Santa Clara Valley
Urban Runoff
Pollution Prevention Program

Watershed Monitoring and Assessment Program

Integrated Monitoring Report – Part C

Pollutants of Concern Load Reduction Opportunities

March 15, 2014

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ACRONYMS

ABAG	Association of Bay Area Governments
BACWA	Bay Area Clean Water Agencies
BASMAA	Bay Area Stormwater Management Agencies Association
BMP	Best Management Practices
CCCWP	Contra Costa Clean Water Program
CEDEN	California Environmental Data Exchange Network
CFL	Compact Fluorescent Lamp
CSN	Chesapeake Stormwater Network
CW4CB	Clean Watershed for a Clean Bay
EPR	Extended Producer Responsibility
ESPS	Ettie Street Pump Station
FER	Feasibility Evaluation Report
FY	Fiscal Year
GIS	Geographic Information Systems
HHW	Household Hazardous Waste
IMR	Integrated Monitoring Report
LID	Low Impact Development
MIP	Model Implementation Process
MRP	Municipal Regional Permit
MS4	Municipal Separate Storm Sewer System
MDE	Maryland Department of the Environment
NPDES	National Pollutant Discharge Elimination System
PCBs	Polychlorinated Biphenyls
POCs	Pollutants of Concern
POTW	Publicly Owned Treatment Work
O&M	Operation and Maintenance
PCBs	Polychlorinated Biphenyl
SFRWQCB	San Francisco Regional Water Quality Control Board
SAP	Sampling and Analysis Plan
SFEI	San Francisco Estuary Institute
SFEP	San Francisco Estuary Partnership
SMCWPPP	San Mateo Countywide Water Pollution Prevention Program
SCVURPPP	Santa Clara Valley Urban Runoff Pollution Prevention Program
TMDL	Total Maximum Daily Load
TRC	Thermostat Recycling Corporation
TSS	Total Suspended Solids
USEPA	United States Environmental Protection Agency
WWTP	Wastewater Treatment Plant

1. INTRODUCTION

1.1. 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 tissue 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 plans developed by the California Regional Water Quality Control Board, San Francisco Bay Region (Regional Water Board).[1] Local public agencies (i.e., Permittees) subject to requirements in National Pollutant Discharge Elimination System (NPDES) permits for MS4s discharges are required to implement control measures in an attempt to reduce POCs from entering stormwater runoff and the Bay. Pollutant reductions from MS4s are anticipated to assist with improving water quality in the Bay and reducing the levels of POCs in Bay fish tissue. These control measures, also referred to as best management practices (BMPs), are the tools that Permittees can use to help restore water quality in the Bay.

NPDES permit requirements associated with Bay Area Phase I Permittees 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, mainly on a pilot basis. The results and findings of control measure implementation and effectiveness evaluations conducted to-date are presented in Integrated Monitoring Report (IMR) – Part B.

1.2. Objectives and Management Questions

This report, IMR Part C, provides a preliminary initial analysis of POC loads from Santa Clara County Permittee MS4s, potential POC load reduction opportunities, and associated costs of implementation based on available information. **<u>The results of the analyses presented in this report should be considered preliminary and will likely be revised in the future based on additional information</u>**. Significant uncertainties with regard to POC sources, opportunity areas, and control measure benefits, costs and feasibility are currently present and should be taken into account when interpreting the results and conclusions contained herein. Additional significant uncertainties also exist in the PCBs and Mercury TMDLs for the San Francisco Bay, including TMDL targets and load reductions needed to achieve water quality standards. Substantial issues that need to be addressed prior to and during future POC control measure implementation, including revisions to the TMDLs are presented at the end of the report.

IMR Part C builds upon the information presented in IMR Part B and is intended to address 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 types of POC sources and their locations, land use based pollutant yields, and annual pollutant loads from each Santa Clara County Permittee, based on available information, including monitoring data collected during and prior to the term of the MRP;
- Develop preliminary cost estimates for implementing POC control measures described in IMR Part B;
- Evaluate the costs and benefits of implementing different hypothetical control measure implementation scenarios for reducing POCs in MS4 discharges to the Bay;
- Provide preliminary data to inform future discussions regarding potential future POC control measure implementation strategies and related efforts, including further

[1] See IMR Part B for additional information on POC sources and pathways.

information 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 preliminary estimated costs and benefits of implementing various control measure scenarios in high and moderate opportunity areas?
- What additional information is needed to further identify the location of high and moderate opportunity areas and strategies for cost-effective control measure implementation in these areas?
- What is the recommended process for collecting this information?

1.3. Organization of IMR Part C

The organization of Part C is based on the objectives and associated management questions listed above. Section 2.0 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 (grams/year) and loading yields (mg/acre/year) associated with MS4s are provided. In Section 3.0, preliminary cost estimates and load reduction benefits are provided for each POC control measure described in IMR Part B. Section 4.0 includes a preliminary analysis of costs and water quality benefits for seven hypothetical MS4 control measure implementation scenarios, which include various source and treatment controls. Lastly, Section 5.0 describes information gaps and uncertainties, and provides preliminary guidance on future information collection and control measure implementation.

The most current information readily 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. Despite this, 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 into this IMR Part C through revision or by addenda to inform scientific and regulatory discussions.

2. POC SOURCES, LAND USE-BASED YIELDS AND LOADINGS

In this section, water quality monitoring, land use, and other Bay Area data recently collected or compiled were used to preliminarily identify areas within each Permittee's jurisdiction that may have sources of POCs and contribute elevated loads to the Bay via MS4s. The data were analyzed to evaluate relationships between POC loading rates per unit area, or yields (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 loading rates (i.e., grams/year) associated with runoff from land use 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 yields from Bay Area watersheds (Davis et al. 2013) and knowledge of potential POC sources located within these land areas. <u>The results of the analysis however should be considered preliminary and may be revised in the future based on additional information</u>.

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 POC yields 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 provide first order estimates of POC yields from high, moderate and low opportunity areas.

2.1.1. Source Area Mapping

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, and to a lesser extent mercury sources, are generally associated with areas where equipment containing POCs were transported or used, and facilities that recycle or recycled POCs or POC-containing devices and equipment. These sources include current and historic metal, automotive and hazardous waste recycling and transfer stations, electric power facilities, and rail lines. These sources are typically located in land use areas that were industrialized between the late 1920's and the late 1970s, the timeframe when PCB and mercury production was greatest in the U.S (see IMR Part B).

Bay Area monitoring data support the assumption that PCBs are generally associated with areas industrialized during the 1920-1980 timeframe. An examination of PCB concentrations in street dirt and sediment in stormwater conveyances indicate that of the 700+ dirt/sediment samples analyzed, 99% of samples with >1 mg/kg PCBs were identified in areas industrialized during this timeframe (Gunther et al. 2001; KLI and EOA 2002; EOA 2002, 2003, 2007; Salop et al. 2002; City of San Jose and EOA 2003; SMSTOPPP 2002, 2003, 2004; Kleinfelder 2005, 2006; SFEI 2010; Yee and McKee 2010). Additionally, moderate and lower PCB concentrations have been consistently observed in older urban (non-industrialized) areas and new urban/open space areas, respectively.

To assist Permittees in identifying potential POC sources and source areas, a number of preliminary Geographic Information Systems (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 showing the locations of current facilities where PCBs potentially were or are used and released; and,

- historical and current rail lines where PCBs may have been applied for dust control, used in electrical equipment, or 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 areas; 2) 1968 aerial photographs for the Bay Area at 30,000 scale acquired from the United State Geological Society'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 examining 1968 aerial photography and identifying industrial land areas outside of the areas characterized by ABAG as industrial land use in roughly 2005. 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 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. Many of these "new industrial" areas are within Santa Clara County, which was generally urbanized later than much of the rest of the Bay Area.

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 in whether an area in the 1968 photographs was industrial, then the area was classified based on the ABAG land use data layer. As a final check, the 1968 aerial photographs were also compared to current aerial photographs, and each parcel that has 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 areas that depict areas urbanized prior to and after 1974, respectively, were also developed. These areas were developed using an urban extents layer from 1974, the closest year to 1968 with available data. All areas that were within the urban extent were defined as old urban. Those areas that fell outside of this extent were classified as new urban.

2.1.2. Identification of Potential POC Associated Facilities

The location of a number of facility types that may be associated with either PCBs or mercury were also identified and mapped as "points" in GIS datalayers. 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 project (funded by a Proposition 13 grant) and contains data from a variety of sources including the California Air Resources Board, Envirostor, Superfund, Department of Toxic Substances Control, and the California State Water Resources Control Board. Appendix A contains a list of facilities identified as PCB or mercury remediation sites where past industrial, military or other use of PCBs or mercury resulted in releases to the environment leading to soil and/or groundwater contamination. The list of facilities was acquired from the State Water Resources Control Board's Envirostor database and should be considered preliminary.

Certain facility types for which point location data were developed were mapped in greater detail to develop polygons that 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 use area maps 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. The resulting data layer was attributed with additional information such as city, county and watershed.

Table 2.1 depicts the acreage within each Santa Clara County Permittee boundary that drains to the Bay and falls within old industrial, old urban, new urban, open space, and other land use categories. Definitions of each land use category are provided in the footnotes to the table. Additionally, the acreage in the Leo Avenue watershed where pilot POC control measures are currently being implemented is also depicted.

Table 2.1. Old industrial, old urban, and other land use areas within the boundaries of each Permittee that drain to San Francisco Bay.

Permittee	Permittee Area Draining to SF Bay by Land Use Type					
	Old Industrial (Pre-1968)[1]	Old Urban (Pre-1974)[2]	Open Space[3]	New Urban[4] and Other[5]	Pilot Watershed (Leo Avenue)[6]	Total Acres[7]
Campbell	153	3,425	127	194		3,898
Cupertino	72	4,768	1,299	953		7,091
Los Altos	1	4,062	73	37		4,173
Los Altos Hills	0	4,206	1,045	441		5,692
Los Gatos	0	2,531	1,813	603		4,946
Milpitas	284	3,033	2,183	3,168		8,668
Monte Sereno	0	463	33	0		496
Mountain View	506	5,243	699	990		7,439
Palo Alto	405	6,466	4,906	352		12,129
San Jose	2,700	53,146	22,648	17,569	543	96,604
Santa Clara	931	7,472	705	2,495		11,603
Santa Clara County	88	7,180	84,398	4,455		96,121
Saratoga	52	6,028	1,109	702		7,891
Sunnyvale	1,183	8,993	514	1,692		12,382
Total	6,375	117,016	121,552	33,651	543	279,136
%	2%	42%	44%	12%	0.19%	-

[1] Areas industrialized prior to 1968. Includes ports, railroads, and old electrical generation properties, including areas subsequently redeveloped into other land uses.
[2] Areas urbanized prior to 1974 that were not identified as old industrial.
[3] Includes local and regional parks, forested and range land, Baylands, and agriculture.
[4] Areas urbanized after 1974.
[5] Military land and airports
[6] Located in the City of San Jose.
[7] Total acres may differ slightly due to rounding.

2.1.3. Average POC Yields for Monitored Watersheds

Estimated POC yields from different land uses and preliminary estimates of POC annual loads associated with Permittee MS4s were developed through the following steps:

- Reviewed readily available water quality monitoring data on POC loading rates per unit area (also known as yields) from Bay Area watersheds;
- Characterized land use and period of urbanization information for watersheds where yields are available;
- Developed regression equations linking POC yields to watershed attributes (i.e., land uses), deriving average POC yields for different land uses; and,
- Applied land use based POC yields to estimate POC loads from each Permittee's jurisdictional area.

The following sections provide further details of the analysis conducted to estimate POC loads from Permittee MS4s.

PCB Yields

The San Francisco Estuary Institute (SFEI) recently released the draft *PCB Synthesis Report* (Davis et al., 2013) that summarizes information and lessons learned to-date from water quality monitoring of PCBs in San Francisco Bay and in the watersheds that discharge to the Bay. Monitoring data are presented for various media including fish tissue, sediment, and water. POC yields for monitored watersheds were also provided in Davis et al. (2013). Figure 2.1 provides the average annual watershed POC loading rates per unit area from these watersheds (i.e., yields).

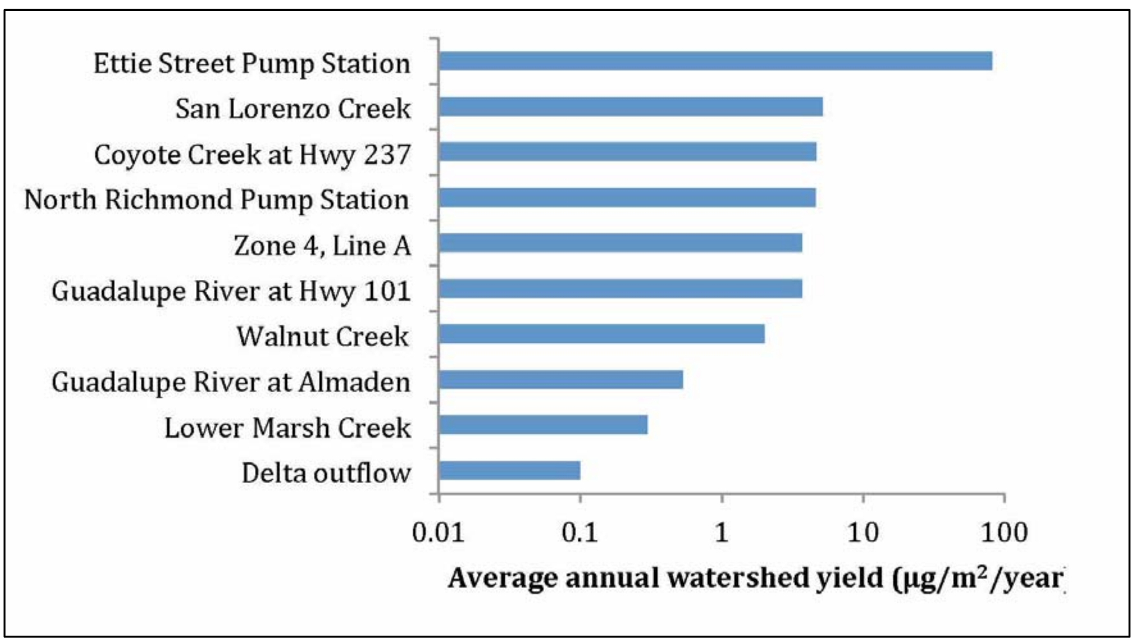

Figure 2.1. Average Annual Watershed PCB Yields (Davis et al. 2013).

SFEI also reported PCB yields data for Lower Marsh Creek, San Lorenzo Creek, Walnut Creek, Sunnyvale East Channel, and the Ettie Street Pump Station in the *POC Loads Monitoring Data, Water Year 2011 Report* (McKee et al. 2012). The estimated PCB yields from these sources are provided in

Table 2.2. PCB yield estimates cover a range from approximately 0.4 to 320 mg/acre/yr. The lowest yield for these watersheds is associated with the Delta outflow and the highest yield is associated with the Ettie Street Pump Station watershed in Oakland.

Table 2.2. Mean Annual PCB Yields as Measured at POC Loads Monitoring Stations.

Watershed	Drainage Area (Acres)[1]	PCB Yield (mg/m^2/yr)	PCB Yield (mg/acre/yr)	Watershed Cluster No.[2]
Ettie Street Pump Station	1,203	0.082	320	1
Sunnyvale East Channel	3,657	0.0048	19	2
Coyote Creek at Hwy 237	75,086	0.0048	19	6
North Richmond Pump Station	481	0.0047	19	NA
Zone 4, Line A	1,062	0.0038	15	1
Guadalupe River at Hwy 101	58,272	0.0038	15	6
San Lorenzo Creek	30,875	0.0026	10	6
Walnut Creek	57,367	0.0020	8	6
Guadalupe River at Almaden	19,521	0.00054	2.2	6
Lower Marsh Creek	20,658	0.00030	1.2	NA
Delta Outflow	154,000	0.00010	0.4	NA

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* Greenfield et al. (2010).

[1]With the exception of Delta Outflow, only includes the drainage area below major reservoirs.

[2] 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.

Mercury Yields

Yield estimates for total mercury in watersheds monitored by SFEI and BASMAA member agencies were also provided in the *POC Loads Monitoring Report – Water Year 2011* (McKee et al., 2012). These preliminary yields are summarized in Table 2.3.

Table 2.3. Mean Annual Mercury Yields as Measured at POC Loads Monitoring Stations.

Watershed	Drainage Area (Acres)[1]	Total Mercury Yield (mg/m2/year)	Total Mercury Yield (mg/acre/yr)	Watershed Cluster No.[2]
Ettie Street Pump Station	1,203	0.079	300	1
Walnut Creek	57,367	0.029	110	6
Sunnyvale East Channel	3,657	0.013	50	2
Lower Marsh Creek	20,658	0.009	35	NA
San Lorenzo Creek	30,875	0.008	31	6

Source: *POC Loads Monitoring Data WY 2011* (Table 13, McKee et al., 2012)

NA – not identified in list of watersheds in Greenfield et al. (2010).

[1]With the exception of Delta Outflow, only includes the drainage area below major reservoirs.

[2] 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.

Data summarized above show that average PCB and mercury yields vary among watersheds. Therefore, an analysis was conducted to look for factors that relate yields to watershed characteristics.

In 2009, SFEI conducted a watershed characterization study where 185 watersheds in the Bay Area were categorized into eight “clusters” depending on land cover, imperviousness, historical industrial land use and other features (Greenfield et al. 2010). As indicated in Table 2.2 and Table 2.3, 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)

The analysis indicates that generally the highest yielding watersheds tend to be in clusters 1 and 2, which are smaller, more developed and more impervious watersheds.

A further analysis was conducted as part of IMR Part C development to examine whether the watersheds could be classified based on observed water quality, rather than watershed characteristics alone. For this purpose, stormwater data collected as part of s watershed reconnaissance study conducted by McKee et al. (2012) were examined.[2] Figure 2.2 illustrates the mean particle ratios[3] compared to the mean total PCB concentrations measured at various locations in the reconnaissance study (total of 17 watersheds). The bars represent the range of observations.

Differences in POC Yields

Based on the data presented in Figure 2.2, two categories of watersheds were distinguished, those represented by black circles and those with significantly higher concentrations, represented by colored squares. A similar distinction was found by McKee et al. (2012) in their analysis of particle ratio data.

The elevated (higher concentration) watersheds consist of the Ettie Street Pump Station (Oakland), Santa Fe Channel (Richmond), and Pulgas Creek North and South (San Carlos), of which the latter three are in Cluster No. 2. Those watersheds closer to 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.

[2] Source of Data: California Environmental Data Exchange Network (CEDEN), SFEI River Loading Study Program, http://www.ceden.us/AdvancedQueryTool
[3] 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.

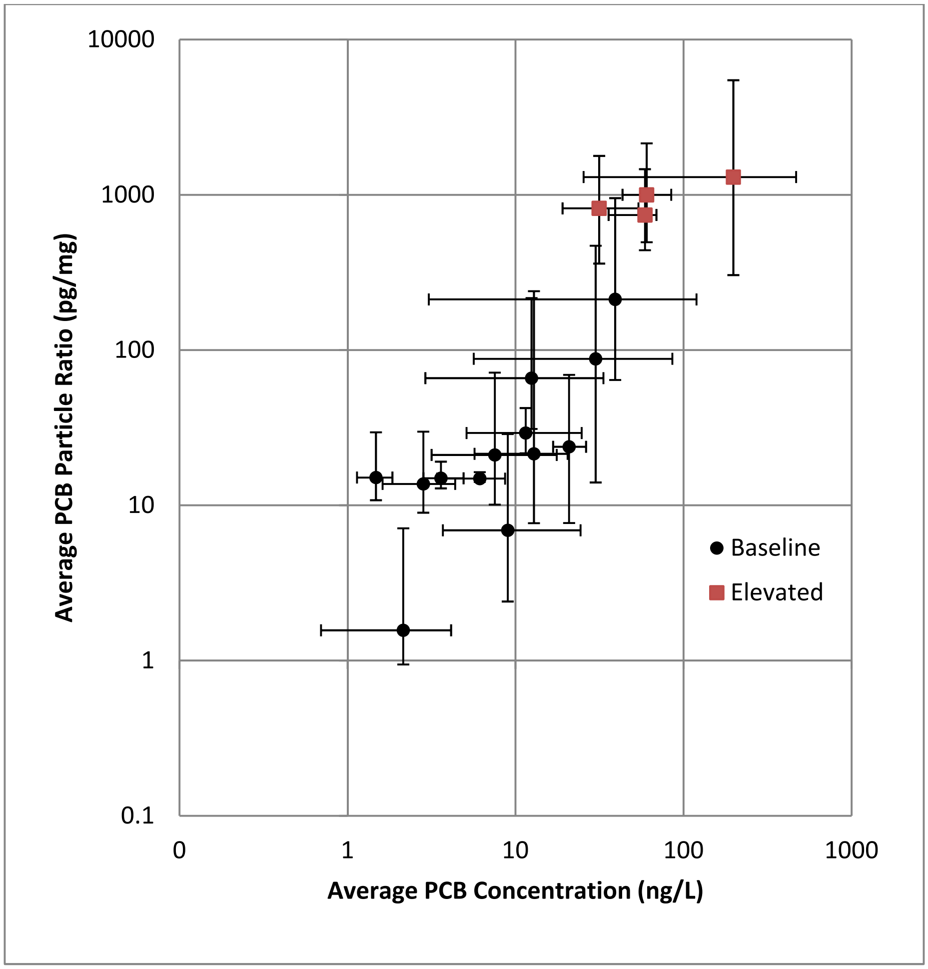

Figure 2.2. Comparisons between PCB mean concentrations and particle ratios in various Bay Area watersheds monitored.

A similar analysis for total mercury indicated that most of the watersheds that had higher in PCB concentrations were also higher in total mercury concentrations, but the data exhibited more of a continuum (McKee et al. 2012). So for the purposes of identifying POC loading rates for watersheds, the decision was made to not distinguish watersheds for mercury 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 mercury yields (see Table 2.3) and the current understanding of mercury sources, which suggests that mercury is more uniformly distributed than PCBs in watersheds.

To estimate POC yields for specific land use and source areas within Bay Area watersheds, an analysis was conducted using data collected by McKee et al. (2012) during watershed reconnaissance study. The analysis used data from selected baseline watersheds where measured average yields for the entire watershed were available from the PCB Synthesis (Davis et al., 2013). These watersheds included San Lorenzo Creek, North Richmond Pump Station, Zone 4 Line A, Guadalupe River at 101, Marsh Creek and Walnut Creek. Data from Coyote Creek at 237 were available, but not used because the watershed was not considered representative, in that most of the development in the watershed is relatively new compared to the other watersheds.

The following equation was used during the analysis to develop the “best fit” land use specific POC yields for the watersheds where loading data were available. These best fit POC yields developed based on this analysis are presented in Table 2.4.

$$\textbf{Watershed Yield (mg/acre/yr)} = \frac{(R_{OI} \times A_{OI}) + (R_{OU} \times A_{OU}) + (R_{NU} \times A_{NU}) + (R_{OP} \times A_{OP}) + (R_{OT} \times A_{OT})}{A}$$

where:

R	=	POC Loading Rate (mg/acre-yr)
A	=	Watershed Area (acres)
OI	=	Old Industrial
OU	=	Old Urban
NU	=	New Urban
OP	=	Open Space
OT	=	Other

Table 2.4. Best fit POC yields for specific land uses.

Land Use	Description	Best Fit Average PCBs Yield (mg/acre/year)	Best Fit Average Total Mercury Yield (mg/acre/year)
Old Industrial	Areas industrialized prior to 1968. Includes ports, railroads, and old electrical properties, including areas subsequently redeveloped into other land uses.	50	1,000
Old Urban	Areas urbanized prior to 1974 that were not identified as old industrial.	17.5	165
New Urban	Includes local and regional parks, forested and range land, Baylands, and agriculture.	2	25
Open Space	Areas urbanized after 1974.	2.5	25
Other	Military land and airports.	2	20

This analysis confirmed the importance of land use types on PCB yields, with the old industrial land use 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. The best fit yields also indicate that older (pre-1974) urban land use areas (which do not include old industrial land uses) also have significant PCB yields, although less than old industrial yields by roughly a factor of three. The yields of other land uses are relatively low; however, these land uses may still contribute significant loads since they comprise a large portion of the land area in Santa Clara County (see Table 2.1).

Figures 2.3 and 2.4 compare the predicted watershed POC yields for the five watersheds (San Lorenzo Creek, North Richmond Pump Station, Zone 4 Line A, Guadalupe River at 101, Marsh Creek and Walnut Creek) using the land use based best fit yields derived during this analysis to those reported in McKee et al. 2012, which were based on empirical measurements. For PCBs, the correlation analyses indicate that roughly 90% (r^2 = 0.87) of the variability in PCB yields and 75% (r^2 = 0.76) of the variability in total mercury yields can be explained by land use. The importance of old industrial, and to a lesser extent old urban land use, is similar between mercury and PCBs.

