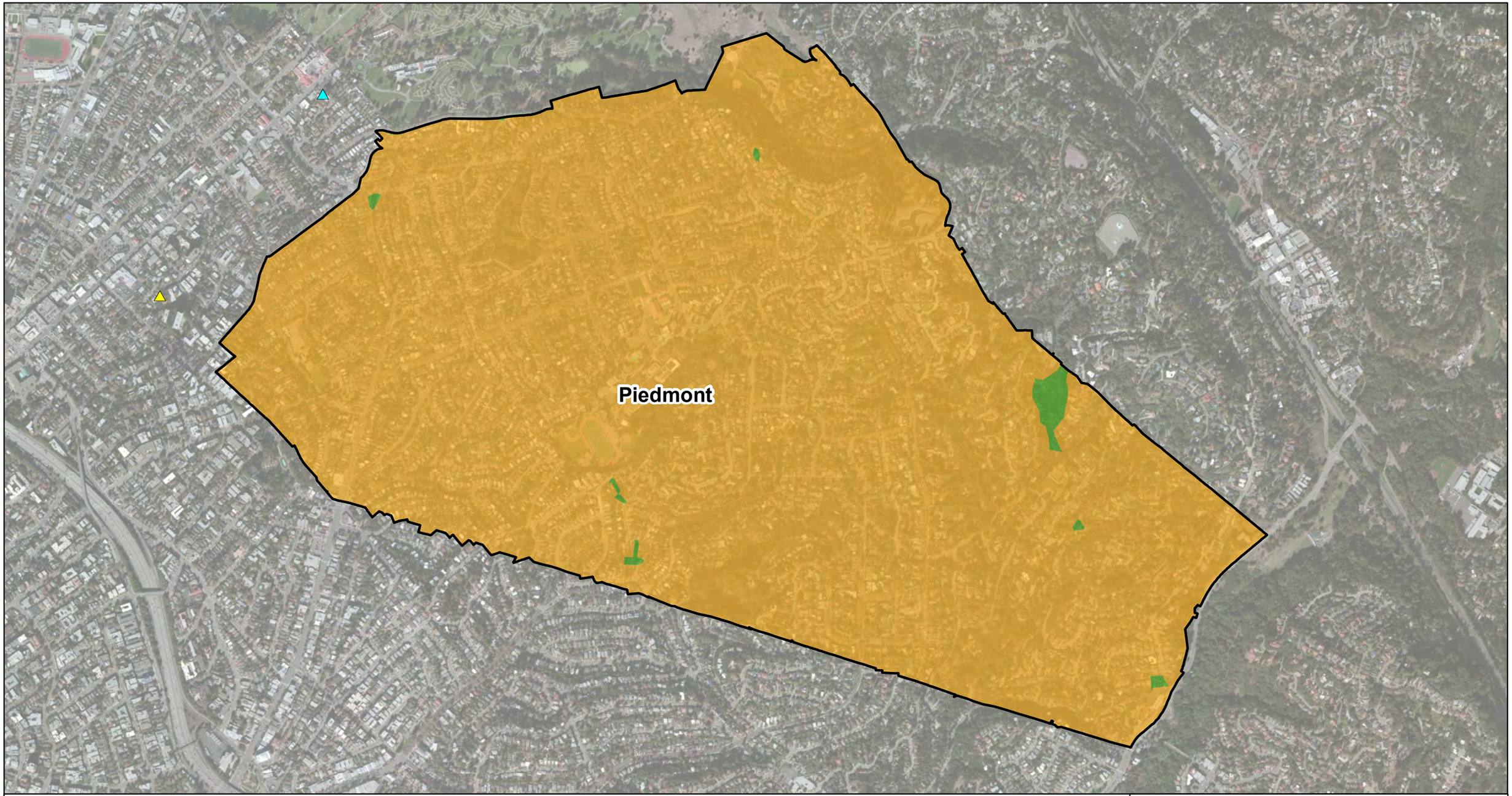
Figure A-11

P:\GIS\BASMAA_IMR\Projects\2014Jan\Alameda_Weighted_PCBs_Oakland2_Appendix_11.mxd



Legend

Pollutant Source Areas
- Transportation/Shipping
- Metals Recycling
- Recycling Drums
- Automotive Recycling
- General Waste Recycling
- Metals Manufacturing
- Cremation Facility
- Self Reported PCB Source
- Municipal Boundary

Sampling Site PCB Concentration (mg/kg)
- < 0.1 (1-25th Percentile)
- 0.1 - 0.3 (25-50th Percentile)
- 0.3 - 1.0 (50-75th Percentile)
- >1 (75-99th Percentile)

Land Use (Category)
- Old Industrial (1)
- Old Urban (2)
- New Urban (3) & Other (5)
- Open Space (4)

