

Desktop Evaluation of Controls for Polychlorinated Biphenyls and Mercury Load Reduction

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ACRONYMS

| | |
|----------|---|
| ABAG | Association of Bay Area Governments |
| ACCWP | Alameda Countywide Clean Water Program |
| BASMAA | Bay Area Stormwater Management Agencies Association |
| BMP | Best Management Practices |
| CALTRANS | California Department of Transportation |
| CASQA | California Stormwater Quality Association |
| CIWMB | California Integrated Waste Management Board |
| CWP | Center for Watershed Protection |
| EOA | Eisenberg, Olivieri & Associates |
| KLI | Kinnetic Laboratories, Inc. |
| PCB | Polychlorinated Biphenyl |
| RWQCB | Regional Water Quality Control Board |
| SFEI | San Francisco Estuary Institute |
| TMDL | Total Maximum Daily Load |
| TSS | Total Suspended Solids |
| USEPA | United States Environmental Protection Agency |

EXECUTIVE SUMMARY

The San Francisco Regional Water Quality Control Board (RWQCB) has adopted a Total Maximum Daily Load (TMDL) for discharges of mercury and Polychlorinated Biphenyls (PCBs) into San Francisco Bay. The TMDLs establish allocations to various sources including sources associated with urban stormwater runoff. The San Francisco Estuary Institute (SFEI) received a grant under the Proposition 13 Coastal Nonpoint Source Program to review and evaluate existing literature, and conduct additional monitoring and analysis to better understand the sources, transport, fate, and efficacy of alternative control measures. The ultimate goal of the project was to develop information and tools that could assist local agencies in developing their local TMDL implementation plans.

As part of the project a White Paper titled “Review of Methods to Reduce Urban Stormwater Loads” was developed that analyzed mercury and PCB usage in the San Francisco Bay Area and identified and quantified the various sources. As part of the desk top analysis, we started by converting the original source identification information provided in the White Paper into sources by land use. This analysis provided estimates of the annual loads of mercury and PCBs to the San Francisco Bay from various land use categories. Using the results from the source and land use characterization analysis, we developed BMP scenarios and evaluated their effectiveness in terms of reducing the loads to the Bay.

For each BMP scenario, we developed a workbook that was designed to be easy to follow, transparent and flexible. Each workbook allows the user to understand the source of the data, change the assumptions, and to refine the calculations as more data become available. The concept behind providing workbooks that can be updated reflects the uncertainty in the current estimates, especially as relates to the absolute values of the projection, and will allow users in the future to conduct sensitivity analysis and improve the confidence in the absolute estimates.

The source and land use characterization analysis showed that the highest unit loadings for both mercury and PCBs were in industrial and commercial areas, so we often focused on industrial and commercial areas when selecting BMP scenarios. We developed scenarios to reduce the load of mercury and PCBs to the San Francisco Bay through a variety of means: pollution prevention, maintenance, and treatment.

The BMP scenarios we considered were:

Institutional Controls (Pollution Prevention):

1. Fluorescent Bulb Recycling (Mercury)
2. Thermostat Recycling (Mercury)
3. Building Demolition and Recovery (PCBs)

4. Regional Atmospheric Sources (e.g., crematoria) (Mercury)

Institutional controls (Maintenance):

- 5. Street Sweeping,
- 6. Street Washing,
- 7. Drop inlet Cleaning,

Treatment (or cleanup for elevated industrial areas):

- 8. Redevelopment,
- 9. Elevated Industrial Areas¹
- 10. Pump Station Diversions to waste water treatment plants

With respect to mercury load reduction, street washing and pump station diversions are projected to achieve very low load reductions, in part because the areas where such practices could be conducted were assumed to be limited to areas in reasonable proximity to waste water treatment plants. Treatment BMPs targeting elevated industrial areas and redevelopment are projected to have low load reductions because runoff concentrations of mercury are low and treatment effectiveness for mercury based on the settling tests conducted by SFEI are modest. The most effective scenarios tend to be those that address source control and maintenance, namely air emissions, recycling, street sweeping, and drop inlet cleaning. The underlying concept is that the closer one gets to the source, the more effective the control. Controls like recycling that address the product at its point of usage are superior in effectiveness.

In contrast to mercury, the projected load reductions of PCBs are generally less than 1 kg/yr. PCB recovery as part of building demolition may be higher, but the available data exhibits an order of magnitude range in projected effectiveness². Street sweeping, and drop inlet cleaning in industrial areas are projected to result in relatively higher load reductions. Also treatment of runoff from elevated industrial areas in the case of PCBs shows improved load reductions over that for Hg. Treatment of industrial areas as part of redevelopment projects shows comparable results to those achieved with Hg.

¹ Elevated industrial areas are defined as industrial areas where PCB or mercury concentrations in soils or street dirt are in upper quartile of data (further discussed under scenario).

² The San Francisco Estuary Partnership is planning a study with a goal of developing Bay Area- specific best management practices (BMPs) to prevent release of BCBs from building materials into urban runoff, which will help refine these estimates.

For each scenario we identify the key assumptions and sources of uncertainty. In many of the scenarios we provide a range of projections based on different assumptions that allow the reader to appreciate the uncertainty in the projections. The major sources of uncertainty consisted of:

- ***Projecting into the Future:*** In a number of scenarios we projected load reductions out to 20 years that were based on current data and information. It is very likely that in the future changes in product usage, community awareness, regulations, development patterns, and other factors will be quite different from that assumed in the scenarios. This was the driving consideration in our desire to provide scenario workbooks that ideally could easily be modified as conditions and new information become available.
- ***Projecting Local Study Results to San Francisco Bay Area as a Whole.*** Although a number of data sets that were utilized to characterize current conditions are regional, in a number of scenarios we depended on local data developed by one or more municipal agencies (generally cities or counties). This then required that the results of individual studies be projected based on some type of translator such as land use, area, or population.
- ***Inability to Accurately Incorporate Land Use in Scenario Development:*** The data analysis conducted as part of this project shows a strong land use signal, and thus land use is a key consideration when considering implementation strategies. Most scenarios did so, but in some cases, we were required to make assumptions that did not necessarily take into account land uses to the extent desirable.
- ***Potential for Overlap Amongst Scenarios:*** Some of the scenarios clearly overlap. For example, any efforts to address atmospheric deposition will, if effective, reduce the effectiveness of scenarios such as street sweeping that is designed to reduce the accumulation of constituents on watersheds. At this level of analysis, we are not able to quantitatively take into account the possible effects of such potential linkages.

This analysis is considered a “work in progress” that should be updated as additional information becomes available. With the advent of the MRP, various municipal agencies are planning to continue or implement additional pilot studies that should help to refine the scenarios contained herein, and to develop new scenarios. As shown in this report a key element in crafting effective control measures is taking into account land use type and condition. It is strongly recommended that the design of such studies take into account land use types and conditions within a land use that may be important in characterizing loads and prioritizing controls. It is also recommended that agencies consider adapting the workbooks developed as part of this project, to assist in identifying, prioritizing, and extrapolating the results from their pilot studies.

1.0 INTRODUCTION

1.1 TMDL Requirements

The San Francisco Regional Water Quality Control Board (RWQCB) has adopted a Total Maximum Daily Load (TMDL) for mercury discharges into San Francisco Bay. The RWQCB also has developed a Polychlorinated Biphenyls (PCB) TMDL that was approved by the US EPA on March 29, 2010. The purpose of the TMDLs is to protect sport fishing, human health, aquatic organisms, wildlife and rare and endangered species in the San Francisco Bay. The mercury TMDL calls for a load reduction of 78 kg/yr mercury, which is approximately a 50% reduction from the current estimated loads for the baseline year of 2003. The corresponding load reduction for PCBs is 18 kg/yr, which represents a 90% reduction from estimated loads for 2003, the assumed baseline year.

1.2 Proposition 13 Grant

The San Francisco Estuary Institute (SFEI) received a grant under the Proposition 13 Coastal Nonpoint Source Program to review and evaluate available existing literature and local implementation of best management practices (BMPs) used to reduce loadings of sediment-associated contaminants in urban stormwater discharges to the bay. The Project is intended to address:

- Sources of mercury and PCB in the urban environment, including the magnitude and distribution, and the processes by which mercury and PCB are mobilized by rainfall and stormwater runoff, especially in the context of areas which could be mitigated by all kinds of management options including institutional BMPs, soil remediation on public and private lands, and treatment control BMPs;
- Processes by which mercury and PCB are transported and transformed within the urban drainage, and factors that affect the treatability of these constituents in BMPs and the placement of treatment control BMPs; and
- The efficacy of source control programs to prevent these constituents from entering the storm drainage network, and the efficacy of treatment devices in removing mercury and PCB from stormwater in the drainage network.

The Desktop Evaluation addresses the last topic, the efficacy of source and treatment controls. The Project Grant called for conducting an initial Desktop Evaluation to help identify: (1) the more promising control options, and (2) data gaps and monitoring requirements to verify and refine the load reduction estimates. A monitoring plan was then developed and implemented by SFEI to fill some of the data gaps. This Desktop Report was then revised in 2010 taking into account data obtained by SFEI.

1.3 Elements of the Desktop Evaluation

The Desktop Evaluation consists of two parts: the characterization of sources by land use, and the evaluation of BMP scenarios.

The land use analysis builds on a previous task that culminated in a White Paper (McKee et al, 2006) which described and quantified the sources of mercury and PCBs entering San Francisco Bay. To select and prioritize controls such as treatment or maintenance activities, we characterized the sources, as identified in the White Paper, in terms of the likely land uses affected by those sources. This analysis was performed with the aid of spreadsheets used to calculate the annual loads of mercury to the San Francisco Bay from various land use categories.

The selection of BMP scenarios was guided by what was learned from the land use source evaluation. The analysis of effectiveness was captured with BMP scenario spreadsheets which incorporated local, regional and national data to calculate the mercury and PCB load reduction estimates for the BMP scenarios.

1.4 Organization of Report

The report is organized into two main sections. In Section 2 we assign PCB and mercury source information developed in the White Paper to various land uses, as land uses as many of the BMP scenarios are organized by land use. In Section 3 we describe each scenario and projected load reductions using the associated spreadsheet model. In each description we outline the approach, assumptions, and limitations. Two short sections at the end of the report discuss overall uncertainty (Section 4) and summarize results and make recommendations (Section 5).

2.0 CHARACTERIZATION OF SOURCES BY LAND USE

2.1 Approach and Data Sources

A White Paper titled “The Review of Methods to Reduce Urban Stormwater Loads” (McKee et al, 2006), which was developed early in the project, formed the basis for the land use and source characterization spreadsheets. The White Paper characterized the sources, the means of transport, and the contribution to San Francisco Bay Area storm water loads of mercury and PCBs.

The White Paper described and quantified the sources of mercury and PCBs entering San Francisco Bay in a series of pie charts. Although this information is ideal for addressing pollutant prevention, it is convenient to characterize sources by land use when selecting and prioritizing other types of controls such as treatment or maintenance activities that will be deployed spatially throughout the drainage system. The purpose of the land use characterization is to apply the source information from the White Paper to those land uses that are most likely to be affected by the sources. This was accomplished using a spreadsheet in a diagram format to calculate the annual loads of mercury and PCBs to the San Francisco Bay from various land use

categories (see Appendix A). The diagrammatic format uses arrows to display the flow of calculations. Where no data were available from the White Paper, other data sources or professional judgment were used to apportion loads. The apportionment of loads in the spreadsheets is, in many cases, subjective, but represents the best available information at this time.

2.2 Spreadsheet Features and Organization

Two diagram spreadsheets were developed, one for PCBs and one for mercury. Printed representations of the spreadsheets can be found in Appendix A. The first column of the spreadsheet includes contributions from various sources, which were grouped by pathway. These pathways include erosion, atmospheric deposition, volatilization/deposition, and contaminated soil. The mercury or PCB load from each source was apportioned by land use and then summed to find the total load from each land use. These resultant loads were broken down by “impervious surface type” (i.e. roofs, streets, parking and soils) to find the loads associated with pervious and various types of impervious urban surfaces.

2.3 Results

The results of the analysis were portrayed in a pie chart that displays the estimated percentage of mercury and PCBs which enter the storm water system originating from industrial, commercial, residential, and open space/agricultural areas. To compare the relative loads from land uses, we computed a “unit loading” by dividing the annual loads from each land use by the area of that land use. We then computed a “normalized unit loading” by dividing the units loads associated with various urban land uses by the unit load for open/agriculture. The land use areas were based on the 1995 Association of Bay Area Governments land use statistics as presented by Davis, et al. (2000). The “unit loading” and “normalized unit loading” is shown in the histograms in Figures 2-1 and 2-2, and in Tables 2-1 and 2-2.

Results from the spreadsheet model indicate the largest contribution of mercury loads to the San Francisco Bay is from open/agriculture areas, followed by residential, industrial, and commercial land uses. The largest contribution of PCB loads to the San Francisco Bay is from was estimated to be industrial areas, followed by open/agriculture, residential, and commercial land uses (Figure 2-2 and Table 2-2).

For both mercury and PCBs, the unit loading is highest for industrial and commercial, and lowest for residential and open/agriculture, which is consistent with our conceptual understanding of the source distribution and transport processes of these contaminants in the environment.

The differences between the land use loading for mercury and PCBs are likely caused by two primary factors. PCBs have not been manufactured in the United States since 1977, and are therefore considered a legacy pollutant. Thus, PCBs are most likely to be present in areas built and used for manufacturing prior to 1977. Though commercial production and use of Mercury has greatly decreased mercury continues to be used in some commercial applications such as

LCDs in TVs, cell phones, and PDAs, lighting (for example compact fluorescent bulbs), laboratories etc, and is additionally produced in the burning of fossil fuels, so it is both a legacy pollutant and a contemporary pollutant. An important mechanism that affects the distribution of mercury in the environment is volatilization and redistribution via atmospheric circulation and deposition (Tsai and Hoenicke, 2001). For these reasons, when compared with mercury, PCBs are more concentrated in current and historical industrial areas than in other land use types.

The highest unit loadings for mercury and PCBs are in industrial and commercial areas. Loadings from these areas are on the order of 2 to 8 times greater than unit loadings from residential and open areas. Therefore, BMP scenarios may be best targeted in industrial and commercial areas.

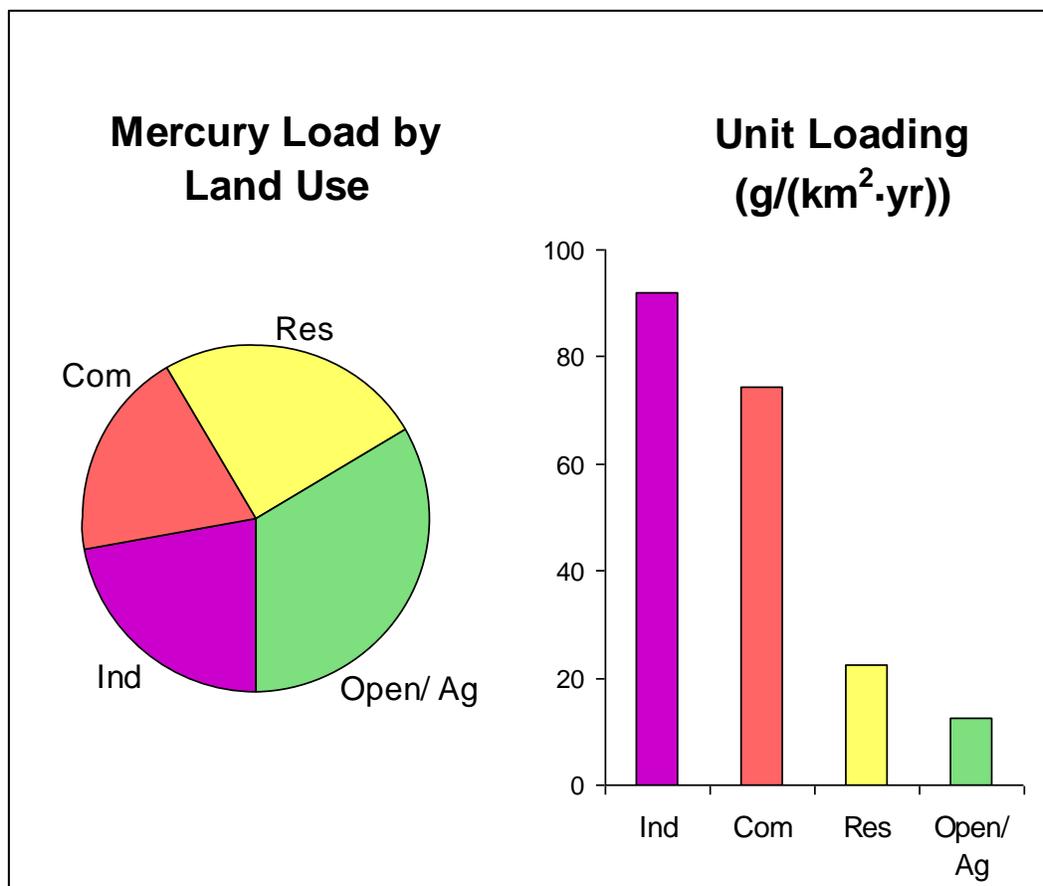


Figure 2-1: Annual Mercury Load and Unit Loading to the Stormwater System by Land Use

Table 2-1: Mercury Load to the Stormwater System by Land Use

| Land Use | Load (kg/yr) | Area ¹ (km ²) | Unit Loading (g/(km ² ·yr)) | Loading Normalized on Open Space |
|-------------------|--------------|--------------------------------------|--|----------------------------------|
| Industrial | 34 | 374 | 92 | 7 |
| Commercial | 30 | 404 | 74 | 6 |
| Residential | 39 | 1,726 | 22 | 2 |
| Open/ Agriculture | 52 | 4,147 | 12 | 1 |
| Total | 155 | | | |

¹The land use areas are from an analysis by Davis, et al. (2000) using the 1995 Association of Bay Area Governments land use statistics.

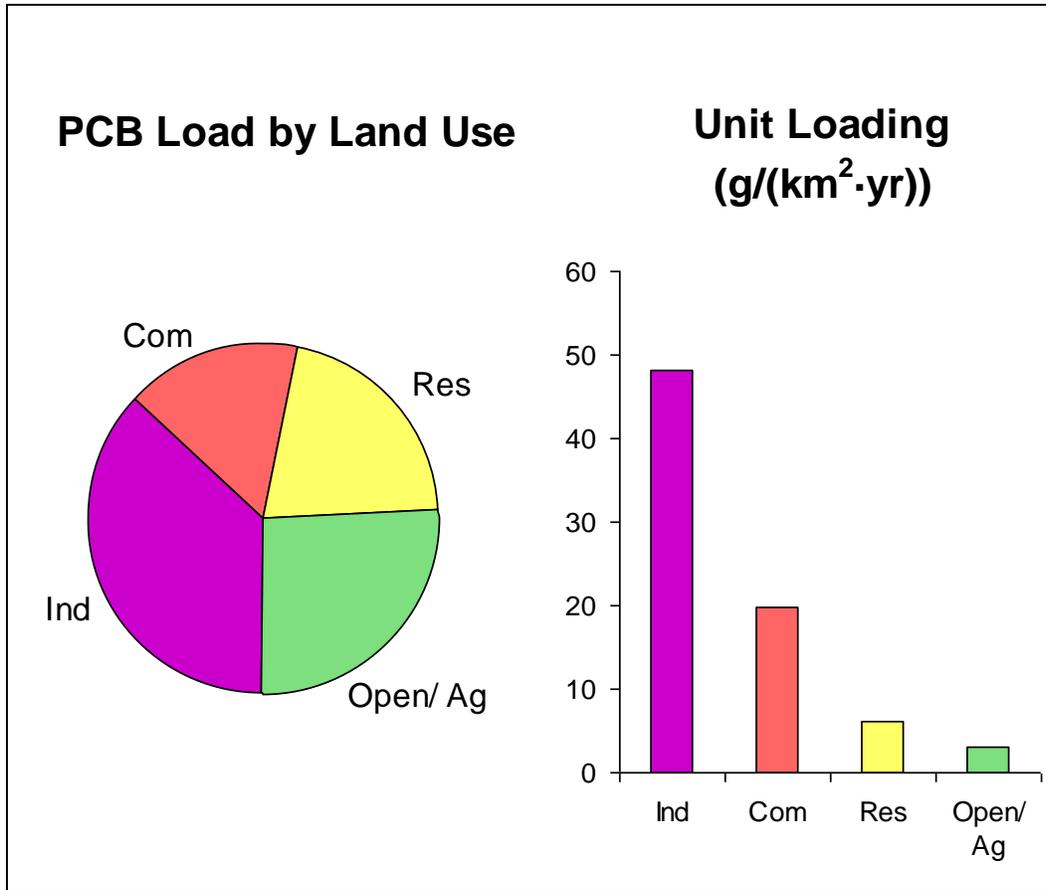


Figure 2-2: Annual PCB Load and Unit Loading to the Stormwater System by Land Use

Table 2-2: Annual PCB Load to the Stormwater System by Land Use

| Land Use | Load (kg/yr) | Area ¹ (km ²) | Unit Loading (g/(km ² ·yr)) | Loading Normalized on Open Space |
|-------------------|--------------|--------------------------------------|--|----------------------------------|
| Industrial | 18 | 374 | 48 | 16 |
| Commercial | 8 | 404 | 20 | 7 |
| Residential | 10 | 1,726 | 6 | 2 |
| Open/ Agriculture | 12 | 4,147 | 3 | 1 |
| Total | 49 | | | |

¹The land use areas are from an analysis by Davis, et al. (2000) using the 1995 Association of Bay Area Governments land use statistics.

3.0 EVALUATION OF EFFECTIVENESS OF BMP SCENARIOS

3.1 Approach and Data Sources

BMP scenarios were identified and evaluated in terms of effectiveness using a spreadsheet format. The BMP scenario spreadsheets were designed to be easy to follow, transparent and flexible, and to allow the user to change inputs and refine calculations as more data become available. All data sources are labeled and all calculation formulas are retained in the spreadsheet. Any input value can be changed and the calculations within the spreadsheet will update automatically, allowing the change in the estimated effectiveness of the scenario to be displayed immediately.

The effectiveness of each BMP scenario depends on the source control options being evaluated. However common factors that influence the effectiveness of all BMP scenarios include the magnitude of the source, the mercury and PCB concentrations associated with the source, the potential for stormwater to intercept the source prior to entering the Bay, and the estimated magnitude of the mass of mercury and PCBs intercepted. The official regulatory baseline for both TMDLs is 2003, so any load reduction associated with controls implemented before 2003 cannot be credited toward the TMDL goal. As a practical matter, much of the data used in the BMP scenarios is contemporary and effectively applies to current conditions in 2010.

The BMP scenario spreadsheets were designed to include the most current data to estimate the load reductions as accurately as possible with the information available. Several sources were used, and San Francisco Bay Area sources were used whenever possible. The following sections describe key data sources used in the evaluation.

3.1.1 Stormwater Runoff Monitoring Data Analysis of TSS Concentrations

Mercury and PCBs tend to adsorb to particulates, so in scenarios involving treatment, the effectiveness of the BMP starts with evaluating performance to treat total suspended solids in water (TSS) and specific grain sizes of TSS. Thus characterization of runoff TSS concentrations from land uses in the San Francisco Bay Area was used as a scenario spreadsheet input³ as was grain size and settling data (Yee and McKee, 2010).

3.1.2 Mercury and PCB Concentrations in Local Sediments

Although there is limited data on concentrations of mercury and PCBs in runoff in the San Francisco Bay Area, there is available data which includes concentrations of these pollutants in embedded sediments in drainage lines. The Joint Stormwater Agency Project to Study Urban

³ The Bay Area Stormwater Management Agencies Association (BASMAA) summarized stormwater runoff monitoring data in “San Francisco Bay Area Runoff Monitoring Data Analysis 1988-1995” (Woodward Clyde Consultants, 1996).