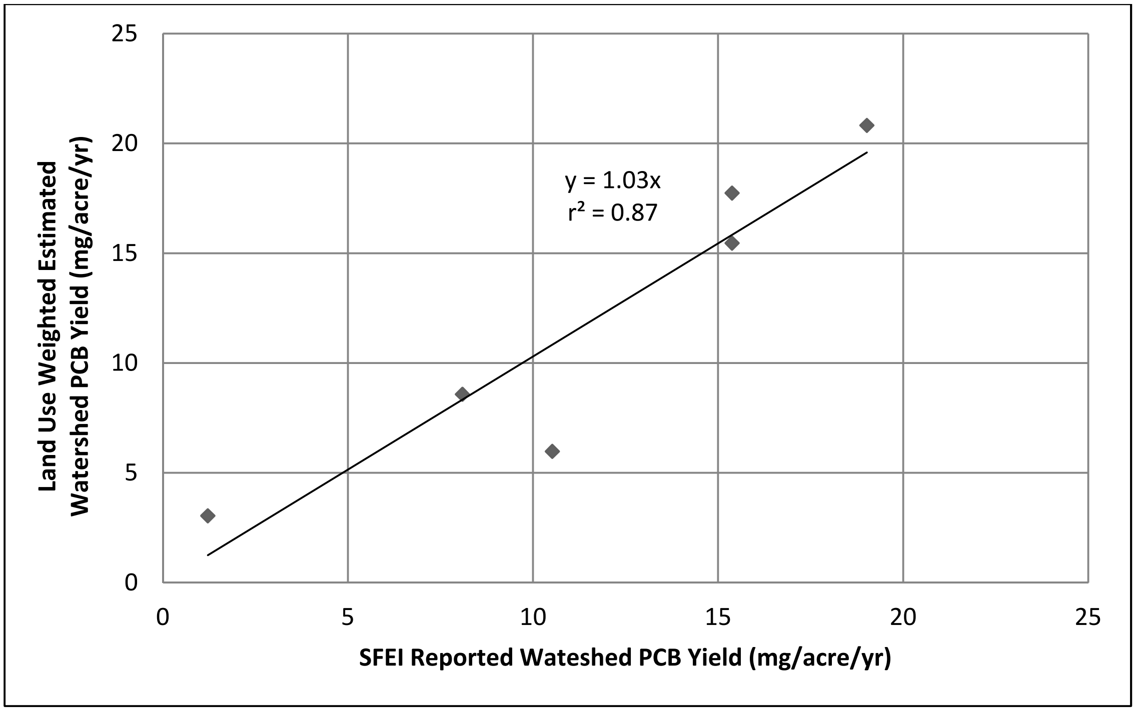

Figure 2.3. Comparison of Estimated PCB Yields for Watersheds with Loads Monitoring Data to Watershed Yields Estimated Based on Land Use Best Fit.

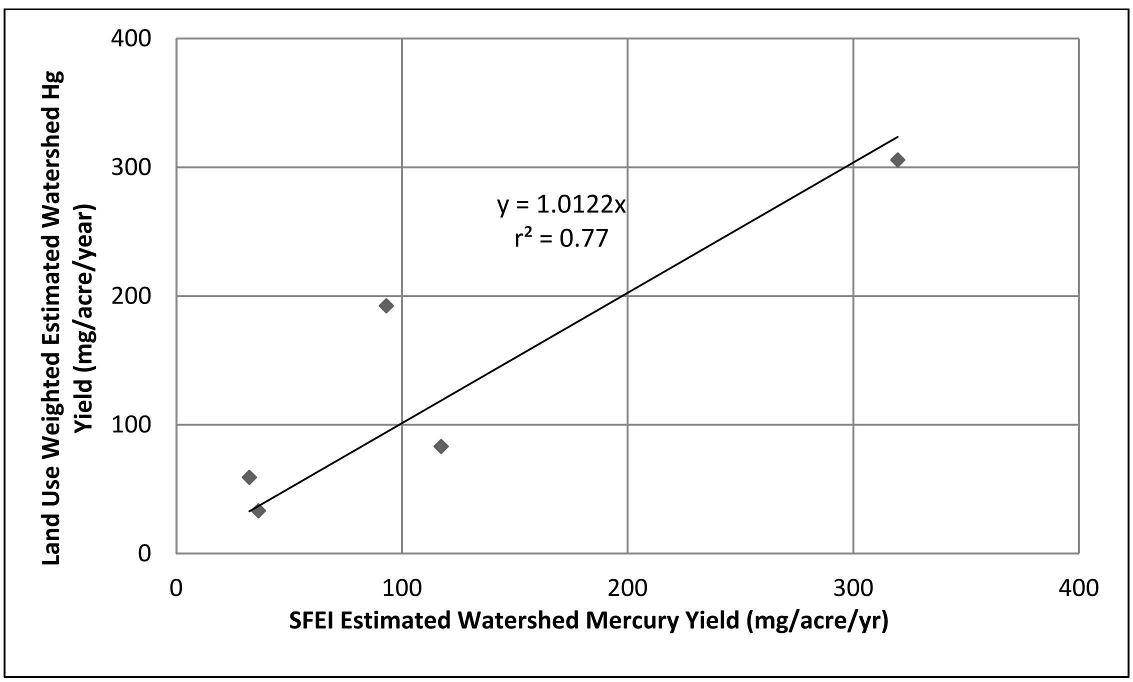

Figure 2.4. Comparison of Estimated Total Mercury Yields for Watersheds with Loads Monitoring Data to Watershed Yields Estimated Based on Land Use Best Fit.

2.2. Estimated POC Loads from Permittees

Based on the best-fit, average land-use based yields and the area of each land use within a Permittee's jurisdictional boundary, preliminary average annual POC loads were estimated for each Permittee in Santa Clara County. For known elevated PCB areas described in Section 2.1.3 (i.e., Leo Avenue in San Jose), the PCB load from this watershed was calculated based on monitoring data from the Ettie Street Pump Station watershed rather than the land use based best-fit method developed for baseline watersheds. Based on the Ettie Street data, average annual PCB yields from the Leo Avenue watershed are assumed to be 332 mg/acre. Since the Leo Avenue watershed is not known to be an elevated mercury area, estimated mercury loads from the watershed are incorporated in the applicable land use categories.

Preliminary load estimates of PCBs (g/yr) and total mercury (kg/yr) developed through this analysis are provided for each Permittee in Tables 2.5 and 2.6, respectively. For PCBs, the estimated loads from Santa Clara County stormwater are roughly half the load presented in the PCBs TMDL and approximately 70% of the load presented in the Hg TMDL. It is important to note however that the estimates presented in Tables 2.5 and 2.6 are within the range of uncertainty of the TMDL load estimates and therefore should be considered roughly equal to the TMDL estimates for the purposes of the cost-benefit analyses and load reduction scenarios presented later in this report. The proportions of the POC loads from each land use type are key outputs from this analysis.

Table 2.5. Estimated Annual PCB Loading (g/yr) to the Bay from Santa Clara County Permittees.[1]

Municipality	PCB Loading (g/yr) by Land Use					Total Loading (g/yr)
	Old Industrial	Old Urban	Open Space	New Urban and Other	Leo Avenue	
Campbell	8	60	0	0		68
Cupertino	4	83	3	2		92
Los Altos	0	71	0	0		71
Los Altos Hills	0	74	3	1		77
Los Gatos	0	44	5	1		50
Milpitas	14	53	6	6		79
Monte Sereno	0	8	0	0		8
Mountain View	25	92	2	2		121
Palo Alto	20	113	12	1		146
San Jose	135	930	57	35	179	1,336
Santa Clara	47	131	2	5		184
Unincorporated Santa Clara County	4	126	211	9		350
Saratoga	3	106	3	1		112
Sunnyvale	59	157	1	3		221
Total	319	2,048	304	68	179	2,917
%	11%	70%	11%	2.3%	6.2%	

[1]Load estimates were calculated based on the area within each land use (Table 2.1) and the regression-based yields developed for each land use category (Table 2.4). For elevated areas (e.g., Leo Avenue area) the estimated yield for ESPS (330 mg/acre-year) was applied rather than the baseline watershed yield.

Table 2.6. Estimated Annual Total Mercury Loading (kg/yr) to the Bay from Santa Clara County Permittees.[1]

Municipality	Mercury Loading (kg/yr) by Land Use				Total Loading (kg/yr)
	Old Industrial	Old Urban	Open Space	New Urban and Other	
Campbell	0.2	0.6	0.0	0.0	0.8
Cupertino	0.1	0.8	0.0	0.0	0.9
Los Altos	0.0	0.7	0.0	0.0	0.7
Los Altos Hills	0.0	0.7	0.0	0.0	0.7
Los Gatos	0.0	0.4	0.0	0.0	0.5
Milpitas	0.3	0.5	0.1	0.1	0.9
Monte Sereno	0.0	0.1	0.0	0.0	0.1
Mountain View	0.5	0.9	0.0	0.0	1.4
Palo Alto	0.4	1.1	0.1	0.0	1.6
San Jose	3.0	8.8	0.6	0.4	12.7
Santa Clara	0.9	1.2	0.0	0.0	2.2
Unincorporated Santa Clara County	0.1	1.2	2.1	0.1	3.5
Saratoga	0.1	1.0	0.0	0.0	1.1
Sunnyvale	1.2	1.5	0.0	0.0	2.7
Total	6.6	19.3	3.0	0.8	29.8
%	22%	65%	10%	2%	-

[1]Load estimates were calculated based on the area within each land use (Table 2.1) and the regression-based yields developed for each land use category (Table 2.4).

Preliminary mercury loading estimates from Santa Clara County Permittee areas presented in Table 2.6 do not include one potentially important land use that is outside of the jurisdiction of Permittees, but is included in the loading estimate in the PCB and mercury TMDLs – Highways and Interstates. To address this potential mercury source, provision C.11.j.i of the MRP requires Permittees to:

> "*Develop an equitable mercury allocation-sharing scheme in consultation with the California Department of Transportation (Caltrans) to address Caltrans facilities (e.g., highways and interstates) within the TMDL area, and report the details to the Water Board. Alternatively, Caltrans may choose to implement mercury load reduction actions on a watershed or regionwide basis in lieu of sharing a portion of an urban runoff management agencies' mercury allocation."*

This provision also requires that Permittees to "submit in their Integrated Monitoring Report the manner in which the urban runoff mercury TMDL allocation will be shared between the Permittees and Caltrans."

To address this MRP provision, Permittee representatives and Caltrans met several times to review provision C.11.j and to discuss the manner by which the allocation would be shared. Those discussions led to a general understanding that Permittees and Caltrans would take an alternative approach (consistent with provision C.11.j) to implementing mercury load reduction actions on a watershed or region-wide basis, consistent with TMDL and implementation requirements included in the Caltrans' MS4 Permit, and including developing an equitable sharing scheme with Permittees. In the attached letter (see Appendix B), Caltrans states their interest in working with MRP Permittees in manner involving implementation of actions on a watershed or region-wide basis that is consistent with TMDL implementation requirements within the Caltrans' MS4 Permit and its proposed amendments. 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.

2.3. Limitations and Uncertainties

There are a variety of sources of uncertainty in the POC loading estimates presented in Table 2.5 and 2.6, 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 relatively high PCB loading rates. These watersheds were considered outliers and excluded from the regression analysis. There may be additional elevated watersheds that have not been identified because of the limitations in the spatial and temporal extent of monitoring.
- Land Use Database Accuracy – Land use is the basis for the analysis conducted, and not only is the type of land use important, but in the case of PCBs, the age of the land use also is critical. The analysis attempted to characterize the historical evolution of land use based on available data and aerial photo interpretation. However, the land use maps have not been "groundtruthed" at this time and therefore pose an important uncertainty in the analysis. Specifically, land use areas identified as old industrial for the purposes of this analysis may have been recently redeveloped, and thus may have lower yields of POCs than assumed.
- Data Limitations – The amount of monitoring data used to develop average POC yields for watersheds was limited due to the limited number of watersheds and storm events sampled.
- Land Use as a Surrogate – Land use is used as a surrogate for actual PCB and mercury source release and transport. Although the types of potential POC sources have been identified, the actual locations of all sources and their pollutant contributions were not determined at the level of analysis conducted during the development of this report.

It is difficult to assess the quantitative implications of these uncertainties and limitations on the magnitude of the projected loads, especially as loading estimates move from regional to smaller spatial scales. Experience with the difficulty in making loading estimates suggests that readers should consider the projected loads presented in this report as first order estimates only. These estimates do, however, provide a starting point to continue identifying high opportunity areas where the most cost-effective control measure implementation should be focused and for evaluating the costs and benefits of implementing control measures.

3. PLANNING LEVEL COSTS TO PERMITTEES AND WATER QUALITY BENEFITS OF CONTROL MEASURES

This section addresses the costs and benefits of the eight control measures discussed in IMR Part B Sections B.2 through B.9. Preliminary cost and benefit estimates are provided in order to evaluate which control measures or combinations of measures might be most cost effectively employed to reduce POC loads (e.g., mercury and PCBs) from the locations identified in Section 2.0 via hypothetical implementation scenarios identified in Section 4.0. Cost-effectiveness for each control measure was evaluated by combining planning level cost and benefit estimates.

The eight types of control measures evaluated for cost-effectiveness are listed in Table 3.1. In order to evaluate the cost-effectiveness of these eight control measures, they were divided into two general categories: 1) source controls, which generally prevent the release of POCs into the environment and/or into the MS4; and 2) pollutant mass interception controls, including operation and maintenance practices and stormwater treatment controls, which remove POCs that have been transported to an MS4. Additional details about the extent to which these eight control measures have been implemented to-date in the Bay Area are provided in IMR Part B. Additionally, a summary of actions taken to-date by Permittees (consistent with MRP provisions C.11.i and C.12.i) to develop and implement or participate in effective programs to reduce PCBs-related risks to humans is included in Appendix C.

Table 3.1. Pollutant of Concern Control Measures Evaluated.

Category	Control Measure
Source Controls	Reduction/Elimination and Recycling of Mercury in Devices, Products and Equipment
	Identification of PCBs during Industrial Inspections
	Control of PCBs During Building Demolition and Renovation
	Investigations and Abatement of Sources in Drainages
Pollutant Mass Interception	Enhanced Street Sweeping
	Enhanced Operation and Maintenance (O&M) Practices
	Stormwater Treatment Retrofits
	Diversion to Wastewater Treatment Plants (POTWs)

Planning level cost and benefit estimates for each of the eight control measures listed in Table 3.1 were developed, as described in detail in Appendix D and summarized in tables at the end of this section. The cost estimates described in Appendix D were based on available information from the literature, cost data provided by local municipal agencies based on planning and implementation of the control measure pilot studies being conducted in compliance with MRP requirements, and best professional judgment in cases where cost data were limited or unavailable.

The form of the cost estimates varied, depending on the type of control measure. For example, some costs may be reported in terms of unit of implementation (e.g., dollars per curb mile swept for street sweeping, or cost per drainage area treated), whereas other costs may be reported as a total cost per year over the expected life of a given control measure, accounting for engineering, construction and ongoing maintenance. However, for the purpose of evaluating cost effectiveness, all reported cost data were converted into units of dollars per acre (e.g., area treated and/or area of implementation).

Cost estimates for a number of measures were based on costs incurred during MRP pilot projects, many of which were implemented through the Clean Watersheds for a Clean Bay (CW4CB) grant. Where local estimates were not available, regional and national cost estimating sources developed by the Water

Environment Research Foundation (WERF), the Low Impact Development (LID) Center, and others were utilized as needed. Where appropriate, life-cycle cost estimates were provided that take into account the anticipated service life of the equipment or installation. In addition, Appendix D provides summaries of the budgets for MRP pilot projects described in IMR Part B based on records of expenditures and/or projections that were available at the time of report preparation.

Preliminary cost estimates presented generally focus on the costs that would be incurred by a municipality to implement a given control measure, or to enhance existing programs. Costs estimates are based on the following seven general cost categories:

1. **Project Concept and Planning:** These costs are typically one-time costs that are required at the beginning of the process for pre-implementation planning, which depending on the control measure, may include one or more of the following: site discovery; surveying; CEQA; permitting; bid and selection of design, engineering, construction, and/or equipment contractors; hiring new municipal staff and/or training existing staff on the use/operation/maintenance (etc.) of new technologies or practices needed to implement the control measure; public outreach in areas where new or enhanced control measures will be implemented.
2. **Design:** These costs are for the engineering and associated overhead costs for site, structural and landscape design and engineering plans.
3. **Construction and Installation:** These costs are for the land, capital, labor, material and overhead costs associated with construction or installation of a given control measure.
4. **Equipment:** These costs are for the purchase or rental of new or upgraded equipment required to implement a given control measure (e.g., structural control device costs; street sweepers);
5. **Operating:** These costs are for the ongoing annual operation costs to implement, inspect and/or monitor a given control measure, including labor, equipment maintenance and replacement parts, fuel, and sediment disposal costs.
6. **Reporting:** These costs include any reporting required during planning and implementation of a given control measure for community outreach and/or to meet regulatory requirements. For example, performance tracking may be required to establish load reductions from a given control measure in order to show continued progress towards load reduction goals called for by the PCBs and Hg TMDLs.

Where available, lifecycle costs are also presented for some control measures. Lifecycle costs attempt to incorporate as appropriate all of the above costs to implement a given control measure over the lifetime of the control measure. These costs may be presented as a unit cost (e.g., cost per curb mile swept or cost per mass of TSS removed from stormwater) or as a total project cost over a given timeframe. Lifecycle costs provide a simple metric for comparing costs across a wide variety of control measures and implementation scenarios. When combined with load reduction benefits, these costs can be used to identify the most cost-effective control measure options. A 25% mark-up was applied to lifecycle costs to account for administrative and other costs associated with implementing a given control measure.

Not all cost categories apply to all control measures and the types of costs included within each category may vary by control measure type. Cost data for all of the categories described above may not currently be available, but all of the categories are identified here for completeness.

For the purpose of the cost-effectiveness evaluation, the benefits of each control measure were defined as either: (1) for source control measures, the load avoidance or expected percent load avoidance of POC mass, sediment and/or suspended sediment mass; or (2) for interception control measures, the load reduction or expected percent load reduction of POC mass, sediment and/or suspended sediment mass. Because both PCBs and Hg are primarily associated with sediment, benefits are presented as the mass of sediment or suspended sediment reduced because for most of the control measures, data on sediment or suspended sediment mass removal rates are more readily available than data on specific POC mass removal rates. In Section 4.0, POC concentration data are used to convert mass of sediment/suspended sediment removed to POC mass loads reduced. To the extent possible, all control measure benefits were expressed in terms of benefit per acre for ease of comparison among the different control measures and/or to allow evaluation of combinations of control measures in the scenario building exercise in Section 4.0.

The load avoidance or load reduction benefits were estimated based on the best available data including data gathered during the MRP pilot projects and from the literature, as described in Appendix D. For source control measures, load avoidances were based on the estimated mass of POC that would potentially, in the absence of the control measure, have been introduced into stormwater, while for interception control measures, load reductions were based on the estimated sediment load reduction and/or suspended sediment percent removal per unit of implementation. As with the units for costs, the load avoidance or load reduction units reported in the literature varied by control measure. For example, literature data on street sweeping reported units of mass of sediment removed per curb-mile swept, while stormwater treatment controls were more typically presented as the mass of suspended sediment removed per drainage area treated. However, to the extent possible, all benefits were converted to a mass removed (or % removed) per acre of implementation or drainage area using conversion factors described in detail in Appendix D for each control measure type.

Tables 3.2 and 3.3 provide a summary of the preliminary planning level cost and benefit estimates for the eight different POC control measures evaluated. For each control measure type, the average or best estimate, and the range of costs and/or load reduction benefits were calculated using the data presented in Appendix D. **All costs and benefits presented in Tables 3.2 and 3.3 should be considered preliminary and subject to revision based on additional information**.

Table 3.2. Summary of Planning Level Costs and Benefits of Stormwater Source Control Measures

Control Measure		Costs		Benefits	
		Cost Metric	Best Estimate	Benefit Metric	Best Estimate
Source Controls	Recycling of Mercury in Devices, Products and Equipment via Household Hazardous Waste Facilities	$/Hg-containing bulb or lamp recycled	$1 ($0.24 - $2.27)	Total Hg prevented from reaching stormwater due to recycling across all MRP Permittees (Kg/Year) [2,3]	0.34
		$/ton of solid waste disposed	$2.15[1]		
		$/household/year	$9.55[1]		
		$/year	$233,000[3]	Hg prevented from reaching stormwater due to recycling at the Santa Clara County HHW facility in 2013 (Kg/Year) [2,4]	0.15
	Identification of PCBs During Industrial Inspections	$/county/year	$47,000 ($4,000 - $90,000)[5]	Unknown[2]	
	Control PCBs During Building Demolition and Renovation	$/building >1 mg/kg renovated or demo	No Cost Estimates available[6]	Unknown	
	Investigations and Abatement of Sources in Drainages [7]	$/acre	$570 ($139 - $1,067)[8]	mass TSS reduced/acre	TBD

[1]These are different types of fees that have been used to fund Household Hazardous Waste Recycling Programs.
[2]Although benefits for these measures are challenging to quantify, because these programs have already been established and are currently ongoing, any load reduction benefit from these measures has been accounted for in the yields reported in Section 2.0. If these measures were discontinued, loads would be expected to increase.
[3]Total sum of mercury prevented from stormwater due to recycling at Permittee facilities from Table 3.2.
[4]Labor and disposal costs for recycling Hg-containing devices at the Santa Clara HHW facility in 2013 and the estimated mass of Hg avoided due to recycling at that facility in 2013.
[5]Cost range is for individual training vs. county-wide training programs.
[6]Public sector costs would likely be limited to costs for Ordinance adoption and permit enforcement associated with removal of PCBs in caulk before or during demolition/renovation.
[7]Costs are limited to Permittee costs to implement investigations and identify potential source properties; does not include costs for private property owners to abate identified source properties.
[8]Monitoring costs are included because monitoring is required to identify potential source properties.

Table 3.3. Summary of Planning Level Costs and Benefits of Stormwater Pollutant Mass Interception Control Measures.

Control Measure			Costs		Benefits	
			Cost Metric	Best Estimate	Benefit Metric	Best Estimate
Pollutant Mass Interception Control Measures	Enhanced Municipal Operation and Maintenance Practices[1]	Street Sweeping - Mechanical Broom	$/curb-mile swept	$48 ($33 - $50)	lbs street dirt reduced/ curb-mile swept	50 (10-160)
		Street Sweeping -Regenerative Air/Vacuum Assisted	$/curb-mile swept	$80 ($29 - $81)	lbs street dirt reduced/ curb-mile swept	200 (100-400)
		Pump Station Maintenance	$/cleanout	$25,000 ($7,500 - $35,000)	lbs sediment removed/ cleanout	16,000 (16,000-123,000)
		Storm Drain Line Cleaning/flushing	$/linear foot of pipe flushed	$40	lbs sediment removed/ linear foot of pipe flushed	5.1
		Street Flushing	$/linear mile of street flushed	$10,000 ($10,000 - $574,000)	lbs street dirt reduced/ linear mile of street flushed	600 (240-960)
	On-Site Stormwater Treatment via Retrofits[2]	King and Hagan (2011)[3]	$/acre-yr	$10,869 ($3,131 - $19,830)	N/A	
		CW4CB Pilots[4,5]	$/acre-yr	$28,300 ($10,400 - $60,400)	% TSS mass reduced	73% (55-90%)[6]
		Green Street pilot retrofits[5]	$/acre-yr	$16,300 ($7,200 - $27,400)	% TSS mass reduced	64% (60-67%)
		CW4CB Pilots: Hydrodynamic Separator Units	$/acre	$262 ($64 - $460)	mass TSS reduced/acre	Unknown[7]
	Diversion to POTW[8]	Constructed diversion with gravity feed to POTW	$/year	$85,000 ($15,000 - $210,000)	g POC/MG diverted/year	0.19 (0.004-0.76)
		Constructed diversion requiring pumped connection to POTW	$/year	$72,500 ($35,000 - $135,000)	g POC/MG diverted/year	0.19 (0.004-0.76)

[1]Costs include capital, operating and administrative costs per unit of implementation.
[2] Total costs (including design/construction/operating/ administrative costs) were annualized over 20 years
[3] Report on misc. treatment controls (Infiltration, filtering, bioretention, swales, and permeable pavement
[4] Bioretention facilities; tree wells; vegetated swales; media filters.
[5]To account for annual operating costs, the average and range of estimated operating costs per acre (Appendix D, Tables A.13 and A.14) were added to the estimated cost/acre for CW4CB pilots and Green Street retrofits. The estimated average annual operating cost was $3,300/acre, with a range of $1,500 - $5,400/acre.
[6] Assumed % TSS mass reduced from CSN (2012)
[7] HDS units have been shown not to reduce TSS; however, PCBs may adhere to coarser particles and these coarser particles can be removed.
[8] Total costs (including design/ construction/operating/administrative costs) were annualized over 20 years. Costs DO NOT include any fees imposed by POTWs to accept diverted stormwater. Cost range reflects higher costs for longer distance between diversion and connection to POTW (adjacent, <500 ft, >500 ft). Assumes PCB or Hg stormwater concentrations of 50 ng/L (best) and 1 ng/L - 200 ng/L.