0 1,000 2,000 3,000
Feet

N

Piedmont
Land Use Categories
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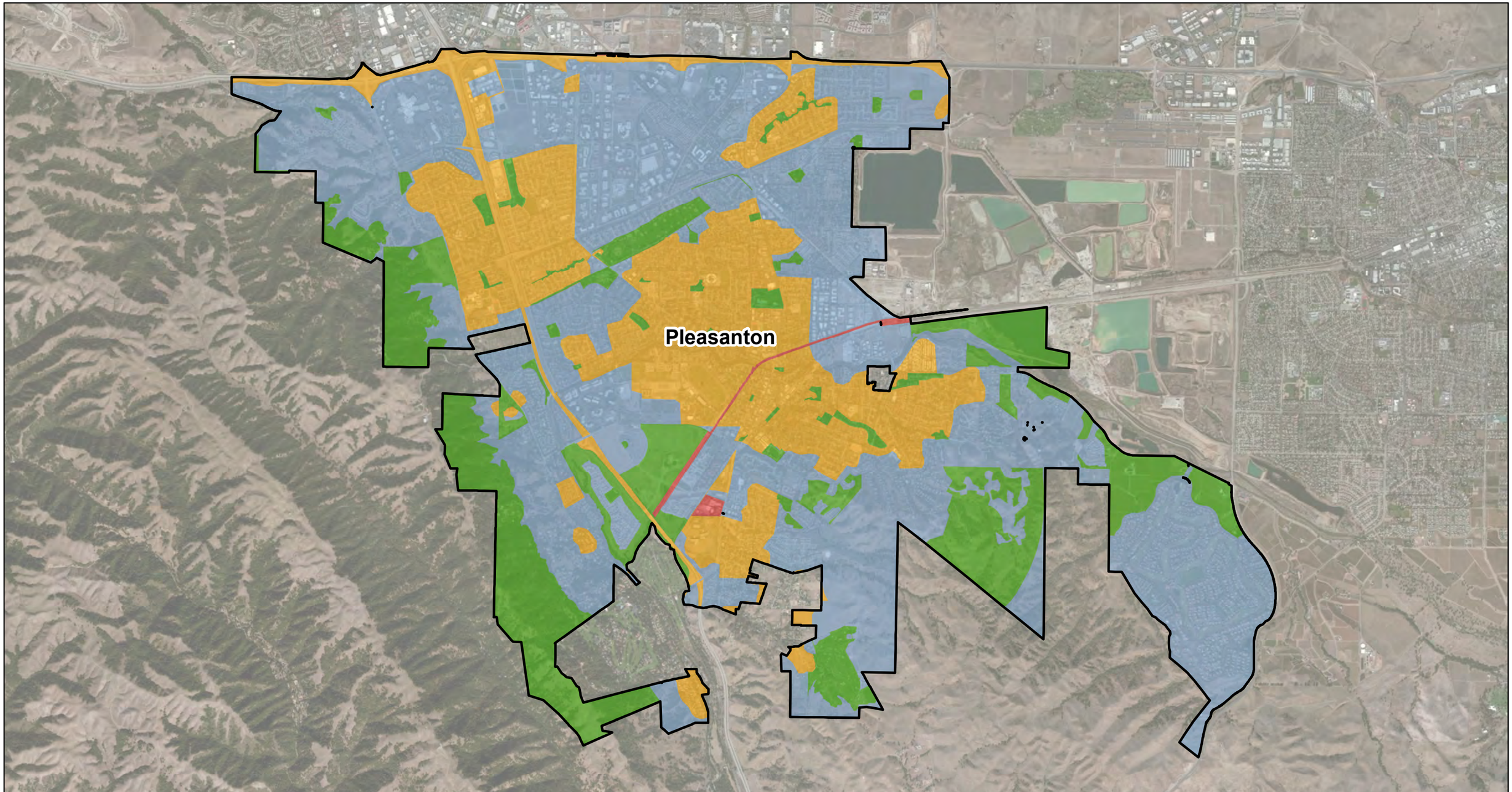
Figure A-12

P:\GIS\BASMAA_IMR\Projects\2014Jan\Alameda_Weighted_PCBs_Piedmont_Appendix_12.mxd



Legend

Pollutant Source Areas
- Transportation/Shipping
- Metals Recycling
- Recycling Drums
- Automotive Recycling
- General Waste Recycling
- Metals Manufacturing
- Cremation Facility
- Self Reported PCB Source
- Municipal Boundary

Sampling Site PCB Concentration (mg/kg)
- < 0.1 (1-25th Percentile)
- 0.1 - 0.3 (25-50th Percentile)
- 0.3 - 1.0 (50-75th Percentile)
- >1 (75-99th Percentile)

Land Use (Category)
- Old Industrial (1)
- Old Urban (2)
- New Urban (3) & Other (5)
- Open Space (4)