Sources of Mercury, PCBs and Organochlorine Pesticides (KLI & EOA, 2002) sampled sediments from storm drains, catchbasins, and open channels located in various land uses which then were analyzed for PCBs and mercury. A statistical analysis was conducted to characterize the concentrations of mercury and PCBs in sediments found in drop inlets and open channels for industrial, residential/commercial, open, and mixed land use areas.

The Alameda Countywide Clean Water Program (ACCWP) also conducted sampling in 2000-2001 of sediment in open channels as part of the effort to address pollutants of concern outlined in the Program's NPDES permit for stormwater discharge. The sampling and analysis included mercury, PCBs, polycyclic aromatic hydrocarbons, dichloro-diphenyl-trichloroethane (DDT), alpha chlordane, gamma chlordane, and percentage of sediment with a grain size of <62.5 microns (i.e. % fines) (Salop, 2002). To refine estimates of the mass of pollutants removed by inlet cleaning and street sweeping, ACCWP conducted sampling in 2004, 2005, and 2006 of material removed from storm inlets, pump stations, and open channels, as well as street sweeper hopper material (Salop, 2006). This study attempted to combine the data collected with reported estimates of the volume of materials collected by municipal programs, but unfortunately, most estimates did not distinguish how the materials were collected nor the associated land uses⁴.

The median concentrations of the data from these studies are summarized in Figure 3-1 and Figure 3-2. The concentrations of mercury and PCBs in embedded sediments obtained from the Ettie Street pump station are also presented. Note that the scale for Figure 3-2 is logarithmic. Exclusive of the Ettie Street Pump Station, the median concentrations of mercury generally found in embedded sediments (for urban land uses) varies from about 0.1 to 0.2 mg/kg (100 to 200 µg/kg); whereas the median concentrations of PCBs range between about 10 to 100 µg/kg.

These data provide insight into the distribution of adsorbed mercury and PCBs. As part of this project SFEI consolidated the data from these and other studies into a database along with additional data collected by SFEI as part of the overall Proposition 13 Project. Geosyntec then conducted additional statistical analyses for the various scenarios. Links to the data used to develop the scenarios are available in the spreadsheet models.

⁴ The lack of reporting information on source of materials collected by municipal programs (e.g., street sweeping versus drop inlet cleaning) or the land use (s) limited the utility of these data.

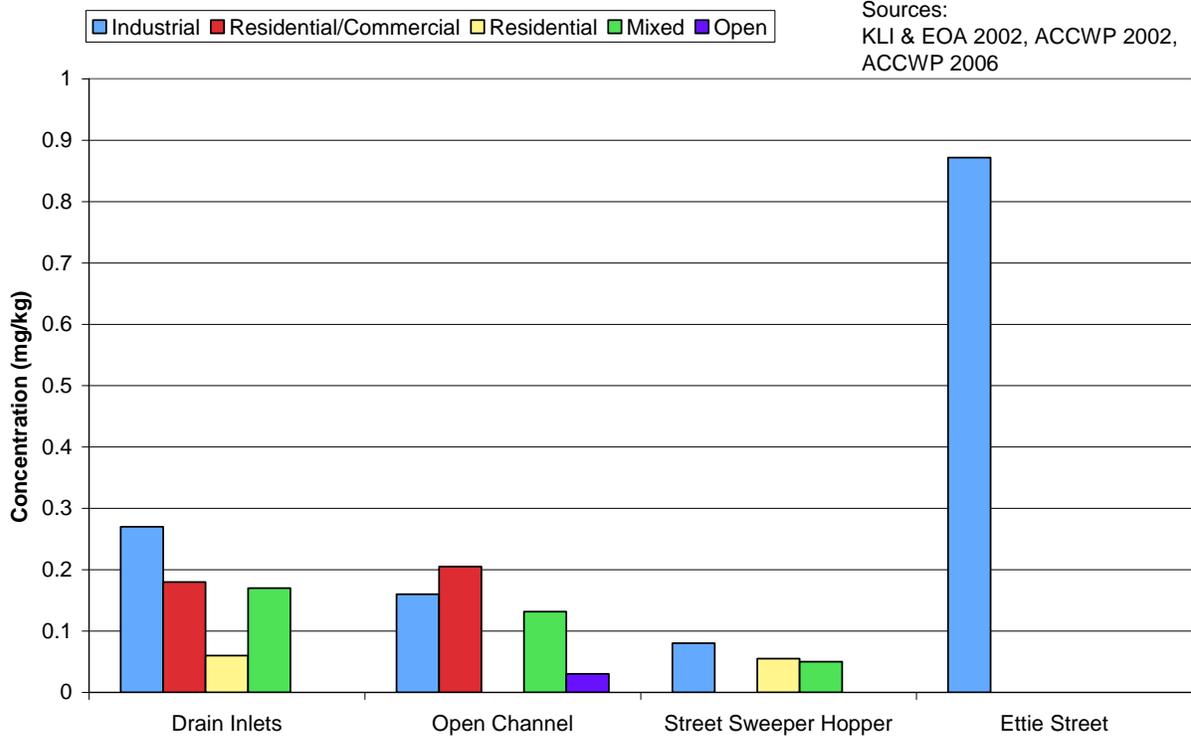


Figure 3-1: Concentration of Mercury in Sediment (from Selected Studies)

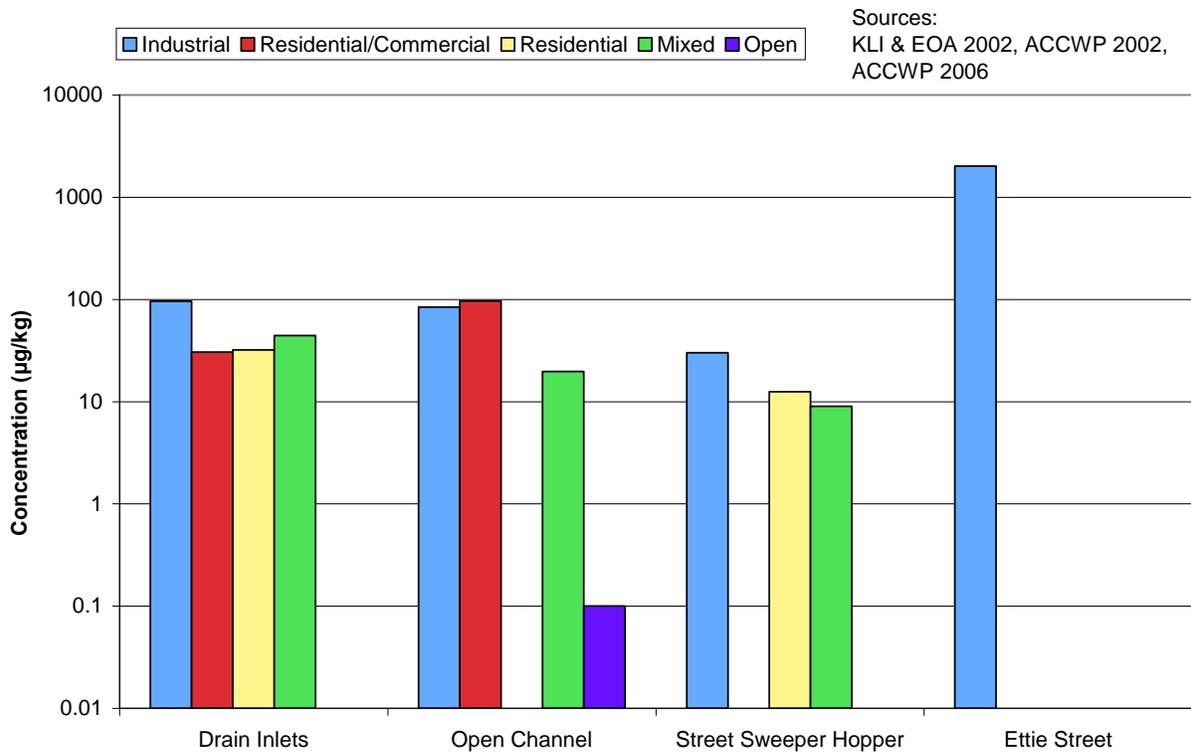


Figure 3-2: Concentration of PCBs in Sediment (from Selected Studies)

3.1.3 Association of Bay Area Governments Land Use Data

Effectiveness projections required information on the areas of various land uses in the San Francisco Bay Area. The Association of Bay Area Governments (ABAG) collects and evaluates land use information for the region. The land use areas used in this report were the 1995 ABAG statistics (ABAG, 1996) as presented by Davis, et al. (2000) for the local tributary watersheds and the urban areas draining to the San Francisco Bay. This land use breakdown is shown in Figure 3-3.

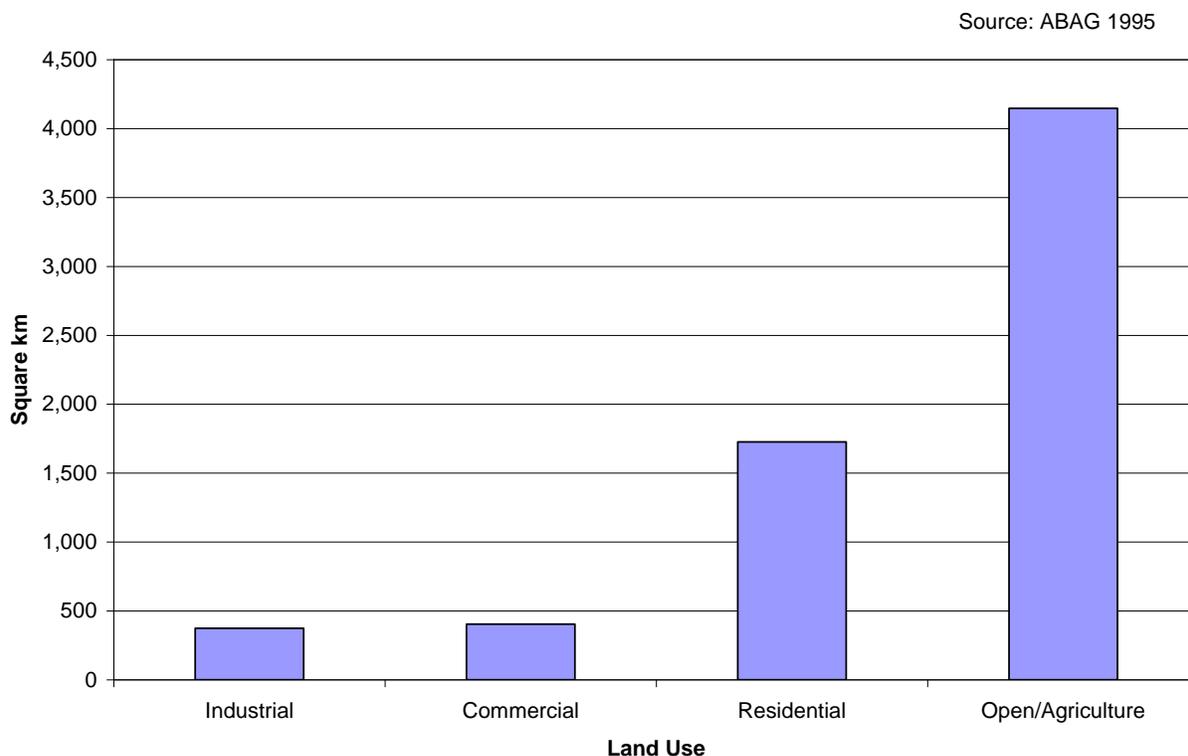


Figure 3-3: San Francisco Bay Area Land Use

3.1.4 Storm Inlet Cleaning Study

Mineart and Singh conducted a storm inlet cleaning study for the Alameda Countywide Clean Water Program in 1994 (Mineart and Singh, 1994). The study was designed to determine the effect of the frequency of cleaning on the amount of material removed (Table 3-1). For each of the three land uses, there were 20 drop inlet stations, 5 of which was monitored annually, 5 monitored semi-annually, 5 monitored quarterly and 5 monitored monthly. The inlets were located in Union City, Fremont, or Newark.

The data are presented in terms of volume and mass removed per cleaning, and intuitively we would see the values decrease with increased frequency of cleaning. Most, but not all of the data indicate this relationship. For example the amount of material removed in those drop inlets in residential areas actually was less with monthly cleaning than annual cleaning. One explanation for this is that (1) the mass of materials collected in residential areas was relatively less than that collected in other land uses, so results are sensitive to small changes in mass, and (2) it is possible that some of the inlets monitored annually had higher material loadings compared to those inlets monitored monthly.

We used the information from this study to estimate the increase in total material removed due to increased frequency of cleaning.

Table 3-1: Effect of Cleaning Frequency on Material Collected from Drop inlets

| Land Use | Cleaning Frequency | Monthly | Quarterly | Semi-annually | Annually |
|-------------|---|---------|-----------|---------------|----------|
| Residential | Number of Times Cleaned | 55 | 20 | 10 | 5 |
| | Mean Volume Collected Per Inlet per Cleaning (ft ³) | 0.42 | 0.41 | 0.62 | 2.17 |
| | Median Volume Collected Per Inlet per Cleaning (ft ³) | 0.4 | 0.34 | 0.57 | 1.7 |
| | Mean Mass Collected Per Inlet Per Cleaning (lbs) | 8 | 7 | 16.7 | 62 |
| | Median Mass Collected Per Inlet Per Cleaning (lbs) | 4.5 | 3 | 14.8 | 63 |
| Commercial | Number of Times Cleaned | 49 | 18 | 7 | 5 |
| | Mean Volume Collected Per Inlet per Cleaning (ft ³) | 0.38 | 0.6 | 0.96 | 1.39 |
| | Median Volume Collected Per Inlet per Cleaning (ft ³) | 0.33 | 0.46 | 0.94 | 0.94 |
| | Mean Mass Collected Per Inlet Per Cleaning (lbs) | 9.9 | 13.1 | 42.7 | 69.8 |
| | Median Mass Collected Per Inlet Per Cleaning (lbs) | 5 | 9.5 | 56 | 36 |
| Industrial | Number of Times Cleaned | 51 | 15 | 7 | 5 |
| | Mean Volume Collected Per Inlet per Cleaning (ft ³) | 0.28 | 0.53 | 0.93 | 0.56 |
| | Median Volume Collected Per Inlet per Cleaning (ft ³) | 0.2 | 0.46 | 0.8 | 0.47 |
| | Mean Mass Collected Per Inlet Per Cleaning (lbs) | 14.5 | 32 | 55.2 | 30.5 |
| | Median Mass Collected Per Inlet Per Cleaning (lbs) | 9 | 18 | 30 | 24 |

Source: Mineart and Singh, 1994.

3.1.5 Alameda Countywide Clean Water Program Maintenance Study

A study conducted by the Alameda Countywide Clean Water Program (ACCWP) inventoried Alameda County maintenance implementation for fiscal years 1998-1999 to 2002-2003 for street sweeping, and 2000-01 to 2004-05 for drop inlet cleaning (Salop, 2006). Volumes for street sweeping operations represent the sum of the “average” annual volumes reported by co-permittees in Alameda County for industrial, mixed, and residential land uses. Following Salop, volumes for drop inlet cleaning are based on 75% of the annual average volume of material collected from by storm drain maintenance operations (considered a median or “best” estimate). See Figure 3-4 for these volume estimates.

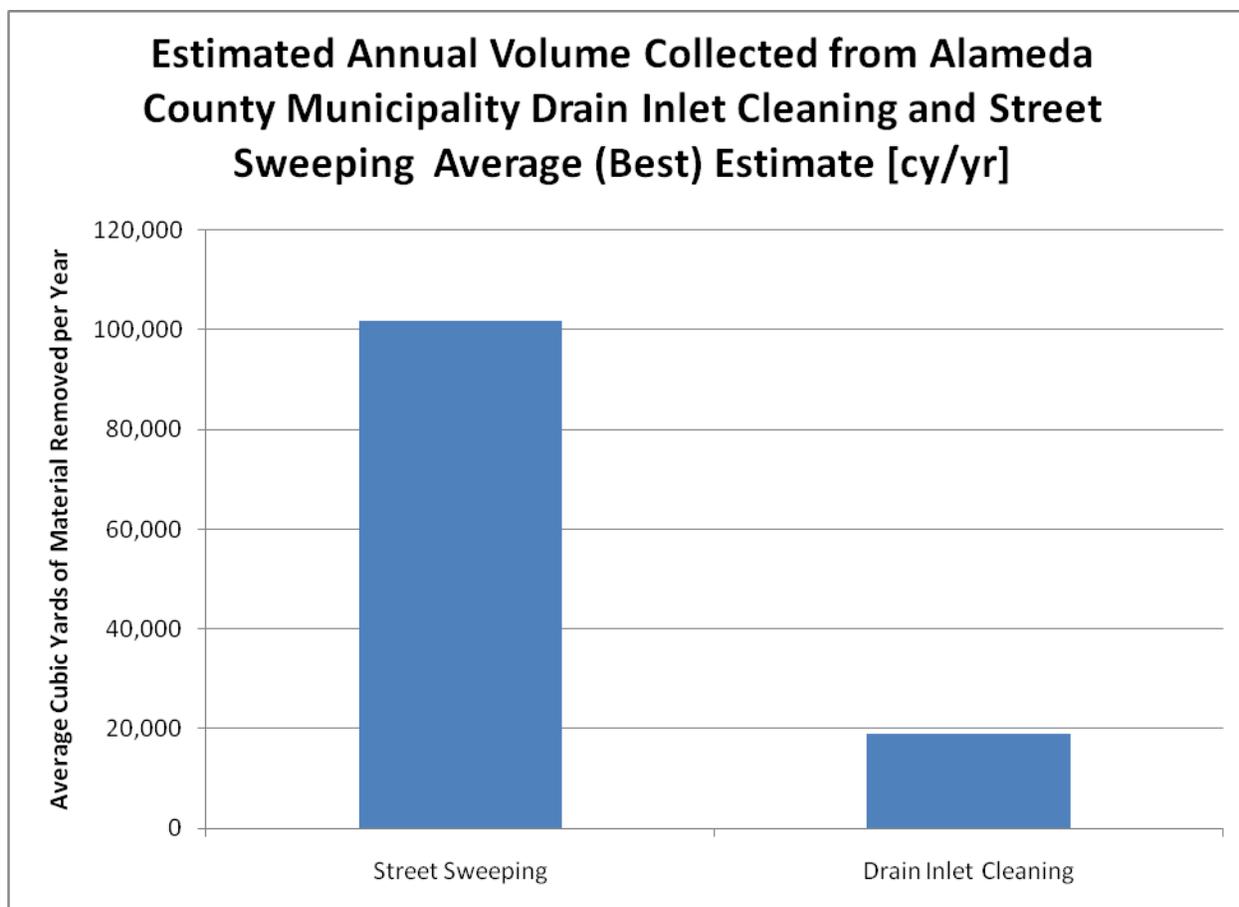


Figure 3-4: Estimated Sediment Management Volumes from Maintenance Activities in Alameda County

3.1.6 Treatment BMP Effectiveness

For the purpose of these BMP scenarios, treatment in the form of a settling BMP was considered for those scenarios incorporating treatment. In the interest of developing local data on PCB and mercury treatability, SFEI conducted settling column tests on stormwater runoff in the San Francisco Bay Area (Yee and McKee, 2010). The study sampled stormwater from two storm events at the sampling station operated in the Zone 4 Line A drainage channel (designated Z4LA) located in Hayward and operated by the Alameda County Flood Control and Water Conservation District. Using 4L bottles as settling chambers, samples were obtained from material which settled out within 2 minutes, and material which settled out within 20 minutes but

after 2 minutes. Based on research conducted by Sansalone⁵ conducted using Imhoff cones for settling, SFEI assumed that material that settled out in less than 2 minutes was >75 um and that which settled out in less than 20 minutes was >25 um. The percentage of total PCBs and mercury contained in each settled fraction was then determined. Although the data had some variability, the trends in the results are summarized in Table 3-2.

Table 3-2: SFEI Fractionation and Settling Study Results

| Constituent | Percent of mass settled out within 2 minutes ¹ | Percent of mass settled out within 20 minutes ¹ |
|-------------|--|---|
| PCBs | 30% | 55% |
| Mercury | 5% | 20% |

¹ Percentage reported to the nearest 5% in order to not overstate the accuracy and interpretability of the results..

Given that these data are specific to PCBs and mercury in the San Francisco Bay Area, these results were used to estimate removal efficiencies for treatment scenarios.

While other BMPs were not considered herein, other BMPs could be considered in the treatment-related scenarios in the future. The results displayed below demonstrate the relative effectiveness of various BMPs at removing solids. To determine the effectiveness of treatment controls in the removal of mercury and PCBs from stormwater, we conducted a short literature review. Little information is available on the removal effectiveness for mercury and PCBs. Since mercury and PCBs in stormwater have strong tendency to attach to particles, TSS removal can be considered a starting point for evaluating mercury and PCB removal effectiveness. The primary sources for data on treatment BMP TSS removal were the International Stormwater BMP Database (<http://www.bmpdatabase.org/>), the California Department of Transportation (CALTRANS, 2004), the Center for Watershed Protection (CWP) (Winer, 2000), and the California Stormwater Quality Association (CASQA, 2003).

The International Stormwater BMP Database contains monitoring data for many BMPs. Data are screened for quality before entry into the database, and the database is frequently updated so information is current.

CALTRANS conducted a BMP Retrofit Pilot Program in 2004. A number of different types of BMPs were installed and monitored in California highway facilities. This monitoring included data collection of TSS removal. The CWP also maintains a stormwater treatment database, the National Pollutant Removal Database for Stormwater Treatment Practices (Winer, 2000). This database also contains data on TSS removal for treatment BMPs. The CASQA California Stormwater BMP Handbook contains fact sheets for many BMPs. Using these sources and others which are included in the Reference section, we assessed the performance of a number of

⁵ Strecker, E., W. Huber, J. Heaney, D. Bodine, J. Sansalone, M. Quigley, M. Leisenring, D. Pankani, A. Thayumanavan, 2005, Critical Assessment of Stormwater Treatment and Control Selection Issues, Water Environment Research Federation Report 02-SW-1.

BMPs in the removal of TSS. Figure 3-5 shows the estimated median effluent concentrations of a number of treatment BMPs and is provided here primarily to represent the relative effectiveness of various BMPs based on the references used.

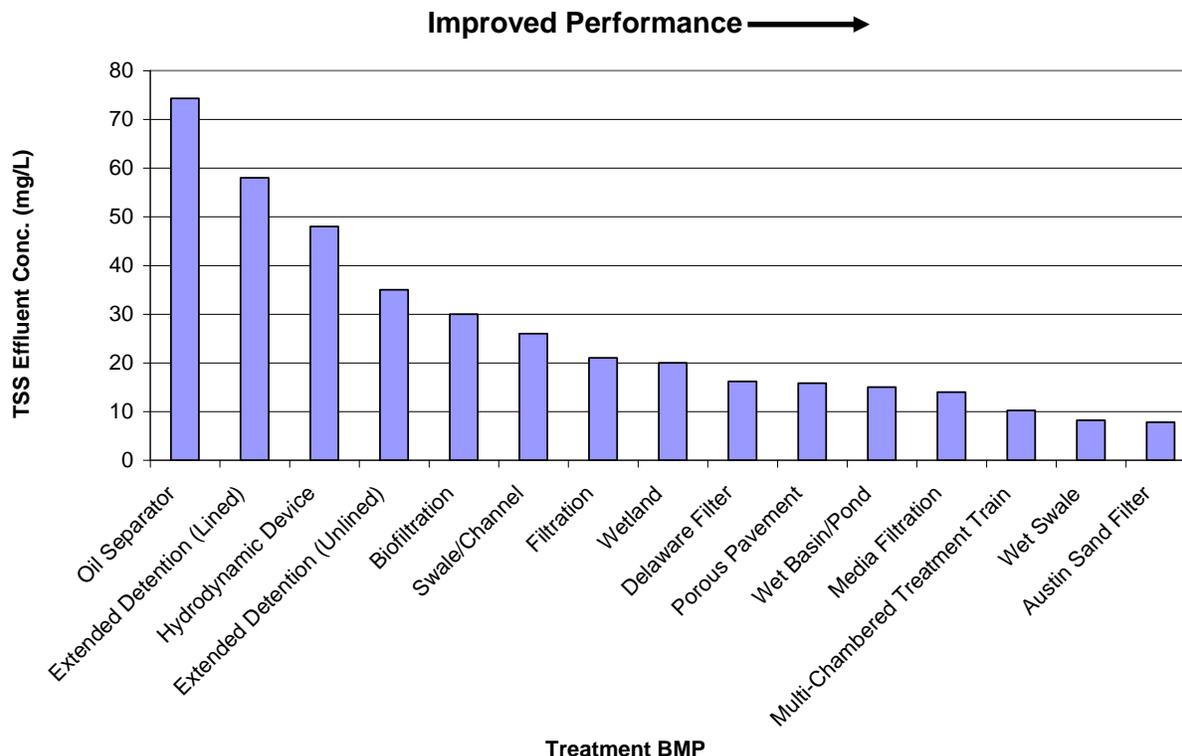


Figure 3-5 – Effluent TSS of Treatment BMPs

3.2 BMP Scenarios

We define a scenario as generally having three attributes:

- Type of control,
- Effectiveness of control in reducing loads, and
- Level of implementation of the control (e.g., frequency of application).