3.1.1. Limitations

All cost estimates presented in this section are based on limited available data that have a number of uncertainties. First, other than the information about the MRP pilot studies, few recent, local cost data are available for any of the control measures considered. The bulk of available cost data that were found during the literature review and used in cost estimating are from studies or reports ten or more years old, and/or from outside the Bay Area. Cost estimates for older data were adjusted to 2013 dollars to mitigate the impact of older data, however, more recent data are preferred. In general, few studies were found in the literature review which reported recent cost data for municipalities' stormwater control measure programs, and fewer recent data on costs from Bay Area cities were found. Thus, cost estimates based on data that were no more than ten years old and/or cost data provided by municipalities which represent actual costs to implement ongoing programs were favored over other estimates. Recent pilot study data which are specifically applicable to Bay Area cities, and/or data provided by Bay Area cities on their control measure programs, provide the most relevant cost estimates for evaluating cost effectiveness of stormwater control measures in Bay Area cities.

Another important limitation is the cost factors that were included and the assumptions used to develop estimates varied between sources and types of control measures. Typically, cost data were presented without all the supporting information on the types of costs that were included within a given estimate. For example, some of the cost estimates for O&M enhancements included the cost for sediment disposal and some did not. This cost can be substantial relative to other cost factors, especially if the sediment must be disposed of as hazardous waste, as was the case in several studies (Appendix D, Table D.8). Further, literature cost estimates for project concept, planning, and reporting were typically not available, or were based on best professional judgment. Administrative costs were also not included in most data, except in limited cases where the total program cost was provided. To address these unknown costs, a 25% mark-up was applied to total costs.

Finally, it is important to note that for many of the control measures, costs will be highly site specific, and thus, the ranges of costs provided in Tables 3.2 and 3.3 should be viewed as order-of-magnitude, planning level cost estimates. More accurate and up-to-date information on control measures currently used in Bay Area cities (e.g., street sweeping, O&M activities, and identification of PCBs during industrial inspections) would require an exhaustive survey of Bay Area municipalities' costs for their current programs, which is beyond the scope of this report. Additional cost information will be available for stormwater treatment controls and POTW diversions once the MRP pilot studies are completed.

In addition to the limitations on the cost estimates, there are limitations on the load avoidance/load reduction benefit estimates. Many inputs to the load reduction estimates were site-and/or project-specific and may or may not be applicable to other locations or similar types of projects. Other inputs were derived from literature values, models, and/or best professional judgment if no reliable local measurement data were available. In particular, data taken from areas of the country with different climates (e.g., Chesapeake Bay) may have limited applicability to the Mediterranean climate of the Bay Area. However, additional measurement data on sediment and stormwater concentrations and control measure load reductions will be available once the MRP pilot projects have been completed, and these data may be used to refine the load reduction effectiveness estimates.

Despite the limitations described above, the ranges of cost estimates and load reduction benefits presented in Tables 3.2 and 3.3 provide a reasonable starting point for comparison of costs to municipalities to implement the various control measures in the Bay Area and the potential POC load reduction that may be achieved for those control measures.

4. COST AND BENEFITS OF FUTURE CONTROL MEASURE IMPLEMENTATION SCENARIOS

In this section, the planning level cost and benefit data developed in Section 3.0 are used to evaluate cost-effectiveness in terms of cost per gram of POC load reduced or avoided for a number of hypothetical enhanced control measure implementation scenarios. The scenarios focus on enhanced or new actions and therefore do not include the POC reductions or costs associated with control measures currently implemented by Permittees in Santa Clara County (e.g., reductions/recycling of mercury in devices and equipment, identification of PCBs during existing industrial inspections, or existing stormwater treatment) that are described in IMR Part B.

The three hypothetical enhanced implementation scenarios that were evaluated are summarized below and in greater detail later in this section. **<u>Is it important to note that these scenarios are not recommendations for future implementation but instead are intended to help inform future discussions regarding the costs and benefits of enhanced control measure implementation to address PCBs and mercury in stormwater.</u>**

1. <u>Scenario A - Targeted New Control Measures in High Opportunity Areas</u>. Four implementation scenarios were developed for areas with elevated concentrations of PCBs or mercury. Combination the following control measures were included Scenario A - property/source identification and abatement, enhanced street sweeping, stormwater treatment retrofits, and street flushing. Scenarios were selected to compare the cost-effectiveness of many combinations of control measures and may not be feasible for specific high opportunity areas. Scenario A is described in detail in Section 4.2.

2. <u>Scenario B - Opportunistic Control Measure Implementation in Moderate Opportunity Areas</u>. Scenario B evaluates the costs and benefits of implementing “Green Street” As redevelopment of older urban areas occurs and/or as green street retrofit projects are implemented by Permittees for reasons other than TMDL requirements, additional POC load reductions will be achieved opportunistically. Green street retrofit projects provide the opportunity for integration of POC load reductions with other drivers and funding sources (e.g., transportation projects). Additionally, LID requirements imposed on developers will contribute to POC load reductions, in addition to other benefits. The costs to Permittees are assumed to be minimal for private redevelopment and associated LID measure implementation. Potential implementation scenarios assuming the use of green street retrofits and bioretention stormwater treatment to meet LID requirements are presented in Section 4.3.

3. <u>Scenario C - Diversion of Stormwater to POTWs in High/Moderate Opportunity Areas</u>. Two potential diversion scenarios (presented in Section 4.4) were developed which assume implementation of stormwater diversions to a POTW in a location with the necessary watershed conditions and POTW acceptance to make such implementation feasible. While diversion of stormwater to POTWs would be most cost-effectively implemented in high opportunity areas, these areas are not necessarily located where diversions are feasible. For example, high or moderate opportunity areas may not make up a large enough fraction of the area served by a given sanitary sewer line to provide cost effective load reduction benefits. Other limitations include institutional barriers between stormwater agencies and POTWs, which have not been fully explored, but likely further reduce opportunities for diversion projects.

4.1. Scenario Development

Control measure implementation scenarios presented in this section built upon the analysis presented in Section 2.0 that identified land use categories and associated POC yields. The steps used to develop the hypothetical implementation scenarios for which cost-effectiveness was evaluated are described. As an initial step in scenario development, all of the land area within Santa Clara County that drains to the Bay (Table 2.1) was assigned to one of three POC load reduction opportunity categories, which are assumed to have the following characteristics:

- **High Opportunity** – areas mainly within old industrial land uses with known PCBs/mercury sources or where PCBs/mercury were used or recycled. High opportunity areas have relatively high concentrations of PCBs/mercury in street dirt, sediment removed from the MS4, or in stormwater runoff. These areas have the highest PCBs/mercury yields and provide relatively high opportunity for cost-effective control measure implementation.

- **Moderate Opportunity** – land areas in the moderate opportunity category include old urban land uses and old industrial areas that do not fall into the high opportunity category and have not been recently redeveloped. Moderate opportunity areas have moderate concentrations of PCBs/mercury in street dirt, sediment removed from the MS4, or in stormwater runoff. These areas have moderate PCB/mercury yields and provide moderate opportunity for cost-effective controls.

- **Low/No Opportunity** – land areas in the low/no opportunity category include newly urbanized areas, open spaces, and parks where PCBs/mercury were unlikely to have been used, transported or recycled. PCBs/mercury concentrations in street dirt, sediment removed from the MS4, or in stormwater runoff from these areas are near, at, or below analytical detection limits. These areas have relatively low PCB/mercury yields and provide little or no opportunity for cost-effective controls.

Initial assignment of a land areas to a given opportunity category was primarily based on relationships between land-uses and POC sources as described in Section 2.0. Specifically, areas within watersheds known to contain PCB sources (i.e., Leo Avenue) and old industrial land use areas were provisionally categorized as high opportunity, older urban areas were categorized as moderate opportunity, and new urban and open space areas were categorized as low/no opportunity. Further refinement of these assignments, however, was needed based on the large ranges of concentrations of POCs observed in street dirt and sediment in the stormwater conveyance system within each land use class, suggesting that not all old industrial or older urban areas should be placed in a single opportunity category. The process of refining high, moderate and low/no opportunity land area assignments is described below and illustrated in Figures 4.1 and 4.2.

4.1.1. Potential High Opportunity Areas

To-date, a limited number of high opportunity areas have been identified in Santa Clara County. The best documented of these areas is within the Leo Avenue watershed. This watershed is an urban drainage in San Jose comprised mainly of old industrial land uses and known to have relatively high levels of PCBs in sediments from street and stormwater conveyances in comparison to other Bay Area watersheds. Based on these data, areas identified as high opportunity for the purposes of assessing cost-effectiveness of PCB control measures include a small portion (8 acres) of the watershed that is believed to produce high yields of PCBs. Except for this relatively small area, the vast majority of the Leo Avenue watershed does not appear to contribute high PCB yields to stormwater, and for PCBs is therefore identified as moderate opportunity. Since no sources of mercury have been documented in the Leo Avenue watershed, assignments to opportunity categories are based on land uses.

In addition to the high opportunity area within the Leo Avenue watershed, 5% of old industrial land use areas in Santa Clara County were also identified as high opportunity for the purpose of building the control measure implementation Scenarios A and B. This percentage was based on the percentile of sediment samples collected in old industrial areas within the county that had a PCB concentration of greater than 1 mg/kg (i.e., top 5th), the provisional threshold used by Bay Area stormwater programs to identify high priority PCB source areas. To remain consistent with PCBs, 5% of old industrial land use areas in the county were also assumed to be high opportunity for mercury reduction.

4.1.2. Potential Moderate Opportunity Areas

The land area that was provisionally identified as moderate opportunity for control measures implementation is comprised the remaining 95% of old industrial area that was not identified as high opportunity, and 20% of the older urban land use area. The decision to include 20% of the older urban area was based on sediment data collected in older urban areas across Santa Clara County (KLI and EOA 2002; City of San Jose and EOA 2003; Yee and McKee 2010). These data indicate that the top 20% of PCB concentrations in old urban areas are above urban background PCB concentrations of about 0.1 mg/kg. Similar to the high opportunity areas, moderate opportunity areas for mercury reduction were defined using the same criteria as PCBs.

4.1.3. Potential Low/No Opportunity Areas

Low opportunity areas include those land area where little to no opportunity for POC reduction is likely. The land area within the low/no opportunity category is comprised of the remaining 80% of old urban areas not included in the moderate opportunity category, along with all new urban, open space, and other land uses.

4.1.4. Reapportionment of POC Loads

The process by which average annual POC yields were developed for different land use categories is described in Section 2.0. These yields and associated land areas were multiplied together to estimate the average annual load of PCBs and mercury from Santa Clara County to the Bay. As these land areas were reapportioned to high, moderate and low/no opportunity categories, the yields for high and moderate opportunity areas were also adjusted to better reflect the POC yield associated with these areas, while conserving the estimated total annual loading from Santa Clara County to the Bay that was reported in Section 2.0 (see Tables 2.5 and 2.6). For example, for PCBs the high opportunity category was assigned a refined yield of 1,000 mg PCBs/acre-year, similar to the estimated yields from other Bay Area high opportunity areas outside of Santa Clara County. These areas are assumed to have a high yield than the typical old industrial areas, so this yield is higher than the average yield for the old industrial land use category (i.e., 332 mg PCBs/acre-year). On the opposite end of the continuum, the PCB yield for low/no opportunity areas remained the same as the yield for new urban and open space land uses (i.e., 2-2.5 mg PCBs/acre-year). Moderate opportunity areas were adjusted accordingly to conserve the PCB loading estimate for the county. Similar reapportionments were also conducted mercury.

Figures 4.1 and 4.2 illustrate the reapportionment of land areas and POC yields for PCBs and mercury, respectively

.

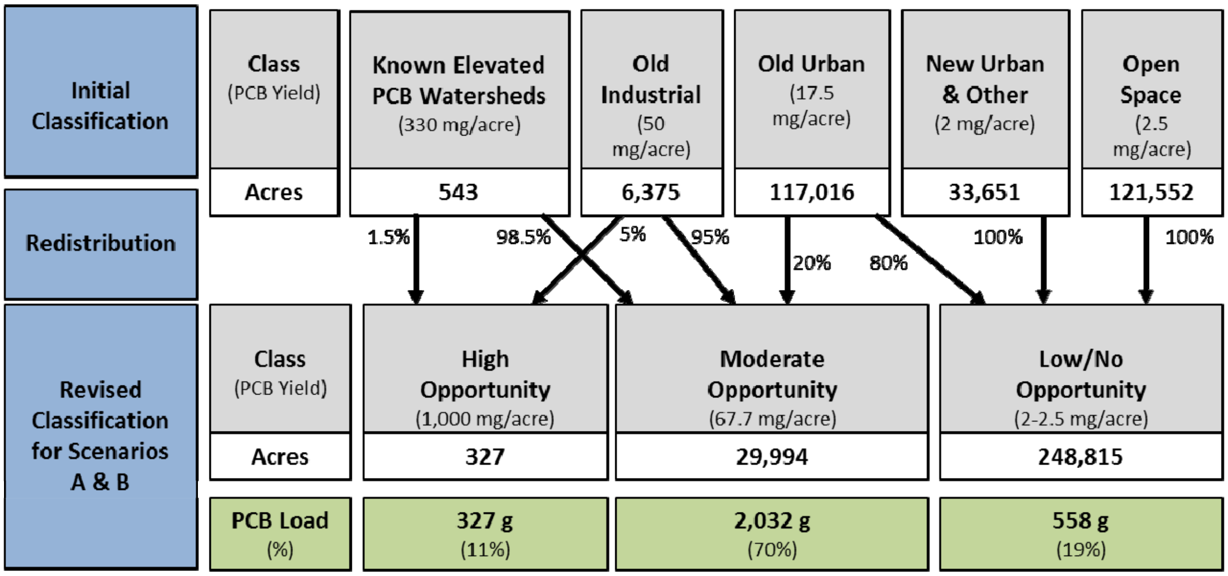

Figure 4.1. Santa Clara County Land Use Areas, PCB Yields, and Assigned Opportunity Categories for Cost-Benefit Scenarios A and B.

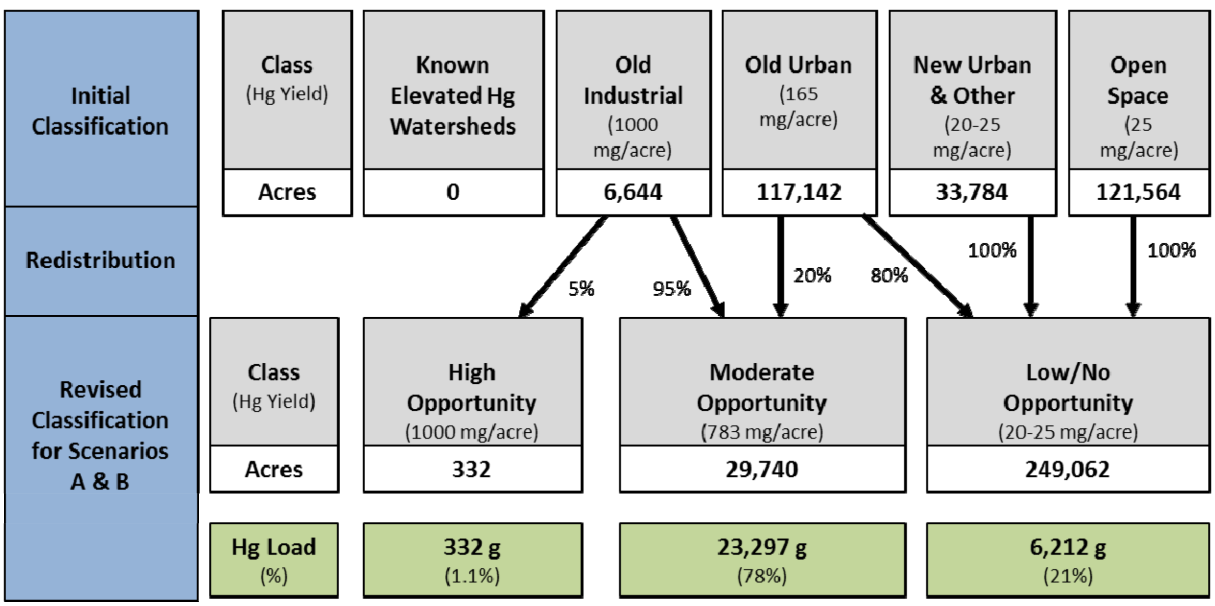

Figure 4.2. Santa Clara County Land Use Areas, Total Mercury Yields, and Assigned Opportunity Categories for Cost-Benefit Scenarios A and B.

4.2. Scenario A: Implementation in High Opportunity Areas

Four hypothetical scenarios were developed for control measure implementation in high opportunity areas (Table 4.1). For each scenario presented in Tables 4.2 – 4.8, cost-benefit calculations were made based on implementation of a given control measure in a fixed percentage of the high opportunity area each year. For all four PCB load reduction scenarios in high opportunity areas, the costs to implement source property identification and abatement were applied to the entire high opportunity area because these costs are associated with the entire area that is investigated to identify source properties. However, load reduction benefits were calculated based on an assumption that 10% of the high opportunity area investigated would be identified as source properties and subsequently abated by property owners. Estimated costs to Permittees included in Tables 4.2 – 4.8 for this control measure only include the costs to investigate and identify source properties. Abatement costs were not included in the estimates, as these costs were assumed to be the responsibility of the property owner(s). Because of the unlikelihood that source properties could be identified for mercury, no source property identification and abatement control measures were applied to the mercury load reduction scenarios.

Table 4.1. Control measure implementation scenarios A1 – A4 for potential high opportunity areas in the Santa Clara County.

Control Measure	% of High Opportunity Area to which Control Measure is Applied in each Scenario			
	A1	A2	A3	A4
Source Property ID and Abatement[1]	10%	10%	10%	10%
Enhanced Street Sweeping	50%	-	-	45%
Street Flushing	-	50%	-	45%
Stormwater Treatment Retrofits	40%	40%	90%	-

[1] Implementation scenarios for total mercury do not include source property identification and abatement controls and therefore other control measures are assumed to apply to 90% of high opportunity areas.

The following data inputs and assumptions were applied to calculate the load reductions, cost effectiveness, and total costs for each of the control measures within a given scenario.

1. Cost and benefit data presented in the summary Table 3.2 and 3.3 and further described in Appendix D were used for calculating the cost effectiveness of the control measures.

2. Annual costs for each control measure were calculated assuming that total project costs are spread out equally over twenty years.

3. The total high opportunity acreage was based on the assignments presented in Figures 4.1 and 4.2.

4. Concentrations of PCBs and Hg from the top 25% of concentrations measured in street dirt within industrial land uses in the Bay Area were selected as the best data sets to estimate PCBs and Hg concentrations in street dirt from high opportunity areas (PCBs: n=55; Hg: n=50). As these data were log-normally distributed, the geometric means of 0.56 mg/kg (PCBs) and 0.59 mg/kg (Hg) were used for all calculations of mass removed in street sweeping and street flushing activities. The San Francisco Estuary Institute (SFEI) Proposition 13 database which incorporates PCB and mercury sediment concentration data from a number of past field studies was the primary source

of these concentration data (Gunther et al. 2001; KLI and EOA 2002; EOA 2002, 2003, 2007; Salop et al. 2002; City of San Jose and EOA 2003; SMSTOPPP 2002, 2003, 2004; Kleinfelder 2005, 2006; SFEI 2010; Yee and McKee 2010).

5. Lifecycle costs per curb-mile swept were converted to acres based on a conversion factor of 1 curb-mile in 13.5 acres of developed, urban land area per curb-mile. Similarly, for street flushing, total costs per linear-mile of street flushed were converted to acres based on a conversion factor of 27 acres of developed, urban land area per linear mile.

6. Enhanced sweeping was assumed to include weekly sweeping with an advanced sweeper technology (e.g., regenerative air or vacuum assisted sweepers). The load reduction due to baseline sweeping, assumed to be twice monthly sweeping with a mechanical broom sweeper, was already accounted for in the loading rates predicted in Section 2.0. Enhancements were assumed to increase load reduction above the load reduction effectiveness achieved by baseline efforts, as reported in Appendix D, Table D.7.

7. Street flushing is assumed to occur on weekly basis.

8. For load reductions due to Source Property Identification and Abatement, abatement of identified source properties was assumed to result in a reduction of the loading rate from the High Opportunity rate to the Low/No Opportunity rate (e.g., similar to New Urban land use). Costs only reflect the costs to municipalities to investigate and identify properties for abatement, not the cost of the actual abatement, which is assumed to be borne by the property owners.

9. Costs for hazardous material disposal and/or wastewater disposal were not included in these scenarios for street sweeping, street flushing, or pump station maintenance given that PCB concentrations typically observed in sediments are below thresholds (50 ppm) set by the US EPA (1998).

10. The costs for implementation of each control measure scenario for PCBs and mercury are not additive if the high opportunity areas for both POCs are geographically the same. Costs will increase to the extent this is not the case.

Table 4.2. Scenario A1 for Assessing the Costs and Benefits of Reducing PCB Discharges to the Bay from Santa Clara County MS4s.[1]

Control Measure	High Opportunity Areas Addressed	Estimated Load Reduction (g PCB)	Estimated Load Reduction[2]	% Countywide Load Reduced[3]	Estimated Cost Effectiveness ($/g PCB removed)	Estimated Annual Cost to Permittees[4] ($/Year)	Estimated Cost to Permittees Over 20 Years ($)
Source Property ID and Abatement[5]	10% (33 acres)	33	10%	1.1%	$1,900 ($460 - $3,600)	$62,000 ($15,000 - $120,000)	$186,000 ($45,000 - $360,000)
Enhanced Street Sweeping	50% (163 acres)	24 (8 – 38)	7.5% (2.5% - 12%)	0.8% (0.3% - 1.3%)	$2,100 ($480 - $6,400)	$50,000 ($18,000 - $51,000)	$1M ($360,0000 - $1M)
Stormwater Treatment Retrofits	40% (131 acres)	95 (72 - 118)	30% (23% - 37%)	3% (2.5% - 4%)	$39,000 ($19,000 - $67,000)	$3.7M ($1.4M - $7.9M)	$74M ($27M - $160M)
Totals	100% (327 acres)	151 (112 - 189)	46% (34% - 58%)	5% (4% - 6.5%)	$25,000 ($13,000 - $43,000)	$3.8M ($1.4M - $8M)	$76M ($29M - $160M)

[1] Best estimates and low and high estimates in parentheses if applicable.
[2] Total high opportunity load as predicted in IMR Part C.2 is 327g
[3] Total countywide load as predicted in IMR Part C.2 is 2,917g
[4] Assumes equal annual costs over the course of 20 years, with the exception of Source Property ID and abatement, which assumes costs during 3 years (i.e., project duration).
[5]Source Property Identification and Abatement assumes all 327 acres of high opportunity areas are investigated, but only 10% of this area will be identified as source properties and subsequently abated.

Table 4.3. Scenario A1 for Assessing the Costs and Benefits of Reducing Total Mercury (Hg) Discharges to the Bay from Santa Clara County MS4s.[1]

Control Measure	High Opportunity Areas Addressed	Estimated Load Reduction (g Hg)	Estimated Load Reduction[2]	% Countywide Load Reduced[3]	Estimated Cost Effectiveness ($/g Hg removed)	Estimated Annual Cost to Permittees[4] ($/Year)	Estimated Cost to Permittees Over 20 Years ($)
Enhanced Street Sweeping	50% (166 acres)	26 (9 - 41)	8% (3% - 12%)	0.09% (0.03% - 0.1%)	$2,000 ($450 - $6,100)	$51,000 ($19,000 - $51,000)	$1M ($370,000 - $1M)
Stormwater Treatment Retrofits	40% (133 acres)	96 (73 - 120)	29% (22% - 36%)	0.3% (0.2% - 0.4%)	$39,000 ($19,000 - $67,000)	$3.8M ($1.4M - $8M)	$75M ($28M - $160M)
Totals	90% (299 acres)	122 (82 - 161)	37% (25% - 48%)	0.4% (0.3% - 0.5%)	$25,000 ($13,000 - $43,000)	$3.8M ($1.4M - $8M)	$76M ($29M - $160M)

[1] Best estimates and low and high estimates in parentheses if applicable. Costs for mercury load reduction presented here assume that there is no overlap between the high opportunity areas for PCBs and mercury. If there is geographic overlap between mercury and PCBs high opportunity areas, then the total costs for mercury and PCBs load reductions presented in Tables 4.2 and 4.3 for Scenario A1 would be less than presented.
[2] Total high opportunity load as predicted in IMR Part C.2 is 332g
[3] Total countywide load as predicted in IMR Part C.2 is 29,842g
[4] Assumes equal annual costs over the course of 20 years

Table 4.4. Scenario A2 for Assessing the Costs and Benefits of Reducing PCB Discharges to the Bay from Santa Clara County MS4s[1].

Control Measure	High Opportunity Areas Addressed	Estimated Load Reduction (g PCB)	Estimated Load Reduction[2]	% Countywide Load Reduced[3]	Estimated Cost Effectiveness ($/g PCB removed)	Estimated Annual Cost to Permittees[4] ($/Year)	Estimated Cost to Permittees Over 20 Years ($)
Source Property ID and Abatement[5]	10% (33 acres)	33	10%	1.1%	$1,900 ($460 - $3,600)	$62,000 ($15,000 - $120,000)	$186,000 ($45,000 - $360,000)
Street Flushing	50% (163 acres)	48 (19-77)	15% (6% - 24%)	1.6% (0.7% - 3%)	$66,000 ($160,000 - $2.4M)	$3.1M ($3.1M - $180M)	$63M ($63M - $3.6B)
Stormwater Treatment Retrofits	40% (131 acres)	95 (72 - 120)	29% (22% - 36%)	3% (2.5% - 4%)	$39,000 ($19,000 - $67,000)	$3.7M ($1.4M - $7.9M)	$74M ($27M - $160M)
Totals	100% (327 acres)	180 (120-230)	54% (38% - 69%)	7% (5% - 9%)	$39,000 ($37,000 - $830,000)	$6.9M ($4.5M - $189M)	$140M ($90M - $3.8B)

[1] Best estimates and low and high estimates in parentheses if applicable.
[2] Total high opportunity load as predicted in IMR Part C.2 is 327g
[3] Total countywide load as predicted in IMR Part C.2 is 2,917g
[4] Assumes equal annual costs over the course of 20 years, with the exception of Source Property ID and abatement, which assumes costs during 3 years (i.e., project duration).
[5]Source Property Identification and Abatement assumes all 327 acres of high opportunity areas are investigated, but only 10% of this area will be identified as source properties and subsequently abated.