N

0 4,000 8,000 12,000
Feet

Pleasanton
Land Use Categories
ACCWP IMR

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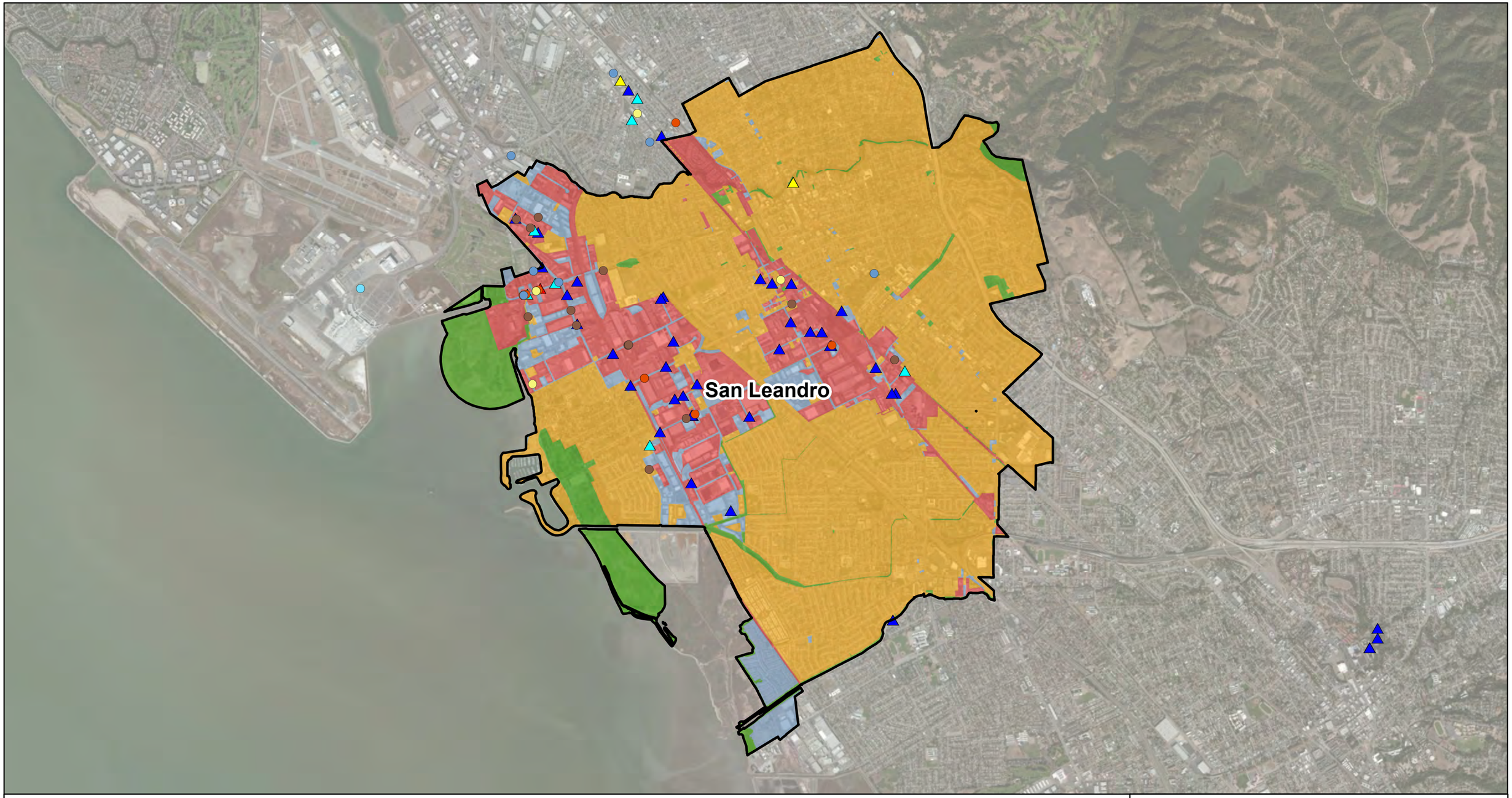
Figure A-13

P:\GIS\BASMAA_IMR\Projects\2014Jan\Alameda_Weighted_PCBs_Pleasanton_Appendix_13.mxd



Legend

Pollutant Source Areas
- Transportation/Shipping
- Metals Recycling
- Recycling Drums
- Automotive Recycling
- General Waste Recycling
- Metals Manufacturing
- Cremation Facility
- Self Reported PCB Source
- Municipal Boundary

Sampling Site PCB Concentration (mg/kg)
- < 0.1 (1-25th Percentile)
- 0.1 - 0.3 (25-50th Percentile)
- 0.3 - 1.0 (50-75th Percentile)
- >1 (75-99th Percentile)

Land Use (Category)
- Old Industrial (1)
- Old Urban (2)
- New Urban (3) & Other (5)
- Open Space (4)

N

0 3,500 7,000 10,500
Feet

San Leandro
Land Use Categories
ACCWP IMR

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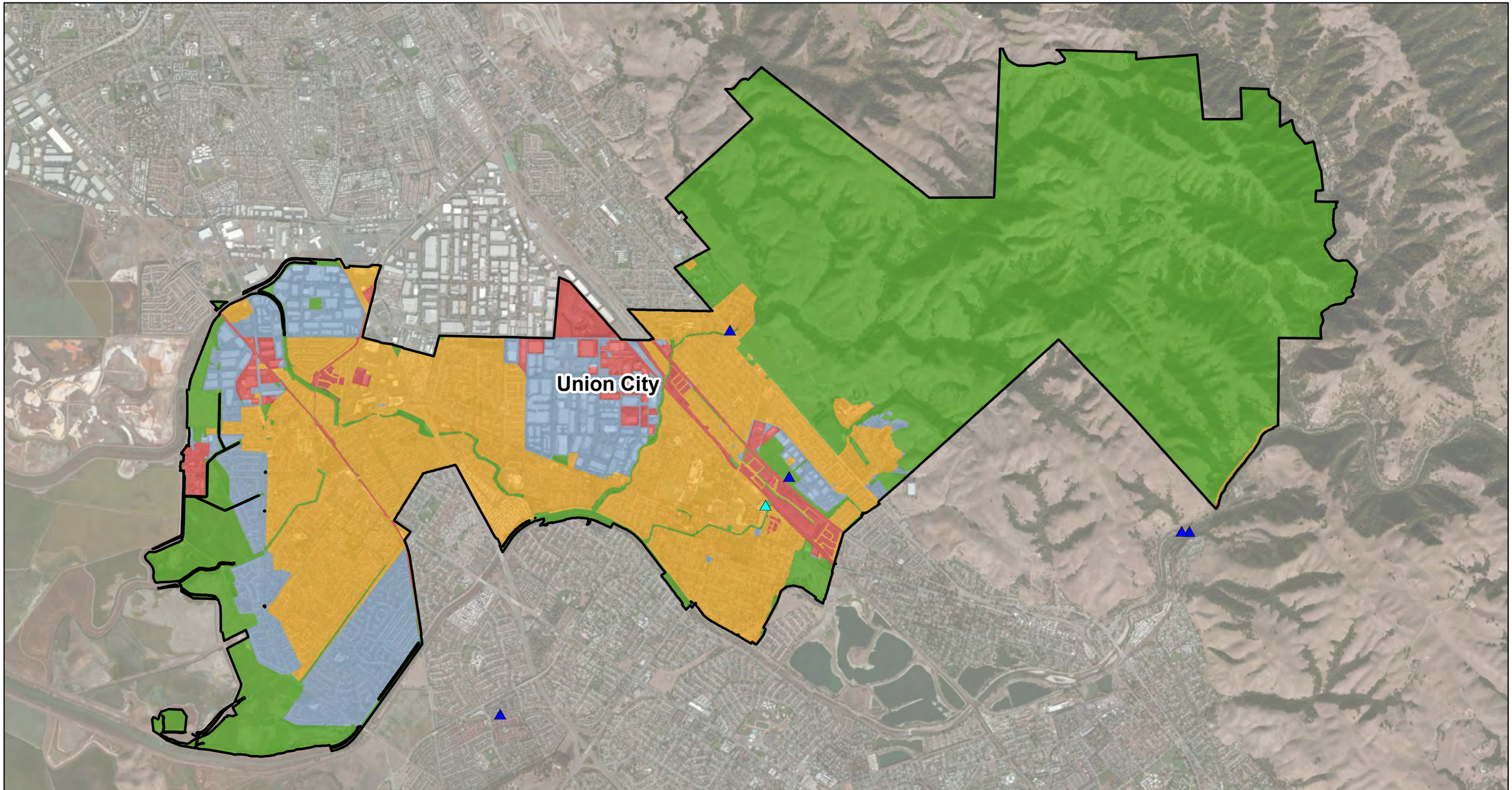
Figure A-14