The BMP scenarios can be classified as follows under the broader categories of pollution prevention, maintenance, and treatment.

Institutional Controls (Pollution Prevention):

- Fluorescent Bulb Recycling (Mercury)
- Thermostat Recycling (Mercury)
- Building Demolition and Recovery (PCBs)
- Regional Atmospheric Sources (e.g., crematoria) (Mercury)

Institutional controls (Maintenance):

- Street Sweeping,
- Street Washing,
- Drop inlet Cleaning,

Treatment (or cleanup for elevated industrial areas):

- Redevelopment,
- Elevated Industrial Areas⁶
- Pump Station Diversions to waste water treatment plants

The scenarios address mercury and PCBs unless otherwise indicated. The pump station diversion scenario addresses first flush flows, whereas the treatment scenarios address wet weather load reduction.

3.3 Methodology Used to Estimate BMP Effectiveness

The overall methodology to estimate BMP effectiveness consisted of the following steps.

1. *Select BMP Scenarios* – BMP scenarios were selected to represent pollution prevention, maintenance, and treatment strategies that had sufficient data to support an effectiveness evaluation.
2. *Define BMP Scenario* – As described above, BMP scenarios were defined in terms of type of control, and level of implementation in terms of where control would be implemented, and for certain types of controls, frequency of implementation.

⁶ Elevated industrial areas are defined as industrial areas where PCB or Hgmercury concentrations in soils or street dirt are in upper quartile of data (further discussed under scenario).

3. *Literature Review* - Geosyntec and SFEI conducted additional research and literature review to characterize and further refine the BMP scenarios.
4. *Data Collection and Analysis* – Data relevant to the BMP scenarios that were available from studies conducted in the San Francisco Bay by municipal agencies and others were compiled into a master database by SFEI. SFEI also maintained a GIS data base that included land use and other information. The SFEI data and other relevant data were then compiled and statistically analyzed for each scenario, the results of which can be found in the scenario workbooks.
5. *Estimate Baseline Load Reduction for Existing Controls* – Utilizing existing San Francisco Bay Area monitoring data, estimate baseline load reductions associated with each scenario.
6. *Estimate Load Reduction Associated with Implementation of BMP Scenario* – Estimate effectiveness of BMP scenario based on local, regional, statewide, or national data.
7. *Make Regional Projections* – Baseline conditions and BMP effectiveness were projected from the local data sets that covered limited areas to those areas served by separate storm drain systems within the San Francisco Bay Local Watershed. Projections were commonly based on area, land use, or population.

3.4 **Assumptions**

The load reduction projections made herein are designed to assist municipalities in evaluating the relative merits of alternative control options. The projections are based on available data, which often was collected in the San Francisco Bay Area. Nonetheless, the projections include a number of assumptions and simplifications, and some scenarios rely on limited data. Where appropriate, we have attempted to address the uncertainty by providing a range in the projected effectiveness.

Key assumptions are as follows:

- *BMP Scenarios are assumed to be independent of each other* – In some cases, the implementation of one BMP scenario could affect the effectiveness of a second BMP scenario. For example, depending on how effectiveness is measured, reducing air emissions could affect the accumulation rates on streets which in turn could reduce the effectiveness of street sweeping or drop inlet cleaning. Evaluating the potential interaction of these scenarios quantitatively was beyond the level of analysis conducted herein although potential interactions between scenarios are identified and discussed where appropriate.
- *Baseline conditions and BMP effectiveness are assumed to be uniform over the San Francisco Bay local watershed* – Conditions vary among the various municipalities

that contribute runoff to San Francisco Bay. Thus projecting results obtained by studies conducted at specific locations may not be representative of the watershed as a whole. As a practical matter, we had no alternative but to assume that projections to the whole watershed, based on area, land use, or population, were adequate for this level of analysis.

- *Best Management Practice (BMP) Effectiveness Assumptions* – Most data on BMP effectiveness does not address PCBs or mercury. Where there is data available on the effectiveness of a BMP in reducing TSS or SSC, we have estimated mercury and PCB effectiveness by combining the measured effectiveness in removal of TSS/SSC with the measured concentration of PCBs or mercury in sediment collected in catch basins or in other depositional locations. In a number of scenarios the effectiveness of current and projected controls relies on our general understanding of the literature and professional judgment.
- *Mercury and PCB Concentrations in Depositional Sediments are Representative of Concentrations in Suspended Sediments* – Some scenarios require an estimate of mercury and PCB concentrations where the only data available is in the form of TSS or SSC. In some scenarios we assume that the concentration of mercury or PCBs in depositional areas (which have been monitored in the region) is representative of the mass of PCBs or mercury on sediments suspended in the flow. Note, the one exception to the above is the treatment scenarios where we use SFEI settling experiments to estimate mercury and PCB removals.
- *Scenario Duration of 20 years* – Some scenarios rely on a duration of implementation to estimate effectiveness, and in these cases, we assume a 20 year time frame. These projections do not take into account what will likely be future changes in technology, product substitution, and consumer practices and in this sense, these projections should be viewed as “snapshots” in time that will require modifications in the future. It is this assumption that drove the design of the spreadsheets to facilitate updating as better information becomes available.

Each BMP scenario also contains assumptions that will be addressed under the BMP Scenario descriptions in Section 3.6.

3.5 Design of Workbooks

The evaluation of the effectiveness of each scenario used an EXCEL workbook format, one workbook per scenario. The workbooks are intended to be standalone and include a summary worksheet that is linked to supporting worksheets that contain the original data and data analysis results that were ultimately used in estimating the load reduction. The summary worksheet contains color coded cells that contain key inputs that a user may wish to modify in the future.

The sources of key inputs are also provided in a reference list in the summary worksheet. The workbooks are provided in a separate CD associated with this report.

3.6 BMP Scenario Effectiveness Projections

3.6.1 Scenario 1: Fluorescent Bulb Recycling (Mercury Load Reduction)

According to the White Paper⁷ source identification analysis, fluorescent bulb recycling is one of the larger sources of mercury in products. With the adoption of the Federal Universal Waste Rule, it is expected that the amount of recycled mercury will greatly increase. The Universal Waste Rule, which went into effect in February 2006, mandates recycling of mercury in households and small and large businesses. If fluorescent bulbs, which contain mercury, are broken, it is possible for some of the mercury to volatilize and enter the environment. Some of the volatilized mercury may later become attached to particulates and be deposited, via wet and dry deposition, onto the ground or directly onto the Bay. During wet weather, some of this sediment containing mercury can be mobilized, enter the stormwater system, and potentially be conveyed to the Bay. If bulbs are properly disposed of and recycled, much less mercury enters the Bay. In this scenario, we estimate the load reduction if mercury recycling were greatly increased in response to the Universal Waste Rule and supporting efforts of stormwater programs. The following describes the assumptions made for this source control quantification spreadsheet analysis.

In the San Francisco Bay Area, households and small businesses use 1.8 million fluorescent bulbs annually, and large businesses use 10.2 million annually⁸. The amount of bulbs available for recycling each year was assumed based on two independent estimates (AB1109⁸ and ALMR⁹), extrapolated by 2008 Census population data, and ranges from 2.9 million⁸ to 16 million⁹. Recycled bulbs are estimated to be largely tube lamps, which have an average amount of mercury per tube of 21.4 mg⁹. There are two independent estimates of the 2009 fluorescent bulb recycling rates corresponding to 10%¹⁰ and 25%¹¹ of the number of bulbs available for

⁷ The “White Paper” referred to herein refers to a report titled “Review of Methods to Reduce Urban Stormwater Loads: Task 3.4, SFEI Contribution 429 published as part of this study. The report summarizes international literature on sources, transport, fate and effectiveness of management measures in addressing PCBs and mercury (McKee et al, 2006).

⁸ San Francisco Regional Water Quality Control Board Options Matrix (unpublished data).

⁹ Weighted average for fluorescent tube lamps based on IMERC Fact Sheet: Mercury use in Lighting NEWMOA, 2008, <http://www.newmoa.org/>

¹⁰ Statewide estimate from the household hazardous waste recycling centers as cited in CA AB1109, 2008 Lighting Task Force Report, converted to San Francisco Bay Area based on population

¹¹ Personal communication with Paul Abernathy, Executive Director of Association of Lighting and Mercury Recyclers (ALMR)

recycling per year. The mass of mercury that is not recycled enters a variety of environmental compartments including atmosphere, land (and landfills) and water.

The percentage of mercury that is assumed to enter the San Francisco Bay is based on a Barr Engineering Company study¹² conducted in Minnesota and Wisconsin that focused on the fate of mercury from household products, combined with a partitioning analysis. The authors estimated the amount of mercury which volatilizes into the atmosphere, resulting from breakage, transfer and transit, as well as air emissions following disposal in landfills, combustion, and incineration is thirty-seven percent of the mercury contained in material being recycled. We assumed that recycling would eliminate this volatilization pathway.

The report did not account for the percentage of this mercury that will partition into water and end up in water bodies. The following partitioning analysis was used to estimate the amount of mercury from San Francisco Bay Area thermostats that could potentially enter San Francisco Bay.

1. Henry's law: Henry's law (at 20° C) for elemental mercury is as follows:
 - i. $K_{HCC} = 0.305$ [mol mercury/L air]/ [mol mercury/L water]
 - b. While the mechanics are complex, this can roughly be interpreted as 30.5% of the mass of mercury in the air will be fated to water particles in the air or directly to surface water bodies that volatilized mercury comes in contact with.
2. Rain-out: As these water particles are rained-out or washed-out of air, mercury containing water will fall on land and water.
3. Partitioning Coefficient K_d : The K_d is a determination of how much mercury will partition from water to soil when coming in contact with soil. The K_d for mercury is approximately 1000, meaning that for every 1000 mg of mercury in a kg of water, 1 mg of mercury will partition to 1 liter of water. In essence, we can assume that all mercury which comes in contact with soil will partition to soil. This also contributes to dry deposition pathways.
4. Impervious areas: While mercury in water that falls on impervious areas may partition onto soil or pavement particles, it is assumed that most mercury (~60-70%) on impervious surfaces will eventually be mobilized by rainfall and be conveyed by storm drains to the Bay. Based on current land use information, the local San Francisco Bay watershed is ~60-70% imperviousness overall.

Based on the above analysis, the following equation allows one to determine the amount of mercury from thermostats fated to the Bay:

¹² Barr Engineering Company, 2001. Substance Flow Analysis of Mercury in Products, Prepared for Minnesota Pollution Control Agency, August 15.

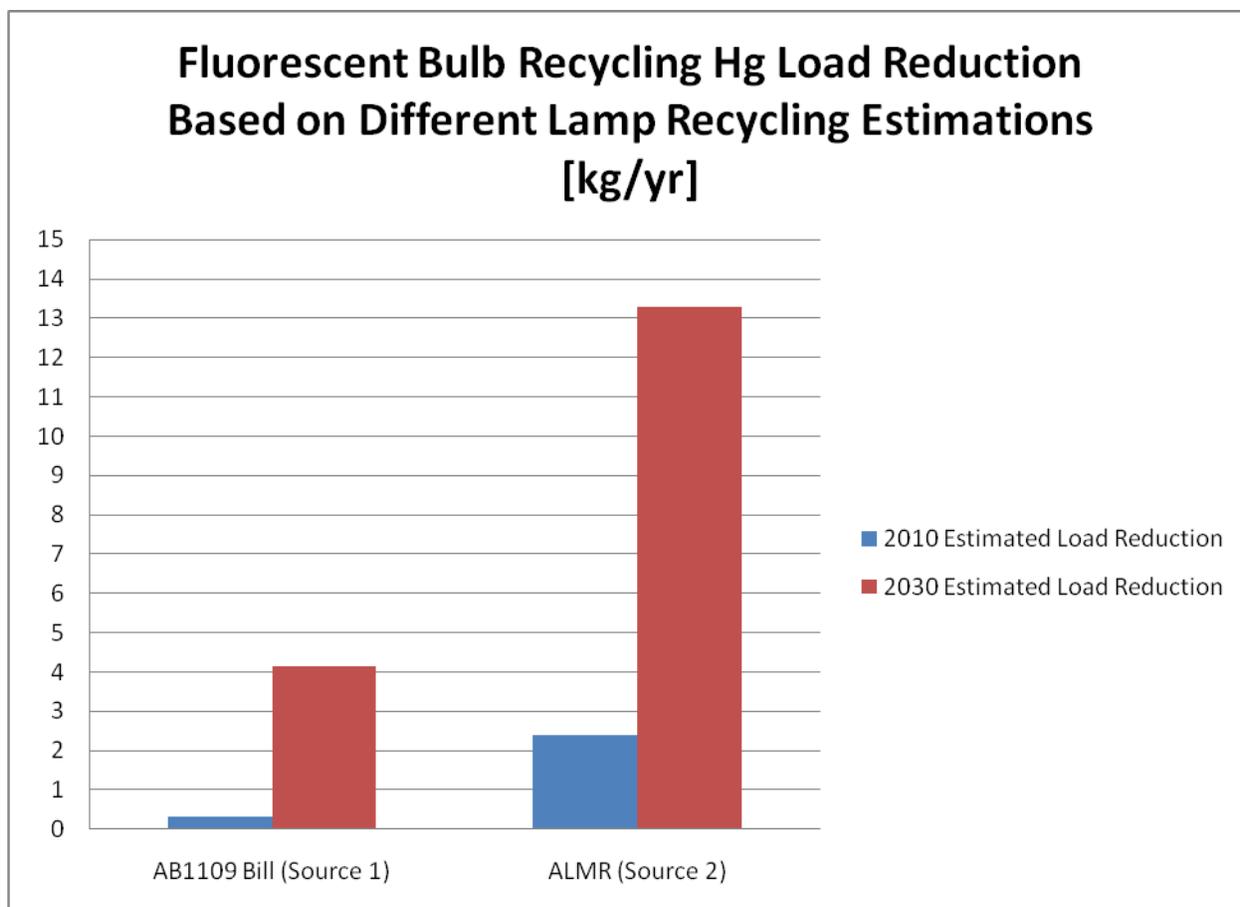


Figure 3-6: Estimated Fluorescent Bulb Recycling Mercury Load Reduction

3.6.2 Scenario 2: Thermostat Recycling (Mercury Load Reduction)

Many old thermostats contain mercury contained in glass bulbs (ampoules). Information obtained from the Thermostat Recycling Corporation indicated that, based on national data, there are generally one or two bulbs per thermostat (average is 1.4 bulbs) and each bulb contains an average of 2.8 grams of mercury yielding approximately 4 g mercury per thermostat¹³.

Data provided by National Electrical Manufacturers Association (NEMA)¹⁴ indicates that approximately 1,446 thermostats were recycled in the San Francisco Bay Area in 2006, or a total of 9.3 kg of mercury recycled. This compares to an estimated total number of thermostats in California available for recycling in 2006 of 365,282¹⁵ (when normalized by population, this

¹³ SFEI, 2007. "Mercury Switch Thermostats and Fluorescent Bulbs".

¹⁴ National Electrical Manufacturers Association (www.nema.org/gov/ehs/trc)

¹⁵ Household Universal Waste Generation in California, (CIWMB 2002).

means approximately 20% or 73,000 thermostats are available for recycling in San Francisco Bay Area). Based on these estimates, there appears to be ample availability of thermostats for recycling in the future.

Using recycling data from 2001 to 2006, SFEI (2007) conducted a linear regression analysis and determined that the thermostat recycling rate was increasing by ~1.7 kg/yr (the 95% confidence interval for the incremental increase was 0.81-2.5 kg increase per year). In a 20 year period, incorporating this estimated incremental increase in mercury recycling, the total incremental increase in recycled mercury from thermostats would be ~35 kg per year from projected 2010 recycling rates to projected 2030 recycling rates.

Based on our partitioning analysis, approximately 4.8% of the mercury used in thermostats may potentially enter San Francisco Bay via stormwater runoff. Applying this percentage to the projected mass of thermostats recycled in any given year results in projected load reduction for 2010 of 0.8 kg/yr and a projected load reduction for 2030 of 2.4 kg/yr, resulting in an incremental increase of 1.6 kg/yr from 2010 to 2030.

Key Assumptions

- The mass of mercury per switch is approximately 4 grams (reference). There are sufficient mercury containing switches in older buildings to support future recycling for a number of years.
- Recycling of mercury containing thermostats in the San Francisco Bay Area was recorded to be about 10 kg/year in 2006 and is projected to increase each year by about 1.7 kg/yr.
- Thirty seven percent of the mercury in thermostats that are not recycled will ultimately volatilize and enter the atmosphere. A partitioning analysis indicates that about 5% of that which volatilizes will ultimately enter the San Francisco Bay via stormwater.

Sources of Uncertainty

Local recycling centers document the number and type of recycled items, but are not involved in measuring the amount of any contaminant contained in recycled items. Thus there appears to be limited (if any) local data on the number and mercury content of recycled thermostats. This scenario assumes a constant increase in recycling of mercury containing thermostats for a period of 20 years, based on approximately 5 years of San Francisco Bay Area data. However, this estimate could increase with improved education or decrease with advances in technology that limit or eliminates the usage of mercury in thermostats.

Projections

The projected incremental load reduction associated with recycling mercury containing thermostats is shown in Figure 3-6. The total load reduction is estimated to be ~0.8 kg/yr for 2010 and ~2.4 kg/yr for 2030, which is equivalent to an incremental load reduction (from base year) of about 1.6 kg/yr.

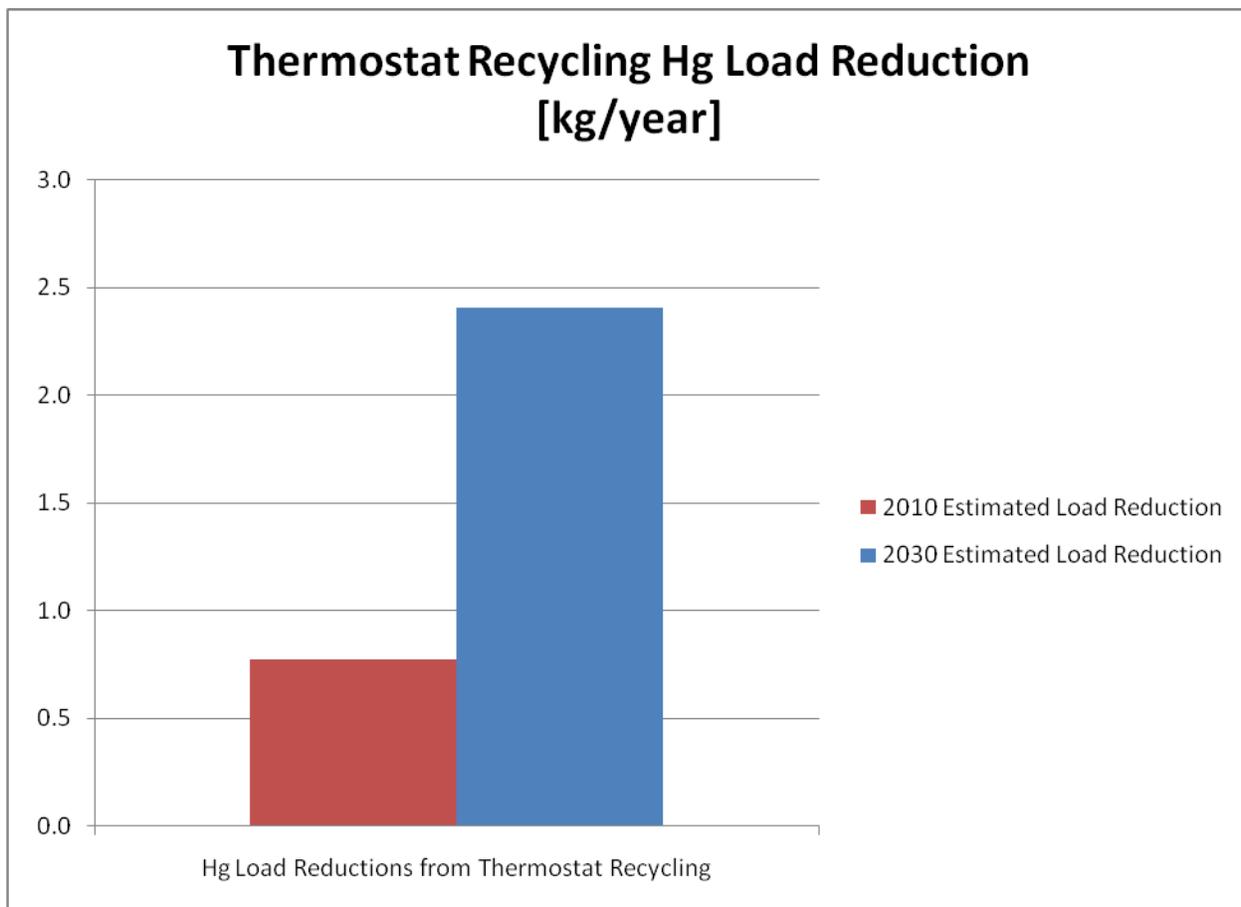


Figure 3-7: Estimated Thermostat Recycling Mercury Load Reduction

3.6.3 Scenario 3: Building Demolition and Recovery (PCBs)

PCBs were manufactured in the U.S. between 1929 and 1977 and were used in a variety of products, including building materials such as joint sealants (e.g., window caulking) and paints¹⁶.

¹⁶ Larry Walker Associates, TDC Environmental, A. Blake, 2006. PCB TMDL Implementation Plan, Clean Estuary Project, May.

A survey by the Swiss government of joint sealants in 1,348 buildings constructed between 1950 and 1980 found that almost half of the buildings had PCB containing joint sealants, and almost 10% of the sealants contained PCB concentration exceeding 10% by weight¹⁷. When buildings containing PCBs are remodeled or demolished, PCBs can be released onto the ground and can be washed off by urban runoff.

The San Francisco Estuary Partnership (SFEP) is initiating a study to develop best management practices to reduce or prevent the discharge of PCBs during building demolition/remodeling that will include developing methods to identify PCB-containing building materials and properly manage those materials through the various steps of handling, containing, transport, and disposal¹⁸. This scenario is intended to provide a framework for evaluating PCB recovery effectiveness that could be refined following the outcome of the SFEP project.