Table 4.5. Scenario A2 for Assessing the Costs and Benefits of Reducing Total Mercury (Hg) Discharges to the Bay from Santa Clara County MS4s[1].

Control Measure	High Opportunity Areas Addressed	Estimated Load Reduction (g Hg)	Estimated Load Reduction[2]	% Countywide Load Reduced[3]	Estimated Cost Effectiveness ($/mg Hg removed)	Estimated Annual Cost to Permittees[4] ($/Year)	Estimated Cost to Permittees Over 20 Years ($)
Street Flushing	50% (166 acres)	51 (21 - 82)	15% (6% - 25%)	0.2% (0.07% - 0.3%)	$62,000 ($160,000 - $2.2M)	$3.2M ($3.2M - $180M)	$64M ($64M - $3.7B)
Stormwater Treatment Retrofits	40% (133 acres)	96 (73 - 120)	29% (22% - 36%)	0.3% (0.2% - 0.4%)	$39,000 ($19,000 - $67,000)	$3.8M ($1.4M - $8M)	$75M ($28M - $160M)
Totals	90% (299 acres)	150 (94 - 200)	44% (28% - 61%)	0.5% (0.3% - 0.7%)	$47,000 ($48,000 - $950,000)	$7M ($4.6M - $190M)	$140M ($92M - $3.8B)

[1] Best estimates and low and high estimates in parentheses if applicable. Costs for mercury load reduction presented here assume that there is no overlap between the high opportunity areas for PCBs and mercury. If there is geographic overlap between mercury and PCBs high opportunity areas, then the total costs for mercury and PCBs load reductions presented in Tables 4.4 and 4.5 for Scenario A2 would be less than presented.
[2] Total high opportunity load as predicted in IMR Part C.2 is 332g
[3] Total countywide load as predicted in IMR Part C.2 is 29,842g
[4] Assumes equal annual costs over the course of 20 years

Table 4.6. Scenario A3 for Assessing the Costs and Benefits of Reducing PCB Discharges to the Bay from Santa Clara County MS4s[1].

Control Measure	High Opportunity Areas Addressed	Estimated Load Reduction (g PCB)	Estimated Load Reduction[2]	% Countywide Load Reduced[3]	Estimated Cost Effectiveness ($/g PCB removed)	Estimated Annual Cost to Permittees[4] ($/Year)	Estimated Cost to Permittees Over 20 Years ($)
Source Property ID and Abatement[5]	10% (33 acres)	33	10%	1.1%	$1,900 ($460 - $3,600)	$62,000 ($15,000 - $120,000)	$186,000 ($45,000 - $360,000)
Stormwater Treatment Retrofits	90% (294 acres)	210 (160 - 260)	65% (50% - 80%)	7% (5% - 9%)	$39,000 ($19,000 – $67,000)	$8.3M ($3.1M - $18M)	$170M ($61M - $360M)
Totals	100% (327 acres)	250 (200 - 300)	75% (60% - 90%)	8% (7% - 10%)	$30,000 ($16,000 – $60,000)	$8.4M ($3.1M - $18M)	$170M ($61M - $360M)

[1] Best estimates and low and high estimates in parentheses if applicable.
[2] Total high opportunity load as predicted in IMR Part C.2 is 327g
[3] Total countywide load as predicted in IMR Part C.2 is 2,917g
[4] Assumes equal annual costs over the course of 20 years, with the exception of Source Property ID and abatement, which assumes costs during 3 years (i.e., project duration).
[5]Source Property Identification and Abatement assumes all 327 acres of high opportunity areas are investigated, but only 10% of this area will be identified as source properties and subsequently abated.

Table 4.7. Scenario A3 for Assessing the Costs and Benefits of Reducing Total Mercury (Hg) Discharges to the Bay from Santa Clara County MS4s[1].

Control Measure	High Opportunity Areas Addressed	Estimated Load Reduction (g Hg)	Estimated Load Reduction[2]	% Countywide Load Reduced[3]	Estimated Cost Effectiveness ($/mg Hg removed)	Estimated Annual Cost to Permittees[4] ($/Year)	Estimated Cost to Permittees Over 20 Years ($)
Stormwater Treatment Retrofits	90% (299 acres)	220 (160 - 270)	65% (50% - 81%)	0.8% (0.6% - 0.9%)	$39,000 ($19,000 - $67,000)	$8.5M ($3.1M - $18M)	$170M ($62M - $360M)
Totals	90% (299 acres)	220 (160 - 270)	65% (50% - 81%)	0.8% (0.6% - 0.9%)	$39,000 ($19,000 - $67,000)	$8.5M ($3.1M - $18M)	$170M ($62M - $360M)

[1] Best estimates and low and high estimates in parentheses if applicable. Costs for mercury load reduction presented here assume that there is no overlap between the high opportunity areas for PCBs and mercury. If there is geographic overlap between mercury and PCBs high opportunity areas, then the total costs for mercury and PCBs load reductions presented in Tables 4.6 and 4.7 for Scenario A3 would be less than presented.
[2] Total high opportunity load as predicted in IMR Part C.2 is 332g
[3] Total countywide load as predicted in IMR Part C.2 is 29,842g
[4] Assumes equal annual costs over the course of 20 years

Table 4.8. Scenario A4 for Assessing the Costs and Benefits of Reducing PCB Discharges to the Bay from Santa Clara County MS4s[1].

Control Measure	High Opportunity Areas Addressed	Estimated Load Reduction (g PCB)	Estimated Load Reduction[2]	% Countywide Load Reduced[3]	Estimated Cost Effectiveness ($/g PCB removed)	Estimated Annual Cost to Permittees[4] ($/Year)	Estimated Cost to Permittees Over 20 Years ($)
Source Property ID and Abatement[5]	10% (33 acres)	33	10%	1.1%	$1,900 ($460 - $3,600)	$62,000 ($15,000 - $120,000)	$186,000 ($45,000 - $360,000)
Enhanced Street Sweeping	45% (147 acres)	22 (7 - 35)	7% (2.2% - 11%)	0.7% (0.2% - 1.2%)	$2,100 ($480 - $6,400)	$45,000 ($16,000 - $46,000)	$900,000 ($330,000 - $920,000)
Street Flushing	45% (147 acres)	43 (17 - 69)	13% (5% - 21%)	1.5% (0.6% - 2.4%)	$66,000 ($66,000 - $2.4M)	$2.8M ($2.8M - $160M)	$57M ($57M - $3.3B)
Totals	100% (327 acres)	97 (57 - 136)	30% (17% - 42%)	3% (2% - 5%)	$30,000 ($30,000 - $1.2M)	$2.9M ($2.9M - $163M)	$59M ($58M - $3.3B)

[1] Best estimates and low and high estimates in parentheses if applicable.
[2] Total high opportunity load as predicted in IMR Part C.2 is 327g
[3] Total countywide load as predicted in IMR Part C.2 is 2,917g
[4] Assumes equal annual costs over the course of 20 years, with the exception of Source Property ID and abatement, which assumes costs during 3 years (i.e., project duration).
[5]Source Property Identification and Abatement assumes all 327 acres of high opportunity areas are investigated, but only 10% of this area will be identified as source properties and subsequently abated.

Table 4.9. Scenario A4 for Assessing the Costs and Benefits of Reducing Total Mercury (Hg) Discharges to the Bay from Santa Clara County MS4s[1].

Control Measure	High Opportunity Areas Addressed	Estimated Load Reduction (g Hg)	Estimated Load Reduction[2]	% Countywide Load Reduced[3]	Estimated Cost Effectiveness ($/mg Hg removed)	Estimated Annual Cost to Permittees[4] ($/Year)	Estimated Cost to Permittees Over 20 Years ($)
Enhanced Street Sweeping	45% (149 acres)	23 (8 - 37)	7% (2% - 11%)	0.08% (0.03% - 0.12%)	$2,000 ($450 - $6,100)	$46,000 ($17,000 - $47,000)	$920,000 ($330,000 - $930,000)
Street Flushing	45% (149 acres)	46 (18 - 74)	14% (6% - 22%)	0.15% (0.06% - 0.25%)	$62,000 ($62,000 - $2.2M)	$2.9M ($2.9M - $170M)	$58M ($58M - $3.3B)
Totals	90% (299 acres)	69 (26 - 111)	21% (8% - 33%)	0.2% (0.09% - 0.4%)	$42,000 ($42,000 - $1.5M)	$2.9M ($2.9M - $170M)	$58M ($58M - $3.3B)

[1] Best estimates and low and high estimates in parentheses if applicable. Costs for mercury load reduction presented here assume that there is no overlap between the high opportunity areas for PCBs and mercury. If there is geographic overlap between mercury and PCBs high opportunity areas, then the total costs for mercury and PCBs load reductions presented in Tables 4.8 and 4.9 for Scenario A4 would be less than presented.
[2] Total high opportunity load as predicted in IMR Part C.2 is 332g
[3] Total countywide load as predicted in IMR Part C.2 is 29,842g
[4] Assumes equal annual costs over the course of 20 years

4.3. Scenario B: Control Measure Implementation in Moderate Opportunity Areas

This hypothetical scenario assumes additional POC load reductions will be achieved opportunistically as a percentage of the land area in the moderate opportunity category (e.g., Old Urban/Old Industrial land) is redeveloped over a twenty-year period of time. As redevelopment of older urban areas occurs and/or as green street retrofit projects are implemented for reasons other than TMDL requirements, additional POC load reductions are anticipated. This scenario includes two redevelopment/retrofit components:

- Green Streets **-** Retrofitting streets within older urbanized areas to incorporate "Green Street" stormwater treatment and impervious area minimization concepts that will significantly reduce POCs transported to the Bay via MS4s; and,
- Low Impact Development (LID) – incorporation of stormwater treatment (i.e., bioretention) through the incorporation of LID concepts into redevelopment projects that focus on parcels within older urbanized areas.

Green street retrofit projects provide the opportunity for integration of POC load reductions with other drivers and funding sources (e.g., transportation projects). Low Impact Development (LID) requirements imposed on developers are also anticipated to contribute to POC load reductions, in addition to other benefits to communities.

The calculations used to estimate cost effectiveness for Scenario B (presented in Tables 4.10 and 4.11) were based on the following data inputs and assumptions:

1. The total acreage assumed to be moderate opportunity (~30,000 acres) in Santa Clara County was based on the assignments presented in Figures 4.1 and 4.2. The moderate opportunity area includes all old industrial areas not assumed to be high opportunity, and 20% of the streets and properties identified as older urban land uses.[4]
2. Cost and benefit data presented in the summary Tables 3.2 and 3.3 and further described in Appendix D were used for calculating the cost effectiveness of the control measures.
3. Cost effectiveness for each control measure was calculated assuming the annual costs represent the total project cost spread out equally over twenty years.
4. The costs presented generally represent estimated costs to Permittees with the exception of costs associated with stormwater treatment during property redevelopment. Costs for redevelopment of parcels are assumed to be applicable to private developers, and not Permittees.
5. The costs for implementing each control measure scenario for PCBs and mercury should not be considered additive if the moderate opportunity areas for both POCs are geographically in the same area. Costs will increase to the extent this is not the case.
6. Green street retrofit projects cost and benefit data in Appendix D were used to estimate the cost effectiveness of such projects in public roadways in moderate opportunity areas.
7. Roads in the green street scenario do not include freeways or Interstates.
8. A redevelopment rate of 2% per year was used to estimate the total moderate opportunity area that would be redeveloped and include LID treatment or green street retrofits.

[4] The assumption that 20% of old urban land areas are moderate opportunity is based on the finding that 20% of the sediment samples collected from streets and stormwater conveyances in old urban areas are above the urban background PCB concentration of about 0.1 mg/kg (KLI and EOA 2002; City of San Jose and EOA 2003; Yee and McKee 2010).

Table 4.10. Scenario B for Assessing the Costs and Benefits of Reducing PCB Discharges to the Bay from Santa Clara County MS4s.[1]

Control Measure	Land Use Categories	Moderate Opportunity Areas Addressed	Estimated Load Reduction (g PCB)	% Countywide Load Reduced[2]	Estimated Cost Effectiveness ($/g PCB removed)	Estimated Annual Cost[3,4] ($/Year)	Total Estimated Cost Over 20 Years ($)[4]
Green Streets	Old Urban/ Old Industrial	2% per year over 20 years (2,220 acres total)	96 (90 - 100)	3.3% (3.1% - 3.5%)	$380,000 ($180,000 - $600,000)	$36M ($16M - $61M)	$720M ($320M - $1.2B)
Bioretention (C3 Retrofits)	Old Urban/ Old Industrial	2% per year over 20 years (9,778 acres total)	480 (360 - 600)	16% (12% - 20%)	$580,000 ($280,000 - $990,000)	$280M ($100M - $590M)	$5.5B ($2B - $12B)
Totals		11,998 acres over 20 years	580 (450 - 700)	20% (16% - 24%)	$540,000 ($260,000 - $930,000)	$313M ($118M - $650M)	$6.3B ($2.3 - $13B)

[1] Best estimates and low and high estimates in parentheses if applicable.
[2] Total countywide load as predicted in IMR Part C.2 is 2,917g.
[3] Assumes equal annual costs over the course of 20 years.
[4]Green Street costs are assumed to be Permittee costs; Bioretention (C3 retrofits) costs are assumed to be borne primarily by private developers, and not Permittees.

Table 4.11. Scenario B for Assessing the Costs and Benefits of Reducing Total Mercury Discharges to the Bay from Santa Clara County MS4s.[1]

Control Measure	Land Use Categories	Moderate Opportunity Areas Addressed	Estimated Load Reduction (g Hg)	% Countywide Load Reduced[2]	Estimated Cost Effectiveness ($/g Hg removed)	Estimated Annual Cost[3,4] ($/Year)	Total Estimated Cost Over 20 Years ($)[4]
Green Streets	Old Urban/ Old Industrial	2% per year over 20 years (2,201 acres)	1,100 (1,000 – 1,200)	3.7% (3.5% - 3.9%	$33,000 ($15,000 - $52,000)	$36M ($16M - $60M)	$720M ($320M - $1.2B)
Bioretention (C3 Retrofits)	Old Urban/ Old Industrial	2% per year over 20 years (9,695 acres)	5,500 (4,200 – 6,800)	18% (14% - 23%)	$50,000 ($24,000 - $86,000)	$270M ($100M - $590M)	$5.5B ($2B - $12B)
Totals		11,896 acres over 20 years	6,600 (5,200 – 8,000)	22% (17% - 27%)	$47,000 ($22,000 - $81,000)	$310M ($117M - $650M)	$6.2B ($2.3M - $13B)

[1] Best estimates and low and high estimates in parentheses if applicable. Costs for mercury load reduction presented here assume there is no overlap between the moderate opportunity areas for PCBs and mercury. If there is geographic overlap between mercury and PCBs moderate opportunity areas, then the total costs for mercury and PCBs load reductions presented in Tables 4.10 and 4.11 for Scenario B would be less than presented.
[2] Total countywide load as predicted in IMR Part C.2 is 29,842g
[3] Assumes equal annual costs over the course of 20 years.
[4]Green Street costs are assumed to be Permittee costs; Bioretention (C3 retrofit) costs are assumed to be borne primarily by private developers, and not Permittees.

4.4. Scenario C: Stormwater Diversions to POTWS

Two hypothetical scenarios were developed to represent potential stormwater diversions to Publically Owned Treatment Works (POTWs). Neither of these scenarios takes into account existing institutional barriers (e.g., POTW conditions for accepting stormwater flow into their treatment plant) which currently exist and which would need to be addressed on a case-by-case basis, should such a project be attempted. Both diversion scenarios assume implementation in areas with elevated stormwater POC concentrations (as defined below). If such diversions were implemented in areas with lower stormwater POC concentrations, load reduction benefits would be reduced accordingly.

4.4.1. Scenario C-1 – Dry Weather Only Diversion

Flow - The San Jose Conceptual Stormwater Diversion Assessment (September 2010) ruled out wet weather diversions as infeasible. That report evaluated 10 of the existing stormwater pump stations and determined the average dry weather flows to range from 0.001 to 1.83 mgd. The median flow from the 10 pump stations was 0.25 mgd and associated with the City of Santa Clara Nelo/Victor pump station. Nelo/Victor was also one of two pump stations for which more detailed cost estimates were derived and used to extrapolate to the other pump stations. Therefore 0.25 mgd will be used as the design flow for this scenario. By way of comparison, the Ettie Street Pump Station (ESPS) pilot project was designed to divert 75 gallons per minute (gpm) or about 0.11 mgd. During the period of dry weather ESPS pilot testing, the total flow pumped by the overall ESPS averaged 0.52 mgd (range 0.31 to 0.86 mgd). This is a large pump station servicing a 1,180 acre drainage area and having a nominal pumping capacity of 468,000 gpm (674 mgd).

San Jose defined dry weather flow seasonally, extending from April 15 through October 15. This does not account for dry weather “interludes” that occur during the wet season between storms. For consistency among the two diversion scenarios, it is assumed that there would be 20 days of rainfall during each year when the dry weather diversion facilities would be shut down, and no flow for 24 hours during each of those 20 days would be diverted. Therefore the total annual dry weather flow diverted would be 345 days times 0.25 mgd or 86 million gallons per year.

POC Concentrations - Limited dry weather PCB and mercury data are available. Table 4.12 presents the results of the Waste Municipal Utilities District (EBMUD) stormwater diversion and characterization pilot project report for the ESPS (EBMUD 2010). Likely effluent concentrations are lower than the ESPS influent concentrations because of some solids settling in the wet well. Absent other dry weather POC data, the ESPS effluent results of 2.93 ng/L (PCBs) and 7 ng/L (Hg) were used in the scenarios for calculating dry weather loads diverted.

Table 4.12. EBMUD Ettie Street Pump Station Supplemental Environmental Project and Environmental Enhancement Project (April 2008 to February 2010) 70 Sample Average PCB and Mercury Concentrations (ng/L) (EBMUD 2010).

Analyte	Weather Type	Ettie Street PS Influent	Ettie Street PS Effluent
PCBs	Dry Weather	4.65	2.93
	First Flush	36.8	19.9
	Wet Weather	50.5	34.5
Mercury	Dry Weather	10	7
	First Flush	180	92
	Wet Weather	40	33

Costs - From the San Jose Diversion Assessment Report (2010), the San Jose Nelo/Victor pump station project was estimated to have capital costs of $800,000 to divert 0.25 mgd of dry weather flow. This included $540,000 of diversion facility cost plus $260,000 for 1,800 feet of pipeline to connect to the sanitary sewer. Cost variations were primarily a function of the distance of sanitary sewer pipeline required. Diversion facility costs for the 10 San Jose/Santa Clara pump stations evaluated ranged from $540,000 to $600,000. Costs in the San Jose report were based on an ENRCCI = 8564 (August 2009 20 Cities Average), and R.S. Means Location Factor = 117.1. The report did not provide annual operating costs for the diversion project facilities themselves, only for treatment at the Water Pollution Control Plant. For Scenario C-1, the assumed capital cost is $800,000.

Wastewater treatment fees, connection fees, and monitoring and reporting fees are extremely variable and site-specific, and therefore difficult to estimate. The BASMAA Stormwater Pump Station Diversions Feasibility Evaluation Report (2010) noted that POTW connection fees could range from $9,000 to $18,000 per thousand gallons per day, and that POTW treatment fees could range from $300 to $4,200 per MG treated. The FER assumed that constructed diversion project conventional operating costs would range from $10,000 to $60,000 per year. Smaller and simpler projects, such as those operating by gravity diversion, would have costs at the lower end of the range. Larger projects with more complicated pumping and controls would have costs at the higher end of the range. For Scenario C-1, the assumed average annualized connection and treatment fees and operating costs is assumed to be $142,000 to $635,000.

For this 0.25 mgd dry weather diversion scenario, it is assumed that the operating costs would be low, given that they would likely represent a small increment above the existing operating costs for the stormwater pump station where the diversion facilities would be constructed. Therefore, a value of $10,000 per year is used in Scenario C-1. Twenty-year total costs would therefore be $800,000 plus $142,000 to $635,000 times 20 years, for a total of $3.6 to $13.5M over 20 years. Average annual costs over 20-years would be between $182,000 and $675,000 per year.

POC Removal and Unit Costs - Diverting 86,000,000 gallons/year containing 2.93 ng/L PCBs would remove 0.95 grams/year, and over 20 years, 19.0 grams. For PCBs, the cost-effectiveness at $182,000 to $675,000 per year to remove 0.95 grams would be between $191,000 and $710,000 per gram. Similarly for mercury, diverting 86,000,000 gallons/year containing 7 ng/L mercury would remove 2.3 grams/year, and over 20 years, 46 grams. The cost-effectiveness at $182,000 to $675,000 per year to remove 46 grams would be between $79,000 and $293,000 per gram.

4.4.2. Scenario C-2 – Passive (Gravity) Low Flow Wet Weather Diversion

Flow - This scenario applies to high opportunity locations that require no additional pumps and minimal if any controls where a storm sewer is located adjacent to a sanitary sewer line with excess capacity. A passive wet weather diversion structure would be installed whereby stormwater could be conveyed by gravity flow to the sanitary sewer (such as in Palo Alto). For this scenario it is assumed that the structure would be designed to limit flow to the sanitary sewer to a maximum of 1 mgd. It is assumed that there would be 20 wet weather events per year that would generate sufficient sustained flow to divert one mgd over a 24 hour period during each storm event. Therefore the total flow diverted would be 20 million gallons per year.

To simplify this scenario, it is assumed dry weather diversion of 0.25 mgd the other 345 days per year is not diverted because the types of infrastructure (and associated capital and operating costs) would be different. The cost and benefit of the dry weather diversion presented in scenario C-1 could be added to the wet weather scenario, if needed.

POC Concentrations - It is assumed that any of the alternative diversion scenarios would only be implemented in high opportunity areas. Stormwater monitoring conducted by SFEI staff in 17 selected watersheds in the Bay Area during Water Year 2011 (McKee et al. 2012) found that with the exception of the Santa Fe Channel site (198 ng/L), mean concentrations of PCBs were below about 60 ng/L, with several sites in the low ng/L range. Excluding Santa Fe Channel, the average of the next five highest sites (Ettie Street, Pulgas North, Sunnyvale Channel, Pulgas South, and Glen Echo Creek) is 44 ng/L.

Based on these findings, a value of 50 ng/L for PCBs is assumed for purposes of calculating wet weather loads diverted in this scenario. The EDMUD data (see Appendix D) generally support use of 50 ng/L as an upper end value for characterizing wet weather flows from high opportunity areas. For mercury data from the same SFEI monitoring (McKee et al. 2012), the average mercury concentrations in stormwater ranged from 14 to 500 ng/L, with a mean concentrations of 91 ng/L. This value fits within the range of effluent concentrations reported by EBMUD (see Appendix D), and will be used for calculating wet weather loads diverted in this scenario.

<u>Costs</u> - Assumed costs are taken from Table D.17 (Appendix D, as modified from the BASMAA Feasibility Evaluation Report (2010)). Option 6 from that Table was selected as most closely approximating the conditions and likely costs of this scenario. Option 6 is described as "Constructed pilot diversion with moderate connection distance (<500 feet) to sanitary sewer large enough to support gravity feed." Option 4 "Constructed pilot diversion adjacent to sanitary sewer large enough to support gravity feed" would characterize the ideal situation of immediate proximity of storm and sanitary sewers. However, the Option 4 capital cost of $100,000 seems unrealistically low for a 1 mgd facility. More importantly, the assumed proximity of the storm and sanitary lines limits the applicability in "real world" situations. For these reasons, the low end of the range of capital costs from Option 6 of $500,000 was used in developing costs for scenario C-2.

Wastewater treatment fees, connection fees, and monitoring and reporting fees are extremely variable, site-specific, and therefore difficult to estimate. The BASMAA Stormwater Pump Station Diversions Feasibility Evaluation Report (2010) noted that POTW connection fees could range from $9,000 to $18,000 per thousand gallons per day, and that POTW treatment fees could range from $300 to $4,200 per MG treated. The FER assumed that constructed diversion project conventional operating costs would range from $10,000 to $60,000 per year. Smaller and simpler projects, such as those operating by gravity diversion, would have costs at the lower end of the range. Larger projects with more complicated pumping and controls would have costs at the higher end of the range. For Scenario C-2, the assumed average annualized connection and treatment fees and operating costs is between $41,000 and $193,000 annually.

Total costs over the course of twenty years would therefore be $500,000 in capital plus $41,000 to $193,000 times 20 years, for a total of $1.3 and $4.4 million. Average annualized costs over 20-years would be between $65,000 and $218,000 per year.