P:\GIS\BASMAA_IMR\Projects\2014Jan\Alameda_Weighted_PCBs_SanLeandro_Appendix_14.mxd



Legend

Pollutant Source Areas
- Transportation/Shipping
- Metals Recycling
- Recycling Drums
- Automotive Recycling
- General Waste Recycling
- Metals Manufacturing
- Cremation Facility
- Self Reported PCB Source
- Municipal Boundary

Sampling Site PCB Concentration (mg/kg)
- < 0.1 (1-25th Percentile)
- 0.1 - 0.3 (25-50th Percentile)
- 0.3 - 1.0 (50-75th Percentile)
- >1 (75-99th Percentile)

Land Use (Category)
- Old Industrial (1)
- Old Urban (2)
- New Urban (3) & Other (5)
- Open Space (4)

N

0 3,500 7,000 10,500
Feet

Union City
Land Use Categories
ACCWP IMR

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Figure A-15

P:\GIS\BASMAA_IMR\Projects\2014Jan\Alameda_Weighted_PCBs_UnionCity_Appendix_14.mxd

ACCWP IMR PART C

APPENDIX B

Projected Mean Annual PCB Load Estimates by Municipality

ACCWP IMR Part C Appendix B

Alameda County Estimated Annual PCB Loading

Annual PCB Loading by Land Use Type for Alameda County Municipalities (g/yr)						
Municipality	**Old Industrial**	**Old Urban**	**Open Space**	**New Urban and Other**	**ESPS Load**	**Total Loading**
Alameda	9.9	56.4	1.5	5.2	0.0	73.0
Unincorporated Alameda County	28.8	177.7	316.7	2.0	0.0	525.2
Albany	2.1	17.8	0.2	0.0	0.0	20.1
Berkeley	19.0	107.1	0.2	0.3	0.0	126.5
Dublin	0.5	36.0	9.5	7.0	0.0	53.0
Emeryville	20.9	5.1	0.1	0.1	0.0	26.2
Fremont	50.2	210.9	44.9	15.7	0.0	321.6
Hayward	62.4	152.1	15.1	6.8	0.0	236.5
Livermore	46.5	92.8	12.2	11.7	0.0	163.2
Newark	24.0	48.9	2.7	2.5	0.0	78.1
Oakland	183.7	354.5	12.7	6.1	391.1	948.1
Piedmont	0.0	18.9	0.0	0.0	0.0	18.9
Pleasanton	3.6	69.0	7.3	16.5	0.0	96.5
San Leandro	69.1	95.1	1.5	1.3	0.0	167.0
Union City	24.6	57.9	17.5	3.0	0.0	103.0
Total	545.1	1500.4	442.0	78.2	391.1	**2956.7**

ACCWP IMR PART C

APPENDIX C

Projected Mean Annual Total Mercury Load Estimates by Municipality

ACCWP IMR Part C Appendix C

Alameda County Estimated Annual Mercury Loading

Annual Mercury Loading by Land Use Type for Alameda County (g/yr & kg/yr)							
Municipality	**Old Industrial**	**Old Urban**	**New Urban**	**Open Space**	**Other**	**Total Hg Loading (grams)**	**Total Hg Loading (kilograms)**
Alameda	197.3	532.0	24.1	15.1	32.5	801.1	0.8
Unincorporated Alameda County	575.6	1675.6	25.4	3166.7	0.0	5443.3	5.4
Albany	42.3	167.8	0.2	1.6	0.0	211.8	0.2
Berkeley	379.8	1009.5	3.7	1.8	0.0	1394.7	1.4
Dublin	9.8	339.5	57.3	94.8	24.0	525.4	0.5
Emeryville	418.3	48.2	1.4	0.5	0.0	468.4	0.5
Fremont	1003.1	1989.0	195.8	448.7	0.0	3636.6	3.6
Hayward	1247.4	1434.2	74.0	151.4	9.2	2916.2	2.9
Livermore	929.7	874.9	137.6	122.2	6.7	2071.0	2.1
Newark	479.9	461.2	31.7	26.9	0.0	999.7	1.0
Oakland	3899.9	3479.2	26.8	127.4	42.0	7575.4	7.6
Piedmont	0.0	178.1	0.0	0.2	0.0	178.3	0.2
Pleasanton	72.5	651.0	206.1	73.2	0.0	1002.9	1.0
San Leandro	1382.0	896.7	16.6	14.6	0.0	2309.9	2.3
Union City	491.8	546.1	36.9	175.1	0.0	1249.9	1.2
Total	11129.5	14283.0	837.5	4420.1	114.5	**30784.5**	**30.8**