The scenario is based on an estimate of the number of demolished buildings in the San Francisco Bay Area, with the assumption that 10% of those buildings were built during the years when PCBs were used in the United States. In a summary of primarily European studies, an estimate of PCBs entering urban runoff from a 7 story building was from 2 to 20 grams.¹⁹ This represents one of the few estimates of releases of PCBs to stormwater from building materials and was used herein as the basis for projecting a range of load reductions per year associated with building demolition. It was also assumed that 40-80% of the demolished buildings would be subject to hazardous waste controls. These assumed controls vary in effectiveness from 50-80%. These current assumptions are placeholders, subject to change when more information is available for the San Francisco Bay Area as part of the SFEP project²⁰ or other studies.

Key Assumptions

- Approximately 1070 buildings are demolished per year in San Francisco Bay Area, 10% of which were built during period when PCBs were used in building materials and assumed to contain PCBs.
- For each demolished building potentially containing PCBs, assume a range of 2-20 grams of PCBs released to surface waters.

¹⁷ Moran, K. S. Klosterhaus, L. McKee, J. Davis, B. Elzufon, K. Lundberg, and P. Salop, 2007. Memorandum to Arleen Feng, titled "First Phase Support Information for PCB Portion of Taking Action for Clean Water Grant". Grant was awarded by California State Water Resources Control Board to San Francisco Estuary Project.

¹⁸ San Francisco Estuary Partnership, 2010. Request for Proposals to Develop Best Management Practices (BMPS) to Reduce or Prevent Discharge of PCBs During Building Demolition/Remodeling.

¹⁹ LWA, TDC Environmental, Blake, A, 2006. PCB TMDL Implementation Plan Development, Clean Estuary Project.

- Assume controls applicable to 40-80% of buildings and that control effectiveness is 50-80% where ranges apply to the lower and upper estimates of effectiveness.

Uncertainty

This scenario relies on limited information from primarily European studies where the estimated release to runoff ranged over an order of magnitude from 2-20 grams.

Results

As shown in Figure 3-8, the projected effectiveness of this scenario ranges from a low estimate of 0.1 kg/yr to a high estimate of 3 kg/yr.

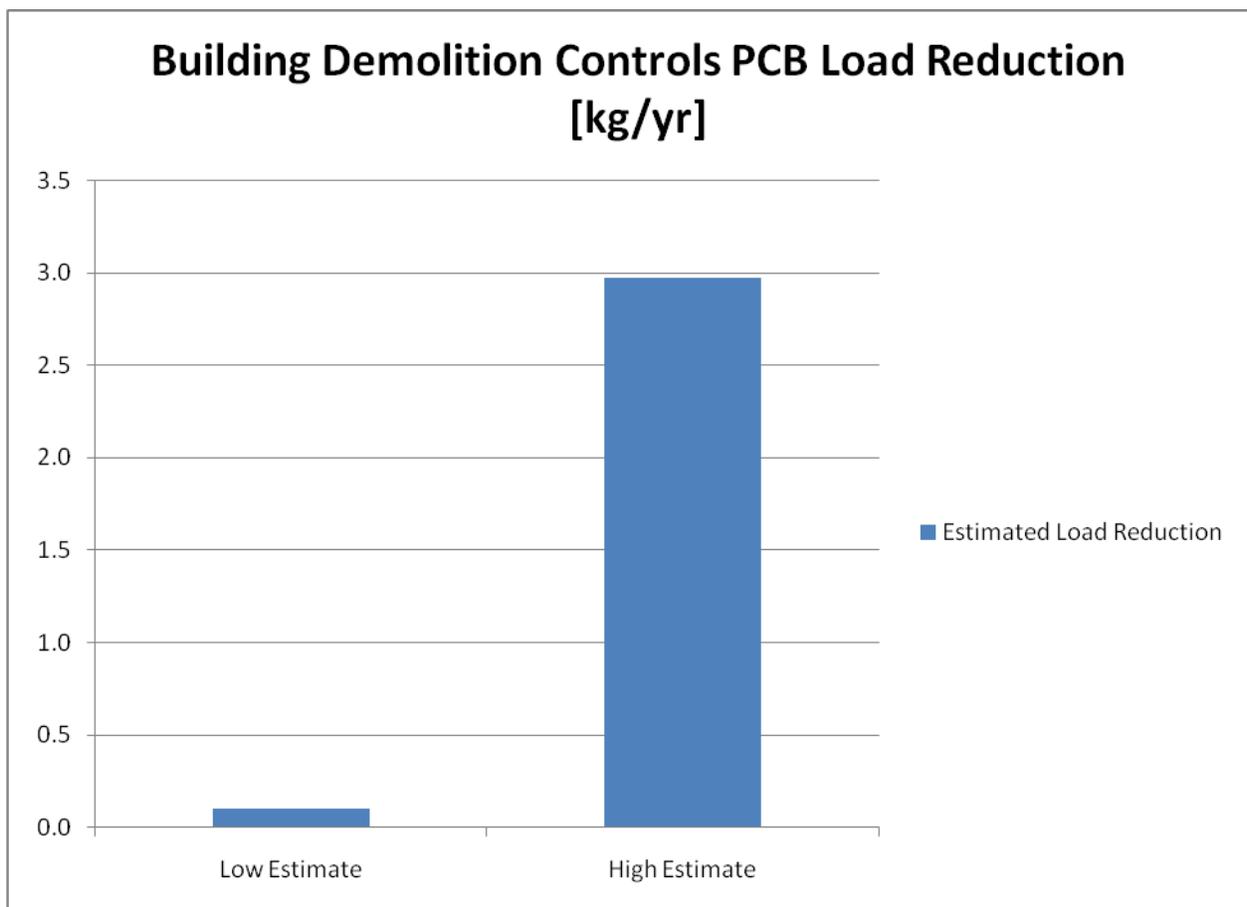


Figure 3-8: Estimated PCB Load Reduction from Building Demolition Controls

²⁰ Moran, K. S. Klosterhaus, L. McKee, J. Davis, B. Elzufon, K. Lundberg, and P. Salop, 2007. Memorandum to Arleen Feng, titled "First Phase Support Information for PCB Portion of Taking Action for Clean Water Grant". Grant was awarded by California State Water Resources Control Board to San Francisco Estuary Project.

3.6.4 Scenario 4: Regional Atmospheric Sources (Mercury Load Reduction)

This scenario addresses the following 2 sources of air emissions containing mercury:

- Lehigh Hanson Permanente Cement Plant, and
- San Francisco Bay Area crematoria.

The analysis considers current emission estimates to the San Francisco Bay Area Air Basin, the portion of emissions that may deposit on the surface of San Francisco Bay, and the anticipated effect that reductions in emissions will make in reducing the current mercury depositional loads. The depositional analysis focuses specifically on deposition to land surfaces in the local San Francisco San Francisco Bay watershed, as this contributes mercury loadings to the Bay.

The total estimated emissions of mercury from all air sources within the San Francisco air basin are estimated at 214 kg/yr²¹. The emissions from the Lehigh Hanson Permanente Cement Plant located in western Santa Clara County are estimated at 61 kg/yr²². The preheater kiln used at this facility is one of the largest in the U.S. and is fueled by petroleum coke, which is considered to be a primary source of atmospheric mercury when burned. Annual emissions from the approximately 40 crematoria in the nine county San Francisco Bay Area²³ have been estimated to range from a most probable value of 12 kg/yr to a worst case of 47 kg/yr²⁴. The primary source of the mercury in the crematoria emissions is assumed to be dental fillings.

Air emissions to the San Francisco Bay Area have several pathways: direct deposition to San Francisco Bay, deposition on land surfaces within the local San Francisco Bay watershed, and export beyond the San Francisco air basin. Deposition on land surfaces depend on a number of factors, including the locations of mercury sources with respect to the San Francisco Bay, air circulation and transport patterns, and the characteristics of the emitted particulate matter. Such a complex analysis was deemed not appropriate here, given the uncertainty in this estimate; and thus a range of 25 to 75% of the emissions was assumed to be deposited on the watershed land surface. For the Lehigh Hanson Permanente Plant this would yield a range of deposition of approximately 15-46 kg/yr and for the crematoria a range of 3-9 kg/yr assuming the most probable emission rate of 12 kg/yr for crematoria.

²¹ California Air Resources Control Board Facility Search www.arb.ca.gov/app/emsinv/facinfo/facinfo.php

²² Rothenberg, S., L. McKee, A. Gilbreath, D. Yee, M. Conner, X. Fu, 2010. Evidence for Short Range Transport of Atmospheric mercury, *Atmospheric Environment*, 44 (2010) 1263-1273.

²³ Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara, Solano and Sonoma

²⁴ Lindquist, J.H, and B.F. Bateman (2000) Estimate of Mercury Emissions from Crematoria, Bay Area Air Quality Management District (draft)

Anticipated reductions in emissions and direct deposition for the Lehigh Hanson Permanente Cement Plant was assumed to be approximately 80% based on an assumed approval of the current form of the proposed EPA rulemaking²⁵. This would result in a projected reduction in deposition to land surface of 12-37 kg/yr.

A reduction in emissions for the crematoria was also projected on the basis of a reduction in the number and size of fillings and therefore in the amount of mercury used in dental fillings since 1979²⁶. If a similar trend were to continue over the next 20 years, there would be a net reduction of about 20% in emissions and a similar reduction in direct deposition. Such a reduction would reduce deposition loads by 0.6-1.8 kg/yr for the most probable estimate of emissions. Of the load deposited on watershed land surfaces, 33% is assumed to drain to the bay (regardless of loading rate)²⁷.

Assumptions

- Eighty percent reduction in mercury emissions from Lehigh Hanson Permanente Cement Plant in response to new regulations being proposed by EPA, and 20% decrease in emissions from crematoria over a 20 year period assuming current decline in amount of mercury used in dental amalgam.
- 25-75 % of the emissions of mercury from crematoria and the Lehigh Hanson Permanente Cement Plant deposit on land surfaces within the San Francisco Bay watershed.
- 33% of the mercury that deposits on the watershed enters the San Francisco Bay via stormwater runoff (Tsai and Hoenicke, 2001) regardless of loading rate.

Uncertainty

- Emission estimates for crematoria are not based on measured data, but rather on dental statistics on number and amount of mercury used in amalgams.
- Deposition from each source will vary depending on a number of factors affecting the transport and fate of material discharged to the atmosphere.

²⁵ EPA has proposed National Emission Standards for Hazardous Air Pollutants from the Portland Cement Manufacturing Industry that is currently under review following the close of the comment period on June 15, 2009 (<http://www.epa.gov/fedrgstr/EPA-AIR/2009/June/Day-09/a13438.pdf>)

²⁶ CDC has observed a 38% reduction in the amount of mercury used in dental fillings since 1979 (approximately 30 years ago) with a constant trend. Centers for Disease Control and Prevention website (<http://www.cdc.gov>), under Health topics A-Z, Oral Health, Program, Other Issues, Amalgam, (<http://www.cdc.gov/nccdphp/oh/amalgam.htm>)

²⁷ Tsai and Hoenicke, 2001. San Francisco Bay atmospheric deposition pilot study Part 1: Mercury. Oakland, CA.

- Projected decrease in emissions of mercury from Lehigh Hanson Permanente Cement Plant is predicated on approval of proposed EPA regulations. The regulations have not yet been adopted and until adoption, are subject to change.
- The scenario does not account for possible future innovations in dental technology which could conceivably replace mercury in amalgams, or changes in population and future number of cremations per year.

Results

Figure 3-9 shows the estimated projected load reduction from improved management of emissions from crematoria and the Lehigh Hanson Permanente Cement Plant, equivalent to about 8.6 kg/yr.

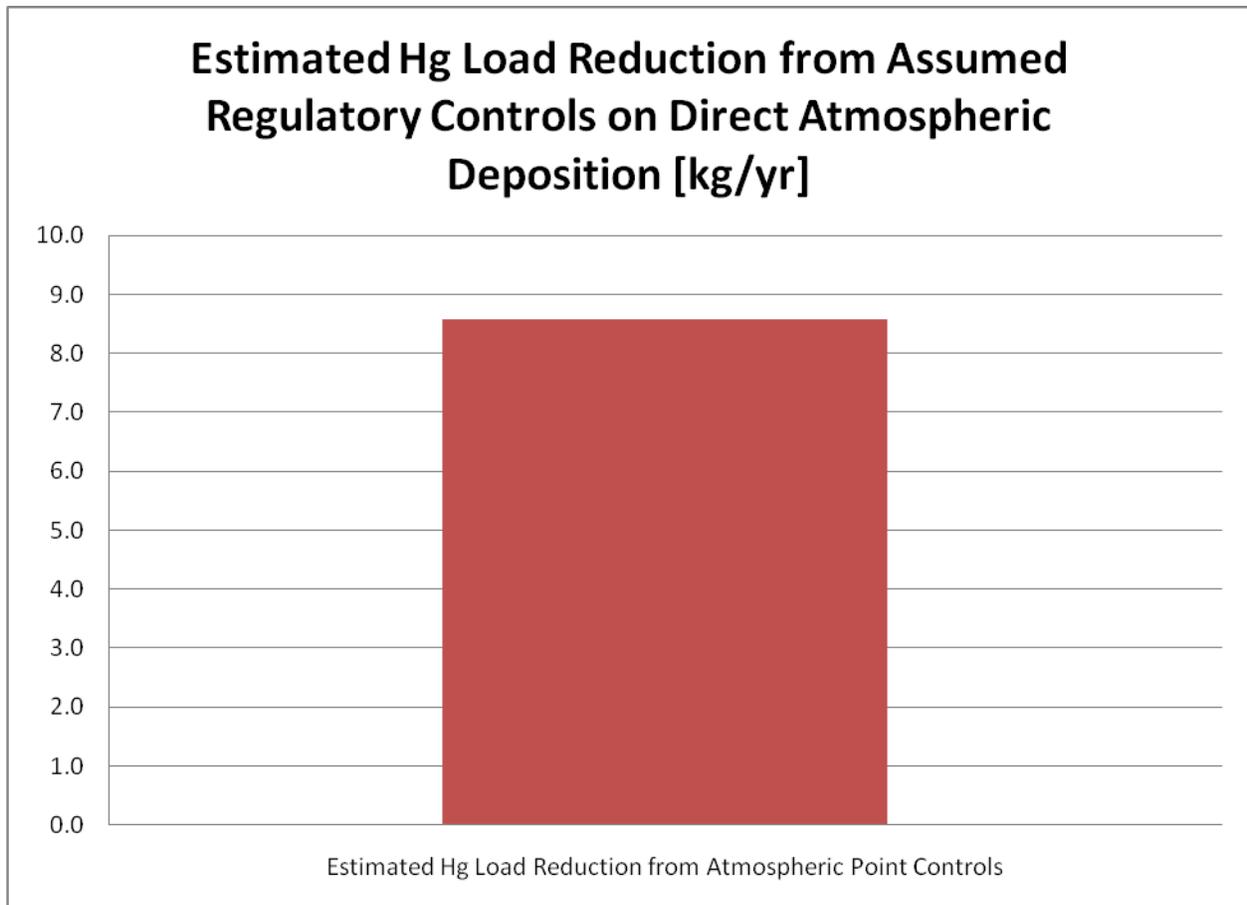


Figure 3-9: Estimated Direct Atmospheric Mercury Deposition Load Reduction

3.6.5 Scenario 5: Street Sweeping

Street sweeping is conducted by most, if not all, municipalities in the San Francisco Bay Area. The traditional purpose of street sweeping is to remove trash and debris that collect in the gutters at the edge of streets. However, street sweeping may also remove sediment and associated pollutants such as mercury and PCBs that would otherwise enter the storm drain system during wet weather. This scenario investigates the increase in the amount of material and associated mercury and PCBs that could potentially be collected and disposed of if the pick-up efficiency of the street sweeping fleet in the San Francisco Bay Area could be improved.

There is disagreement among stormwater practitioners as to whether sweeping pick-up efficiency equates to load reduction. A number of monitoring studies have indicated that it is difficult to distinguish a statistically significant water quality improvement based on an assumed sweeper efficiency, given the variability in stormwater runoff and other confounding factors²⁸. A key point in the issue is the difficulty in designing a monitoring study that isolates the runoff from roadways, which are affected by sweeping, from other sources, including sidewalks, parking lots and roofs, and from nearby pervious surfaces during larger events. Sweeper technology has also advanced considerably over the past 20 years with the emphasis on designing sweepers to remove fine sediments and associated constituents. For example, a study of alternative sweeper types conducted in San Jose in the mid-1990s indicated a significant improvement in pick up efficiency for sediment and copper with regenerative air sweepers compared to broom type sweepers²⁹. A prior study conducted in the 1980s in a catchment that drains to Castro Valley Creek in Alameda County indicated that for fine particle sizes (<45 um), the average pick up efficiency for a regenerative air sweeper ranged between 55-75 % depending on location, compared to a range of 36-61% for mechanical sweepers³⁰. As a practical matter, it is difficult to argue from a qualitative perspective, it is likely that much if not all the material picked up by a sweeper would otherwise be mobilized and transported into the storm drain system during storm events. Based on this qualitative inference, we assume that sweeper pick-up efficiency is a good indicator of sweeper effectiveness, and thus an indicator of the relative effectiveness of the sweeper to reduce loads to San Francisco Bay.

The annual volume of material collected was determined by urbanized land use using estimates from the ACCWP study described in section 3.1.5³¹, and was normalized based on land use

²⁸ Selbig W.R. and R.T. Bannerman, 2007. Evaluation of Street Sweeping as a Stormwater-Quality-Management Tool in Three Residential Basins in Madison, Wisconsin, USGS Scientific Investigations Report 2007-5156.

²⁹ Woodward Clyde Consultants, 1994. San Jose Street Sweeping Equipment Evaluation, prepared for City of San Jose, October 28.

³⁰ Pitt, R. San Francisco Bay Area National Urban Runoff Project, A Demonstration of Non-Point Source Pollution Management on Castro Valley Creek, prepared for US EPA Water Planning Division.

³¹ Salop, P, 2006. Municipal Maintenance Source Control Options Related to TMDL Implementation, prepared for Alameda County Clean Water Program..

areas. The volume of material collected was converted to mass collected using the bulk density of 2025 lb/cy³² ($S_g = 1.2$). A sediment conversion factor was used to determine the mass of sediment smaller than 2 mm. This conversion was necessary because sweepers pick up trash and large organic debris as well as sediment, while the mercury and PCB concentrations in sediment was measured in a sample which was sieved to remove particles larger than 2 mm. Additionally, given that pollutant concentrations are expected to decrease rapidly with increasing particle size, it was assumed that a relatively small mass of POCs is carried on the > 2 mm fraction³³. The conversion factor of 60% was calculated from particle size distribution data for street sweeper material collected in the ACCWP study³⁴.

The concentrations of mercury and PCBs in the sediment fraction (< 2 mm) of street sweeper hoppers were obtained from street sweeping studies conducted in various cities in Alameda County¹², Contra Costa County³⁵, and City of Richmond³⁶. The data were combined and statistically analyzed. Given the variability in the data, concentrations associated with the 25th, 50th, and 75th percentiles were determined. Median values for urbanized land uses were used in the projections.

Improvements in pick-up efficiency were evaluated in terms of ability of improved technologies to pick up fine particles (<250 um) as PCBs and to a lesser extent mercury tend to be in particulate form and associated with finer particles³⁷. Broom type sweepers are best at removing larger particles (>1000um) whereas many studies report a range of sediment removal capabilities at 35 percent or higher.³⁸ In one of the few sweeper studies conducted in the San Francisco Bay Area, the removal of copper in terms of pounds per mile swept increased from approximately

³² California Integrated Waste Management Board (CIWMB) 2003. Diversion Study Guide, Appendix I. <http://www.ciwmb.ca.gov/lglibrary/dsg/default.htm#Table>, as cited in Table 14; Salop, P. 2006. Municipal Maintenance Source Control Options Related to TMDL Implementation, prepared for Alameda County Clean Water Program.

³³ Salop, P. 2006. Municipal Maintenance Source Control Options Related to TMDL Implementation, prepared for Alameda County Clean Water Program.

³⁴ Salop, P. 2006. Municipal Maintenance Source Control Options Related to TMDL Implementation, prepared for Alameda County Clean Water Program.

³⁵ EOA, 2007. Estimating Constituent Load Removals from Street Sweeping Activities in Contra Costa County, CA. Prepared for Contra Costa Clean Water Program, March 9 (draft report).

³⁶ EOA, 2007. Summary of Polychlorinated Biphenyls (PCBs) Data in Sediment Collected from Richmond, California Streets and Storm Drains, October 16, 2007.

³⁷ Mckee, L. Leatherbarrow, Pearce, S., Davis, J. 2002. A Review of Urban Runoff Processes in the Bay Area: Existing Knowledge, Conceptual Models, and Monitoring Recommendations, SFEI Contribution 66, and White Paper (Mckee et al, 2006).

³⁸ Selbig W.R. and R.T. Bannerman, 2007. Evaluation of Street Sweeping as a Stormwater-Quality-Management Tool in Three Residential Basins in Madison, Wisconsin, USGS Scientific Investigations Report 2007-5156.

0.009 lbs/mile using three varieties of broom sweepers to 0.235 lb/mile with two types of regenerative air sweepers³⁹. This is an improvement of approximately 250%.

Frequency of sweeping also affects effectiveness in part because pollutant accumulation on roads following a storm event or street sweeping recovers to pre-storm or pre-swept conditions in a week or two⁴⁰. A recent literature review on pollutant removal rates for street sweeping conducted by the Center for Watershed Protection estimates that the percent of mass of solids removed by sweeping can increase by as much as 50% from monthly to weekly sweeping⁴¹. This may be very important in areas with relatively high loading rates such as industrial areas where wind, runoff from driveways, vehicle wheel, and foot tracking can move a lot of sediment (along with associated contaminants) off private and public lots to roads and other nearby impervious surfaces.

Based on this and other information it is reasonable to assume that increased utilization of more efficient sweepers, coupled with increased frequency and more focus on those land uses that are likely to have larger accumulations of solids containing PCBs and mercury, would improve the overall effectiveness of municipal sweeping programs. If we assume that in those areas suspected to have higher accumulation of solids containing PCBs and mercury, that traditional broom sweepers were replaced over time with more efficient sweepers and the frequency of sweeping were increased from monthly to bi-weekly, it seems reasonable to assume that material pickup could be increased by at least a factor of 2.

The scenario also must address the land uses and areas where improvements in street sweeping would be conducted. For the purpose of comparison we have assumed that 10,000 acres (equivalent to roughly 15 mi² or 50 km²) of each land use in the San Francisco Bay Area would be subject to this change. This is approximately 10% of the industrial area, 10 % of the commercial area, and about 3% of the residential area in the San Francisco Bay Area.

Key Assumptions

- The scenario assumes an improved sweeping program implemented on 10,000 acres each of industrial, commercial/ mixed use, and residential land use, equivalent to (1) approximately 10% of the industrial areas, (2) approximately 10% of the commercial areas, and (3) approximately 3% of residential areas in the San Francisco Bay Area.

³⁹ Woodward Clyde Consultants, 1994. San Jose Street Sweeping Equipment Evaluation, prepared for City of San Jose, October 28.

⁴⁰ Sartor, J.D. and G.B. Boyd, 1971. Water pollution aspects of street surface contaminants. EPA-R2-72-081.

⁴¹ Center for Watershed Protection, 2006. Technical Memorandum 1 – Literature Review, Research in Support of an Interim Pollutant Removal Rate for Street Sweeping and Storm Drain Cleanout Activities (final draft).

- The annual removal of street dirt and debris as reported in the ACCWP study (Salop, 2006), and normalized by land use area, was considered representative of the current street sweeping practice in the San Francisco Bay Area and extrapolated regionally by land use area tributary to the Bay.
- Efficiency of sweepers in picking up sediment in current San Francisco Bay Area would increase by at least a factor of 2 by converting the fleet from primarily brush type sweepers to weekly sweeping using high-efficiency sweepers, with focus on sweeping those areas with higher accumulation of sediments containing mercury and PCBs.
- Conversion of the sweeper fleet will be accommodated with additional measures to support effectiveness including maintenance, operating equipment within limits suggested by vendor, street and curb maintenance, and access to gutter area.