<u>POC Removal and Unit Costs</u> - Diverting 20,000,000 gallons/year containing 50 ng/L PCBs would remove 3.8 grams/year of PCBs. The cost-effectiveness at $65,000-$218,000/year to remove 3.8 grams of PCBs would therefore be between $17,278 and $57,451 per gram of PCBs removed. Similarly for mercury, diverting 20,000,000 gallons/year containing 91ng/L Hg would remove 6.9 grams/year of mercury. The cost-effectiveness at $65,000-$218,000/year to remove 6.9 grams would be between $9,516 and $31,640 per gram of mercury removed.

5. SUMMARY OF SCENARIO RESULTS, PRELIMINARY CONCLUSIONS, UNCERTAINTIES AND NEXT STEPS

This section summarizes estimated preliminary costs and benefits associated with the hypothetical stormwater control measure implementation scenarios presented in Section 4.0. These scenarios are not recommendations for future implementation but instead are intended to serve as a starting point to inform future discussions regarding enhanced implementation actions to address PCBs and mercury in stormwater in Santa Clara County. The results presented in this section demonstrate and extremely high costs associated with control measure implementation to address PCB and mercury TMDL load reductions in stormwater. This section also describes information gaps and uncertainties associated with urban stormwater POC loading estimates included in the Bay mercury and PCBs TMDLs and Section 2.0 of this report. Based on the cost-benefit scenarios, uncertainties, and implementation challenges described, preliminary recommendations are also provided on the future direction of information collection and decision-making regarding feasible and beneficial control measure implementation for Santa Clara County Permittees.

5.1. Summary of Cost Estimates and Associated Benefits

Preliminary estimates of costs and benefits associated with the POC control measure scenarios described in Section 4.0 are summarized in Table 5.1. The estimates are based on available information from the literature, local data from the planning and implementation of the pilot studies being conducted in compliance with MRP requirements, and best professional judgment. The estimates are preliminary, represent only a range of potential costs and associated load reduction benefits for the control measures, and should only be used as a starting point to inform future planning.

With the exception of the parcel re-development portion of Scenario B, the estimates only include the costs that would be borne by Permittees if a control measure scenario was implemented. Costs to private land owners that may be required to implement POC controls in the future as a results of the outcomes Permittee POC load reduction strategies (e.g., abatement of POCs on private properties) are not included. For all control measures involving large capital expenditures, costs were annualized over an assumed twenty-year life of a given project.

5.2. Preliminary Conclusions from Scenario Modeling

Based on the scenarios modeled and the associated costs and benefits described in this report, the following preliminary conclusions were made:

- **At a cost of roughly $1 Billion, SCVURPPP Permittees would achieve a 30% reduction in PCBs and 25% reduction in mercury by implementing the most effective control measure scenarios modeled.** The San Francisco Bay PCBs and Mercury TMDLs require roughly a 90% and 50% reduction from Bay Area stormwater, respectively. Based on the cost-effectiveness analyses conducted as part of this report, implementing the most effective combinations of scenarios would only achieve an approximate 30% reduction in PCBs and 25% reduction in mercury. This includes addressing all high opportunity and part of the moderate opportunity areas in Santa Clara County. Because only moderate and low/no opportunity areas would remain, the cost-effectiveness of implementing additional controls to achieve the remainder of the load reduction identified in the TMDLs would be far less than those described in the scenarios presented in this report.
- **Load reductions from high opportunity areas provide only a small fraction of the reduction needed to achieve TMDL waste load allocations.** Under the highest benefit scenario, less than a 10% reduction in PCBs or mercury from stormwater would be realized from implementing controls in high opportunity areas. This is a reflection of the scenario modeling assumption that high concentrations of PCBs and mercury are present in only a small portion of land area in Santa Clara County and that moderate and low concentrations of PCBs and mercury are more widespread. This assumption is consistent with the available monitoring data.

Table 5.1. Summary of estimated costs and benefits associated with POC control measure scenarios in the Santa Clara County.

Opportunity Category	Scenario	Applicable Stormwater Control Measures[1]	Estimated Load Reduction (grams/year)		Best Estimate of Cost Effectiveness ($ per year spent to reduce each gram of POC)		Estimated Costs to Permittees over 20 Years[2]
			PCBs	Mercury	PCBs	Mercury	
High Opportunity Areas	A-1	• 10% Source Property Abatement (PCBs Only) • 50% Street Sweeping Enhancements • 40% Stormwater Treatment Retrofits	151	122	$25,000 ($13,000 - $43,000)	$25,000 ($13,000 - $43,000)	$76M ($29M - $160M)
	A-2	• 10% Source Property Abatement (PCBs Only) • 50% Street Flushing • 40% Stormwater Treatment Retrofits	180	150	$39,000 ($37,000 - $830,000)	$47,000 ($48,000 - $950,000)	$140M ($90M - $3.8B)
	A-3	• 10% Source Property Abatement (PCBs Only) • 90% Stormwater Treatment Retrofits	250	220	$30,000 ($14,000 – $60,000)	$39,000 ($19,000 - $67,000)	$170M ($61M - $360M)
	A-4	• 10% Source Property Abatement (PCBs Only) • 45% Street Sweeping Enhancements • 45% Street Flushing	97	69	$30,000 ($30,000 - $1.2M)	$42,000 ($42,000 - $1.5M)	$59M ($58M - $3.3B)
Moderate Opportunity Areas[3]	B	Green street retrofits of roadways to treat 2,220 acres over 20 years.	96	1,100	$380,000 ($180,000 - $600,000)	$33,000 ($15,000 - $52,000)	$720M ($320M - $1.2B)
		Parcel re-development with bioretention treating 9,780 acres over 20years.	480	5,500	$580,000 ($280,000 - $990,000)	$50,000 ($24,000 - $86,000)	-- [6]
High and Moderate Opportunity Areas[4,5]	C-1	Passive (gravity) low flow dry weather diversion of 86 MG/year.	0.95	2.3	$191,000 - $710,000	$79,000 - $293,000	$3.6 – $13.5M
	C-2	Passive (gravity) low flow wet weather diversion of 20 MG/year.	3.8	6.9	$17,000 - $57,000	$10,000 - $31,000	$1.3 – $4.4M

[1]The total acres or percent of area provided indicates the assumed treatment area for each control measure within a given opportunity category.

[2]The total costs presented here assume all control measures are applied such that multiple POC benefits are achieved for the same cost. However, if this is not the case, the total cost will increase accordingly.

[3]Assumes a 2% redevelopment rate for arterials/parcels available for C3 redevelopment over twenty years.

[4]Assumes stormwater diversions in areas with elevated POC concentrations (e.g., 50 ng/L). If concentrations in the diverted stormwater are lower, the load reduction would be reduced.

[5]Costs are for constructing and maintaining the diversions only. Any fees imposed by the POTWs would be in addition to these costs.

[6]Costs to Permittee are assumed to be recoverable from private developers and therefore negligible. Twenty-year costs to private developers are estimated at $5.5 Billion for this scenario.

- **Load reductions from high opportunity areas have high costs.** Based on the scenario assumptions (e.g., ~5% of the old industrial areas in Santa Clara County are high opportunity areas with elevated POC yields), only a small portion of the urban landscape is high opportunity (modeled at 327-332 acres in Santa Clara County). As a result, modeled load reduction benefits associated with these areas are limited (<250 grams/year load reduction of PCBs or mercury) at a cost from $59 million to $170 million over 20 years. Annual costs per unit mass reduction range from $25,000 to $47,000 per gram of PCBs or mercury reduced.
- **Costs per unit benefit of reducing POCs in moderate opportunity areas are significantly higher than those in high opportunity areas.** Based on the loading estimates and scenario modeling, moderate opportunity areas contribute about 70% of the PCBs load and 78% of the mercury load in Santa Clara County stormwater runoff discharges to the Bay. However, the POC yield (per unit area) is much lower than for high opportunity areas, making control measure implementation less cost-effective. For example, estimated annual costs of reducing a gram of PCBs in moderate opportunity areas are an order-of-magnitude greater than reducing in high opportunity areas. As a result, the implementation scenarios presented for moderate opportunity areas result in limited load reduction benefits (<20% reduction of PCBs or mercury loads after 20 years) at high costs to Permittees ($320 million to $1.2 billion dollars over 20 years). Addressing the large portion of the urban landscape comprised of moderate opportunity areas (modeled at about 30,000 acres in Santa Clara County) would be incredibly challenging and likely unrealistic in the timeframes identified in the TMDLs. To address this challenge, it is recommended that POC control measure implementation in moderate opportunity areas be integrated with other drivers and funding sources (e.g., transportation projects and other infrastructure improvements) overtime and the TMDL implementation timeframe be revisited (see discussion later in this section).
- **High and moderate opportunity areas for PCBs and mercury may not entirely overlap geographically and therefore costs may be greater than presented.** The costs summarized in Table 5.1 assume high opportunity areas for mercury and PCBs are generally in the same geographic locations. Therefore, it is assumed that control measure implementation will provide load reduction benefits for both POCs concurrently. In reality, full geographical overlap between PCBs and mercury high opportunity areas will likely not occur and overall costs would be higher.
- **Low benefits for PCB and mercury load reduction were modeled for stormwater diversion to POTWs.** Based on the scenario assumptions, modeled load reduction benefits associated with POTW diversions are low (0.95 to 3.8 grams/year PCBs and 2.3 to 6.9 grams/year mercury) at a cost between $1.3 and $13.5 million over 20 years. Costs per unit mass reduction range from $10,000 to $710,000 per gram of PCBs or mercury load reduced per year.

5.3. Uncertainties, Information Gaps and Potential Challenges

There are a number of significant uncertainties and data gaps associated with the land use based POC yield estimates, watershed loading rates, cost estimates, and load reduction benefits presented in this report. These uncertainties should be taken into consideration by Permittees when planning enhanced control measures implementation and establishing associated objectives to reduce impacts to water quality. A number of the uncertainties and associated information gaps are summarized below.

5.3.1. Accuracy of POC Loading Estimates

The mercury and PCB TMDLs for the San Francisco Bay include estimates of pollutant loading from urban stormwater runoff based on the available information at the time the TMDL reports were developed (2006 and 2008). Loading estimates presented in this report account for the most recent readily available water/sediment quality data collected in the Bay Area and as a result differ somewhat from those presented in the TMDLs.

Since the adoption of the TMDLs, Permittees working with the RMP have made significant progress towards developing a better understanding of POC loads to the Bay from urban stormwater and the characteristics and locations of POC source areas. Significant improvements have been made to our conceptual understanding of PCB and mercury sources, source area characteristics, and pollutant source-release-transport mechanisms (see Appendix E). However, due to the complexity and site-specific nature of these processes, the development of loading estimates for these POCs with a high level of confidence remains very challenging. Uncertainties in POC loads and yields create additional uncertainties in estimating the benefits of control measures, which are expensive to implement and maintain. In this report, simplifying assumptions were used to develop yields for specific land use types and loading estimates for individual Permittees in Santa Clara County.

In summary, it is difficult to assess the quantitative implications of these limitations on the magnitude of the projected loads, especially as loading estimates move from regional to smaller spatial scales. While the estimates should only be considered first order, they do provide a starting point for further identification of high opportunity areas where control measure implementation should be focused and for evaluating the costs and benefits of implementing a number of control measure scenarios.

5.3.2. Extent of High, Moderate and Low Opportunity Areas

High and moderate opportunity areas in Santa Clara County watersheds are the likely locations where Permittees will begin to focus additional efforts to collect information on sources and implement POC control measures in the near-term. Due to the varying uses and distribution of POC sources in watersheds, however, the locations of current sources and source areas are challenging to identify. Based on the monitoring data collected and source identification studies conducted to-date, high opportunity areas are believed to be associated with old industrialized areas that contribute sediments with pollutants to MS4s via transport mechanisms such as stormwater runoff, vehicle tracking, and air deposition. Maps identifying old industrial land use areas are based on the interpretation of historic aerial photography. Land use and POC source location maps have not been groundtruthed, an important limitation in identifying the extent of high, moderate and low opportunity areas.

5.3.3. Predicted Load Reduction Benefits

The estimated load reduction benefits of control measures and implementation scenarios presented in this report are based on the best available information regarding control measure effectiveness, extent of pollutant sources, and POC yields from specific land area types. There is a general lack of information on pollutant-specific removal efficiencies for the various control measures described in IMR Part B and in Section 3 of this report. For example, data reported in the literature on the pollutant removal efficiencies of municipal operations activities (e.g., street sweeping) or stormwater treatment measures focus on suspended sediment, not pollutant removal rates. Little to no data are currently available directly addressing mercury or PCB removal rates for stormwater control measures. Although mercury and PCBs are primarily sediment-bound pollutants, any variability in removal efficiencies due to factors such as differential adsorption depending on particle size are not accounted for in the estimates presented in this report. The monitoring results for the ongoing MRP pilot studies conducted via the CW4CB project will provide additional information on pollutant-specific removal efficiencies that may be used to refine estimated load reduction benefits.

Other sources of uncertainty in the load reduction benefit estimates include the use of inputs derived from literature values, models, and/or best professional judgment where no reliable local measurement data were available. These data may have less applicability to locations other than those modeled/monitored. Thus applying these data to other areas that may not have similar conditions introduces uncertainties to the results.

5.3.4. Costs of Implementing and Maintaining Control Measures

The primary sources of uncertainty in preliminary cost estimates presented in this report are: (1) few recent, local cost data are available; (2) even where local data are available, it is difficult to extrapolate costs associated with a specific project to a larger geographic area with a high degree of certainty; and (3) some highly variable and/or unknown costs are not included in these estimates. Site-specific variables may have a large impact on the final costs of any given project. The assumptions that were developed to address the lack of Bay Area specific and/or site-specific data may not be applicable to all projects in all locations. While every effort was made to identify the most applicable cost data and document the assumptions that were used to develop the final cost estimates presented, caution should be used when applying these estimates to specific projects or extrapolating these estimates across a large region. Additional costs not included in these estimates that could have a large impact on the overall total costs of a project, include: wastewater treatment fees, connection fees, and monitoring and reporting fees for stormwater diversions (Scenario C); waste disposal fees for sediments collected during enhancements of municipal operations; or costs associated with utility or other infrastructure relocation that may be required for a green street retrofit project. These cases are examples of additional costs that are extremely variable and site-specific and thus difficult to account for in the cost estimates presented in this report.

5.3.5. PCB and Mercury TMDL Targets and Waste Load Allocations

Sources of uncertainty associated with the PCBs and mercury TMDLs include the establishment of TMDL targets to protect beneficial uses and the linkage between TMDL targets and load reductions required of municipal stormwater programs in the Bay Area. Specifically, addressing the following uncertainties is paramount to planning cost-effective control measure implementation by Permittees:

- The mercury TMDL (adopted in 2006) and the PCB TMDL (adopted in 2008) were developed in response to the State's determination that all segments of the Bay are impaired, primarily due to elevated levels of POCs in sport fish. The TMDL target to protect both human health and wildlife is an average tissue concentration in specific fish species that have the highest concentrations among the species monitored and that are likely to be caught and consumed by members of local communities. The appropriateness of using these fish species as targets for TMDLs remains an uncertainty that should be addressed.
- A formal uncertainty analysis was not conducted during the simple modeling that was used during TMDL development, which would have provided more information on how the model's predictions vary with the uncertainty and variability in input parameters, including stormwater loads. For example, there was a significant discrepancy between direct estimates of POC loads to the Bay and estimates based on the TMDL model, highlighting the uncertainty in the model's predictions. Given the uncertainty and variability in the inputs and outputs of the modeling used in the current TMDL framework, there is currently little certainty that feasible human interventions to reduce urban runoff POC inputs could hasten the Bay's recovery with respect to mercury or PCBs.
- Uncertainty in the feasibility of the implementation schedule included in the TMDL remains a concern to Permittees. The feasibility of the 20-year implementation timeframe selected for the TMDL has never been evaluated with regard to the required load reductions in stormwater discharges.

The uncertainties in the TMDLs will be further described in the Report of Waste Discharge (ROWD) developed and submitted with Permittees' application for NPDES Permit renewal.

5.4. Recommended Future Actions

The following section describes preliminary recommendations on planning for future implementation of control measures that are designed to cost-effectively reduce POCs in urban stormwater runoff discharges that impact applicable beneficial uses of the Bay. Recommended next steps include the development and implementation of a processes to:

- Further document the location of and benefits from POC control measures implemented by Permittees;
- Address key data gaps associated with the location and geographical extent of POC sources and source areas;
- Plan for focused control measure implementation in known high opportunity areas;

- Identify cost-effective control measures for newly identified high opportunity areas;
- Develop implementation plans for newly identified moderate opportunity areas, including enhanced integration with infrastructure improvement projects and associated funding;
- Refine control measure tracking and load reduction calculation methodologies and develop tools to provide more robust estimates of POC reductions in stormwater discharges; and,
- Reevaluate and refine the PCBs and mercury TMDLs, including TMDL targets, waste load allocations, and implementation timeframes.

Preliminary implementation guidance is provided for each of these activities in the following sections.

5.4.1. Focused Control Measure Implementation in Leo Avenue Watershed

Based on the chemical analysis of numerous street and storm drain sediment samples, the best documented high opportunity area in Santa Clara County is the Leo Avenue watershed. Pilot projects underway in this area via the MRP include property identification and abatement, storm drain line flushing, and stormwater treatment (i.e. hydrodynamic separator). Additionally, Leo Avenue is one of three locations where pilot-testing of street sweeping effectiveness is currently underway. As the MRP pilot studies are completed and the results evaluated, a plan for future focused implementation in this watershed will be developed. Based on the information from public right-of-way and private property monitoring of sediments for POCs, it appears that only a small number of parcels that drain directly to the Leo Avenue cul-de-sac should be considered high opportunity areas for future focused implementation control measure implementation. Based on this information, the vast majority of the Leo Avenue watershed does not appear to be contributing relatively high loads of POCs to the MS4 and therefore is not likely a high opportunity area.

For the parcels identified as high opportunity, it is recommended that the City of San Jose (with assistance from SCVURPPP) refer any parcels identified as high opportunity properties to the Water Board for further investigation. To assist in the referral process, a final project report on the Leo Avenue source identification and abatement project is scheduled for completion in late FY 2013-14. This report will provide a summary of the data and information collected to-date to identify PCB sources in the watershed and conclusions regarding likely sources to the City's MS4, which will provide context for the referral to the Water Board. Next steps regarding additional control measure implementation in the watershed will also be included in the final Leo Avenue report.

5.4.2. Control Measure Planning for Additional High and Moderate Opportunity Areas

As part of the development of PCB and mercury loading estimates presented in Section 2.0, SCVURPPP (in collaboration with SFEI) developed preliminary GIS data layers that identify potential PCB and mercury sources and old industrial areas in Santa Clara County. These data layers along with existing data on POC concentrations in sediment and stormwater represent the current state-of-knowledge of POC sources and can inform identification of the geographical extent of high, moderate and low/no opportunity areas. However, additional information on current land uses, facility practices, and POC concentrations in sediment/water is needed to create more refined data layers of POC sources and opportunity areas.

In addition to current POC control measure implementation consistent with the MRP, the following steps are recommended to assist Permittees in further refining POC source area data layers and identifying additional high and moderate opportunity areas. It is recommended that these steps occur in a feasible timeframe consistent with available resources and in preparation for and/or during subsequent permit terms.

- Review the "old industrial" and "old urban" data layers and refine land use designations based on actual existing land use. Consider information on redevelopment and remediation to identify parcels that are incorrectly categorized as old industrial. Additionally, identify other parcels currently designated as old urban that should be categorized as old industrial.

- Conduct field reconnaissance of targeted properties identified as old industrial, old urban or unknown land uses to verify land use status. Priority areas include parcels with questionable land use designations and properties with clear indications of sediment contributions to the public right-of-way or MS4.
- Revise old industrial and old urban land use data layers based on information gained through initial data layer review and field observations. Revisions should take into account land areas that have been recently redeveloped (i.e., post-2002). Develop a work plan for screening old industrial areas to identify them as either high or moderate opportunity areas.
- Implement the work plan by conducting desktop and field review of targeted parcels (e.g., review history and records, supplementary observations by inspectors, windshield surveys) to identify high opportunity areas. Compile the results into revised maps of potential high opportunity areas.
- Prepare a monitoring plan to resolve characterization questions and clarify the extent of high and moderate opportunity areas. Conduct sediment and/or stormwater sampling in the public right-of-ways and stormwater conveyances. Analyze data and revise maps based on a weight-of-evidence approach to identifying high and moderate opportunity areas.
- Identify load reduction opportunities for newly identified high and moderate opportunity areas. Develop an initial suite of potential enhanced control measures in each area and estimate costs of alternative control measure scenarios using revised cost-benefit estimation tools.
- Prepare preliminary and revised POC control measure implementation plans for high and moderate opportunity areas. Integrate implementation planning for moderate opportunity areas into “master planning” for infrastructure improvements such as green street retrofitting and transportation-related projects, including analysis of available funding sources.
- Implement control measures consistent with POC control measure implementation plans for high and/or moderate opportunity areas and goals established in subsequent NPDES municipal stormwater permits for Bay Area Phase I communities.

5.4.3. Enhanced Documentation of POC Control Measure Implementation

Load avoidance and reduction benefits associated with current control measure implementation were estimated during the MRP term and are presented in IMR Part B. These are the best estimates currently available, but were developed based on simplifying assumptions and preliminary methodologies. It is recommended that Permittees review methods used to calculate POC loads reduce/avoided and based on the findings consider whether developing a more refined process for tracking and documenting POC control measures and establishing load reduction benefits associated with each control measure type are needed.

6. REFERENCES

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APPENDIX A

Potential PCB and Mercury High Opportunity Remediation Sites in Santa Clara County

(Envirostor 2014)

Table A-1. Potential PCB High Opportunity Remediation Sites in Santa Clara County (Envirostor 2014).

FACILITY NAME	Located in Old Industrial Land Use	Type	Status	City
Kaiser Aluminum	No	Historical	Refer: RWQCB	Cupertino
Preston Pipeline Inc.	Yes	Historical	Refer: Other Agency	Milpitas
Nasa-Ames Aoi 10	Military Industrial	Voluntary Cleanup	Certified	Mountain View
Nasa-Ames Aoi 5	Military Industrial	Voluntary Cleanup	No Further Action	Mountain View
Aydin Energy	Yes	State Response	Certified / Operation & Maintenance - Land Use Restrictions	Palo Alto
California Avenue Housing Site	Yes	Voluntary Cleanup	No Further Action	Palo Alto
Ford Aerospace	No	Historical	Refer: RWQCB	Palo Alto
Ford Aerospace & Communications	Yes	Historical	Refer: RWQCB	Palo Alto
1633 Old Oakland Road Site	Yes	Voluntary Cleanup	Certified	San Jose
Agnews East	No	School Cleanup	Active	San Jose
Brokaw Road Site	Yes	Voluntary Cleanup	Certified / Operation & Maintenance - Land Use Restrictions	San Jose
Custom Food Machinery	Yes	Voluntary Cleanup	Certified / Operation & Maintenance - Land Use Restrictions	San Jose
Lorentz Barrel & Drum Company	Yes	Federal Superfund - Listed	Active - Land Use Restrictions	San Jose
Orvieto B	Yes	Voluntary Cleanup	Active	San Jose
Orvieto Family Apartments	Yes	Voluntary Cleanup	Certified / Operation & Maintenance - Land Use Restrictions	San Jose
Parkside Townhomes Project	No	Evaluation	Refer: Other Agency	San Jose
Pepper Lane	Yes	State Response	No Further Action	San Jose
Santa Clara County Jail	No	State Response	Certified	San Jose
Silverado Condominiums	No	Evaluation	No Action Required	San Jose
The Montecito Vista Project	Yes	Voluntary Cleanup	Active	San Jose
Certainteed, Santa Clara	Yes	State Response	Certified	Santa Clara
Owens-Corning Fiberglas Corp	Yes	Historical	Refer: RWQCB	Santa Clara
Westinghouse Electric (Sunnyvale Plant)	Yes	Federal Superfund - Listed	Refer: EPA - Land Use Restrictions	Sunnyvale

Table A-2. Potential Mercury High Opportunity Remediation Sites in Santa Clara County (Envirostor 2014).

