A BMP TOOL BOX FOR REDUCING POLYCHLORINATED BIPHENYLS (PCBS) AND MERCURY (HG) IN MUNICIPAL STORMWATER

San Francisco Estuary Institute

In coordination with:

Bay Area Stormwater Management Agencies Association
San Francisco Bay Regional Water Quality Control Board

Project team:
San Francisco Estuary Institute
Lester McKee (Project director)
Don Yee
Kat Ridolfi (Project manager)
Alicia Gilbreath
Sarah Pearce

Geosyntec Consultants
Peter Mangarella

BASMAA
Geoff Brosseau (Executive Director)
Arleen Feng (ACCWP)
Chris Sommers (EOA, Inc. on behalf of SCVURPPP)

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PREFACE

The San Francisco Bay polychlorinated biphenyl's (PCBs) and mercury (Hg) total maximum daily loads reports (TMDLs) developed by the San Francisco Regional Water Quality Control Board (Water Board) call for increasing effort to manage and reduce loads in stormwater in order to improve water quality in San Francisco Bay. Over the past 10 years, members of the Bay Area Stormwater Management Agencies Association (BASMAA) have carried out a number of studies and programs to track and abate sources of PCBs and Hg. Perhaps the most well known of these programs was carried out by the City of Oakland in the Ettie Street watershed where PCB contamination was located in relation to industrial legacies but there are also many city and county programs that successfully capture and recycle mercury. However, despite many examples of previous and ongoing efforts, there is still limited information on where legacy contamination occurs and the most cost efficient management measures. Five years ago, San Francisco Estuary Institute (SFEI) was awarded a grant from the State of California under the Proposition 13 stormwater non-point-source program to investigate options for better managing mercury and PCBs in urban stormwater. This tool box provides a summary of knowledge gained through this grant and preliminary guidance on tracking and controlling mercury and PCBs in urban environments and stormwater.

ACRONYMS

ac	Acre
BASMAA	Bay Area Stormwater Management Agencies Association
BMP	Best Management Practice
Caltrans	California Department of Transportation
CASQA	California Association of Stormwater Quality
CBI	Catch Basin Insert
cf	Cubic Feet
cfs	Cubic Feet per Second
cm	Centimeter
CSO	Combined Sewer Overflows
CWA	Clean Water Act
cy	Cubic Yard
CWP	Center for Watershed Protection
e.g.	For Example
EPA	Environmental Protection Agency
ft	Feet
FY	Fiscal Year
g	Gram
ha	Hectare
Hg	Mercury
hr	Hour
in	Inch
kg	Kilogram equivalent to 2.205 pounds
L	Liter equivalent to 0.2642 gallons
lb	Pound
MEP	Maximum Extent Practicable
m	Meter equivalent to 3.281 feet
metric t	Equivalent to 1.102 U.S. tons or 2205 pound
min	Minute
m3	Cubic Meter
MG	Million Gallons
MGD	Million Gallons per Day
mm	Millimeter
MRP	Municipal Regional Stormwater NPDES Permit
MS4	Municipal Separate Storm Sewer System
NPDES	National Pollutant Discharge Elimination System
NURP	National Urban Runoff Program
O&M	Operation and Maintenance
PCBs	Polychlorinated biphenyls
ppm	Parts per million
SFEI	San Francisco Estuary Institute
sec	Second
SFBRWQCB	San Francisco Bay Regional Water Quality Control Board or Water Board
SSC	Suspended Sediment Concentration
SWRCB	State Water Resource Control Board
TMDL	Total Maximum Daily Load
TSS	Total Suspended Solids
µm	Micrometer
$\mu g/m^2$	Micrograms of mass per square meter of area
UC	University of California
U.S.	United States

USEPA	United States Environmental Protection Agency
yr	Year

GLOSSARY OF TERMS

Baseline: A defined line or standard from which effectiveness can be measured or compared.

Best Management Practice (BMP): Any activity, technology, process, operational method or measure, or engineered system, which when implemented prevents, controls, removes, or reduces pollution. A BMP is also referred to as a control measure.

Best Management Practice System: A BMP system includes any BMP and any related bypass or overflow.

Bypass: The intentional diversion of waste streams from any portion of a treatment (or pretreatment) facility.

Conceptual Model: A model that explicitly describes and graphically represents all existing knowledge on the sources of a pollutant, its fate and transport, and its effects in the ecosystem.

Control Measure: Any action that results in the reduction or prevention of stormwater pollution. Control measures include discontinuing the use of a pollutant-containing product, preventing the release of the product or the pollutant into runoff, and treating runoff containing the pollutant prior to its entering or leaving the stormwater drainage system.