Uncertainty

- The Bay Area projection is based on extrapolation of the removal volumes reported in the Salop (2006) study for Alameda County.
- The effectiveness of street sweeping depends on a number of factors beyond the equipment, including operator care, sweeper speed, access to the gutter, and roadway condition including adequate curbs. All of these factors would have to be addressed in an improved sweeper program.

Results

Results of the various street sweeping scenarios are shown in Figure 3-10 for mercury and Figure 3-11 for PCBs. Sweeping is generally projected to be more effective in commercial and industrial land use areas.

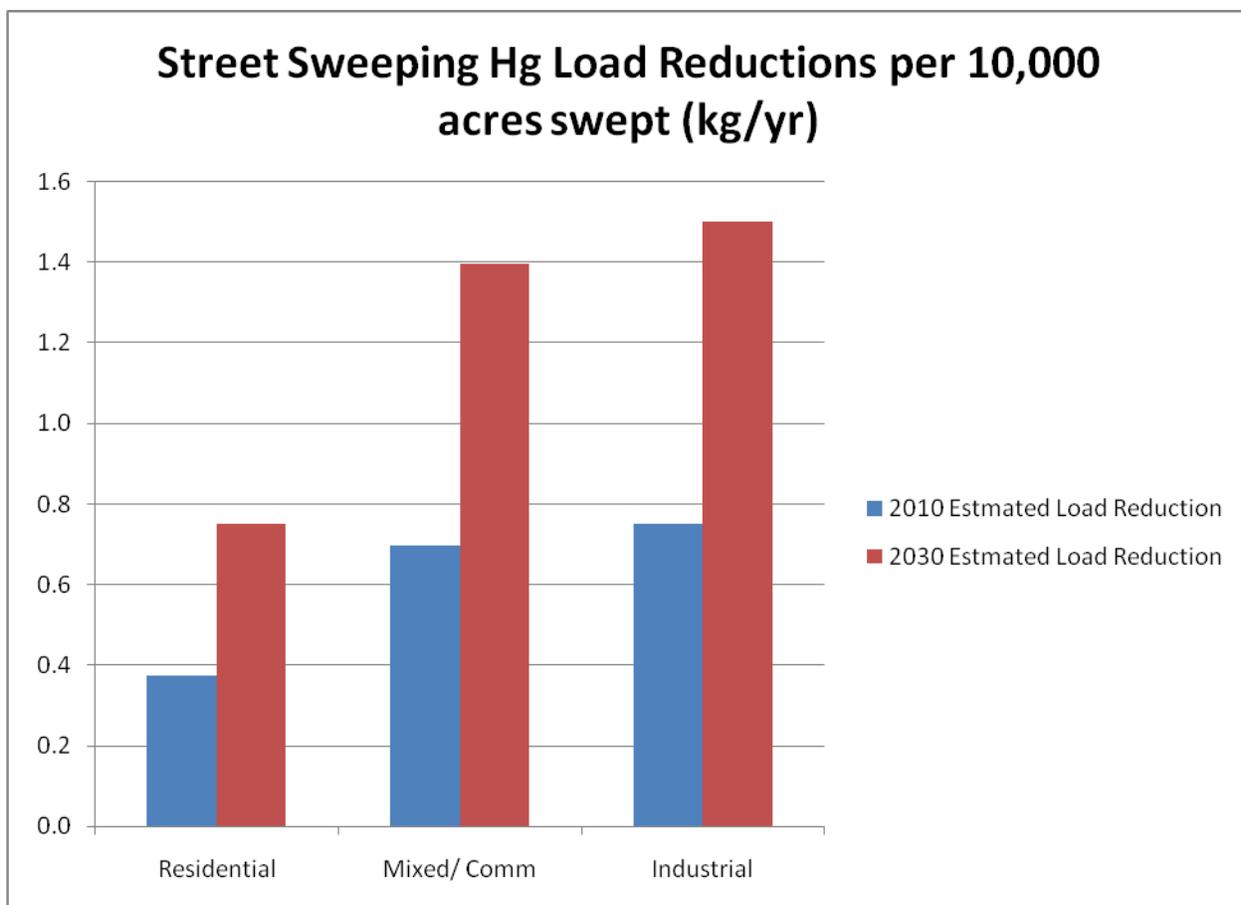


Figure 3-10: Estimated Mass of Mercury Removed by Street Sweeping

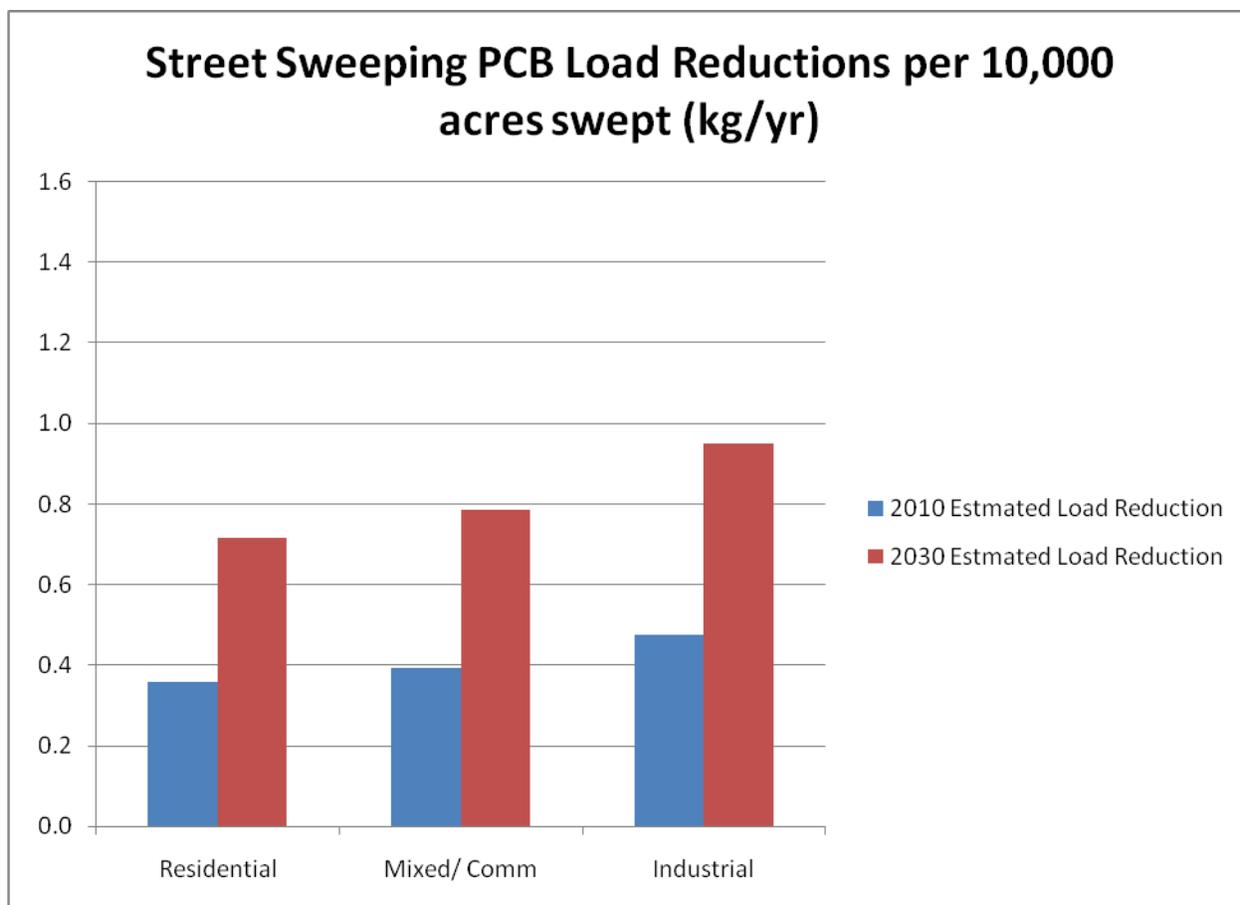


Figure 3-11: Estimated Mass of PCBs Removed by Street Sweeping

3.6.6 Scenario 6: Street Washing

Street washing herein refers to the use of tank trucks equipped with sprays that direct water onto the road surface and flush material into the curb and ultimately into a drop inlet. Street washing in this context does not include the use of hand held power washers that have been used in the San Francisco Bay Area for mobilizing and collecting sediments that contain elevated PCBs⁴².

To be effective, the wash water must be collected for treatment at some point prior to discharging into receiving streams and the San Francisco Bay. Street washing therefore requires treatment at the drop inlet or a sump for runoff capture, or it could be applied in catchments served by pumped stations where dry weather flows could potentially be diverted to a waste water treatment plant or other BMP. This scenario assumed that street washing is only conducted

⁴² Kleinfelder 2006. Final Project Report Ettie Street Pump Station Watershed, Oakland, California, prepared for City of Oakland Public Works Agency.

in catchments with industrial and/or commercial land uses that drain to pump stations where dry weather flows are diverted to local waste water treatment plants. The effectiveness of the plants in treating mercury and PCBs is assumed to be 90% or higher.

Street washing is commonly applied to construction sites where off-site tracking of sediment and dust control can be issues. It tends to be a more limited practice for municipalities compared with street sweeping, which commonly includes road wetting for dust control. Moreover, in semi-arid climates, the availability of water for street washing is an issue, although it seems feasible and appropriate to use reclaimed water.

Data on the effectiveness of street washing is limited. Tests conducted by Sartor and Boyd⁴³ in the 1970s concluded that washing can be a much superior method compared to traditional sweeping for moving street contaminants in the dust and dirt fraction. They also point out that, depending on the amount of water applied, washing can be designed to move pollutants to the curb where a traditional sweeper then could be deployed in a tandem operation⁴⁴. The City of Los Angeles currently conducts regular street washing in portions of downtown Los Angeles frequented by the homeless⁴⁵. This scenario relies heavily on the findings from a study the City of Los Angeles conducted to test effectiveness of street washing. The study was conducted at 4 locations where the average areas of the washed streets ranged from about 4,000 to 10,000 ft². The average water volume used per wash ranged from about 300 to 700 gallons depending on the location. Samples of the wash water running off the streets were obtained by placing small dams at the curb that caused the water to pond.

Samples were analyzed for solids (TSS), nutrients, surfactants, Biological Oxygen Demand (BOD), conductivity, Oil and Grease, and trace metals. Samples also were analyzed for indicator bacteria and toxicity. TSS in the samples ranged from about 300 to 6,000 mg/l depending on location, so two scenarios were considered: a high scenario assuming a wash water TSS of 6,000 mg/l and a low scenario assuming 300 mg/l. The mass of solids removed from the operation was estimated as the product of the applied volume times the TSS, and this was then normalized based on area washed (yielding lb/acre or kg/hectare washed).

For the San Francisco Bay Area scenario, washing was assumed to be conducted monthly in a small portion (10%) of the streets in catchments served by pump stations (see workbook for

⁴³ Sartor, J.D., and G.B. Boyd, 1972. Water Pollution Aspects of Street Surface Contaminants, EPA-R2-72-081.

⁴⁴ Street washing designed to mobilize fine particulates to the curb combined with street sweeping may be an effective strategy that would allow greater application of street washing technology, which otherwise is restricted to locations where water is ultimately diverted to sanitary sewer.

⁴⁵ Los Angeles, City of, 1997. A Study of Pollutants Entering Storm Drains From Street and Sidewalk Washing Operations in Los Angeles, California. Prepared by City of Los Angeles Department of Public Works, Bureau of Engineering, Stormwater Management Division, July.

details). This was extrapolated to 300 acres of street washed for an assumed lower limit or area washed and 900 acres for the upper limit in the range.

The concentrations of mercury and PCBs in the sediment fraction (< 2 mm) of street sweeper hoppers were obtained from street sweeping studies conducted in various cities in Alameda County¹², Contra Costa County⁴⁶, and City of Richmond⁴⁷. The data were combined and statistically analyzed. Given the variability in the data, concentrations associated with the 25th, 50th, and 75th percentiles were determined. Median values for each land use were used in the projections.

Key Assumptions

- Street washing is restricted to streets located in drainages that are served by pump stations where wash water could potentially be diverted to waste water treatment plants. Treatment of the PCBs and mercury in these plants is assumed to be at least 90% effective.
- Street washing was assumed to be conducted on monthly basis (12 times/year).
- Based on the City of Los Angeles Study, the TSS in the wash water runoff range from a low concentration of 300 mg/l to a high of 6000 mg/l.
- PCB and mercury concentrations in suspended solids taken from the Ettie Street study.

Uncertainty

- Projections in this scenario rely heavily on one study conducted by the City of Los Angeles in a downtown area frequented by the homeless. Results from these areas may not be generally representative of San Francisco Bay Area conditions.
- Results dependent on feasibility of implementing dry weather diversions to waste water treatment plants

Results

Projected load reductions in kg/yr for mercury and PCBs for this scenario are shown in Figure 3-12. For mercury the load reduction range is 0.0004 to 0.015 kg/yr. For PCBs the range in load reduction is 0.0003 to 0.009 kg/yr. These rather low reductions reflect the assumed limitations in street washing in terms of being limited to areas where storm drains are connected to sanitary in

⁴⁶ EOA, 2007. Estimating Constituent Load Removals from Street Sweeping Activities in Contra Costa County, CA. Prepared for Contra Costa Clean Water Program, March 9 (draft report).

⁴⁷ EOA, 2006. Fairfield-Suisun Urban Runoff Management Program, FY 2005-2006, February 27 (draft).

the San Francisco Bay Area and in terms of the limited potential for diverting flows from pump stations to nearby WWTPs.

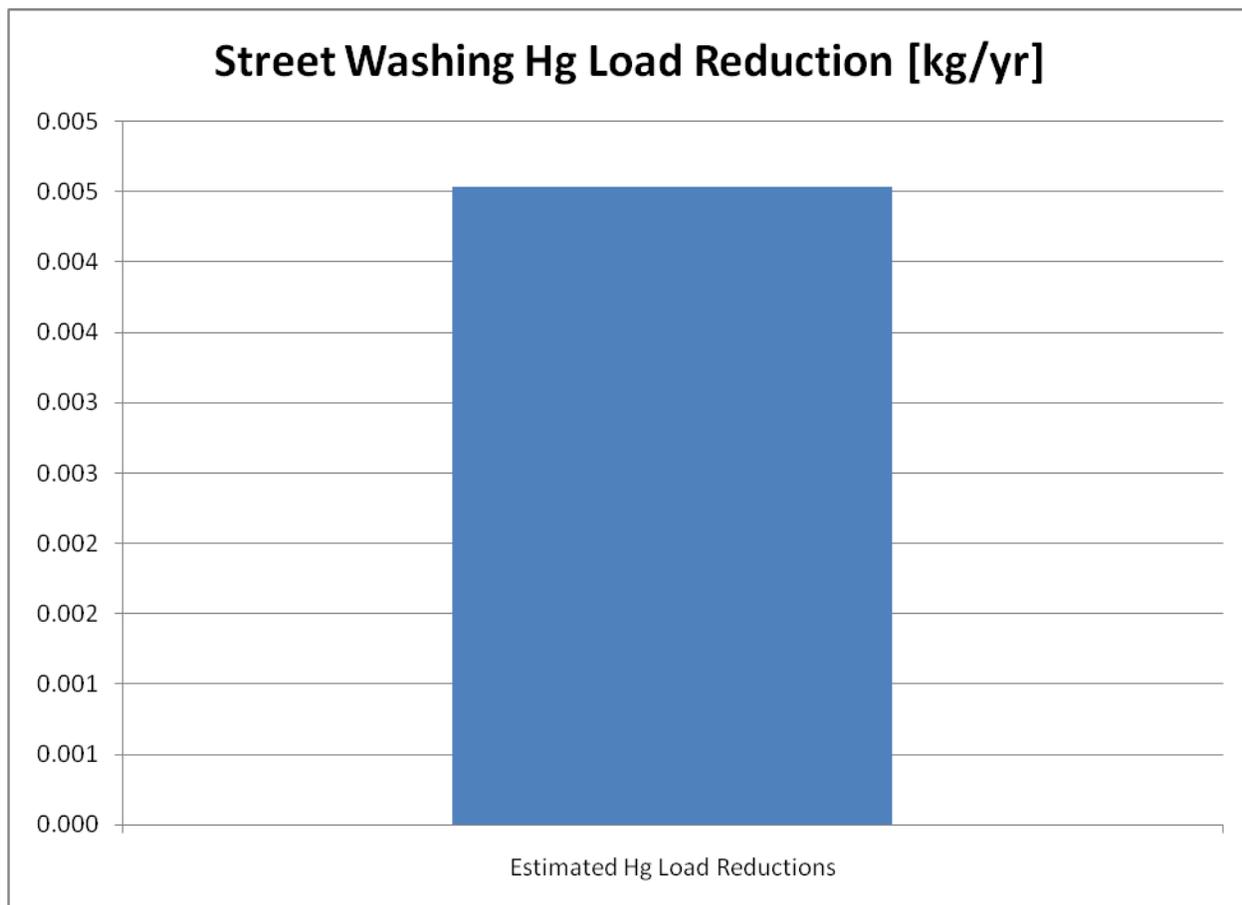


Figure 3-12: Estimated Mass of Mercury Removed from Streets by Street Washing

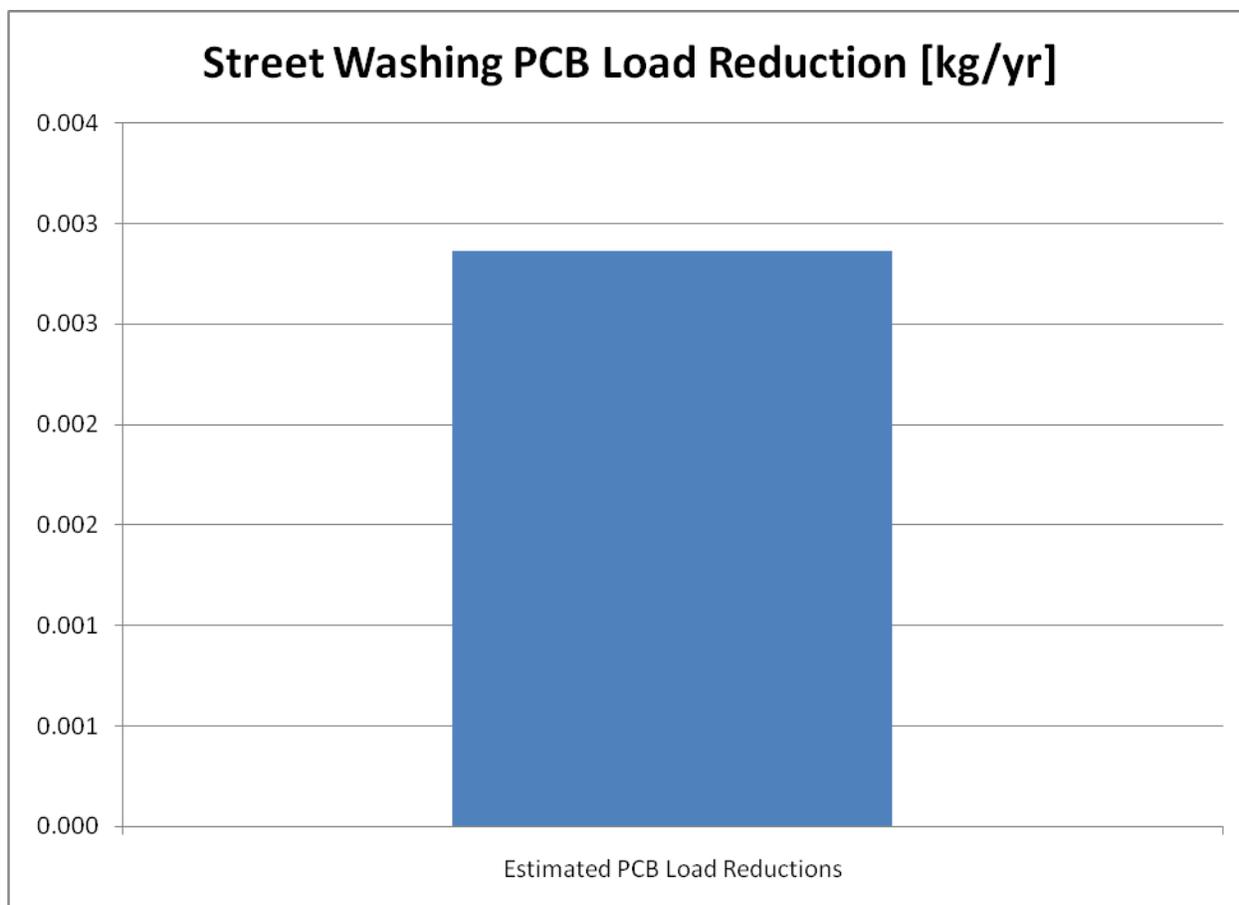


Figure 3-13: Estimated Mass of PCBs Removed from Streets by Street Washing

3.6.7 Scenario 7: Drop Inlet Cleaning

Municipal agencies are responsible for maintaining the storm drain system so that it functions as designed. Maintenance activities aim to avoiding clogging by removing material that may deposit in catch basins, drop inlets, and storm drain pipes. The distinction between catch basins and drop inlets is that the outlet pipe is elevated in a catch basin whereas in a drop inlet the outlet is at the bottom of the inlet. Consequently catch basins tend to collect more material than drop inlets. The distinction between drop inlets and catch basins may not be apparent in reporting information and catch basins appear to be falling out of favor in part because of vector issues. Thus, in this scenario, we have chosen to focus on drop inlets. This scenario is designed to investigate the benefits in terms of reduced loads of mercury and PCBs to the San Francisco Bay associated with cleaning out drop inlets.

Municipal agencies collect and report the volume of material collected from maintenance of their entire storm drain facilities as part of their annual stormwater permit reporting requirement. This

scenario utilizes reported information by municipalities in Alameda County that was compiled and analyzed in a report issued by ACCWP⁴⁸. Unfortunately, as noted by the author (Salop, 2006), the reported volumes were not classified by land use. Although we expect that land use could affect the volumes collected, the volume of material collected per unit area was assumed to be the same between different land uses because of this constraint. As we have discussed previously, part of our goal in this study is to create templates that can be improved as better information becomes available, and consequently we have designed the worksheet to allow for allocation of volumes by land use in the future.

The reported volumes did not distinguish by type of storm drain facility from which the material was removed, and Salop assumed that 75% of the reported volumes were the best estimate of the volume attributable to drop inlet cleaning (see section 3.1.5 for these estimates). Volumes were converted to mass using the assumption of 2025 lb/cy or 914 kg/cy and multiplied by fraction of material <2 mm⁴⁹. These volumes were normalized by land use area and extrapolated to the entire San Francisco Bay tributary watershed to estimate San Francisco Bay Area regional removal estimates by land use. Mercury and PCB concentrations were based on a database compiled by SFEI which includes data from eleven sources⁵⁰. The data was filtered to include only drop inlet sources to obtain median concentrations of mercury and PCBs on drop inlet sediments.

The concept in this scenario was to investigate the benefits (if any) of increasing the frequency of maintenance cleaning. This study evaluated the effects of different cleaning frequencies on the total volume and mass of material collected from drop inlets associated with residential, commercial, and industrial land uses. The study evaluated four cleaning frequencies ranging from annual, semi-annual, quarterly, and monthly. Increases in material collection were based on ratios developed from a study conducted for the Alameda Countywide Program which

⁴⁸ Salop, Paul, 2006. Municipal Maintenance Source Control Options Related to TMDL Implementation, prepared for Alameda Countywide Clean Water Program, March.

⁴⁹ The volume to mass conversion assumed a density of 2025 lb/yd³ (Sg = 1.2) based on data provided by the California Integrated Waste Management Board (2003) and it was further assumed that approximately 70% of the mass of material was sediment and associated with sizes less than 2 mm, in contrast to trash and debris.