ACCWP IMR PART C

APPENDIX D

Potential Control Measures for Ettie Street Pump Station Watershed (ESPSW)

ACCWP IMR Pact C - Appendix D

Potential Control Measures for Ettie Street Pump Station Watershed (ESPSW) to be considered by City of Oakland Unless Otherwise Noted

Control Measure			ESPSW-Current Actions	ESPSW-Enhanced Future Actions
Category	**Name**	**Description**		
Source Property ID & Abatement	Property ID/Referrals	Target High Opportunity properties in historically industrial land use areas where PCBs were used, released, or disposed of and/or where sediment concentrations are elevated above urban background.	CW4CB Task 3 2012 Study – 19 sites were inspected and 29 sediment samples were collected. The CW4CB Task 3 2012 Study resulted in 4 referrals to regulatory agencies – Former Giampolini, CASS, Asbestos Management Group, and Granite Expo for further enforcement action.	For those identified PCB source facilities that are Industrial General Permit Notice of Intent facilities, they will be referred to the State Water Board for enhanced monitoring and BMP implementation.
	USEPA/DTSC-Identified Properties	Target High Opportunity properties currently identified by USEPA or DTSC for remediation per Consent Orders or Cleanup and Abatement Orders.	Former Giampolini Facility - 17.7 mg/kg before remediation (Kleinfelder 2006); 1.7 after (Treadwell & Rollo 2006); 1.3 (2012 CW4CB Task 3)	See above
Operation and Maintenance	Pump Station Cleanout (ACFCWCD)	Partial cleaning of pump station forebays and wet wells. Data from ESPS 2013 cleanout. [1]	CW4CB Task 3 2013 Study – May 2013 Partial Cleanout	Conduct full (all 4 wet wells) cleanout annually.
	Inlet Cleanout [2]	Cleaning of storm drain drop inlets. Assumes industrial land uses. The average reflects annual cleanout, and the range reflects monthly to annual frequencies.	None currently planned	For identified PCB source facilities, conduct or cause to be conducted, enhanced cleaning of drainage area inlets.
	Storm Drain Cleanout	Cleaning of publicly-owned laterals and main lines.	None planned – Storm drain system may not by amenable to storm drain cleanout due to flat topography, depth of pipes, and disposal costs.	None planned
	Street Flushing [3]	Cleaning/flushing of street surface with tandem operation of a dry sweeper followed by tanker truck with high pressure washer, then collecting the material for disposal.	City of Oakland 05/06 Study – Power washed 2 streets after sediment sampling showed high PCB concentrations (Kleinfelder 2006)	None planned - power washing not cost-effective and infeasible for large scale areas.
	Street Sweeping [4]	Use of vacuum-assisted sweeping, regenerative air sweeping, or magnetic brush sweeping. Industrial land use. Use vacuum-assisted sweeping on poorly-maintained streets is preferred.	Continue baseline sweeping	For identified PCB source facilities, conduct or cause to be conducted enhanced street sweeping as appropriate.
Diversion	Diversion to POTW (ACFCWCD)	Diversions of dry weather and/or first flush events from municipal separate storm sewer systems (MS4s) to publicly owned treatment works (POTWs).	C.11.f/C.12.f Pilot Diversion Project - ACCWP working with EBMUD to coordinate implementation of permanent dry weather & pretreated SW diversions from ESPS to EBMUD. Monitored turbidity during FY 12/13 wet season & sampled SW from Nov 2012.	Study: Divert wet weather flows to a settling tank/detention pond for on -site treatment or diversion to EBMUD WWTP

Potential Control Measures for Ettie Street Pump Station Watershed (ESPSW) to be considered by City of Oakland Unless Otherwise Noted

Control Measure			ESPSW-Current Actions	ESPSW-Enhanced Future Actions
Category	**Name**	**Description**		
Treatment	Green Streets (10 Projects)	Green streets retrofit projects incorporate LID techniques for site design and provide stormwater treatment.	San Pablo Avenue Green Spine at San Pablo Avenue at 17th St. in ESPSW	The City is developing an urban greening plan as part of a Prop 84 planning grant, which will identify key opportunities for green infrastructure.
	Other Treatment Control Retrofit	Retrofits of existing development using a variety of control measures (i.e. vegetated swales, bioretention units, sand filters, tree wells).	CW4CB Task 5 – 6 tree wells installed near industrial facilities in ESPSW; Approximately 500 trees have been planted in the ESPSW.	None planned
	C.3. Regulated Projects (40 Facilities)	Treatment applied to new development and redevelopment projects since 2002. No cost to municipalities to implement besides review costs. Assumes that all control measures are privately funded.	Continued C.3 implementation	Continued C.3 implementation
	ESPS Media Filter Pilot Project	Media filter system with two parallel filter beds: One bed contains rhyolite sand and second bed contains mix of media types, including rhyolite sand, zeolite, and GAC. The design media filter flow capacity for each filter is limited to approximately 15 gpm =48.4 ac-ft. per year.	CW4CB Task 5 – ESPS media filters	Continued implementation
	Trash HDS Units	Hydrodynamic Separator (HDS) units collect course trash, debris, and sediment. Data from SJ and Oakland.	None in ESPSW	None planned
Miscellaneous/ Full Implementation Measures	Industrial Inspection	Identify PCBs during routine industrial inspections, document in inspection reports, and refer to appropriate regulatory agency.	Conducted annually through City of Oakland Fire Department	Continued implementation
	PCBs In Caulk	Enhanced: With abatement which means implement municipal policies or ordinance requiring demolition/renovation projects to work with USEPA on implementation of BMPS and a cleanup plan if sampling shows greater than 50 ppm. Costs are likely to be high for project proponents, whether municipal or a privately-owned entity.	None planned	Incorporate as part of building permit process best management practices for containing caulk including enhanced sweeping requirements and dust control.
	Mercury Recycling	Collect and recycle mercury-containing devices and equipment at the consumer level (e.g., thermometers, thermostats, switches, bulbs).	Continued implementation	Continued implementation