Facility Name	Located in Old Industrial Land Use	Type	Status	City
Ernesto Galarza Elementary School	No	School Cleanup	Certified	San Jose
Mazzone Properties	No	Voluntary Cleanup	Active	San Jose
Proposed Communication Hill K-8 School	No	School Investigation	Inactive - Needs Evaluation	San Jose
San Jose Water Company-Dutard Station	No	Voluntary Cleanup	Certified	San Jose
Rivermark Properties	No	Voluntary Cleanup	Certified O&M - Land Use Restrictions Only - Land Use Restrictions	Santa Clara

APPENDIX B

Letter from the California Department of Transportation Acknowledging Willingness to Develop POC Allocation Sharing Scheme

DEPARTMENT OF TRANSPORTATION
DIVISION OF ENVIRONMENTAL ANALYSIS
P.O. BOX 94273, MS-49
SACRAMENTO, CA 94723-0001
PHONE (916)653-7507
FAX (916)653-7751
TTY 711
www.dot.ca.gov

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

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

APPENDIX C

Update on Efforts to Reduce Exposure to Mercury and PCBs from the Consumption of San Francsico Bay Fish

Appendix C
Reducing Exposure to Mercury and PCBs from the Consumption of San Francsico Bay Fish

Provisions C.11.i/C.12.i of the Municipal Regional Permit (MRP) requires that Permittees develop and implement or participate in effective programs to reduce mercury-related risk to humans. Provisions of the Water Boards' Mercury Watershed permit covering industrial and municipal wastewater treatment plant discharges to San Francisco Bay contain a similar requirement to the MRP. A partnership comprised of the Bay Area Clean Water Agencies (BACWA), Western States Petroleum Association (WSPA), and the Bay Area Stormwater Management Agencies Association (BASMAA) was formed to develop a regional approach to raise public awareness regarding fish contamination issues in San Francisco Bay and to encourage fish-consuming populations to reduce their exposure to mercury (and other POCs) in contaminated fish. The partnership engaged the services of the Aquatic Sciences Center (ASC) and the California Department of Health, Office of Environmental Health Hazard Assessment (OEHAA) to manage and develop project entitled San Francisco Bay Fish Project (SFBFP).

The SFBFP was a two-year project (October 2010 to October 2012) implemented by OEHAA. Project oversight was provided by the Bay Area Risk Communication and Exposure Reduction Work Group that included representatives from BASMAA, BACWA, OEHAA, the San Francisco Bay Regional Water Quality Control Board (Water Board), US EPA staff, and County Health Departments. The SFBFP included 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 OEHAA via the Aquatic Science Center (ASC). OEHAA's final project report[5] 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[6]. 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 OEHAA website where the Safe Eating brochures are available in all languages.[7] As of December 2012 OEHAA 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 OEHAA interviewed 37 anglers at 10 fishing sites where signs had been posted for at least one week. OEHAA found that, in general, most anglers noticed the signs and understood the main messages.
- 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. OEHAA 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

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[5]http://www.sfei.org/sites/default/files/users/antonytran/SFB%20Fish%20Project%20Final%20Report-CDPH%2010-29-12.pdf
[6] Brochures and other materials are available as pdf files along with order forms for print versions at http://www.sfei.org/content/educational-materials
[7] www.sfbayfish.org

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 OEHAA 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.

SCVURPPP Outreach on Exposure Reduction

In January 2013, the SFBFP finalized and printed the "Guide to Eating Fish and Shellfish from San Francisco Bay" brochures. The SCVURPPP Watershed Education and Outreach Ad Hoc Task Group (WEO AHTG) discussed using these brochures for conducting local outreach about health impacts of eating San Francisco Bay-caught fish. Though the brochures provide guidance specific to the consumption of fish found in San Francisco Bay, the WEO AHTG agreed that it would be useful to provide these brochures to Santa Clara residents for the following reasons:

- Residents could be travelling outside Santa Clara County to fish.
- This outreach will make residents fishing in local creeks and reservoirs aware about the possibility of mercury contamination.
- The brochures contain useful information for residents that purchase fish and/or eat fish at restaurants.

Based on feedback from the WEO AHTG, an outreach plan was developed to reach residents that are likely to consume fish that are caught locally or from the San Francisco Bay. A summary of activities implemented from February 2013 to February 2014 is provided below:

- **Point of purchase outreach at fishing supply stores** – Program staff contacted the following small local fishing supply stores to find out if they would be interested in making the brochures available to customers:

  - Fisherman's Warehouse – 1140 S. De Anza Blvd., San Jose, CA 95129
  - Orvis Retail Store – 377 Santana Row, Suite 1040, San Jose, CA 95128
  - Coyote Bait & Tackle – 8215 Monterey Rd., Coyote, CA 95101
  - West Marine – 375 Saratoga Ave., Suite C, San Jose, CA 95129

  All stores agreed to distribute the brochures. Program staff visited these stores once every quarter to restock the display racks with brochures.

- **Website posting** – The brochures are posted on the SCVURPPP and Watershed Watch Campaign[8] websites. The brochures also promoted on the Watershed Watch Campaign's Facebook page (a SCVURPPP education and outreach site).

- **Education Programs at the Don Edwards San Francisco Bay Wildlife Refuge** – The Program continues to provide brochures to Don Edwards San Francisco Bay Wildlife Refuge staff for incorporation into outreach conducted through the SCVURPPP funded Watershed Watchers Program. The Watershed Watchers program conducts numerous activities and sessions to educate children about watersheds and urban runoff pollution prevention. SCVURPPP believes that it is particularly important to educate children about the mercury and PCB contamination issues in the Bay. The children can in turn educate their parents about these issues. Currently, the Watershed Watchers program is conducting education on mercury and PCBs in fish through the Webelos Naturalist badge program. Three Webelos Naturalist badge programs have been conducted from February 2013 to February 2014 and 103 people attended them. Future activities planned include the following:

    - On September 25, 2014, Refuge staff will be hosting a seminar on Mercury Outreach for the Mid-Peninsula Environmental Educators Alliance along with staff from the State Water Board and East Bay Regional Parks. The workshop will provide attendees information on concerns about mercury in the South Bay and demonstrate programs that can be used to educate children on this topic.

    - The Refuge summer camp program will incorporate activities related to mercury pollution prevention.

- **Distribution at outreach events** – The brochures will continue to be distributed at SCVURPPP's community outreach events. SCVURPPP attends approximately ten outreach events each year. To reach the target audience of women and children, SCVURPPP staff distributes the brochures at events that are attended by families with children. So far this Fiscal Year, the brochures have been distributed at four outreach events.

- Distribution to ethnic grocery stores – In FY 12-13, the City of San Jose mailed the Spanish and Vietnamese versions of the brochures to ethnic grocery stores located in San Jose. Signage at Santa Clara Valley waterfronts that allow fishing – There are a number of waterfronts in Santa Clara Valley where fishing is allowed. Due to mercury and PCB contamination issues, the following sites in Santa Clara have fish consumption advisories issued by the Office of Health Hazard Assessment:

    - Guadalupe Reservoir
    - Calero Reservoir
    - Almaden Reservoir
    - Guadalupe River
    - Guadalupe Creek
    - Alamitos Creek
    - Vasona Lake
    - Camden Ponds
    - Stevens Creek Reservoir

[8] The Watershed Watch Campaign website www.MyWatershedWatch.org is SCVURPPP's main public education website. The website is promoted in all SCVURPPP public outreach materials including media advertisements, giveaways and brochures.

APPENDIX D

Planning Level Cost and Benefit Estimates for Eight Storm Water Control Measures

Appendix D
Planning Level Cost and Benefit Estimates for Eight Storm Water Control Measures

Planning level cost and benefit estimates for the eight stormwater control measures listed in IMR Part C Section 3.0, (Table D.1) were developed in order to evaluate cost effectiveness of these control measures. The cost estimates developed here were based on available information from the literature, cost data provided by local municipal agencies based on planning and implementation of the control measure pilot studies being conducted in compliance with MRP requirements, and using best professional judgment in cases where cost data were limited or unavailable. The form of the cost estimates varied, depending on the type of control measure. For example, some costs may be reported in terms of unit of implementation (e.g., dollars per curb mile swept for street sweeping, or cost per drainage area treated), whereas other costs may be reported as a total cost per year over the expected life of a given control measure, accounting for engineering, construction and ongoing maintenance. However, for the purpose of evaluating cost effectiveness, all reported cost data were converted into units of dollars per acre (e.g., area treated and/or area of implementation). Cost estimates for a number of measures were based on costs incurred during MRP pilot projects, many of which were implemented through the Clean Watersheds for a Clean Bay (CW4CB) grant. Where local estimates were not available, regional and national cost estimating sources developed by WERF, LID Center, and others were utilized as needed. Where appropriate, life-cycle cost estimates were provided that take into account the anticipated service life of the equipment or installation. In addition, this section presents summaries of the budgets for MRP pilot projects described in IMR Part B based on records of expenditures and/or projections that were available at the time of report preparation.

Table D.1. Pollutant of Concern Control Measures Evaluated.

Category	Control Measure
Source Controls	Reduction/Elimination of Mercury in Devices
	Recycling of Mercury Containing Devices, Products and Equipment
	Identification of PCBs during Industrial Inspections
	Control of PCBs During Building Demolition and Renovation
	Investigations and Abatement of Sources in Drainages
Pollutant Mass Interception	Enhanced Street Sweeping
	Enhanced Operation and Maintenance (O&M) Practices
	Stormwater Treatment Retrofits
	Diversion to Wastewater Treatment Plants (POTWs)

The cost estimates presented here focus on the costs that would be incurred by a municipality to implement a given control measure, or to enhance existing programs based on the following seven general cost categories:

1. **Project Concept and Planning:** These costs are typically one-time costs that are required at the beginning of the process for pre-implementation planning, which depending on the control measure, may include one or more of the following: site discovery; surveying; CEQA; permitting; bid and selection of design, engineering, construction, and/or equipment contractors; hiring new municipal staff and/or training existing staff on the use/operation/maintenance (etc.) of new technologies or practices needed to implement the control measure; public outreach in areas where new or enhanced control measures will be implemented.

2. **Design:** These costs are for the engineering and associated overhead costs for site, structural and landscape design and engineering plans.
3. **Construction and Installation:** These costs are for the land, capital, labor, material and overhead costs associated with construction or installation of a given control measure.
4. **Equipment:** These costs are for the purchase or rental of new or upgraded equipment that is required to implement a given control measure (e.g., structural control device costs; street sweepers, etc.);
5. **Operating:** These costs are for the ongoing annual operation costs to implement, inspect and/or monitor a given control measure, including labor, equipment maintenance and replacement parts, fuel, and sediment disposal costs.
6. **Reporting:** These costs include any reporting required during planning and implementation of a given control measure for community outreach and/or to meet regulatory requirements. For example, performance tracking may be required to establish load reductions from a given control measure in order to show continued progress towards load reduction goals called for by the PCBs and Hg TMDLs.

Where available, lifecycle costs are also presented for some control measures. Lifecycle costs attempt to incorporate as appropriate all of the above costs to implement a given control measure over the lifetime of the control measure. These costs may be presented as a unit cost (e.g., cost per curb mile swept or cost per mass of TSS removed from stormwater) or as a total project cost over a given timeframe. Lifecycle costs provide a simple metric for comparing costs across a wide variety of control measures and implementation scenarios. When combined with load reduction benefits, these costs can be used to identify the most cost effective control measure options. A 25% mark-up was applied to lifecycle costs to account for administrative and other costs associated with implementing a given control measure.

Not all cost categories apply to all control measures and the types of costs included within each category may vary by control measure type. Cost data for all of the categories described above may not currently be available, but all of the categories are identified here for completeness.

For the purpose of the cost effectiveness evaluation, the benefits of each control measure were defined as either: (1) for source control measures, the load avoidance or expected percent load avoidance of POC mass, sediment and/or suspended sediment mass; or (2) for interception control measures, the load reduction or expected percent load reduction of POC mass, sediment and/or suspended sediment mass. Because both PCBs and Hg are primarily associated with sediment, benefits are presented as the mass of sediment or suspended sediment reduced because for most of the control measures, data on sediment or suspended sediment mass removal rates are more readily available than data on specific POC mass removal rates. In Section 4.0, POC concentration data are used to convert mass of sediment/suspended sediment removed to POC mass loads reduced. To the extent possible, all control measure benefits were expressed in terms of benefit per acre for ease of comparison among the different control measures and/or to allow evaluation of combinations of control measures in the scenario building exercise in Section C.4.

The load avoidance or load reduction benefits were estimated based on the best available data including data gathered during the MRP pilot projects and from the literature, as described in each individual control measure section below. For source control measures, load avoidances were based on the estimated mass of POC that would potentially, in the absence of the control measure, have been introduced into stormwater, while for interception control measures, load reductions were based on the estimated sediment load reduction and/or suspended sediment percent removal per unit of implementation. As with the units for costs, the load avoidance or load reduction units reported in the literature varied by control measure. For example, literature data on street sweeping reported units of mass of sediment removed per curb-mile swept, while stormwater treatment controls were more typically presented as the mass of suspended sediment removed per drainage area treated. However, to the extent possible, all benefits were converted to a mass removed (or % removed) per acre of implementation or drainage area using conversion factors described below for each control measure type.

The following sub-sections present the estimated ranges of costs and benefits that were developed for each of the eight stormwater control measures.

Reduction/Elimination and Recycling of Mercury in Devices

Cost Estimates

Permittee costs associated with reduction and recycling of mercury in devices and instruments are in part a function of the type of mercury containing device collected and recycled. As described in IMR Part B (Section B.2.1), the major mercury device categories include fluorescent lamps, thermostats, switches and relays, and other instruments, devices and products. Household hazardous waste (HHW) facilities and associated curbside and door-to-door pickup activities are managed by Permittees to enable residents and small business owners to recycle mercury containing devices. Some businesses that sell mercury containing devices also serve as collection sites. Home Depot, for example, provides national in-store consumer compact fluorescent lamp (CFL) recycling for free at all its locations. While it has been estimated that businesses use approximately 80% of the fluorescent lamps in the U.S., data regarding the number of fluorescent lamps used by businesses annually and recycling rates are generally unavailable.

Mercury containing devices are only one product of many handled by HHW facilities. Limited information was available on HHW waste treatment/management costs by material type. One study of Los Angeles County HHW facilities reported a unit cost to recycle fluorescent tubes of $0.18-$0.25 per linear foot (CIWMB 2008). While not directly comparable, there are firms that provide shipping containers and will recycle fluorescent lamps for about $1 per lamp (e.g., Air Cycle, Veolia Environmental Services). A Lighting Task Force convened by the California Department of Toxic Substances Control assumed collection and recycling costs of $0.60 per lamp for residential lamps (CDTSC 2008). Universal waste (excluding E-scrap) was estimated to comprise 6.9%, 8.1%, 4.3%, and 17.8% of the total pounds collected by the HHWs in Alameda County, Santa Clara County, City of Fremont, and City and County of San Francisco, respectively, based on FY 2009-2010 data (HFH 2012). Fluorescent lamps have been regulated by USEPA under the Universal Waste Rule since 1999. The fraction of the above Universal Waste amounts that was represented by fluorescent bulbs was not reported. The report (HFH 2012) did present other comparative indices for the four entities (e.g., total costs per pound of HHW, operating cost per pound).

The State of Maine in 2009 passed legislation that requires manufacturers to assume responsibility for lamp recycling. They can either 1) establish a program to collect household lamps at no cost; or 2) take over funding of the existing municipal and Public Utilities Commission collection programs. Maine (2010) reported costs for lamp recycling of a four foot T8 bulb ranged from $0.24-$1.04 for on-site pickup and from $0.59-$2.27 for prepaid mail in.

HHW Programs, such as Alameda County's HHW Program, have been funded primarily through a fee on solid waste disposal at landfills located in Alameda County. The fee in Alameda has been set at $2.15 per ton since 2000 (StopWaste 2013). As is the case with programs with disposal based funding, revenues have decreased steadily as landfill diversion efforts have succeeded in reducing the amount of solid waste disposed in landfills, and also as a result of the lower level of economic activity in past years. Out of the current total $3.8M HHW Program cost, staffing is the single largest cost element ($1.2M) followed by the transportation and disposal contract ($1.1M).

While the current Alameda HHW Program service level captured 1,443 tons in FY 2012-2013, as much as 3,400 tons per year of HHW is still disposed of in landfills. To address this issue and declining funding, StopWaste is investigating a Proposed System Expansion to be funded by a new annual fee of $9.55 per single-family and multi-family residential unit. The Expansion would increase service from 45,000 to 72,000 households, and from 1,443 to an estimated 2,501 tons per year. There would be 12 additional one-day drop-off events (estimated to cost $45,000 each, managed by Program staff but largely conducted by contractor-supplied personnel), 2-4 additional business drop-in days, and enhanced outreach. Efforts are also being made to encourage Extended Producer Responsibility (EPR) concepts to shift the physical and financial responsibility for product end-of-life management to producers.

Santa Clara County also funds its Countywide HHW program through a solid waste disposal fee ($2.60/ton). Cities desiring a higher level of service augment the funding provided. The County of Santa Clara Department of Environmental Health HHW Program was awarded a CalRecycle Grant to conduct an educational campaign and to collect mercury-containing waste. The grant funded a three year project that enabled the County and cities to decrease the amount of mercury entering the environment by raising public awareness and providing free drop-off programs for residents and small businesses. Drop-offs of containers of elemental mercury are still reported to occur.

Load Avoidance/Reduction Benefits

Table D.2 (adapted from IMR B.2.1) presents the total mass of mercury containing fluorescent lamps, thermostats, and other mercury containing devices collected by Bay Area County HHW facilities and related programs. Also included in Table 3.2, is the mass represented by thermostats collected by Bay Area businesses and contractors as reported to the Thermostat Recycling Corporation (TRC). The TRC provides collection containers to HHW facilities at no cost. Table 3.2 also presents the mass of mercury contained in the total mass collected based on the IMR B Section B.2.1 assumptions of:

- 2 mg mercury per linear foot of fluorescent tube lamp;
- 4.5 mg mercury per compact fluorescent lamp (CFL);
- 35 mg mercury per kg of total mass of linear fluorescent lamps or CFLs collected;
- 4,000 mg mercury per thermostat; and
- 4.8% of the total mercury collected would have reached stormwater via breakage if not recycled (Mangarella et al. 2010).

Table D.2. Mercury-containing device collection by Permittee-managed HHW facilities, drop-off events and door-to-door pickup between 2002 and 2011, TRC thermostat collection, and estimated mass of mercury prevented from reaching stormwater from devices collected (mass in kg).

Device Type	Estimated Mass of Devices Recycled (kg)						Mercury Recycled (kg)	Mercury Prevented from Reaching Stormwater[1] (kg)
	Alameda	Contra Costa	San Mateo	Santa Clara	Solano	Total Mass		
Fluorescent Lamps	168,927	185,046	142,716	384,006	3,746	884,440	30.96	1.49
HHW Mercury Thermostats	55	119	0	441	0	615	7.22	0.35
TRC Collected Hg Thermostats	899	345	312	1,024	145	2,724	31.96	1.53
Mercury Switches & Thermometers	621	880	619	1,430	5	3,554	NA	NA
Average Annual Total	17,050	18,639	14,365	38,690	390	89,133	7	0.34

[1]Mercury prevented from reaching stormwater was calculated based on the total mass of mercury recycled between 2002 – 2011 and an assumed 4.8% of that total that would have reached stormwater via breakage, if not recycled (Mangarella et al., 2010).

Santa Clara County HHW reports a total estimated mass of 3.2 kg of mercury was collected from all devices recycled in 2013.Total labor and disposal costs for mercury recycling at the facility in 2013 were approximately $233,000 (Rob D'Arcy, personal communication). If we assume 4.8% of this Hg would otherwise reach stormwater if not recycled, then the total mass avoided in 2013 was 0.15 kg, or $1,553 /g Hg prevented from reaching stormwater. (Rob D'Arcy, personal communication).

Identification of PCBs during Industrial Inspections

Cost Estimates

The costs associated with the identification of PCBs during industrial inspections can be grouped into three general cost categories - project concept and planning, operating, and reporting costs. To the extent possible, cost data for industrial inspections were gathered for each of these cost categories primarily from the cost data available through BASMAA and regional stormwater programs that have implemented inspector training, as summarized in Table D.3 and described in greater detail below.

Project concept and planning costs include the development of training materials to assist industrial inspectors with identifying potential PCBs and/or PCB containing materials and equipment during their existing industrial inspection programs. BASMAA developed regional training and reporting materials to be used by all Permittees to train their individual industrial/commercial facility stormwater inspectors, including an inspector guidance manual and a PowerPoint presentation, as described in IMR Part B Section B.2.2. In addition, a model reporting form was developed to meet the specific MRP inspection-related requirements for PCBs and other POCs. The total budget for the development of these training and reporting a material was $30,000, with approximately half of that budget used specifically for development of PCB-related materials (Table D.3). Because this cost is assumed to be a one-time cost over a ten year period (assumes the training and reporting materials are good for ten years), the total cost was divided among the six county Permittees (based on the percent of the PCB load allocation for each county - IMR Part B Table B.1.2.1) over ten years, or approximately $120 to $640 per county per year (Table D.3).

There may also be an initial cost to municipalities to incorporate PCBs into their existing industrial permit program. The effort to add a new tracking element for PCBs into the existing data management system will vary by city, depending on the complexity of the existing data management system including the effort to make revisions to inspection forms, data tracking systems and/or software programs. No cost estimates were available for this effort; however, discussions with City of San Jose staff indicated the cost was likely to be minimal.

Operating costs include both the ongoing inspector training, and any additional inspector time required during inspections (if any) due to the addition of PCBs or PCBs-containing equipment identification. Training costs depend on the form of training, which may vary among the different Bay Area counties and cities. A relatively low-cost method would be for a county or municipality to provide each of their inspectors with the BASMAA training materials to review independently for approximately two hours each year, which was the time requirement suggested in the San Mateo Countywide Water Pollution Prevention Program's (SMCWPPP) Guidance to Stormwater Inspectors on Meeting MRP's Annual Training Requirements as Self-Training in FY2010-2011 (SMCWPPP 2011). Based on publicly available wage ranges for environmental inspectors for several Bay Area cities of $30 - $50 per hour, and multiplied by a factor of two to account for the fully burdened rate, the total cost would be $120 - $200 per person per year for training (Table D.3). At the other end of the range, a more costly training method would be through a regional training workshop attended by inspectors from different cities within the region. For example, SMCWPPP held a regional stormwater inspector training on April 25, 2012 which was attended by 59 people. The total cost to provide the six hour training program was about $20,000. Based on inquiries to SMCWPPP representatives, there is a baseline cost to hold a regional workshop, with cost above this amount determined by the number of different presenters, presentations, and topics covered at the workshop. As approximately 20% of the 2012 workshop focused on PCBs and related issues, the total estimated cost for PCBs training (baseline costs plus cost to present PCB information) was $12,000. Add to that two hours of labor cost for each inspector to attend the portion of the training session focused on PCB issues, and the cost per person for attendance ranged from $120 - $200 per person for 59 attendees, or $19,000 - $24,000 total for the countywide training.

No cost estimates are currently available for the increased time needed by inspectors to include identification of PCBs/PCB-containing equipment in the existing industrial inspection programs. The additional time needed at a site during a routine stormwater inspection to incorporate identification of PCBs could be considered minimal. However, if PCBs or PCB-containing equipment are found the increased time for documentation, notification and reporting by the inspector could be several hours. The notification and reporting estimates are discussed below.

Reporting requirements include documentation in inspection reports of any incidents of PCBs found during inspections, and then a referral addressing each incident to the appropriate regulatory agency as necessary. In addition, the MRP requires Permittees to report both initial and ongoing training efforts and inspections for PCB identification in their annual reports, beginning with the 2010 Annual Reports. The labor time required for such reporting was assumed as eight hours per year per inspector, or $480 - $800 per inspector per year (Table D.3).

The lifecycle costs were developed assuming a ten year time frame, based on the above cost estimates. These are presented as the cost per county per year (for ten years) for development of the training and reporting materials, plus the range of costs per year for training and reporting time (Table D.3). The low end of the range assumed individual training for the minimum number of inspectors in any of the five Bay Area counties subject to the MRP (e.g., Solano county reported a total of 5 inspectors in their 2013 Annual Report). The upper end of the range assumed the costs for the 59 individuals who were in attendance at the 2012 SMCWPPP training. A 25% mark-up was included in the total costs per county to account for additional administrative costs, and other potential costs not accounted for in the table including unknowns (e.g., additional time for inspections), and contingency.

<u>Load Reduction Benefits</u>

Because of the lack of information on the potential mass of PCBs that may be identified in the future during industrial inspections, combined with the added uncertainty in predicting how much of that mass would otherwise be released to stormwater, load reduction benefits for this control measure are challenging to calculate. However, given the limited cost associated with the addition of PCBs identification to existing Industrial Inspection programs, and the potential benefit associated with proper handling and disposal of any PCBs identified during these inspections, continuation of this minimal effort remains valuable. No PCBs or PCB-containing equipment have yet been identified during industrial inspections. Future load avoidance benefits would depend on the quantity and subsequent proper disposal of any PCBs or PCB-containing equipment identified and reported during future inspections. To estimate the load avoidance benefits of this control measure in the future, the calculations presented in IMR Part B Section B.2 will be applied as PCBs are reported and properly managed to avoid release to stormwater.

Table D.3. Range of Available Cost Estimates for Identification of PCBs During Industrial Inspections.

Source of Cost Data	Project Concept and Planning[1]	Operating[2]			Reporting[3]	Total Costs for County Stormwater Program (Includes 25% Mark-Up[6])[7]
		Independent Training	County-wide Workshop	Attendance at Workshop		
BASMAA	$15,000					
SMCWPPP[4]			$12,000/event	$120 - $200/person		
Calculated - Independent Training and Reporting Time[5]		$120 - $200/person				
					$480 - $800/person	
Lifecycle Costs ($/county/year)	$120 - $640	$600 - $1,000	$19,000 - $24,000		$2,400 - $47,000	***$4,000 - $90,000***

[1]Initial inspector training and reporting materials assumed valid for ten years. Lifecycle cost to develop training materials was divided among the 6 county Permittees (based on the % of the PCB load allocation for each county - IMR Part B Table B.1.2.1) over ten years.

[2]Annual inspector training costs.