⁵⁰ Salop et al., 2002. "2000-01 Alameda County Watershed Sediment Sampling Program: Two-Year Summary and Analysis."; EOA, 2002, "Case Study Investigating Elevated Levels of PCBs in Storm Drain Sediments in San Mateo County."; SMC Stormwater Pollution Program, 2003. "Case Study Investigating Elevated Levels of PCBs in Storm Drain Sediments in the Pulgas Creek Pump Station Drainage, San Carlos, California."; EOA, 2004. "Case Study Investigating PCBs in Storm Drain Sediments from Colma Creek, Colma, California."; Gunther et al, 2001, "Initial Characterization of PCB, Mercury, and PAH Contamination in the Drainages of Western, Alameda County, CA."; KLI, 2002. "Joint Stormwater Agency Project to Study Urban Sources of Mercury, PCBs and Organochlorine Pesticides." Kleinfelder, 2006a. "Private Property Sediment Sampling Report, Ettie St. Watershed, Oakland CA."; Kleinfelder, 2005. "Sediment Sampling Report Ettit St. Pump Station Watershed Oakland, CA."; EOA, 2007. "Summary of Polychlorinated Biphenyls (PCBs) Data in Sediment Collected from Richmond, California Streets."; EOA, 2003. "Year Two Case Study Investigating Elevated Levels of PCBs in Storm Drain Sediments in San Jose, California"; and compiled Industrial land use data sampled by SFEI

reported annual material collected from drop inlets using different cleaning frequencies⁵¹. The scenario evaluates the change in loads that would be projected if current cleaning volumes are assumed to represent annual cleaning, and cleaning frequency in 2030 was increased quarterly in each of the three designated urbanized land uses (industrial, mixed use/commercial, and residential).

Key Assumptions

- The best estimate of the percent of the materials reported that were associated with drop inlet cleaning was 75% of reported volume for FY 2000-2001 through 2004-2005.
- Volume removal increases were based on ratios developed from a single report which resultantly compares different drop inlets from different years and may not represent frequency increases on a single drop inlet.

Uncertainties

- The volumes reported by municipal programs represent all cleaning activities and different methods of estimation and levels of quality control.
- The change in material removed from increased frequency of cleaning was based on one local study that was limited in terms of the number of drop inlets investigated.

Results

The changes in projected loads depend on land use. For industrial area, For mercury, the amount removed changes from an estimate of 1.7 kg/yr to 5.1 kg/yr for a marginal increase of 3.4 kg/yr. the projected change in the mass of PCBs removed is estimated to increase from the current estimate of 0.15 kg/yr to 0.45 kg/yr or a marginal increase of 0.3 kg/yr.

For commercial areas, no significant change is projected, and for residential areas, a decrease in mass removed is projected. This is due to a larger reported median annual volume for drop inlets cleaned once per year than drop inlets cleaned quarterly. One factor that could explain these findings is that drop inlets in industrial areas were reported as having sediments in them about 70% of the site visits whereas sediments were identified in the residential drop inlets only about 34% of the site visits⁵². This observation would reduce the mass found in residential drop inlets such that results could be much more sensitive compared to industrial drop inlets, especially when developing cleaning frequency ratios as described above. Moreover the drop inlets that

⁵¹ Mineart, P. and S. Singh. 1994. Woodward Clyde Consultants. Storm Inlet Pilot Study, prepared for Alameda Countywide Clean Water Program, March.

⁵² Mineart, P. and S. Singh. 1994. Woodward Clyde Consultants. Storm Inlet Pilot Study, prepared for Alameda Countywide Clean Water Program, March.

were monitored had to be different for different cleaning frequencies, and it is possible that some of the inlets cleaned annually had much higher accumulations than those that were cleaned quarterly. A multi-year study where the same inlets were cleaned at different frequencies would help to remove this confounding factor.

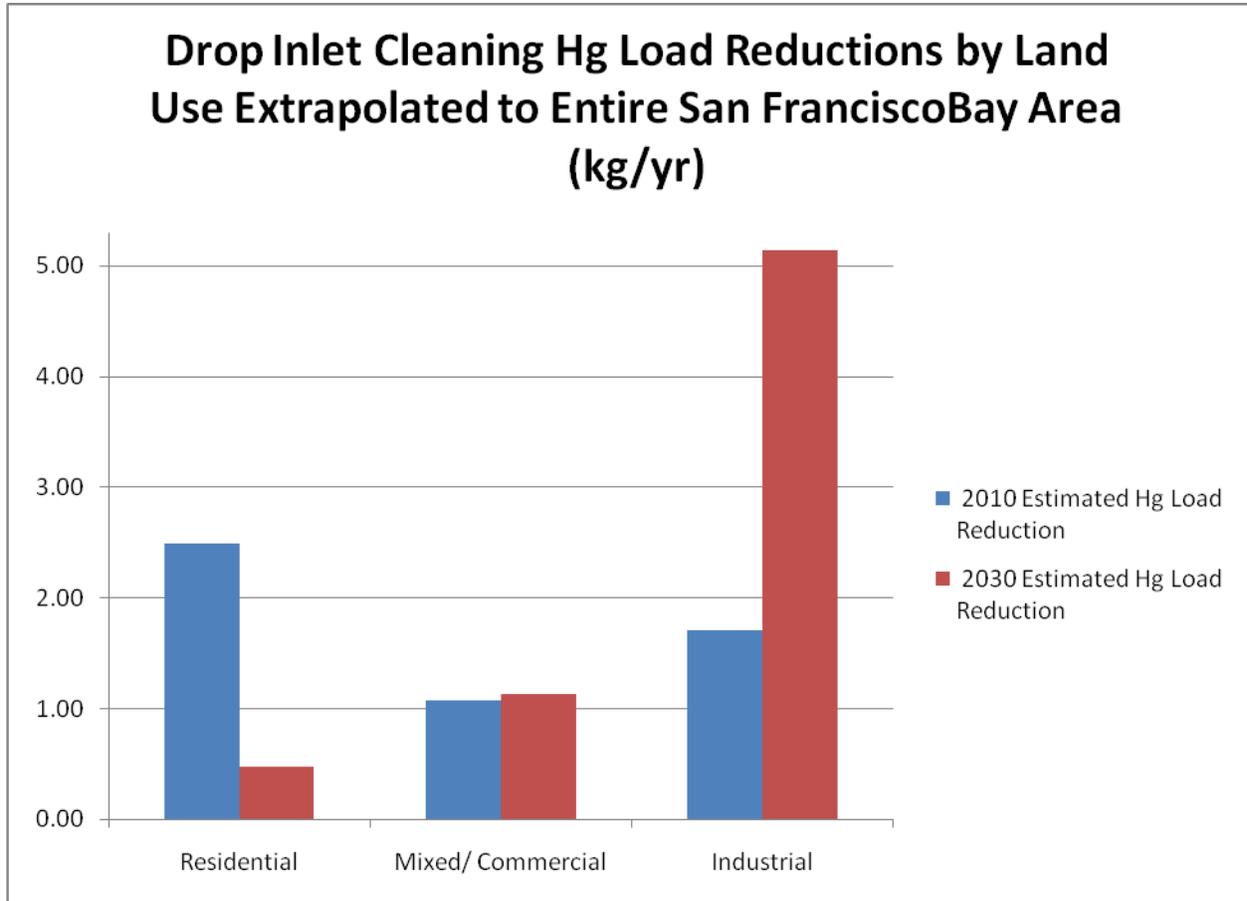


Figure 3-14: Estimated Drop Inlet Cleaning Mercury Mass Removed

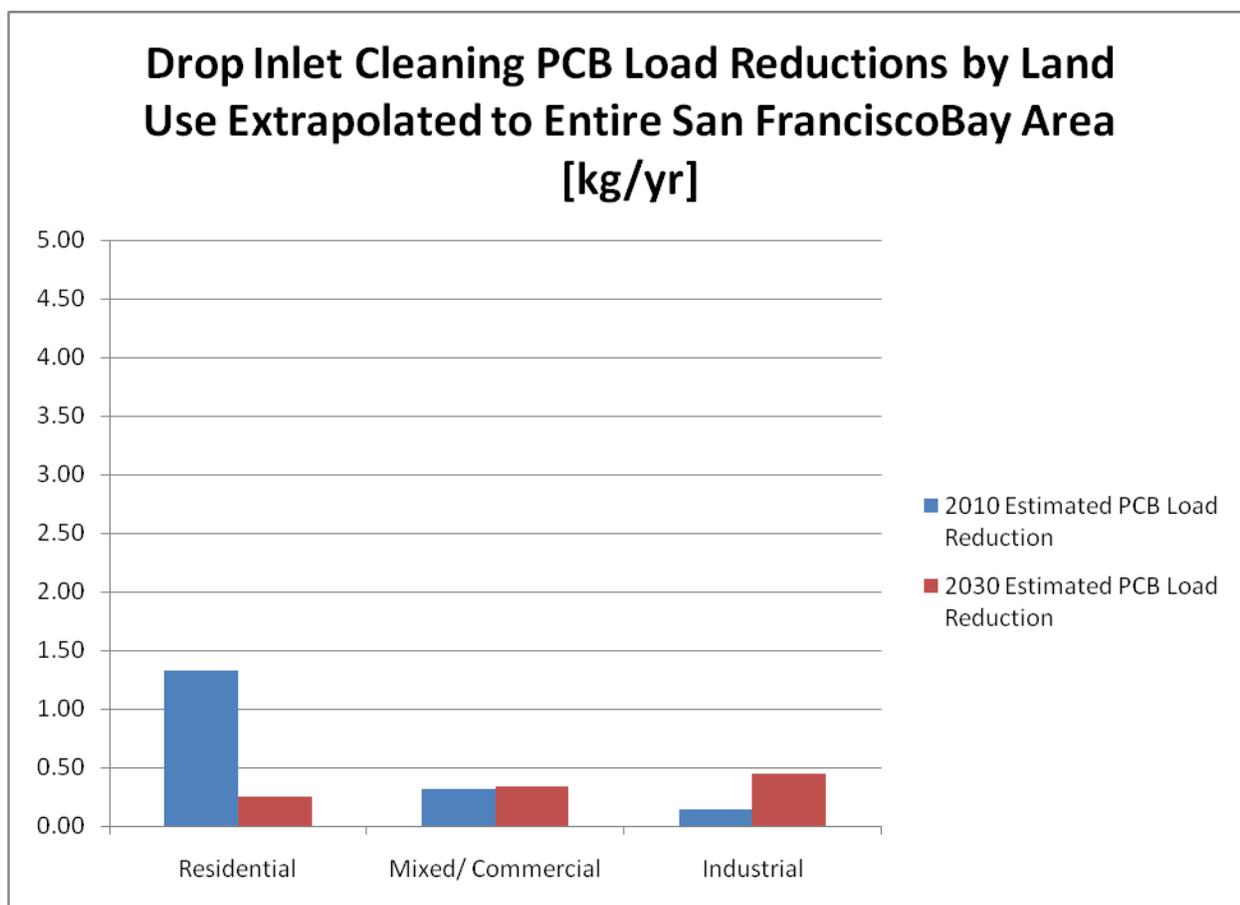


Figure 3-15: Estimated Drop Inlet Cleaning PCB Mass Removed

3.6.8 Scenario 8: Redevelopment

This scenario considers redevelopment with focus on conversion of the older industrial areas located along the San Francisco Bay margins and within other industrial corridors to commercial or mixed (residential/commercial) land uses. The extent of such redevelopment varies considerably depending on economic conditions and other factors. In lieu of actual data on such redevelopment, we assume in this scenario that 1000 acres per year are redeveloped over a period of 20 years. According to the White Paper⁵³ there is approximately 144 square miles or 92,000 acres of industrial land use in the San Francisco Bay Area. So this scenario would consider redevelopment of approximately 20% of the current industrial land uses over a 20 year period.

⁵³ San Francisco Estuary Institute 2010. Review of Methods to Reduce Urban Stormwater Loads.

In this scenario, load reduction is considered to be achieved through two mechanisms: changes in the volume and quality of runoff, associated with the land use change, and installation of source control and treatment (including low impact development measures) as mandated in the MRP.

Baseline runoff volumes were estimated using available local rainfall and runoff information. Runoff concentrations of PCBs and mercury were estimated using TSS concentrations as reported in the BASMAA database⁵⁴ for industrial areas, and assuming concentrations of PCBs and mercury on TSS particles were equivalent to those measured in depositional sediments⁵⁵ in industrial areas. Runoff loads for the redeveloped land use (commercial and mixed use) were estimated in a similar manner but with those concentrations that were measured in samples from commercial and mixed use land uses³.

We assumed that, with redevelopment, the control measures selected would be designed consistent with sizing criteria in the MRP,⁵⁶ resulting in a capture efficiency of approximately 80% of the mean annual runoff from the redeveloped site. The level of treatment was assumed to be consistent with local settling chamber tests conducted by SFEI⁵⁷. Those tests indicated that 5% of the mercury and 30% of the PCBs settled out in the chamber within 2 minutes, and 20% of the mercury and 55% of the PCBs settled out in 20 minutes. It is interesting to note that the reduction in loads associated with the land use change was larger than the effect associated with treatment.

Key Assumptions

- Redevelopment of industrial areas in the San Francisco Bay Area averaging 1,000 acres/yr over a 20 year time period.
- Data on the concentrations of PCBs and mercury collected from sediment depositional areas (e.g., drop inlets, catch basins) are representative of the concentrations of these constituents on suspended solids in urban runoff.
- SFEI settling chamber tests are representative of treatment effectiveness of controls that incorporates settling and have residence time of at least 20 minutes (or 2 minutes).

⁵⁴ Woodward Clyde Consultants, 1996. San Francisco Bay Area Stormwater Runoff Monitoring Data Analysis, 1988-1995, prepared for Bay Area Stormwater Management Agencies Association (BASMAA).

⁵⁵ SFEI database that includes results of Joint Agency Study (KLI & EOA 2002), studies by ACCWP (2002, 2006), and SFEI data contains 483 Hgmercury samples and 575 PCB samples from industrial land uses, and 91 Hgmercury samples, and 107 PCB samples for commercial and mixed land uses.

⁵⁶ The municipal regional stormwater NPDES permit (MRP) Order No. R2-2009-0074, October 2009.

⁵⁷ Yee, D., McKee, L.J., 2010. Task 3.5: Concentrations of PCBs and Hgmercury in soils, sediments and water in the urbanized Bay Area: Implications for best management. A technical report of the Watershed Program, San Francisco Estuary Institute, Oakland CA94621.

Uncertainty

- Assumed magnitude, rates and type of redevelopment (industrial to commercial or mixed use) may not occur in the future as defined in this scenario.
- Treatment options utilized will be site specific and may not be equivalent to those assumed in the scenario.

Results

The projected reductions in mercury loads with this scenario range from approximately 0.4 to 0.5 kg/yr depending on the level of treatment assumed; the corresponding reductions in PCBs range from 0.36 to 0.41 kg/yr.

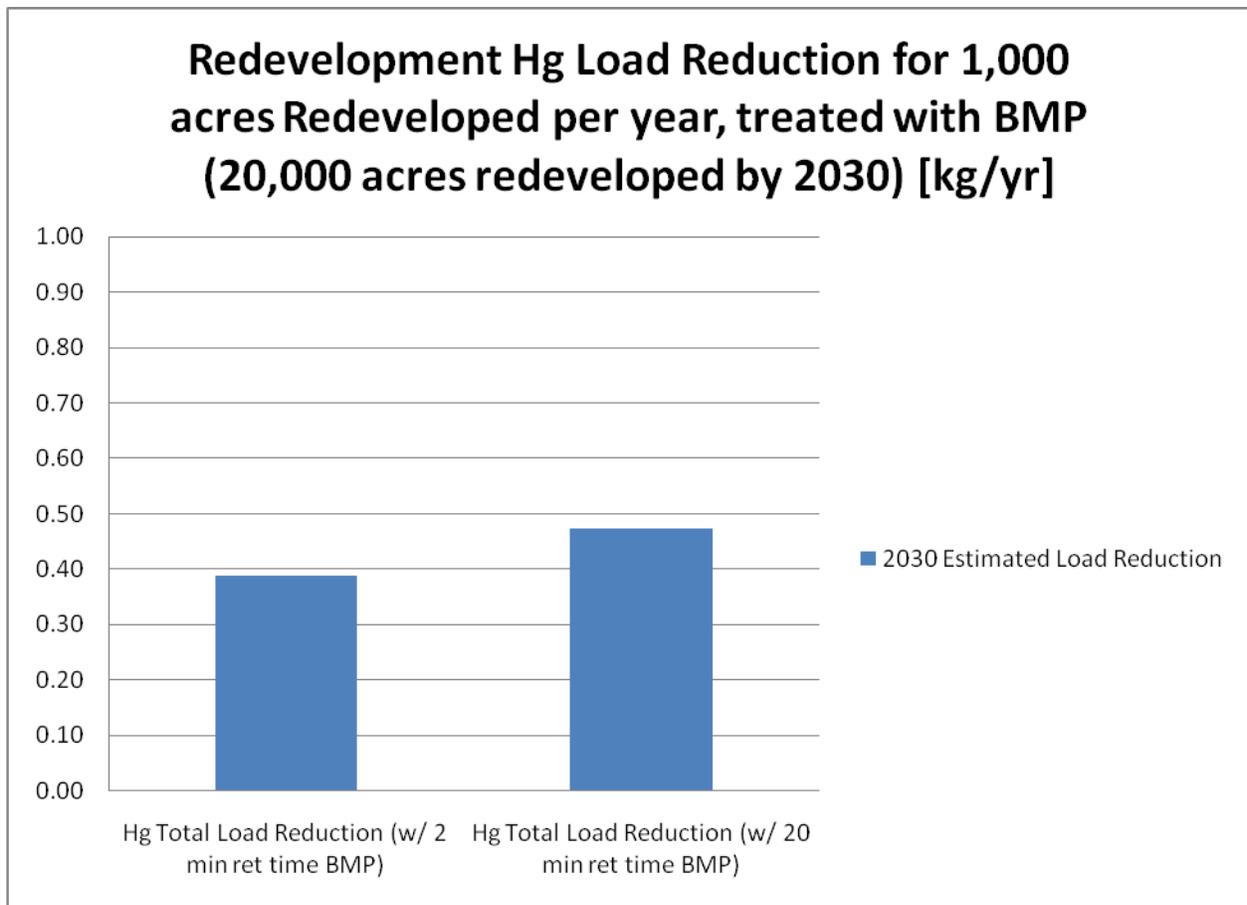


Figure 3-16: Estimated Mass of Mercury Removed via Redevelopment with Treatment

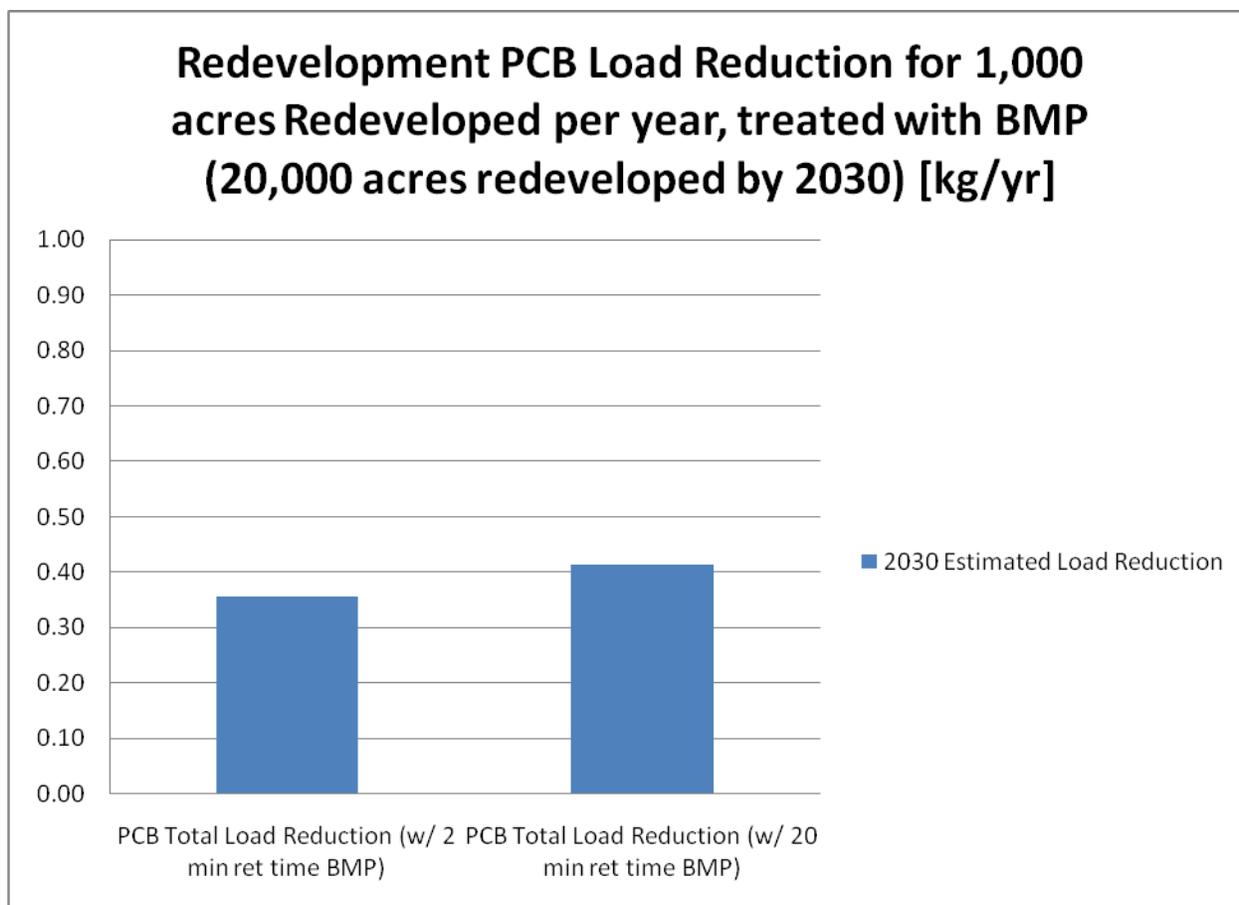


Figure 3-17: Estimated Mass of PCBs Removed via Redevelopment with Treatment

3.6.9 Scenario 9: Treatment of Industrial “Elevated Zones”

Industrial “Elevated Zones” are defined as catchments that, because of historical usage, have elevated concentrations of mercury or PCBs in the soils, likely producing stormwater runoff with similarly elevated levels. An example of such an area is the approximately 1,000 acre Ettie Street watershed in Oakland, where intensive sampling has indicated there are elevated levels of PCBs along streets and within the public right of way. Such areas may be subject to cleanup of localized “hotspots”, but the diffuse nature of the contamination is potentially amenable to treatment, which is the basis of this scenario.

For the purposes of this scenario, the definition of an industrial elevated zone is one where monitoring data compiled by SFEI from sampling industrial land uses lies in the upper quartile

of the distribution⁵⁸. The characteristic concentration for such areas was taken as the 75th percentile PCB and mercury concentration and was approximately 0.3 mg/kg for both constituents.

The total area in the San Francisco Bay Area that would be defined as elevated industrial cannot be determined from these point measurements. In lieu of such information we assume that 1,000 acres of elevated industrial were treated each year for 20 years totaling 20,000 acres treated⁵⁹. This is roughly equivalent to identifying and treating the equivalent of one Ettie Street per year.

Many of the inputs and assumptions for this scenario were identical to the inputs used for the redevelopment and retrofitting scenarios previously discussed. The key difference is the use of the upper quartile of industrial land use designated mercury and PCB sediment concentrations to designate an “elevated zone”.