Potential Control Measures for Ettie Street Pump Station Watershed (ESPSW) to be considered by City of Oakland Unless Otherwise Noted

Control Measure				
Category	**Name**	**Description**	**ESPSW-Current Actions**	**ESPSW-Enhanced Future Actions**
New Measures	Soil and Erosion Control	Use of soil and erosion control BMPs like rumble strips, silt fence, gravel bags, fiber rolls, detention ponds, etc.	None planned	For identified PCB source facilities, install or cause to be installed rumble strips at entrances/exits to reduce offsite tracking of PCBs.
	Illegal Dumping	Illegal dumping areas.	Respond to requests to remove illegal dumping materials. Coordinate with Caltrans and railroad on removal of dumped materials.	Continued implementation
	PG&E	Consists of PG&E substations, poles with mounted electrical transformers, and other PG&E infrastructure.	None planned	State involvement requiring PG&E to monitor and increase cleaning of inlets draining PGE facilities. Work with State to conduct study identifying poles with electrical transformers containing PCBs and replace with mineral oils that do not contain PCBs and to ensure lead cable in vaults are intact and not leaking.

Notes:

1 Volume removed measured by ADH; Per pump station; costs includes supervisor (4 day cleanout) including county staff, confined space entry staff, and vactor truck depreciation, disposal at county transfer station, considered non-hazardous waste.

2 Adapted from Sediment Management Literate Review (EOA and Geosyntec, 2011); Based on analysis of drop inlet data contained in SFEI Sediment Data Base; Cost per cleanout is a provisional estimate (placeholder)

3 Adapted based on Information Contained in Sediment Management Literature Review; Street flushing with high pressure pumps and effective nozzles considered more effective than street sweeping (Sartor and Boyd, 1972); SFEI sediment PCB data base, Alameda County industrial land use, 51 samples; San Carlos Pilot Study Estimate for street flushing 1000 ft. road segment.

4 Adapted based on Information Contained in Sediment Management Literature Review; Based on interpretation of data contained illustrated in Figure 3 of Sediment Management Literature Review; SFEI sediment PCB data base, Alameda County industrial, 51 samples; Cost per curb mile adapted from cost data contained in Sediment Management Literature Review (see Appendix A), USEPA, and inquires to sweeping contractors.

ACCWP IMR PART C

APPENDIX E

Preliminary Estimates of Cost and Effectiveness for Enhanced Control Measures

Table E-1. Preliminary Effectiveness Estimates for Enhanced Control Measures

Control Measure			PCB Mass Captured		
Category	**Name**	**Description**	**Metric**	**Estimate**	**Range**
Source Property ID & Abatement	Property ID/Referrals	Target High Opportunity properties in historically industrial land use areas where PCBs were used, released, or disposed of and/or where sediment concentrations are elevated above urban background.	mg/acre/yr	640[1]	100-990
	USEPA/DTSC-Identified Properties	Target High Opportunity properties currently identified by USEPA or DTSC for remediation per Consent Orders or Cleanup and Abatement Orders.	mg PCB/ property	640[1]	100-990
Operation and Maintenance	Pump Station Cleanout	Full cleanout of ESPS pump station forebays and wet wells.	mg PCB/ cleanout	9500[4]	5000-12000
		Cleaning of pump station forebays and wet wells other than the ESPS.	mg PCB/ cleanout	Unknown	--
	Inlet Cleanout [2]	Cleaning of storm drain drop inlets. Assumes industrial land uses.	mg PCB/ drop inlet	4[5]	1-12[5]
	Storm Drain Cleanout	Cleaning of publicly-owned laterals and main lines.	mg PCB/ curb mile	Unknown	---
	Street Flushing [3]	Cleaning/flushing of street surface with tandem operation of a dry sweeper followed by tanker truck with high pressure washer, then collecting the material for disposal.	mg PCB/ mile	108[8]	43-173
	Street Sweeping[4]	Baseline: Use of broom sweeping. Industrial land use.	mg PCB/curb mile swept	4[10]	1-12
		Enhanced: Use of Advanced Sweeper. Industrial land use.	mg PCB/curb mile swept	15[10]	7-18
Diversion	Diversion to POTW (ACFCWCD)	Diversions of dry and wet weather runoff from ESPS to EBMUD WWTP.	mg PCB/ diversion/yr	(600)[11]	---