[3]Annual report write-ups of training; reports to appropriate regulatory agency(ies) if PCBs/PCB-containing equipment are found during inspections.

[4]Based on costs for the 2012 SMCWPPP inspector training workshop with 59 attendees plus 2 hours of attendees' time based on fully burdened salary estimates of $60 - $100/hour.

[5]Calculated based on public data for Bay Area Cities' Inspector salary ranges; 2 hours/person for annual training; 8 hours/person for annual reporting; the low end of the range was based on 5 inspectors for VSFCD; high range based on 59 attendees at SMCWPPP workshop.

[6]A 25% mark-up was included to account for additional administrative costs, and other potential costs not accounted for in the table including unknowns (e.g., additional time for inspections) and contingency.

[7]Estimated costs per county-wide stormwater program per year; low range assumes independent training for up to 5 inspectors per year; high range assumes county-wide training workshop for up to 59 attendees per year.

Source Property Identification and Abatement

Cost Estimates

The costs associated with Source Property Identification and Abatement fit into three general cost categories, including project concept and planning, operating, and reporting costs. Cost data were gathered primarily from the MRP pilot study budgets for the source property identification and abatement pilot studies which were recently implemented in four Bay Area cities as part of the CW4CB project, as described in IMR Part B Section B.2.3, and a previous City of Oakland investigation of properties in the Ettie Street Pump Station watershed upon which the CW4CB investigations were modeled (Table D.4).

The City of Oakland study was funded 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. The City was awarded a total of $460,000 for the PCB Abatement Grant Project, with approximately $360,000 used for the source property identification and referral process, and $100,000 for abatement (as discussed further in Section 1.5). Applying the $360,000 budget to the watershed area, the unit cost for the source property identification and referral process was approximately $300/acre.

The CW4CB pilot study budgets (Table D.4) were developed based on the best available information at the time of the writing of this report, including both expected EPA grant fund allocations and in-kind contributions from participating Bay Area stormwater programs. The methods used for the CW4CB Source Property Identification Pilot studies were generally based on the previous City of Oakland PCB Abatement Grant Project (Kleinfelder 2006). However, CW4CB adapted and refined the methods as appropriate for local conditions in each of the CW4CB pilot watersheds. Based on the CW4CB pilot studies, the project concept and planning costs included the development of a work plan to guide the source property identification process from planning through reporting, and development of a sampling and analysis plan (SAP) for soil/sediment monitoring that was used to help identify potential source properties. Operating costs included the labor to investigate properties within a given watershed and conduct inspections, as well as the costs for soil/sediment monitoring needed to identify potential source properties. Reporting costs included the monitoring reports as well as reporting of suspect properties to regulatory authorities for follow-up abatement measures. Unit costs were based on the area of the watershed, and the total budgets divided by three years (the approximate time to complete each watershed investigation). The budgets for Leo Avenue and Pulgas Creek Pump Station watersheds are higher because these projects are representative of new efforts, whereas a lower level of effort was required in the Ettie, Lauritzen and Parr Channel watersheds due to extensive previous investigations conducted in those watersheds prior to the start of the CW4CB project.

Load Reduction Benefits

The load reduction benefits from source property identification and abatement depends on the area of the property abated, the type of abatement measure(s) applied, the effectiveness of those measures, and the concentration of POCs in the sediment and/or stormwater on a given property. The abatement measures applied to a given property may include a variety of control measures, including those measures discussed in this document and in IMR Part B. Potential load avoidance benefits for source property identification and abatement will be explored in the cost effectiveness evaluation in IMR Part C Section 4.0, which presents a variety of control measure implementation scenarios that could be applied to potential source properties and/or source areas.

Table D.4. Source Property Investigation and Abatement Pilot Projects Estimated Budgets.

	CW4CB Pilot Studies[1]					Ettie Street Pump Station watershed Investigation, Oakland, CA (Kleinfelder, 2006)
	Leo Avenue Watershed, San Jose, CA	Pulgas Creek Pump Station Watershed, San Carlos, CA	Ettie Street Pump Station Watershed, Oakland, CA	Lauritzen Channel Watershed, Richmond, CA	Parr Channel Watershed, Richmond, CA	
Area of Watershed (acres)	544	260	1,200	939	1,063	1,200
Project Concept, Planning, and Study Design	$20,000	$12,000	$10,000	$5,000	$5,000	n/a
Property Investigation and Inspections	$128,000	$110,000	$44,000	$56,000	$56,000	
Monitoring	$70,000	$70,000	$70,000	$27,000	$27,000	
Reporting	$30,000	$30,000	$30,000	$30,000	$30,000	
Total Budget (includes 25% mark-up)[2]	$310,000	$277,500	$192,500	$147,500	$147,500	$360,000
Unit Cost[3] ($/acre)	$570	$1,067	$160	$157	$139	$300

[1]All budgets are estimated based on expected allocation of CW4CB EPA grant funds and estimated in-kind contributions from participating stormwater programs as of the writing of this report.

[2]Total budgets were marked-up by 25% to account for administrative costs, and other potential costs not accounted for in the table.

[3]Total budgets for Leo Avenue and Pulgas Creek Pump Station watersheds are higher because these projects are representative of new efforts, whereas a lower level of effort was required in the Ettie, Lauritzen and Parr Channel watersheds due to extensive previous efforts conducted prior to CW4CB.

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Control of PCBs during Building Demolition and Renovation

Cost Estimates

IMR Part B Section B.8 describes the results from the PCBs in Caulk Pilot Monitoring Study and from the companion Best Management Practices (BMP) Study managed by the San Francisco Estuary Partnership (SFEP). SFEP also completed a Model Implementation Process project and a Training Strategy project as part of the overall PCBs in Caulk project. The studies resulted in a “mid-range” estimate of 10,500 kg PCBs in caulk (and similar sealants) in buildings (constructed from 1950-1980) in the Bay Area study area, or approximately 4.7 kg PCB per building (including caulk on both the interior and exterior). The median estimate of PCB mass released per year from caulk to stormwater during building demolition and renovation was 0.04 kg. Because PCB releases from caulk scraps that may be left behind at a demolition/renovation site were not included, 0.04 kg/yr value most likely underestimates the actual mass released.

The SFEP GIS analysis estimated that there are approximately 6,300 currently standing buildings that were built from the 1950s to 1980 in the San Francisco Bay Area. The buildings are heavily concentrated in Santa Clara County (48%), with a remaining 26% in Alameda County, 19% in Contra Costa County, 6% in San Mateo County, and less than 1% in the municipalities of Fairfield-Suisun and Vallejo combined. 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 (i.e., identifying high opportunity areas). PCBs were analyzed for in caulk samples collected from existing buildings, but no PCB data were collected during a demolition or renovation project as part of the SFEP work. A literature review found only one case study with monitoring data, from a project in Sweden in 2000. However, the limited information available suggests that BMPs are highly effective for reducing the release of PCBs to the environment (>99% of PCBs in building caulk captured and removed). PCB in caulk BMPs are ideally similar to those employed for asbestos abatement projects, entailing pollutant identification and removal before the renovation or demolition occurs.

Currently, there is no requirement to test for PCBs before conducting renovation or demolition. However, the USEPA has recommended that contractors performing renovation and/or demolition activities at buildings that may contain PCB materials 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. While the goal of the PCBs in Caulk Project was related to reducing 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 at 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.

A literature review found very limited information on PCB in caulk abatement costs associated with building renovation or demolition. The firm Environmental Health & Engineering of Needham, MA, estimated that the abatement costs associated with the pre-construction removal and disposal of PCBs as currently required by EPA when concentrations at or above 50 ppm are known to be present average about $15 per square foot per building. Costs could vary depending on window and/or façade construction and the concentration of PCBs found at the building (http://www.eheinc.com/download/PCBConstructionMatls_v7.pdf).

EPA regulations classify almost all products that contain PCBs greater than 50 ppm as “unauthorized”, making their continued use illegal. Any such PCB-containing building products, such as caulk, must be removed and disposed of as Toxic Substances Control Act (TSCA) classified waste. Additionally, all building components that were in contact with the caulking may require further, more invasive cleaning and restoration efforts. A presentation titled “PCBs in Building Materials: A Consultant Perspective” estimated that costs to cut and remove caulk, and to scarify or remove adjacent substrates could range from $30-$50 per linear foot (Fuss and O’Neil, 2011).

The SFEP Model Implementation Process (MIP) report contains a Model Ordinance for Remodeling and Demolition PCBs Runoff Prevention. The Ordinance, if adopted, would apply to structures 1) constructed of concrete or masonry; 2) built or renovated from 1950 to 1980; and 3) constructed for industrial, institutional, of commercial use, or constructed for residential use including four or more stories above ground level. The Ordinance would also establish a PCBs Screening Assessment requirement for analysis of caulk in affected areas. If PCB concentrations greater than 1 mg/kg (ppm) are detected, the applicant would be required to notify the appropriate regulatory agencies, implement PCBs in caulk BMPs, and to prepare and implement a PCBs Runoff Pollution Plan (unless all PCBs in caulk are indoors).

The costs for these PCB control measures would fall primarily on the project applicant, not on the public entity issuing the remodeling/demolition permit. The Staff Report for the Model Ordinance notes that the "*fiscal impact of this ordinance would be offset by the collection of permit fees to recover the cost of its implementation. The fee increase would be relatively small because the process is based on Applicant certifications and does not require the review of corroborating information. Additional costs would be incurred for public building projects that would involve implementing the requirements of this ordinance. Applicants for demolition or remodeling permits for affected buildings would incur additional costs. Most Applicants would incur costs for the PCBs Screening Assessment. Fewer Applicants would incur the higher costs associated with managing PCBs, if identified*."

Public costs to enhance PCBs in caulk control measures could involve one-time costs for a municipality to adopt an ordinance similar to the SFEP Model Ordinance. This would provide the municipality with the legal authority to require PCB monitoring of caulk for projects seeking building renovation or demolition permits, and meeting the threshold requirements in the Ordinance. After Ordinance adoption, the municipality would incurs costs on a per project basis, only to the extent that the costs associated with implementing the Ordinance requirements (e.g., site inspections, coordination with regulatory agencies), were not able to be recovered by increased permit fees.

Load Reduction Benefits

The load reduction benefits from enacting and enforcing the Model Ordinance would depend on the number, size, and PCB content of buildings now being renovated or demolished without PCB control measures being required, versus those detected by and subject to the Model Ordinance and other state and federal PCB BMP implementation requirements.

Enhanced Street Sweeping

Cost Estimates

The costs associated with street sweeping fit into four general cost categories, including project concept and planning, equipment, operating, and reporting costs. To the extent possible, street sweeping cost data were developed for each of these cost categories from literature sources, equipment manufacturers, direct inquires to local city staff and CW4CB pilot study budgets.

A recent literature review of municipal sediment management practices, including cost estimates, was conducted as part of the CW4CB project (EOA, Inc. and Geosyntec Consultants, 2011). Direct inquiries were also made to manufacturers of sweeper equipment and to two Bay Area cities as part of the CW4CB literature review process. In addition, an effort was made to locate other studies that were not included in the CW4CB literature review and/or additional information in government reports or other publications (e.g., trade journals) on street sweeping costs. Best professional judgment was used to identify and report cost data that were most applicable to potential street sweeping scenarios in Bay Area cities.

Cost estimates identified in both the CW4CB literature review and the follow-up review are summarized in Table D.5. All cost data in Table D.5 have been adjusted to 2013 dollars using http://www.usinflationcalculator.com/.

Table D.5. Cost Estimates for Implementing Street Sweeping Programs.

Source of Cost Data[1]	Project Concept and Planning; Reporting ($/curb-mile)	Equipment ($ per sweeper)	Operating ($/curb-mile)	Lifecycle Costs ($/curb-mile)[2]	Notes:
City of Oakland, CA				$33	Annual budget of $4.5 M, 20 mechanical broom sweepers; assumes annual mileage of 7,000/sweeper.
City of Richmond, CA				$81	Annual budget of $1.7 M, 3 regenerative air sweepers; assumes annual mileage of 7,000/sweeper.
USEPA (1999) Schilling (2005)		$120,000	$48	$50	Mechanical Broom Sweeper; lifecycle costs calculated by factoring both equipment and operating costs over 10 years.[3]
USEPA (1999) Schilling (2005)		$240,000	$24	$29	Vacuum-Assisted Dry Sweeper; lifecycle costs calculated by factoring both equipment and operating costs over 10 years.[3]
Olympia, WA; Blosser et al. (2003)		$390,000		$50	EV1 High Efficiency Vacuum Sweeper operated 6 months of the year; assumes 3,328 curb-miles swept per year.
Seattle, WA; SPU & Herrera (2009)	$7			$64	Regenerative Air Sweeper, every other week; Lifecycle costs included 15% for implementing the enhanced program, including performance tracking and $15/curb-mile for disposal costs.
Partland (2001)		$80,000 - $160,000			Mechanical Broom - Regenerative Air Sweepers
		$320,000 - $410,000			EV1 High Efficiency Vacuum Sweeper
EOA & Geosyntec (2011)		$177,000 - $208,000			Regenerative Air Sweeper
		$260,000 - $291,000			Dustless Regenerative Air
Range of Cost Estimates	$7	$80,000 - $410,000 OR $2 - $8/curb-mile	$24 - $48	$29 - $81	

[1]All cost data were adjusted to 2013 dollars using http://www.usinflationcalculator.com.

[2] Lifecycle costs include 25% mark-up where administrative costs were not included.

[3]Based on 7,000 curb-miles swept per year over a ten year lifespan, 8% annual interest.

As reported in the CW4CB literature review, discussions with City of San Jose staff indicated a typical sweeper may sweep approximately 7,000 curb miles per year with a lifespan of about ten years, for a total of 70,000 curb-miles swept. Based on this information, the ranges in Table D.5 for sweeper equipment costs ($80,000 to $410,000) and an interest rate of 8%, the total capital cost contributes approximately $2 - $8/curb-mile to the lifecycle cost of operating a given sweeper.

SPU and Herrera (2009) provided the only cost estimate that was found for reporting on the implementation of a sweeping program enhancement and performance tracking, which was based on best professional judgment of 15% added to the lifecycle cost per curb-mile. No other cost data on project concept and planning or reporting for street sweeping enhancements were found in the literature.

Based on informal discussions with staff from one small Bay Area city which sweeps approximately monthly in residential areas and twice monthly in commercial areas using a regenerative air sweeper, an estimate of operating costs is $52/curb-mile. Adding in equipment costs over an assumed ten year lifespan of the sweeper of approximately $6/curb-mile, and 15% for project planning and reporting, the lifecycle cost was $66/curb-mile, which fits well within the range of the lifecycle cost estimates in Table D.5.

Finally, it is important to note that nearly all Bay Area municipalities already include some level of street sweeping as part of their current activities. Thus, the cost of an enhancement is site-specific and largely depends on the existing sweeping program at that site, and the proposed level of enhancement. Because most street sweeping cost data are typically presented as the cost for a given set of conditions (e.g., sweeper type, frequency, and total area swept), the estimated net cost for a given street sweeping enhancement will be the difference in costs between baseline and enhanced conditions.

<u>CW4CB Street Sweeping Pilot Project Budget</u>

MRP Provisions C.11/12.d require municipalities to conduct pilot studies of methods to enhance the pollutant load reduction benefits of municipal O&M activities that remove sediment from streets and storm drain system infrastructure. Currently, a street sweeping pilot study is being conducted as part of the CW4CB project at four locations in the Bay Area, as described in greater detail in IMR Part B (Section B.2.4). The street sweeping pilot project will monitor the street dirt load before and after sweeping occurs, and these data will be used as inputs to a model which will evaluate the increased load reduction of a number of potential street sweeping enhancements. The pilot project will document the baseline sweeping program in each of the four study areas for sweeper type, sweeping frequency, and level of parking controls. The total estimated budget for the street sweeping pilot project is $560,000, with 15% of that budget allocated to project concept and planning, 77% for monitoring and modeling, and 8% for reporting (Table D.6). All budget estimates are preliminary, as the project has not been completed as of the writing of this report, and include both EPA grant fund allocations and expected in-kind contributions from the participating stormwater programs. None of the pilot project budget will be used to fund any of the street sweeping that will occur during the study.

Table D.6. Clean Watersheds for a Clean Bay (CW4CB) Street Sweeping Pilot Project Estimated Budget.

Description	Budget	Percent of Total Budget
Project Planning, site selection and study design	$85,000	15%
Monitoring at Four Locations	$340,000	61%
Modeling of Street Sweeping Enhancements	$90,000	16%
Reporting	$45,000	8%
Total Budget:	$560,000	100%

Load Reduction Benefits

The load reduction benefits of street sweeping enhancements are dependent on a number of factors, including sweeper type, initial street dirt loading, and frequency, as described in more detail in IMR Part B (Section B.5). Load reduction benefits for street sweeping were estimated for baseline conditions which included use of a mechanical broom sweeper, and enhanced conditions, which included the use of more advanced sweeper technologies (e.g., vacuum-assisted or regenerative air technology). For both baseline and enhanced conditions, the mass of street dirt removed per curb mile was calculated from a range of expected initial street dirt loadings and assumed removal efficiencies (Table D.7). The same range of initial street dirt loadings were applied to baseline and enhanced conditions, while higher removal efficiencies were assumed for enhanced conditions. Estimates for the range of initial street dirt loadings as well as removal efficiencies were based on interpretation of literature data compiled in the CW4CB Municipal Sediment Management Practices Literature Review (EOA, Inc. and Geosyntec Consultants, 2011).

Table D.7. Street Dirt Load Reduction Benefits for Street Sweeping.

Sweeping Conditions	Initial Street Dirt Loading (lbs/curb-mile)	Percent Effectiveness	Street Dirt Load Reduction (lbs/curb-mile)
Baseline (Mechanical Broom)	800	20	160
	500	10	50
	200	5	10
Enhanced (Advanced Sweeper)	800	50	400
	500	40	200
	200	30	60

Enhanced MS4 Operation and Maintenance

Cost Estimates

The cost estimates for enhanced O&M activities are focused on street flushing, pump station maintenance, and storm drain line cleanouts. The costs associated with these activities generally fit into four cost categories, including project concept and planning, equipment, operating, and reporting costs. To the extent possible, cost data were gathered for each of these cost categories from the literature, direct inquires to local city staff and MRP pilot study budgets.

A recent literature review of municipal sediment management practices that included cost estimates was conducted as part of the CW4CB project (EOA, Inc. and Geosyntec Consultants, 2011). Additional review was conducted to locate any other relevant cost data not included in the CW4CB literature review on municipal O&M costs, including direct inquiries to staff from several Bay Area cities. Best professional judgment was used to identify and report cost data that were most applicable to potential O&M enhancements by Bay Area Permittees.

Cost estimates identified in both the CW4CB literature review and the follow-up review are summarized in Table D.8. All cost data in Table D.8 have been adjusted to 2013 dollars using http://www.usinflationcalculator.com/. To supplement the limited available literature data on municipal costs to implement street flushing, pump station maintenance, and storm drain line cleaning/flushing, direct inquiries about costs were made to staff from several Bay Area cities, and the information provided was used to develop cost estimates based on expected or measured mass of sediment removed, and the length of storm drain line cleaned or street flushed. Generally, the unit cost data provided in Table D.8

include both labor and equipment costs to perform a given O&M activity, but not other costs such as any associated administrative costs and/or sediment disposal costs. The total costs for both the Kleinfelder (2006) street flushing abatement project and City of San Jose Leo Avenue storm drain line cleanout were higher compared with other reported unit costs because sediment disposal costs were included, and because these projects were planned and implemented as individual projects, and were not done as part of the city's routine municipal O&M activities. Thus, the total costs for the projects included all aspects from planning through final reporting. No specific information on planning or reporting costs were identified in any of the other available cost data. To better reflect these costs, as well as other administrative costs associated with implementing these types of activities, a 25% mark-up was applied to the cost data reported in Table D.8, except for the City of San Jose (2011) and Kleinfelder (2006) projects, which already included all costs associated with these projects.

Table D.8. Cost Estimates for Municipal Operation and Maintenance Activities.

O&M Activity	Source of Cost Data[1]	Unit Costs[2] $ per cleanout or per project	Unit Costs[2] $ per linear mile flushed	Unit Costs[2] $ per lb of sediment removed	Range of Cost Estimates	Notes:
Pump Station Maintenance	Kleinfelder (2006)	$35,000		$0.28	$7,500 - $35,000 per cleanout	Ettie Street Pump Station cleanout costs estimated for 2001 - 2006, approximately 123,000 lbs of sediment removed; includes 25% mark-up to account for administrative/other costs.
	Salop et. al. (2006)			$0.31 - $0.38		Calculated from Salop et. al. (2006) estimated quantify of sediment removed in a partial (~20 cubic yards, or 57,000 lbs) or full (~33 cubic yards, or 93,000 lbs) cleanout of the Ettie Street Pump Station and the expected cleanout cost for the CW4CB pilot study budget (see Table 3.5.2). Does not include disposal costs.
	Ettie Street Pump Station Cleanout (May 2013)	$25,000				Ettie Street Pump Station cleanout in May 2013, plus 25% mark-up for administrative/other costs.
	City of San Carlos (2013)	$7,500		$0.47		Pulgas Creek Pump Station cleanout in Fall 2011, plus 25% mark-up for administrative/other costs.
Street Flushing	City of San Carlos (2013)	$20,000	$10,000		$10,000 - $574,000 per linear mile of street flushed	Labor cost for flushing ~2 linear miles of street - plus 25% mark-up to account for administrative/other costs. No hazardous material disposal costs were included because none were required for this project.
	Kleinfelder (2006)	$100,000	$574,000	$2.78		Street flushing - 36,000 lbs of sediment removed from 921 linear feet; costs include those associated with the disposal of sediment/water as hazardous waste; if disposal as hazardous waste is not necessary, then costs would be significantly less.
Storm Drain Line Cleanout	City of San Jose (2011)	$60,000	$40 per linear foot of pipe flushed	$8.00	$40 per linear foot of pipe flushed	Leo Ave storm drain line cleanout in 2005, approximately 7,700 lbs of sediment removed from ~1,500 feet of pipe; includes disposal as hazardous waste

[1]All cost data were adjusted to 2013 dollars using http://www.usinflationcalculator.com.

[2]Only the Kleinfelder street flushing study and the City of San Jose Leo Avenue storm drain line cleanout cost estimates include all costs associated with these projects (planning, labor, disposal, reporting), so these costs were not marked-up. All other cost estimates presented above include municipal staff labor costs and equipment usage to implement the O&M activity, plus a 25% mark-up to account for administrative/other costs.

CW4CB O&M Enhancement Pilot Projects Budgets

Three pilot projects on municipal O&M enhancements are currently being conducted (one each in the Ettie Street Pump Station, Leo Avenue, and Pulgas Creek Pump station watersheds) as part of the CW4CB project. These projects are being conducted to satisfy MRP Provisions C.11/12.d which require municipalities to conduct pilot studies of methods to enhance the pollutant load reduction benefits of municipal O&M activities that remove sediment from streets and storm drain system infrastructure. One pilot project is an enhanced pump station maintenance study at the Ettie Street Pump Station in Oakland, CA. The second is an enhanced cleanout of the Leo Avenue storm drain line in the Leo Avenue watershed, San Jose, CA. The third is a street flushing study in the Pulgas Creek Pump Station Watershed in San Carlos, CA. These pilot studies are described in greater detail in IMR Part B (Section B.2.4). The total estimated budget for each of the O&M enhancement pilot studies, including both EPA grant funds and in-kind funds from participating stormwater programs is detailed in Table D.9. Approximately 16% of those budgets were allocated for project concept, planning, and study design, 33% for implementation of the actual enhancements, 34% for monitoring, and 16% for reporting. Because these budgets likely underestimate the full contributions from stormwater program and city staff for planning and implementing these projects, as well as administrative costs, an additional 25% mark-up was applied (Table D.9). All budget estimates are preliminary, as these projects have not been completed as of the writing of this report.

Table D.9. Clean Watersheds for a Clean Bay (CW4CB) Municipal Operation and Maintenance Enhancement Pilot Project Budgets.

Budget Category	Leo Avenue Storm Drain Line Cleanout, San Jose, CA	Street Flushing Study, San Carlos, CA	Ettie Street Pump Station Enhanced Cleanout, Oakland, CA
Project Concept, Planning, and Study Design	$20,000	$20,000	$20,000
Implementation of O&M Enhancement	$60,000	$26,000	$35,000
Monitoring	$25,000	$54,000	$47,000
Reporting	$20,000	$20,000	$20,000
Total Budget	$156,250	$150,000	$152,500
Unit Implementation Cost (does not include monitoring/reporting) + 25% mark-up[2]	$100,000 per cleanout	$28,750 per mile of street flushed	$68,750 per cleanout

[1]All budgets are estimated from expected allocation of CW4CB EPA grant funds and the in-kind contribution commitment from participating stormwater programs, based on the information available as of the writing of this report.

[2]A 25% mark-up was applied to the unit implementation cost to account for administrative and other unknown costs that may be associated with these projects.

Load Reduction Benefits

The load reduction benefits for O&M activities that remove sediment from storm drain infrastructure were calculated from the total mass of sediment removed during a given activity, or from estimated sediment removal effectiveness for a given activity. The load reduction benefit for pump station maintenance was calculated using the estimated mass of sediment removed per cleanout during the pump station cleanouts previously identified in Table D.8. The estimated pump station load reduction benefits represent a range of sediment mass removed during recent pump station cleanouts in the Bay Area (Table D.10). The mass of sediment removed per cleanout was converted to a mass removed per acre based on the total drainage area to a given pump station.