Treatment of the elevated zones is assumed to be equivalent to a BMP that incorporates settling as a treatment process. This allows the use of results from the SFEI settling chamber tests, which are representative of local conditions⁶⁰. Those tests indicated that 5% of the mercury and 30% of the PCBs settled out in the chamber within 2 minutes, and 20% of the mercury and 55% of the PCBs settled out in 20 minutes. Other forms of mitigation including removal or capping of contaminated soils could potentially increase the projected effectiveness of this scenario, but this also would depend on a number of site factors, and the ability to identify rather precisely the extent of contamination.

Assumptions

- Elevated industrial zones assumed to be those whose PCB and mercury concentrations are in the upper quartile of the data.
- Scenario assumes treatment of 1,000 acres of elevated industrial per year for 20 years, for a total area treated of 20,000 acres. This represents about 22% of the industrial area in the San Francisco Bay Area.

⁵⁸ The SFEI data base (and the worksheet for this scenario) contains 315 Mercury and 268 PCB soil samples taken from industrial areas in the San Francisco Bay Area. Note, upper quartile was also discussed by Yee and McKee (2010).

⁵⁹ The total industrial area in the San Francisco Bay Area is 144 square miles or approximately 92,000 acres (SFEI White Paper), so 20,000 acres represents 22% of the total industrial area in the San Francisco Bay Area.

⁶⁰ Yee, D., McKee, L.J., 2010. Task 3.5: Concentrations of PCBs and Mercury in soils, sediments and water in the urbanized Bay Area: Implications for best management. A technical report of the Watershed Program, San Francisco Estuary Institute, Oakland CA94621.

Sources of Uncertainty

- The total area corresponding to the definition of elevated industrial zones is not available, and further sampling at finer resolution may be needed to estimate the extent of such areas.
- The treatability of mercury and PCBs is based on settling alone; whereas a number of potential treatment BMPs include adsorption or filtration, and the net treatment effectiveness for a BMP that incorporates multiple treatment processes is unknown for mercury and PCBs.
- Elevated industrial zones may also be subject to remediation of selected hot spots, and a more realistic scenario could potentially focus on remediation or a combination of remediation and treatment.

Results

The results from this scenario indicate that, after 20 years of implementation, PCB load reductions of 0.46 kg/yr could be achieved with a BMP that can achieve quiescent settling for at least 2 minutes, and 0.85 kg/yr for a settling time of 20 minutes. The corresponding reductions for mercury are projected to be 0.08 kg/yr and 0.32 kg/yr.

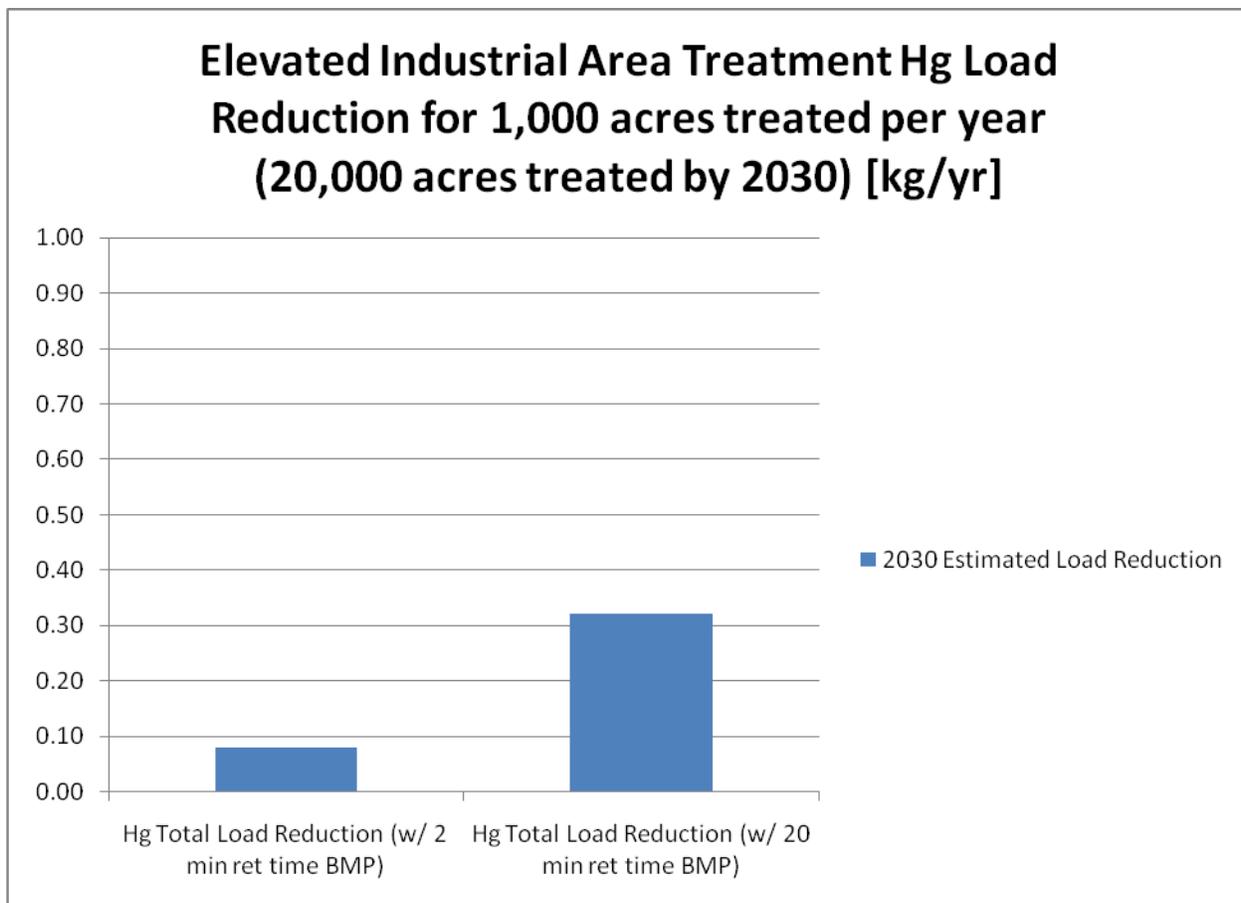


Figure 3-18 - Mercury Removal with Treatment of Elevated Industrial Areas

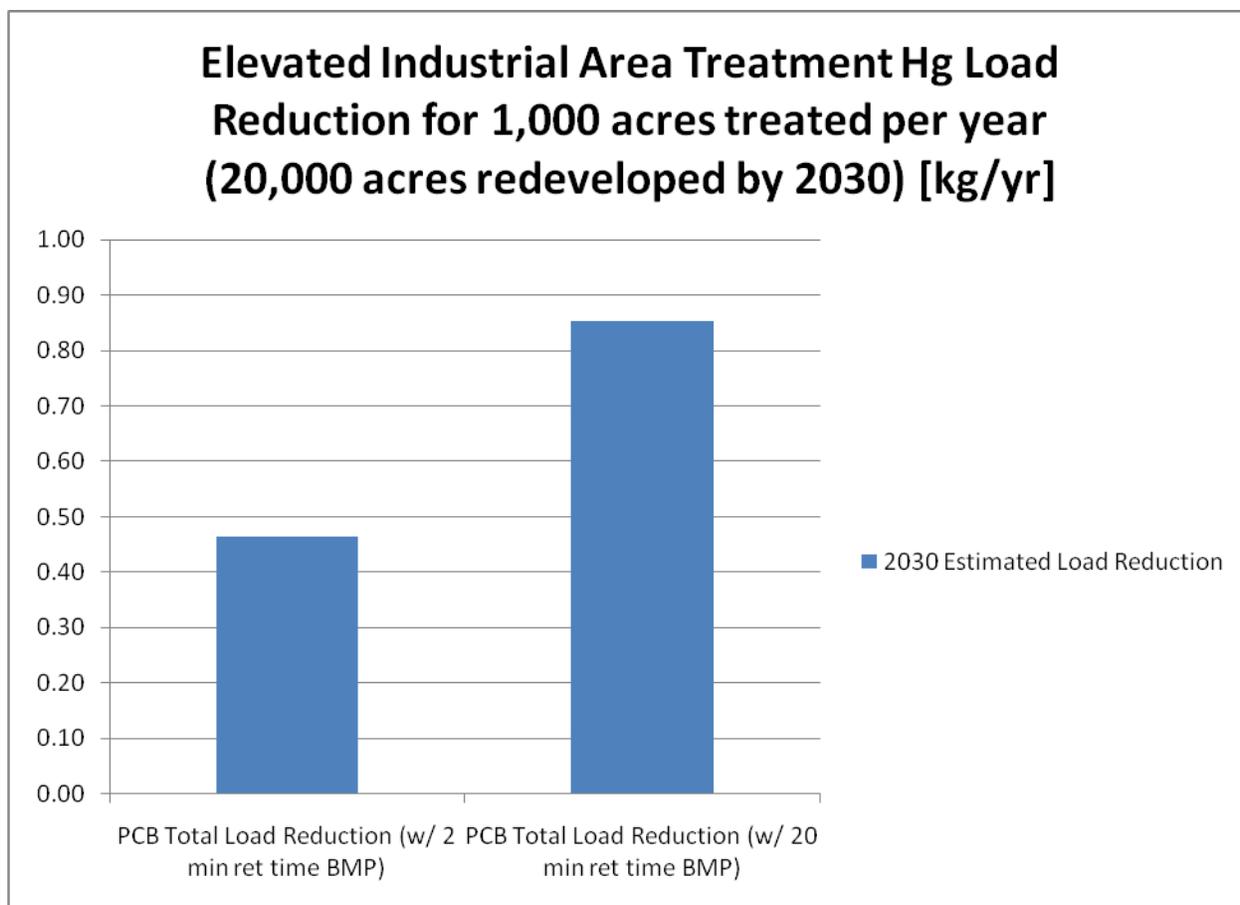


Figure 3-19: PCBs Removal with Treatment of Elevated Industrial Areas

3.6.10 Scenario 10: Pump Station Diversion

Much of the land immediately surrounding San Francisco Bay, often referred to as the San Francisco Bay Margin, is below sea level. Stormwater runoff from these areas must therefore be routed to a pump station where the water is then pumped into the Bay. These areas are often current or historical industrial areas. Treatment of runoff that is served by pump stations provides a unique opportunity to treat runoff from catchments with possibly higher than average concentrations of mercury and PCBs, by diverting the pumped water to treatment plants.

According to data compiled to-date by SFEI there is approximately 280 pump stations that discharge into San Francisco Bay. Note, provision C.2.d.ii(1) of the MRP⁶¹ calls for further work to improve the knowledge about pump stations. Based on spatial GIS data, the total catchment area that drains the pump stations is estimated to be about 40,000 acres. Restrictions on

⁶¹ The municipal regional stormwater NPDES permit (MRP) Order No. R2-2009-0074, October, 2009.

diversion to pump stations include the necessity of reasonable proximity to the pump station and available excess capacity for accepting stormwater runoff. In this scenario we assume that these restrictions may apply to 20% of the total catchment area or approximately 8,300 acres.

Diversion of wet weather flows also will require the installation of conveyance and possibly storage and for this scenario it was assumed that a reasonable diversion would be 20% of the runoff from the 8300 acres. In this regard, the scenario addresses the initial runoff (or “first flush”) generated from the catchment area.

The inputs for the hydrology calculations were annual precipitation⁶², San Francisco Bay Area industrial specific runoff coefficients⁶³, and land uses for the areas served by pump stations contained in the SFEI database.

Mercury and PCBs concentrations were estimated as the product of TSS times the concentrations of mercury and PCBs on pump station embedded sediments. The mean runoff TSS was estimated from the BASMAA database⁶⁴. The median mercury and PCB concentrations were obtained from the analysis of embedded sediments taken from pump stations in industrial areas⁶⁵. To determine the mass removed by the treatment plant, it is assumed that the treatment plant removes 90% of mercury and PCBs.

Assumptions

- Approximately 20% of the pump stations in the San Francisco Bay Area are potential candidates for diversion
- The required infrastructure to accomplish diversion including storage, pumping, conveyance, and WWTP excess capacity limits the amount of runoff that could potentially be diverted to 20%.
- Embedded sediment data for mercury and PCBs provide reasonable estimates for the concentrations of mercury and PCBs in suspended sediment.

⁶² Approximately 22 in/yr based on median of measurements from various San Francisco Bay Area National Climatic Data Center (NCDC) raingages as reported in KLI & EOA, 2002.

⁶³ Approximately 0.6 based on $C = \% \text{ imp} * 0.009 + 0.05$ (FHWA) and impervious data from KLI & EOA, 2002.

⁶⁴ Woodward Clyde Consultants, 1996. San Francisco Bay Area Stormwater Runoff Monitoring Data Analysis, 1988-1995, prepared for Bay Area Stormwater Management Agencies Association (BASMAA)

⁶⁵ Joint Agency study (KLI & EOA, 2002).

Uncertainty

- The feasibility of diversions rests on a number of engineering, regulatory, and economic factors, not the least of which is the conditions that WWTP may be required to stipulate regarding acceptance of stormwater.

Results

The results of this scenario indicate that only 0.02 kg of PCB would be reduced and only 0.04 kg of mercury would be reduced through this diversion. The principal constraint in this scenario is areas tributary to pump stations are limited and the assumption is that only 20% of the pump stations are feasible for diversions.

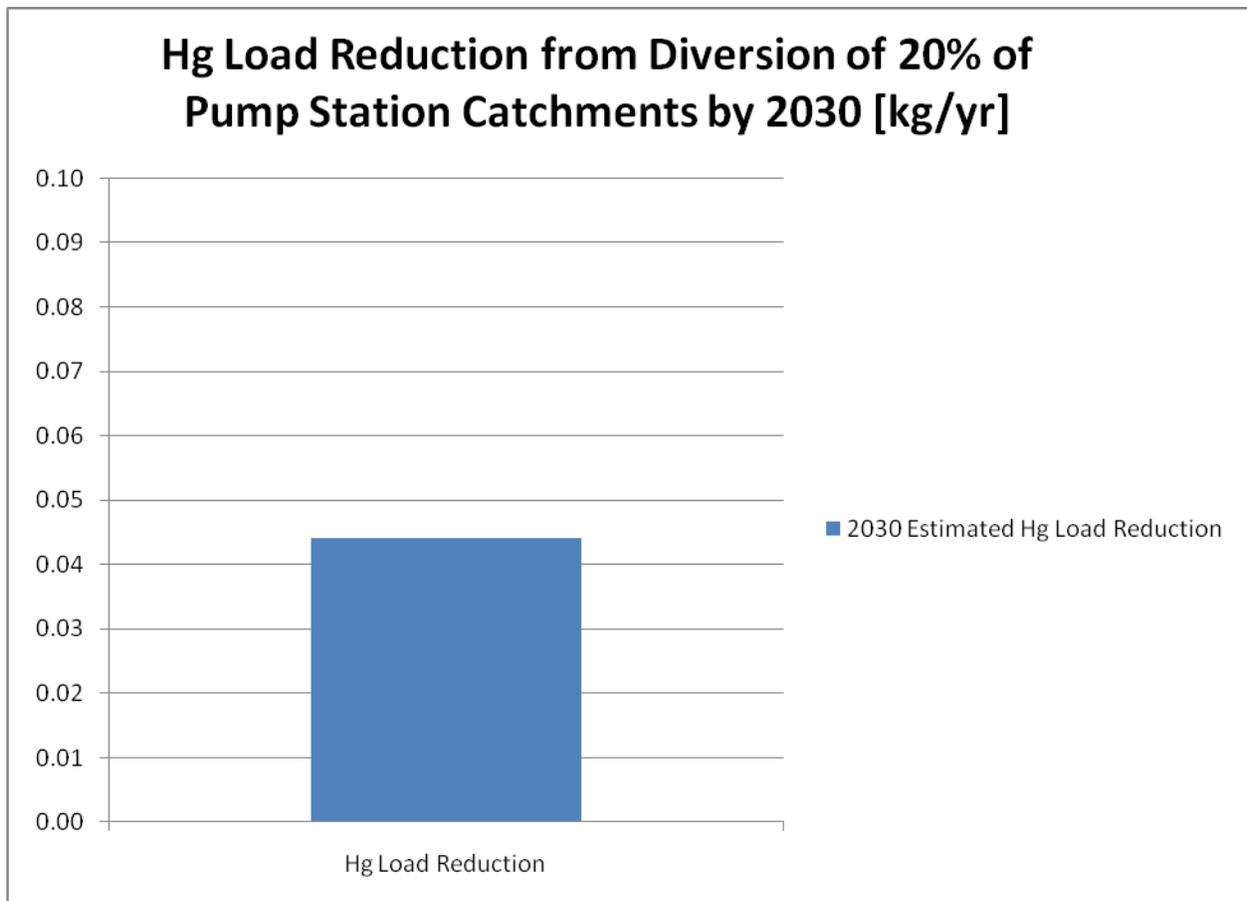


Figure 3-20 - Mercury Mass Removal with Diversion of 20% of Pump Station Tributary Area

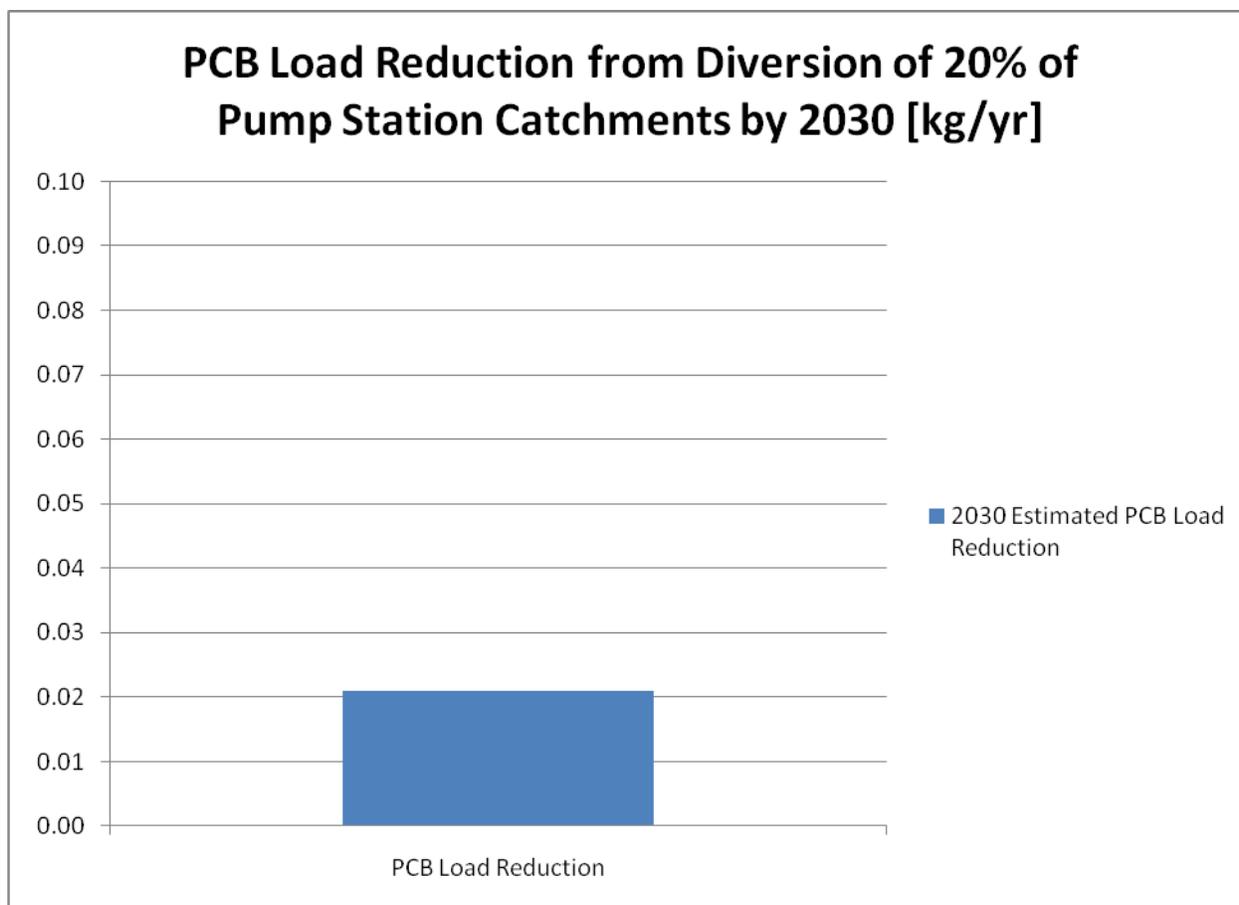


Figure 3-21 - PCB Mass Removal with Diversion of 20% of Pump Station Tributary Area

3.6.11 Overlap between Scenarios

The calculations for each scenario were performed independently of the other scenarios, so there is the potential for overlap. This primarily reflects the fairly basic level of analysis used in contrast say to a comprehensive model that accounted for the interaction between sources, transport, control, and fate of constituents. The only linkage we did avoid was that between local point source of mercury emissions and maintenance controls like street sweeping and drop inlet cleaning. So in addressing local emission sources, we restricted the scenario to direct deposition to San Francisco Bay.

The following table shows the potential overlap in the land uses addressed by each scenario. As indicated in the table, the most potential for overlap lies with industrial areas. However it is important to note that most scenarios addressing industrial areas focus on a specific subset of industrial areas, such as areas with elevated mercury and PCBs, areas subject to redevelopment, or areas served by pump stations. In many cases, but not all, these areas may be mutually exclusive.

Table 3-3 - Land Uses Associated with Scenarios

| Scenario | Industrial | Commercial | Residential |
|---|------------|------------|-------------|
| 1. Fluorescent Bulb Recycling (Mercury) | ✓ | ✓ | ✓ |
| 2. Thermostat Recycling (Mercury) | ✓ | ✓ | ✓ |
| 3. Building Demolition (PCBs) | ✓ | ✓ | |
| 4. Air Emissions (Mercury) | ✓ | | |
| 5. Street Sweeping | ✓ | ✓ | ✓ |
| 6. Street Washing | ✓ | ✓ | |
| 7. Drop inlet Cleaning | ✓ | ✓ | |
| 8. Redevelopment | ✓ | ✓ | |
| 9. Elevated Industrial Areas | ✓ | ✓ | |
| 8. Pump Station Diversion | ✓ | | |

4.0 UNCERTAINTY

Specific sources of uncertainty have been summarized above for each scenario. Additionally in some of the scenarios we provide a range of projections based on different assumptions that allow the reader to comprehend the magnitude of uncertainty in the projections. Given the considerable uncertainty associated with these projections, the projections are best viewed as a means of estimating the relative benefits of different load reduction techniques, rather than as reliable predictors of absolute load reductions.

The following describes sources of uncertainty that tend to be characteristic of all the scenarios.

Projecting into the Future: The projections of future load reductions that we assumed are considered to be the most indeterminate source of uncertainty in the scenario spreadsheets. These projections are based on assumptions of more intense implementation of existing practices or incorporation of new practices. In a number of scenarios load reductions were projected 20 years in the future, based on current data and information. It is very likely that future changes in product usage, community awareness, regulations, development patterns, and other factors will differ greatly from those changes assumed in the scenarios. This ambiguity was the driving consideration in our desire to provide scenario workbooks that could ideally be easily modified as new information becomes available.

Projecting Local Study Results to San Francisco Bay Area as a Whole: A number of data sets that were utilized to characterize current conditions in scenario spreadsheets are regional (see footnotes to scenario summaries for references); however, some scenarios were developed from studies conducted by one or more municipal agencies (generally cities or counties), which focused on localized results rather than a representation of the San Francisco Bay Area as a whole. The results of these localized studies were projected to the entire San Francisco Bay Area based on some type of translator such as land use, area, or population. Because the San Francisco

Bay Area encompasses vastly different land uses, densities, and pollution sources which vary depending on location, there is a considerable amount of uncertainty associated with these projections. Despite this uncertainty, projections of local data were used when possible instead of national or global data because this local data is believed to best represent the conditions of the San Francisco Bay Area even with study location constraints. The spreadsheets can be modified to incorporate new information when more robust regional data becomes available.