Control Measure			PCB Mass Captured		
Category	**Name**	**Description**	**Metric**	**Estimate**	**Range**
Treatment	Green Streets [12] (6 Projects) Low Opportunity Areas	Green streets retrofit projects incorporate LID techniques for site design and provide stormwater treatment.	mg PCB/ drainage acre	4	3-6
	Green Streets (4 Projects) High Opportunity Areas	Green streets retrofit projects incorporate LID techniques for site design and provide stormwater treatment.	mg PCB/ drainage acre	150	120-160
	Other Treatment Control Retrofit[14]	Retrofits of existing development using a variety of control measures (i.e. vegetated swales, bioretention units, sand filters, tree wells).	mg PCB/ drainage acre	146	115-163
	C.3. Regulated Projects (40 Facilities) [16]	Treatment applied to new development and redevelopment projects since 2002. No cost to municipalities to implement besides review costs. Assumes that all control measures are privately funded.	mg PCB/ drainage acre	122	65-191
	ESPS Media Filter Pilot Project	Media filter system with two parallel filter beds: One bed contains rhyolite sand and second bed contains mix of media types, including rhyolite sand, zeolite, and GAC. The design media filter flow capacity for each filter is limited to approximately 15 gpm =48.4 ac-ft. per year.	mg PCB/gpm	80	---
	Trash HDS Units	Hydrodynamic Separator (HDS) units collect course trash, debris, and sediment. Data from SJ and Oakland.	mg PCB/HDS	---	---

Control Measure			PCB Mass Captured		
Category	**Name**	**Description**	**Metric**	**Estimate**	**Range**
Miscellaneous/ Full Implementation Measures	Industrial Inspection	Identify PCBs during routine industrial inspections, document in inspection reports, and refer to appropriate regulatory agency.	mg PCB /inspection	Unknown	---
	PCBs In Caulk [18]	Baseline: During demolition or renovation of buildings containing PCBs, removal of various building materials, including sealants that were applied around windows and doors, between concrete and other materials, and around openings for ducts and other conduits.	Kg PCB /1.5 story bldg.	6.6	0.5-5
		Enhanced: With abatement which means USEPA implementation of a cleanup plan if sampling shows greater than 50 ppm.	Kg PCB /1.5 story bldg.	7.1	0.6-16
	Mercury Recycling	Collect and recycle mercury-containing devices and equipment at the consumer level (e.g., thermometers, thermostats, switches, bulbs).	mg PCB/lb	Unknown	---

Notes:

1 Effectiveness assumes remediation reduces yield from 990 mg/acre/yr (high opportunity) to 350 mg/acre/yr (old urban)

2 Administrative cost for municipal staff to assist in developing referral request, coordination with property owner and regulatory agencies.

3 Does not include cost of remediation to property owner which in general addresses multiple constituents in addition to PCBs

4 Adapted from monitoring conducted during ESPS partial cleanout conducted approximately May 14 - 21, 2013 and budget information provided by pump station supervisor

5 Estimate assumes quarterly cleaning, range reflects annual to monthly cleaning based on data from Singh and Mineart (1994). Limited cost information, estimate is based on professional judgment and intended to be conservative.

6 Narayanan and Pitt, 2006.

7 Estimate by EOA, Inc. based on City of San Jose Leo Avenue cleanout of approximately 8000 lbs of sediment from 1500 linear feet of storm drain in 2005. PCB concentrations not available.

8 Adapted from Sediment Management Literature Review; and SFEI sediment PCB data base, Alameda County industrial land use, 51 samples

9 Estimate by EOA, Inc. based on City of San Carlos street flushing pilot project conducted in 2013. Does not include disposal costs.

10 Adapted from Sediment Management Literature Review, including Figure 3; SFEI sediment PCB data base, Alameda County industrial, 51 samples; Cost per curb mile for advanced sweeper based on program budgets that include administration, capital and O&M.

11 EBMUD Environmental Enhancement Project and Supplemental Environmental Project (2010), involved 75 gpm diversion into existing sanitary line from April 2008-March 2010. This value is a placeholder subject to change pending details of proposed permanent diversion pipe.

12 Packard Foundation, Stanley BLVD, Sustainable Streets, San Pablo Green Spine, Hacienda Avenue, Southgate. Average Annual PCB Load estimates from Draft BASMAA IMR Report Part B (Geosyntec 2013); Project information from CW4CB Task 5 Project Leads; Total project costs are design plus construction costs.

13 Average Annual PCB Load estimates from Draft BASMAA IMR Report Part B (Geosyntec 2013); Capital cost of $260,000 cover planning, design, construction plus 25% contingency. Life cycle cost based on Capital/20 years plus 20% for O&M

14 Adapted from EOA CW4CB cost data that includes planning, design, construction, and 25% contingency.

15 Average Annual PCB Load estimates from Draft BASMAA IMR Report Part B (Geosyntec 2013); Project information from CW4CB Task 5 Project Leads; Total project costs are design plus construction costs.

16 Average Annual PCB Load estimates from Draft BASMAA IMR Report Part B (Geosyntec 2013); Some of the thirty two regulated projects reported multiple treatment measures constructed on-site, which totaled to forty facilities.

17 HDS units were not assumed to reduce TSS (and therefore PCBs) loads as the International BMP database does not demonstrate significant difference between influent and effluent TSS.

18 PCB Concentration in Caulk from Klausterhaus et al (2010); Average Annual PCB Load estimates from Draft BASMAA IMR Report Part B (Geosyntec 2013); $/building includes cost to municipality to oversee compliance prior to issuing building demolition permit and to coordinate with regulatory agencies if required (provisional est.); Effectiveness range represents range in PCB concentrations in caulk. Costs represent administrative costs to oversee compliance.