Table D.10. Stormwater Pump Station Maintenance Load Reduction Benefits.

Pump Station	Data Source	Cleanout Date(s)	Sediment Removed During Cleanouts (lbs)
Pulgas Creek Pump Station, San Carlos	City of San Carlos	2011	16,000
Ettie Street Pump Station, Oakland, CA	Kleinfelder (2006)	2001 - 2006	123,000
	Salop et. al. (2006)	2006	57,000 - 93,000
	Ettie Street Pump Station Cleanout	2013	18,000

Similarly, storm drain line cleanouts were calculated from the available data on sediment mass removed during cleanouts. Storm drain line cleanouts for purposes of reducing POC loads are not part of the regular O&M activates for most municipalities; more typically storm drain line cleanouts are done to remove blockages and to prevent flooding. However, in cases where sections of storm drain lines have been identified with stored sediments known or suspected to have elevated POC concentrations, a clean out of that line may provide load reduction benefits. As reported in the CW4CB Sediment Management Practices Literature review (EOA and Geosyntec, 2011), a strategic cleanout of the Leo Avenue storm drain line removed approximately 7,700 lbs of sediment containing 4 to 70 g of PCBs based on the range of PCB concentrations previously measured in Leo Ave storm drain line sediments from an approximately 1,500 foot section of the storm drain line. Few other data are available on the load reduction benefits of storm drain line cleanouts, but based on this single case, the estimated load reduction for this cleanout was 5.1 lbs of sediment containing 0.003 to 0.05 g PCBs per linear foot of storm drain line cleaned. Given that this section of storm drain was known to contain a dip in the line where sediment accumulated over many years, and is located in an area of historically elevated PCB concentrations, these estimates would likely only be applicable to other locations with similar levels of sediment accumulation and sediment POC concentrations.

The load reduction benefits of street flushing were calculated similarly to the street sweeping effectiveness with the following modifications: (1) street dirt removal efficiency for street flushing is assumed to be higher than street sweeping; (2) to adjust the units from curb mile to linear mile, the initial street dirt load in Table D.7 was doubled for street flushing (e.g., the units for street flushing includes the entire width of the street from curb to curb for one linear mile flushed, while the units for street sweeping include only one side of the street per curb-mile swept); (3) flushing is not part of the current baseline conditions (Table D.11). The estimates for the range of initial street dirt loadings as well as removal efficiencies were based on interpretation of literature data compiled in the CW4CB Municipal Sediment Management Practices Literature Review (EOA, Inc. and Geosyntec Consultants, 2011).

Table D.11. Street Flushing Load Reduction Benefits

Initial Street Dirt Loading (lbs/linear mile)	Effectiveness	Street Dirt Load Reduction (lbs/linear mile flushed)
1,600	60%	960
1,000	60%	600
400	60%	240

Stormwater Treatment Measures

Cost Estimates

The cost estimates for stormwater treatment measures are focused on those types of measures that are currently being pilot tested to meet MRP requirements, including both the CW4CB stormwater treatment retrofit pilot projects and other MRP green street retrofit projects, as described in IMR Part B (Section B.7). The costs associated with these types of BMPs generally fit into six cost categories, including project concept and planning, design, construction and installation, equipment, operating, and reporting, costs. To the extent possible, cost data were gathered for each of these cost categories from the literature, direct inquires to local city staff and MRP pilot study budgets.

The International Stormwater BMP Database (www.bmpdatabase.org) was reviewed for cost data. The database was queried for stormwater treatments with associated cost information, since it is not mandatory to provide cost information with a project submittal. There were approximately 50 records since the year 2000 with variable and inconsistent levels of cost information. About half of these 50 BMPs involved apparently proprietary filter type devices located at I-95 Plazas along the North Eastern coast of the United States. The Center for Watershed Protection Online Watershed Library (http://www.cwp.org/owl-online-watershed-library/cat_view/63-research/73-economics) was also reviewed for BMP cost information. There were approximately 35 reports cited containing BMP related economic information. One particularly useful document was a 2011 report "*Costs of Stormwater Management Practices in Maryland Counties*" by King and Hagan (2011). This study was commissioned by Maryland Department of the Environment (MDE) to assist Maryland communities with developing cost estimates for their urban BMP scenarios developed to meet the Chesapeake Bay TMDL using the Maryland Assessment and Scenario Tool.

King and Hagan (2011) present life cycle costs per impervious acre treated for 24 urban stormwater BMPs in 2011 dollars. Sources of the cost data provided include a national literature review of published articles and reports, previously developed stormwater cost databases and models, Maryland MS4 reports submitted to MDE, interviews with Maryland local stormwater staff, contractors and others who work on stormwater projects in the state, and applications of the WERF stormwater unit cost model using cost adjustment indicators developed for Maryland counties with MEANS 2011 Regional Construction Cost Indicators.

Cost estimates presented in King and Hagan (2011) for a subset of stormwater treatment retrofit types are summarized in Table D.12 below. The cost data include the following: pre-construction, construction, land, and total post-construction costs plus total costs over 20 years and annualized costs for each BMP type per impervious acre treated. There were a number of assumptions and caveats presented with the cost estimates (see footnotes, Table D.12). Overall, the estimates assume a design life of 20 years or greater, and do not reflect replacement costs over that 20 year time period. It is also important to note that the estimates relied on site-specific data for Maryland, and may not be representative of Bay Area specific costs.

Table D.12. Summary of Planning Level Stormwater Treatment Retrofit Cost estimates Per Impervious Acre Treated as Reported in Table ES-1 of King and Hagan (2011).

Stormwater Management Practice	Pre-Construction Costs[1]	Construction Costs[2]	Land Costs[3]	Total Initial Costs	Total Post-Construction Costs[4]	Total Costs over 20 Years	Average Annual Costs over 20 Years
Hydrodynamic Structures	$7,000	$35,000	-	$42,000	$3,531	$112,620	$5,631
Infiltration Practices w/o sand	$16,700	$41,750	$5,000	$63,450	$866	$80,770	$4,039
Infiltration Practices w/ sand/veg	$17,500	$43,750	$5,000	$66,250	$906	$84,370	$4,219
Filtering Practices (sand, above ground)	$14,000	$35,000	$5,000	$54,000	$1,431	$82,620	$4,131
Filtering Practices (sand, below ground)	$16,000	$40,000	-	$56,000	$1,631	$88,620	$4,431
Bioretention (retrofit-highly urban)	$52,500	$131,250	$3,000	$186,750	$1,531	$217,370	$10,869
Bioswale	$12,000	$30,000	$2,000	$44,000	$931	$62,620	$3,131
Permeable Pavement w/o sand, veg	$21,780	$217,800	-	$239,580	$2,188	$283,347	$14,167
Permeable Pavement w/ sand, veg	$30,492	$304,920	-	$335,412	$3,060	$396,603	$19,830

[1]Includes cost of site discovery, surveying, design, planning, permitting, etc.

[2]Includes capital, labor, material and overhead costs, but not land costs.

[3]It is assumed that the opportunity cost of land for stormwater BMPs that require land is $50,000 per acre.

[4]Combined annual operating, implementation and maintenance costs.

Only one of the projects in Table D.12 was identified as a stormwater treatment retrofit, similar to the type of stormwater treatments that can be constructed in a highly developed region such as the Bay Area. However, cost data are provided for other stormwater treatments that would be constructed as part of new development to highlight the difference in costs between retrofits. These differences are further demonstrated by the comparatively higher cost estimates for the CW4CB stormwater treatment pilot projects (Table D.13), all of which are retrofits, and not associated with new development, as discussed below.

<u>CW4CB Stormwater Treatment Retrofit Pilot Project Budgets</u>

Cost data are available for eight retrofit pilot projects that were or will be constructed in Alameda, Contra Costa, San Mateo, Santa Clara, and Solano counties. These pilot projects are part of the CW4CB project to satisfy MRP Provisions C.11/12.e which require Permittees to evaluate and quantify the removal of mercury and PCBs 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. Further details about each of these projects are provided in IMR Part B (Section B.7). The budgets for these pilot projects (Table D.13) were estimated based on the best available information at the time of the writing of this report, including both EPA grant fund allocations for design/constructions costs, and expected in-kind contributions from participating county stormwater programs. A 25% mark-up was applied to the total budget to account for administrative costs, as well as provide some allowance for contingency. The unit cost estimates were based on the total estimated project costs for planning, design and construction divided by the treatment area for each project, and annualized costs over twenty years. Monitoring, annual operating costs and reporting were not included in the total and unit costs. However, operating costs were estimated to range between $2,700 - $5,400 per acre treated per year. All budget estimates are preliminary, as construction and monitoring have not been completed for all projects as of the writing of this report. These budget estimates provide current costs for Bay Area municipalities to design, construct and monitor various stormwater treatment retrofits at specific locations in the Bay Area, and could provide a reasonable basis for future planning purposes.

Table D.13. Clean Watersheds for a Clean Bay Stormwater Treatment Control Measure Pilot Project Estimated Budgets[1]

Pilot Retrofit Project:	Project Concept and Planning	Design	Construction/Installation	Monitoring	Annual Operating ($/acre)[2]	Reporting	Total Budget for Planning/Design/Construction ONLY		
							Total Cost (includes 25% Mark-Up)	Unit Cost[3] ($/acre)	Annual Cost over 20 Years ($/acre-year)[5]
West Oakland Industrial Area Tree Wells, Oakland, CA	$25,000	$30,941	$220,395	$160,768	-	$5,000	$345,420	$431,775	$21,600
Alameda and High Street Hydrodynamic Separator Unit, Oakland, CA	$25,000	$30,941	$200,000	$0	-	$5,000	$319,926	$9,140	$460
Leo Avenue Hydrodynamic Separator Unit, San Jose, CA	$25,000	$54,000	$139,161	$76,139	-	$15,000	$272,701	$1,274	$64
Bransten Road Curb Extensions – Bioretention areas with and without underdrains, San Carlos, CA	$25,000	$175,930	$466,888	$136,576	$2,700	$15,000	$834,773	$456,160	$22,808
PG&E Substation - 1st & Cutting Bioretention, Richmond, CA	$25,000	$113,000	$240,000	$173,000	-	$7,500	$472,500	$284,639	$14,200
Broadway and Redwood Flow-through Biotreatment (Swale), Vallejo, CA	$25,000	$30,721	$76,268	$17,000	$5,400	$7,500	$164,986	$177,405	$8,900
Ettie Street Pump Station Sand Filters, Oakland, CA	$25,000	$32,610	$53,800	$149,225	$3,000	$5,000	$139,263	-- [4]	-- [4]
PG&E Substation Catch Basin Media Filter, Vallejo, CA	$25,000	$30,721	$59,548	$78,688	$3,000	$7,500	$144,086	$1,108,356	$55,400

[1]All budgets are estimated based on expected allocation of CW4CB EPA grant funds and estimated in-kind contributions from participating stormwater programs as of the writing of this report.

[2]Estimates for annual operating costs were available for some of the projects and provided here for informational purposes only; these costs were NOT included in the total pilot project budgets.

[3]Unit cost was calculated for each treatment based on expected drainage areas as follows (in acres): Ettie: (954); Alameda & High (35);West Oakland tree wells (0.8); Leo (214); Bransten Rd (1.83); Broadway&Redwood (0.93); PG&E Substation Richmond (1.66); PG&E Substation Vallejo (0.13).

[4]Data available are on the acre-feet of water treated and therefore are not included in this table.

Green Street Pilot Project Budgets

In addition to the CW4CB projects, cost data are available for six green street pilot retrofit projects conducted to satisfy MRP Provision C.3.b.iii. This provision requires Permittees to complete green street projects which incorporate low impact development (LID) techniques. These projects are described in greater detail in IMR Part B (Section B.7). The costs for these pilot projects (Table D.14) were summarized from the data provided in the Final Green Street Pilot Projects Summary Report (Geosyntec, 2013) and include design, construction and (in some cases) annual operating costs. Annual operating costs were estimated to range from $1,500 to $3,800 per acre treated per year. The unit cost estimates were based on the total estimated project cost divided by the expected drainage area for each project.

These cost estimates provide current costs for Bay Area municipalities to design and construct various green street retrofit projects at specific locations in the Bay Area, and provide a reasonable basis for future planning purposes. However, the costs in Table D.14 do not include any planning, reporting, or monitoring costs, which, if included, would increase the total cost of each project. A mark-up of 25% was applied to the total costs to better reflect planning and administrative costs, as well as provide some allowance for contingency.

Table D.14. Green Street Pilot Retrofit Project Estimated Costs[1]

Pilot Project:	Design	Construction/ Installation	Annual Operating ($/acre)[2]	Total Costs w/ 25% mark-up[3] (excludes operating costs)	Drainage Area (acres)	Unit Cost[4] ($/acre)	Annual Cost over 20 Years ($/acre-year)
Codornices Creek Restoration Project, Berkeley and Albany, CA	$35,000	$140,000	$1,500	$218,750	1.93	$113,342	$5,700
El Cerrito Green Streets Project, El Cerrito, CA	Unknown	$324,127	$3,800	$405,159	1.33	$304,631	$15,000
Stanley Blvd Safety and Streetscape Improvement Project, Alameda County, CA	Only total budget available, not individual cost categories			$14,500,000	33	$439,394	$22,000
Sustainable Streets and Parking Lots Demonstration Project, Burlingame, CA	$55,000	$215,000	NA	$337,500	1.32	$255,682	$13,000
Hacienda Avenue Green Street, Campbell, CA	Only total budget available, not individual cost categories			$4,635,000	30.65	$151,223	$7,600
Southgate neighborhood Green Street, Palo Alto, CA	$300,000	$800,000	Not Available	$1,375,000	Not Available	-	-

[1]All costs are estimated based on the data reported in the Final Green Street Pilot Projects Summary Report (Geosyntec, 2013).

[2]Annual operating costs were estimated for some of the projects and provided here for informational purposes only, these costs were NOT included in the total project costs.

[3]Total budgets (excluding operating costs) were marked-up by 25% to account for administrative costs, and other potential costs not accounted for in the table.

[4]Unit cost was calculated for each project based on drainage area and total estimated costs (excluding Operating costs).

Load Reduction Benefits

The estimated load reduction benefits for stormwater treatment retrofits focused on literature reported ranges of expected percent mass load reduction of suspended sediment concentrations for a given BMP type, or as a range of expected suspended sediment effluent concentrations for a given BMP type. Table D.15 provides a recent summary of approved removal rates by the Chesapeake Stormwater Network (CSN) following an extensive compilation of available data on pollutant removal performance for a number of retrofit BMPs and review by an expert BMP review panel for stormwater retrofits (CSN 2012). It should be noted that these removal rates were based on data from facilities in the Chesapeake Bay Area. The rates may be different in the San Francisco Bay Area with its Mediterranean climate and seasonal versus year round rainfall pattern.

Table D.15. Approved Suspended Sediment Removal Rates for Urban BMPs in the Chesapeake Bay Area (CSN 2012).

Stormwater Management Practice	Suspended Sediment Mass Load Reduction %
Filtering Practices (Sand Filters)	80%
Bioretention with Underdrain	55-80%
Bioretention without Underdrain	90%
Bioswale	80%
Permeable Pavement with Underdrain	55-70%
Permeable Pavement without Underdrain	85%

Table D.16 provides a range of percent reductions in TSS mass calculated from estimated influent TSS concentrations reported in Geosyntec (2013) and expected effluent TSS concentrations for green streets projects as reported in the International BMP Database (www.bmpdatabase.org).

Table D.16. Calculated Load Reduction Effectiveness for MRP Green Street Pilot Projects.

	Calculated Average Annual TSS Mass Load Reduction (%)		
Assumed Infiltration Rate	*25%*	*50%*	*75%*
Bransten Road Curb Extensions - Bioretentions with and without underdrains, San Carlos, CA	62%	65%	67%
Codornices Creek Restoration Project, Berkeley and Albany, CA	62%	65%	67%
El Cerrito Green Streets Project, El Cerrito, CA	62%	65%	67%
Stanley Blvd Safety & Streetscape Improvement Project, Alameda County, CA	60%	63%	67%
Sustainable Streets & Parking Lots Demonstration Project, Burlingame, CA	60%	63%	67%
Hacienda Avenue Green Street, Campbell, CA	60%	63%	67%
Average	64%		
Range	60% – 67%		

Diversion to POTWs

Cost Estimates

IMR Part B (Section B.9) presents the results to-date of the Stormwater Pump Station Pilot Diversion Projects. Limited new cost information has been developed given that three of the five pilot projects (Palo Alto, Pulgas Creek Pump Station, and Ettie Street Pump Station) are small scale demonstration efforts, diverting approximately 500 gallons to a holding tank during a given dry or wet season monitoring event. Pilot project costs are expected to be in the $100,000 to $200,000 range, covering planning, mobilization, sampling, analysis, and reporting for the scheduled monitoring events during FY 2012-2013 and FY 2013-2014. The Fairfield/Suisun State Street Pump Station project diverted 825 and 1,200 gallons on a batch basis from the pump station sump during summer 2012.

The Contra Costa North Richmond Pump Station project remains in the planning and design phase. The estimated construction cost is $764,000 (as of December 2012). 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 current recommended approach is a “hard-piped” diversion, with flows routed into the nearest sanitary sewer collection system. 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.

Most of the available cost information on stormwater diversions has been focused on dry weather diversions, based on projects in Southern California implemented primarily for control of flows with elevated bacteria concentrations to bathing beaches. The Bay Area Clean Water Agencies (BACWA) prepared a Stormwater Diversion White Paper (2010) that summarized unit construction costs ($/gallons per day, gpd) for several dry weather diversion projects. Diverted flows ranged from 2,000 to 234,000 gpd, construction costs ranged from $14,000 to $463,000 and unit costs ranged from $0.14 to $6.50 per gallon per day.

The City of San Jose (2010) also prepared a Conceptual Stormwater Diversion Assessment that initially investigated peak wet weather diversions, but determined them to be infeasible and instead evaluated dry weather flow diversions. San Jose also based much of its evaluation on information from existing Southern California projects. San Jose and Santa Clara each developed cost estimates for one stormwater pump station in their respective service areas and then extrapolated those costs to other pump stations. Operating costs were assumed to be a function of the costs associated with treating flow only (at the SJ/SC WPCP). Construction costs were associated with installing piping to a sanitary sewer, a screening manhole, a pump/flow control manhole, miscellaneous costs, and 80% contingency costs.

As an example, the San Jose Nelo/Victor pump station project was estimated to cost $800,000 to divert 0.25 million gallons per day (mgd) of dry weather flow. This included $540,000 of diversion facility cost plus $260,000 for 1,800 feet of pipeline to connect to the sanitary sewer. Cost variations were primarily a function of the length of sanitary sewer connection pipeline required. The annual operating costs presented were solely the costs to treat the flow at the SJ/SC WPCP, not operating costs associated with the pump station diversion. For Nelo/Victor this was estimated at $20,000 (based on $400/million gallons (MG) treatment cost).

Probably the most pertinent cost information is contained in the Stormwater Pump Station Diversions Feasibility Evaluation Report (FER) prepared for BASMAA (2010). Table D.17 (modified from Table 2.3 from that report) provides capital and operating cost information on a variety of potential dry and wet weather diversion projects. These Table D.17 costs do not include POTW connection fees (typically ~$9,000 to $18,000 per thousand gallons per day) or POTW treatment fees (typically ~$300 to $4,200 per MG treated). As outlined in the FER, there are a large number of institutional issues that would need to be addressed and overcome prior to implementation of a full-scale diversion project.

One of the simplest and most and cost-effective diversion approaches is represented by Project 4 (Table

D.17), which represents a situation where storm drain lines are located in close proximity to sanitary sewers and at appropriate elevations such that wet weather overflows could be designed to flow by gravity into the sanitary sewer. This is similar to the Palo Alto pilot diversion project that was constructed in 1993 at a cost of approximately $135,000 (includes design and construction cost estimates, adjusted to 2013 dollars using http://www.usinflationcalculator.com) and designed to divert up to 0.5 mgd.

Projects 6 through 9 (Table D.17) represent variations on hard-piped constructed diversions from storm sewers located moderate to far (>500 ft piping) distances from a suitable sanitary sewer. These systems could include operational controls that would allow selective pilot diversion of first flush and wet weather events in addition to dry season flows. The proposed Ettie Street and the North Richmond Pump Station Pilot Diversion Projects are examples of this category of diversion project.

The FER project (Table D.17) capital costs ranged from $500,000 to $3,000,000+ with operating costs of $10,000 to $60,000. Systems supporting gravity feed would tend to have operating costs at the lower end of the range. Simple annual costs over 20 years (no compound interest or inflation assumptions) ranged from $15,000 to $210,000 per year. Costs will be highly site specific.

Table D.17. Estimated Costs for Different Pilot Diversion Approaches (based on BASMAA 2010).

Pilot Diversion Approach	Capital Cost ($)	Operating Cost ($/yr)	Total Costs Over 20 Years	Annual Costs Over 20 Years ($/yr)
1. Non-constructed pilot diversion using all rented equipment for strategic cleanout (7 days duration)	0	$28,000	$560,000	$28,000
2. Non-constructed pilot diversion using all rented equipment in wet weather (30 days duration)	0	$180,000	$3,600,000	$180,000
3. Non-constructed pilot diversion using all rented equipment in dry weather (90 days duration)	0	$360,000	$7,200,000	$360,000
4. Constructed pilot diversion adjacent to sanitary sewer large enough to support gravity feed	$100,000	$10,000 – $60,000	$300,000 - $1,300,000	$15,000 - $65,000
5. Constructed pilot diversion adjacent to sanitary sewer requiring pumped feed	$500,000	$10,000 – $60,000	$700,000 - $1,700,000	$35,000 - $85,000
6. Constructed pilot diversion with moderate connection distance (<500 ft) to sanitary sewer large enough to support gravity feed	$500,000 – $1,500,000	$10,000 – $60,000	$700,000 - $2,700,000	$35,000 - $135,000
7. Constructed pilot diversion with moderate connection distance (<500 ft) to sanitary sewer via small diameter conveyance requiring pump	$500,000 – $1,000,000	$10,000 – $60,000	$700,000 - $2,200,000	$35,000 - $110,000
8. Constructed pilot diversion with long connection distance (>500 ft) to sanitary sewer large enough to support gravity feed	$1,500,000- $3,000,000+	$10,000 – $60,000	$1,700,000 - $4,200,000	$85,000 - $210,000+
9. Constructed pilot diversion with long connection distance (>500 ft) to sanitary sewer via small diameter conveyance requiring pump	$500,000 – $1,500,000	$10,000 – $60,000	$700,000 - $2,700,000	$35,000 - $135,000

Temporary pilot diversion costs assume $4,000 per day for labor during dry weather pilot diversions (four person crew) and equipment (one 20,000 gallon storage tank, three pumps, two support trucks, temporary check dams, and incidental equipment). Temporary pilot diversion costs are assumed to be 50 percent higher ($6,000 per day) during wet weather because of difficulties introduced by scheduling, safety and logistics.

Load Reduction Benefits

Limited data are available on the concentration of POCs contained in dry season discharges (or sump cleanings) from stormwater pump stations. Such discharges may contain minimal loads of POCs. Dry season discharges would likely, however, present fewer capacity challenges than first flush discharges for POTWs with collection system and/or treatment system hydraulic constraints.

Pump station cleaning and controlled dry season discharges could be coordinated with otherwise routine pump station inspection and/or DO monitoring events (MRP Provision C.2.d). This alternative is described in Table D.17 (above) under Pump Station Maintenance. Project (1) in Table D.17 is a variation on sump cleanout where it is assumed that over a period of seven days during dry weather, accumulated contaminated sediments would be removed for a section of the stormwater conveyance system. The FER used an example where a total of ten kilograms of sediments would be removed having an average PCB concentration of 10 mg/kg, resulting in a removal of 100 mg of PCBs.

Table D.18 below (excerpted from Table 6 in IMR Section B.2.8 on Stormwater Pump Station Diversions) shows the range in grams of PCBs diverted under various assumptions of gallons diverted and PCB concentration in the diverted flow. For example, if the average PCB concentration in diverted stormwater was 50 ng/L, each million gallons diverted would reduce PCB loads discharged to the Bay by about 0.2 grams. The FER assumed that POTWs would remove essentially all (> 95%) of the PCBs from stormwater delivered to them.

Table D.18. Grams PCBs Diverted for Assumed Flow Diverted and PCB 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

APPENDIX E

Summary of PCB and Mercury Fate and Transport Studies

Summary of POC Fate and Transport Studies

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 provide updates on the status of these studies.

The RMP Multi-Year Plan[9]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
- 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 2013 the 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 200x 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

[9] 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

not been integrated among different sections of the synthesis or finalized to incorporate review comments but may include:

- o Continuing RMP monitoring of sport fish and small fish, with consideration of additional sampling locations or time series to support multiple objectives.
- o Assessment of sediment trends data and the potential value of continuing to track dry season trends.
- o Assessment of PCBs in the Bay margins using indicator species and sediment.
- o Identification of high-leverage watersheds or groups of watersheds contributing high PCBs in marginal areas
- o Identification of source areas for cleanup, with more emphasis on source control,
- o 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.

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