Inability to Accurately Incorporate Land Use in Scenario Development: The data analysis conducted as part of this project demonstrate correlations between land use designations and PCB and Hg loads; thus land use is thought to be a key consideration when evaluating implementation strategies. When possible, land use was considered in data analysis and projections of BMP scenario effectiveness. But land use-based information was not always reported or available. In cases where land use information was unavailable, assumptions were made regarding how the data applied to different land uses. Based on our experience, pairing source controls to target land uses (and other attributes of land use such as age of development) is important in selecting efficient control strategies.

Potential for Overlap between Scenarios: Some of the BMP scenarios have the potential to overlap, which could affect effectiveness estimates. For example, efforts to address atmospheric deposition will, if effective, reduce the effectiveness of maintenance scenarios (such as street sweeping), by limiting or reducing the amount of available pollutant-laden material that can be collected by such efforts. At this level of analysis, we are not able to quantitatively take into account the possible effects of such potential linkages.

5.0 SUMMARY AND RECOMMENDATIONS

5.1 Summary

This report builds on the White Paper, which described and quantified the sources of mercury and PCBs entering San Francisco Bay. To select and prioritize controls, we started by identifying sources by land use using spreadsheets that converted the original source identification provided in the White Paper. These spreadsheets provide estimates of the annual loads of mercury and PCBs to the San Francisco Bay from various land use categories. Using the results from the source and land use characterization analysis, we developed BMP scenarios and evaluated their effectiveness in terms of reducing the loads to the Bay.

For each BMP scenario, we developed a workbook that was designed to be easy to follow, transparent and flexible. Each workbook allows the user to understand the sources of the data inputs, change the assumptions, and to refine the calculations as more data become available. The source and land use characterization analysis showed that the highest unit loadings for both mercury and PCBs were in industrial and commercial areas, so we often focused on industrial and commercial areas when selecting BMP scenarios. We developed scenarios to reduce the

load of mercury and PCBs to the San Francisco Bay through a variety of means: pollution prevention, maintenance, and treatment.

The BMP scenarios we considered were:

Institutional Controls (Pollution Prevention):

1. Fluorescent Bulb Recycling (Mercury)
2. Thermostat Recycling (Mercury)
3. Building Demolition and Recovery (PCBs)
4. Regional Atmospheric Sources (e.g., crematoria) (Mercury)

Institutional controls (Maintenance):

5. Street Sweeping,
6. Street Washing,
7. Drop inlet Cleaning,

Treatment (or cleanup for elevated industrial areas):

8. Redevelopment,
9. Elevated Industrial Areas⁶⁶
10. Pump Station Diversions to waste water treatment plants

⁶⁶ Elevated industrial areas are defined as industrial areas where PCB or Hgmercury concentrations in soils or street dirt are in upper quartile of data (further discussed under scenario).

5.1.1 Mercury Load Reduction Projections

The projected effects of all of the scenarios for mercury are shown in Figures 5-1 and 5-2. Table 5-1 summarizes the projections for mercury and PCBs for each scenario. The reader is cautioned here that the effectiveness of each scenario is highly dependent on the assumptions with each scenario, and there is no overarching common basis for comparison (see recommendations). Because of the range of projected load reductions for the scenarios, Figure 5-1 illustrates the results for those scenarios where the projected load reduction is less than 1.0 kg/yr, and Figure 5-2 illustrates the load reductions that are projected to achieve load reductions of 10 kg/yr or less. Each bar displays the projected reduction in loads that could be achieved by the BMP scenario in 2030.

Street washing and pump station diversions are projected to achieve very low load reductions, in part because the areas where such practices could be conducted are limited relative to the size of the local watershed⁶⁷. Treatment BMPs targeting elevated industrial areas and redevelopment are projected to have low load reductions because runoff concentrations of mercury are low and treatment effectiveness for mercury based on the settling tests conducted by SFEI are modest. The most effective scenarios are those that address source control and maintenance, namely air emissions, recycling, street sweeping, and drop inlet cleaning.

The underlying message from the scenario analysis is that effectiveness improves as measures move up the continuum from San Francisco Bay to source. Controls like recycling that address the product at its point of usage are generally shown to be superior in effectiveness.

Controls like sweeping or drop inlet cleaning, which address accumulation of pollutants in depositional sediments, can also be relatively effective if the depositional areas contain elevated concentrations of the constituent. Concentrations of suspended sediment and mercury associated with suspended sediment in urban runoff are sufficiently low to illustrate that treatment of urban runoff is projected to be less effective.

5.1.2 PCB Load Reduction Projections

Figure 5-3 shows the projected PCB load reductions associated with the various scenarios. In contrast to mercury, the projected load reductions of PCBs are generally less than 1 kg/yr. PCB recovery as part of building demolition may be a relatively effective measure, but the available data exhibits an order of magnitude range in projected effectiveness⁶⁸. With respect to the further

⁶⁷ Note, that in the case of pump station diversion, new data will soon be available from SFEI (regional low flow estimates and low flow loads) and through the MRP (locations, drainage area and land uses serviced by pump stations) that may help to improve these estimates.

⁶⁸ The San Francisco Estuary Partnership is planning a study to develop Bay Area-specific best management practices (BMPS) to prevent release of PCBs from building materials into urban runoff which will provide important data for improving these estimates.

potential of pollution prevention measures for PCBs, it should be noted that presently there is assumed to be at least 260,000 kg (580,000 lb) of PCBs still in use in the San Francisco Bay Area⁶⁹. This estimate may be low as it does not include any PCBs still in use at the five San Francisco Bay Area oil refineries or any of the electric power generation plants. Here, we did not make an estimate specifically for phasing out these current legal known uses of PCBs.

Street sweeping, and drop inlet cleaning in industrial areas⁷⁰ are projected to result in relatively higher load reductions. Additionally, treatment of runoff from elevated industrial areas in the case of PCBs shows improved load reductions over that for mercury, a result which is correlated to the higher concentrations of PCBs in sediments in industrial areas. Treatment of industrial areas as part of redevelopment projects shows comparable results to those achieved with mercury.

⁶⁹ It is still legal for PCBs to be used in some totally enclosed applications including intact, non-leaking electrical equipment found on industrial sites. These, for the most part, are large scale transformers and capacitors. The USEPA keeps a data base of these ongoing uses which is updated regularly. EPA data base: <http://www.epa.gov/epawaste/hazard/tsd/pcbs/pubs/data.htm>

⁷⁰ Drop inlet cleaning effectiveness in residential areas is actually projected to decrease with increased frequency based on data from Mineart and Singh (1994), but this appears to be an anomalous result.

Table 5-1: Summary of Projected Load Reduction Estimates

| Pollutant of Concern | | Hg (kg/yr) | | | PCBs (kg/yr) | | |
|---|-------------------------|---------------------|---------------------|-------------------------------------|---------------------|---------------------|-------------------------------------|
| Scenario | Sub-category | 2010 Load Reduction | 2030 Load Reduction | Load Reduction Incremental Increase | 2010 Load Reduction | 2030 Load Reduction | Load Reduction Incremental Increase |
| <i>Institutional Controls (Pollution Prevention)</i> | | | | | | | |
| 1. <i>Fluorescent Bulb Recycling</i> | Estimate 1; AB1109 Bill | 0.3 | 4.2 | 3.9 | - | - | - |
| | Estimate 2; ALMR | 2.4 | 13.3 | 10.9 | - | - | - |
| 2. <i>Thermostat Recycling</i> | | 0.8 | 2.4 | 1.6 | - | - | - |
| 3. <i>Building Demolition and Recovery</i> | Low Estimate | - | - | - | - | 0.1 | 0.1 |
| | High Estimate | - | - | - | - | 3.0 | 3.0 |
| 4. <i>Regional Atmospheric Sources</i> | | - | 8.6 | 8.6 | - | - | - |
| <i>Institutional controls (Maintenance)</i> | | | | | | | |
| 5. <i>Street Sweeping (per 10,000 acres swept)</i> | Residential | 0.4 | 0.8 | 0.4 | 0.4 | 0.7 | 0.4 |
| | Mixed/Commercial | 0.7 | 1.4 | 0.7 | 0.4 | 0.8 | 0.4 |
| | Industrial | 0.7 | 1.5 | 0.7 | 0.5 | 1.0 | 0.5 |
| 6. <i>Street Washing</i> | | | 0.005 | 0.005 | | 0.003 | 0.003 |
| 7. <i>Drop inlet Cleaning</i> | Residential | 2.5 | 0.5 | -2.0 | 1.3 | 0.3 | -1.1 |
| | Mixed/Commercial | 1.1 | 1.1 | 0.1 | 0.3 | 0.3 | 0.0 |
| | Industrial | 1.7 | 5.1 | 3.4 | 0.1 | 0.4 | 0.3 |
| <i>Treatment</i> | | | | | | | |
| 8. <i>Redevelopment of Industrial Areas</i> | 2 min ret time BMP | - | 0.4 | 0.4 | - | 0.4 | 0.4 |
| | 20 min ret time BMP | - | 0.5 | 0.5 | - | 0.4 | 0.4 |

| Pollutant of Concern | | Hg (kg/yr) | | | PCBs (kg/yr) | | |
|---|---------------------|----------------------------|----------------------------|--|----------------------------|----------------------------|--|
| <i>Scenario</i> | <i>Sub-category</i> | 2010 Load Reduction | 2030 Load Reduction | Load Reduction Incremental Increase | 2010 Load Reduction | 2030 Load Reduction | Load Reduction Incremental Increase |
| 9. <i>Elevated Industrial Area Mitigation</i> | 2 min ret time BMP | - | 0.1 | 0.1 | - | 0.5 | 0.5 |
| | 20 min ret time BMP | - | 0.3 | 0.3 | - | 0.9 | 0.9 |
| 10. <i>Pump Station Diversion to WWTP</i> | | - | 0.04 | 0.04 | - | 0.02 | 0.02 |

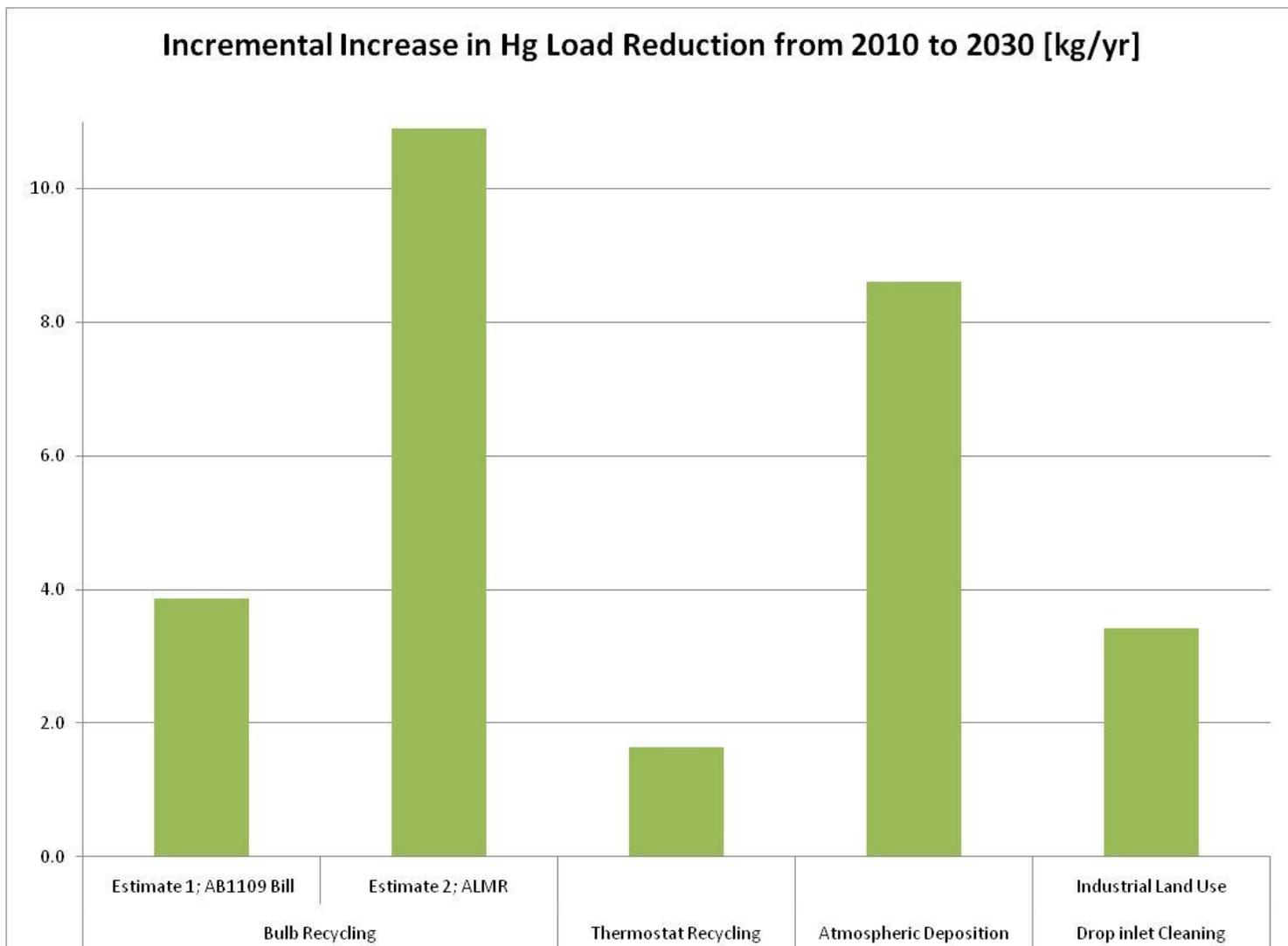


Figure 5-1: Projected Load Reduction for Mercury for Fluorescent Bulb Recycling, Thermostat Recycling, Atmospheric Deposition, and Drop Inlet Cleaning (Industrial Land Use)

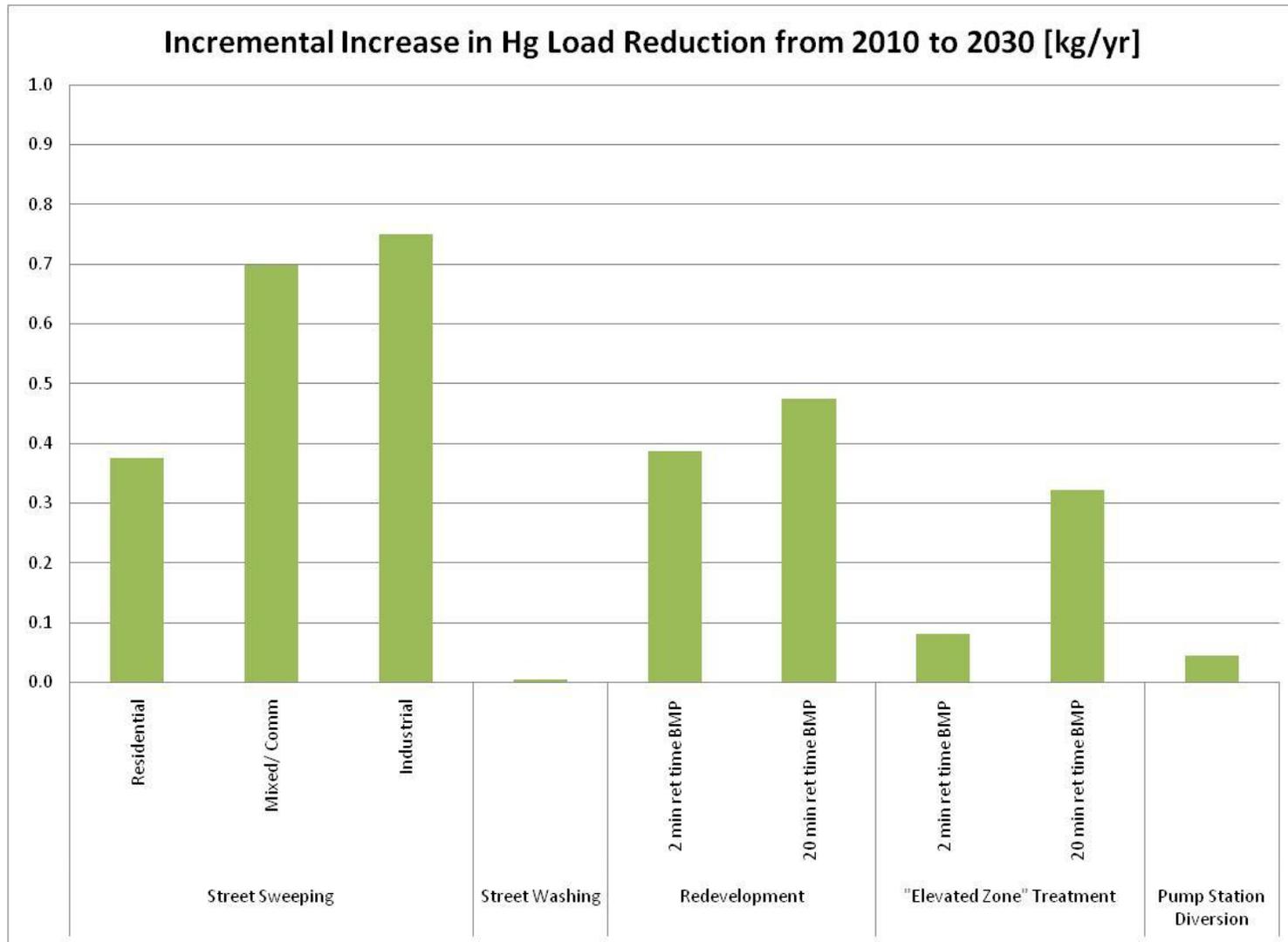


Figure 5-2: Projected Load Reductions for Mercury from Street Sweeping (per 10,000 ac), Street Washing, Redevelopment, Elevated Industrial Area Treatment, and Pump Station Diversion.

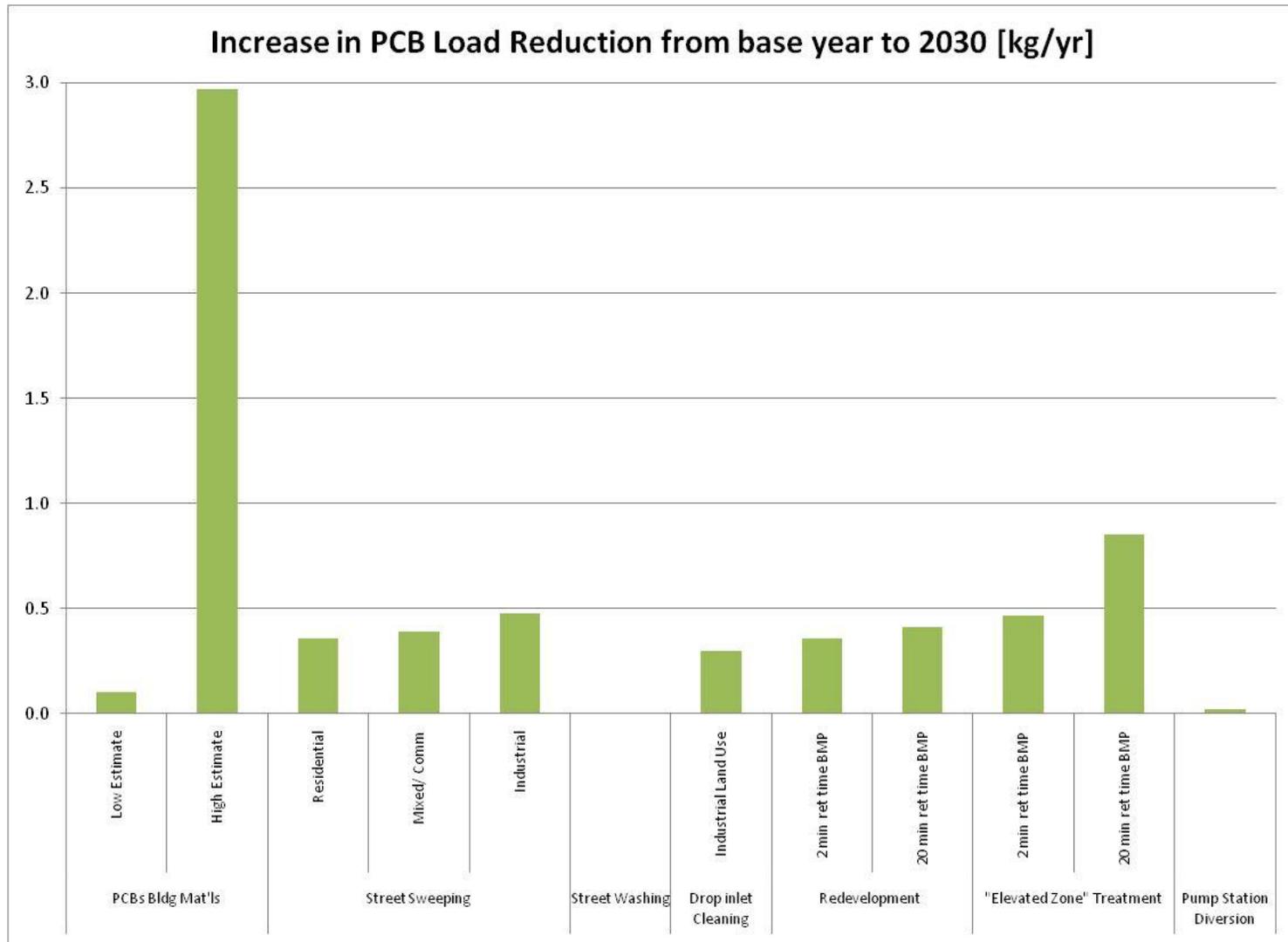


Figure 5-3: Projected PCB Load Reductions for Building Demolition Controls, Street Sweeping, Street Washing, Drop Inlet Cleaning (Industrial Land Use), Redevelopment, Elevated Industrial Area Treatment and Pump Station Diversion

5.2 Recommendations

The above summary of control measures above is limited with respect to making comparisons of effectiveness based on implementation considerations because there is no common basis for comparison. For those scenarios that are building on existing practices, such as recycling, this is less of an issue. However, for new practices or for those practices that may have significant costs associated with increased implementation, there is a need to provide estimates of capital and operational costs associated with each scenario and develop a cost-effectiveness metric (e.g., cost per unit mass of constituent intercepted). Such a metric would facilitate a more meaningful comparison amongst alternatives.

The analyses outlined in this report are considered a “work in progress” that should be updated as additional information becomes available. With the advent of the MRP⁷¹, various municipal agencies are planning to continue or implement additional pilot studies that should help to refine the scenarios contained herein, and to develop new scenarios. As shown in this report, a key element in crafting effective control measures is taking into account land use type and condition. It is strongly recommended that the design of such studies take into account land use types and conditions within a land use that may be important in characterizing loads and prioritizing controls. It is also recommended that agencies consider adapting the workbooks developed as part of this project, to assist in identifying, prioritizing, and extrapolating the results from their pilot studies.

A key factor that can significantly affect the effectiveness of maintenance and treatment measures is the partitioning of mercury and PCBs amongst solids depending on the amount, type and size of the solids. The SFEI fractionation study⁷² which explores the effects of particle size on settling of PCBs and mercury is a start on obtaining a better understanding of these dynamics. Agencies are encouraged to consider study designs that will help improve our understanding of these processes, which have practical implications.

This report clearly indicates that those control measures that address mercury prior to entering the environment are more effective than measures that attempt to capture constituents that may accumulate on streets, or in drop inlets or storm drains. A similar conclusion may not be appropriate for PCBs, given that it is a legacy chemical, though there does appear to be ample reservoirs of PCBs currently stored and used by industry, or present in the form of PCB-laden building materials. It is strongly recommended that practices that focus on preventing these constituents from initially entering the environment receive priority.

⁷¹ Municipal Regional Stormwater Permit Order No. R2-2009-0074, Provision C.11 Mercury Controls, and Provision C12 PCB Controls.

⁷² Yee and McKee, 2010.

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