Table D-2. Preliminary Cost Estimates for Enhanced Control Measures

Control Measure		Cost			Cost Effectiveness		
Category	**Name**	**Metric**	**Estimate**	**Range**	**Metric**	**Estimate**	**Range**
Source Property ID & Abatement	Property ID/Referrals	mg/acre/yr	640[1]	100-990	$/mg PCB removed	$1.5[3]	$1-$50
	USEPA/DTSC-Identified Properties	mg PCB/ property	640[1]	100-990	$/mg PCB removed	$1.5[3]	$1-$50
Operation and Maintenance	Pump Station Cleanout	mg PCB/ cleanout	9500[4]	5000-12000	$/mg PCB removed	$3	$2-$6
		mg PCB/ cleanout	Unknown	--	$/mg PCB removed	Unknown	---
	Inlet Cleanout [2]	mg PCB/ drop inlet	4[5]	1-12[5]	$/mg PCB removed	$50	$6-$200
	Storm Drain Cleanout	mg PCB/ curb mile	Unknown	---	$/mg PCB removed	Unknown	---
	Street Flushing [3]	mg PCB/ mile	108[8]	43-173	$/mg PCB removed	$75	$50-$200
	Street Sweeping [4]	mg PCB/curb mile swept	4[10]	1-12	$/mg PCB removed	$10	$3-$55
		mg PCB/curb mile swept	15[10]	7-18	$/mg PCB removed	$5	$2-$4
Diversion	Diversion to POTW (ACFCWCD)	mg PCB/ diversion/yr	600[11]	---	$/mg PCB removed	Unknown	---

Control Measure		Cost			Cost Effectiveness		
Category	**Name**	**Metric**	**Estimate**	**Range**	**Metric**	**Estimate**	**Range**
Treatment	Green Streets [12] (6 Projects) Low Opportunity Areas	mg PCB/ drainage acre	4	3-6	mg PCB/ drainage acre	$/mg PCB removed	$4,000
	Green Streets (4 Projects) High Opportunity Areas	mg PCB/ drainage acre	150	120-160	mg PCB/ drainage acre	$/mg PCB removed	$100
	Other Treatment Control Retrofit [14]	mg PCB/ drainage acre	146	115-163	mg PCB/ drainage acre	$/mg PCB removed	$120
	C.3. Regulated Projects (40 Facilities) [16]	mg PCB/ drainage acre	122	65-191	mg PCB/ drainage acre	$/mg PCB removed	Unknown
	ESPS Media Filter Pilot Project	mg PCB/gpm	80	---	mg PCB/gpm	$/mg PCB removed	$100
	Trash HDS Units	mg PCB/HDS	---	---	mg PCB/HDS	$/mg PCB removed	---
Miscellaneous/ Full Implementation Measures	Industrial Inspection	mg PCB /inspection	Unknown	---	mg PCB /inspection	$/mg PCB removed	Unknown
	PCBs In Caulk [18]	Kg PCB /1.5 story bldg.	6.6	0.5-5	Kg PCB /1.5 story bldg.	$/kg PCBs removed	$1,000
		Kg PCB /1.5 story bldg.	7.1	0.6-16	Kg PCB /1.5 story bldg.	$/kg PCBs removed	$1,700
	Mercury Recycling	mg PCB/lb	Unknown	---	mg PCB/lb	$/mg PCB removed	Unknown

Notes:

1 Effectiveness assumes remediation reduces yield from 990 mg/acre/yr (high opportunity) to 350 mg/acre/yr (old urban)

2 Administrative cost for municipal staff to assist in developing referral request, coordination with property owner and regulatory agencies.

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ACCWP IMR PART C

APPENDIX F

Caltrans Letter Dated March 7, 2014 - Mercury Allocation Sharing Scheme

DEPARTMENT OF TRANSPORTATION
DIVISION OF ENVIRONMENTAL ANALYSIS
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Flex your power!
Be energy efficient!

March 7, 2014

Geoff Brosseau
Executive Director
Bay Area Stormwater Management Agencies Association (BASMAA)
P.O. Box 2385
Menlo Park, CA 94026

Subject: Mercury Allocation Sharing Scheme

Dear Mr. Brosseau:

Thank you for your letter dated October 30, 2013, and your follow up invitation to the BASMAA Board of Directors meeting held in Oakland on February 27, 2014 to consult with BASMAA and its member agencies regarding provision C.11.j in the Municipal Regional Permit (MRP).

This letter is to follow up with the discussions at the meeting regarding Caltrans' strategy to comply with the TMDL requirements for Mercury. Caltrans is willing work with the MRP Permittees to develop an equitable allocation sharing scheme based on the following parameters applicable to Caltrans' right of way within the San Francisco Bay watershed:

- Watershed Area
- Urbanized area
- Runoff volume
- Runoff characterization (Mercury monitoring data)

We look forward to working with the MRP Permittees in a manner involving implementation of actions on a watershed or region wide basis that is consistent with TMDL implementation requirements within the Caltrans' Municipal Separate Storm Sewer System (MS4) Permit and its proposed amendments.

If you have any questions, please call me directly at (916)653-4446 or via email at scott.mcgowen@dot.ca.gov.

Sincerely,

for B Joshi

G. SCOTT McGOWEN, P.E.
Chief Environmental Engineer

Cc: Thomas Mumley, Assistant Executive Officer, San Francisco Bay RWQCB
Constantine Kontaxis, Watershed Manager, Caltrans
Keith Jones, Environmental Engineering Advisor, Caltrans
Hardeep Takhar, Water Quality Program Manager, Caltrans District 4