Discharge: A release or flow of stormwater or other substance from a conveyance system or storage container.

Effectiveness Assessment: The process that is used to evaluate if BMPs or other implementation programs are resulting in desired outcomes.

Effectiveness (with regard to treatment BMPs): A measure of how well a BMP system meets its goals for all stormwater flows reaching the BMP site, including flow bypasses.

Full Capture Device: A BMP that can trap all particles retained by a 5-mm screen, and has a treatment capacity that exceeds the peak flow rate resulting from a one-year, one-hour storm in the subdrainage area treated by the BMP.

Gross Solids: All materials, man made (i.e. trash or litter) and of natural origin, larger than 5 mm. Synonymous with gross pollutants.

Illegal Dumping: Act of improperly and illegally disposing of waste items, typically in large volumes, in the environment. Illegal dumping primarily occurs to avoid disposal fees or the time, cost, and effort required for proper disposal of items that are not permitted in waste containers (furniture, appliances, hazardous materials, etc) at landfills or recycling facilities.

Institutional Control: The attempt to change civic behavior and institutional management or operations through government regulation/mandate, persuasion, and/or economic incentives. While some institutional BMPs involve physical devices (i.e. street sweeping), it is the optimization of the management of that device that forms an institutional BMP.

Maximum Extent Practicable (MEP): A technology-based standard that applies to municipal separate storm sewer systems (MS4) regulated under the NPDES program. NPDES regulations require municipalities to reduce discharges of pollutants to the maximum extent practicable using management practices, control techniques and systems, design and engineering methods, and other provisions determined to control pollutants, as appropriate. There is no precise definition of MEP, so specific pollutant reduction permit requirements are typically establish for the term of a permit based on an updated assessment of controls and other measures.

Overflow: To be filled beyond the design capacity of a BMP.

Polychlorinated biphenyl's (PCBs): A family of chlorinated organic compounds formed by two benzene rings linked by a single carbon-carbon bond. PCBs are synthetic organic compounds with strong affinity to sediment particles

Performance (with regard to treatment BMPs): A measure of how well a treatment BMP meets its goals for storm water that flows through, or is processed by it.

Pollutant: A substance introduced into the environment that adversely affects or potentially affects the usefulness of a resource.

Pollutant Load: The mass of a pollutant discharged into or from a receiving water body.

Receiving Waters: Water bodies receiving discharges from municipal stormwater drainage systems.

Source Control Measures: Any schedules of activities, structural devices, prohibitions of practices, maintenance procedures, managerial practices or operational practices that aim to prevent stormwater pollution by reducing the potential for contamination at the source of pollution.

Stormwater: Runoff from roofs, roads and other surfaces that is generated during rainfall and snow events and flows into a stormwater drainage system.

Stormwater Drainage System: Any pipe, ditch or gully, or system of pipes, ditches, or gullies, that is owned or operated by a governmental entity and used for collecting and conveying stormwater.

Total Load: Total amount of a given substance entering a water body during a given time (e.g., tons of trash per year).

Total Maximum Daily Load (TMDL): The calculation of the maximum amount of a pollutant that a water body can receive and still meet water quality standards, and an allocation of that amount to the pollutant's sources.

Treatment Control: Any engineered system designed to remove pollutants by simple gravity settling of particulate pollutants, filtration, biological uptake, media adsorption or any other physical, biological, or chemical process. This term can also be referred to as a treatment measure, treatment control measure, or treatment control BMP. Proprietary treatment controls are manufactured devices that are engineered for specific applications or targeted constituents. Non-proprietary treatment controls are landscape-based measures that are more generic in applications and may tend to be effective for a relatively wider range of constituents.

Urban Runoff: All flows in a stormwater drainage system; consists of stormwater (wet weather flows) and non-stormwater illicit discharges (dry weather flows).

Watershed: A defined area of land that catches rain and snow and drains or seeps into a common marsh, stream, river, lake or groundwater.

SECTION 1: PURPOSE AND GUIDE TO THIS DOCUMENT

In October 2005 San Francisco Estuary Institute (SFEI) was awarded a grant to increase knowledge about how to manage mercury (Hg) and Polychlorinated biphenyl's (PCBs) in the urban landscape and stormwater. This tool box provides a summary of the knowledge accumulated during the completion of grant and other referenced sources.

Purpose of this document

This toolbox is intended to assist stormwater managers, municipal officials, and other stakeholders by describing available options for preventing Hg and PCBs entering stormwater or managing soils or waters contaminated with Hg and PCBs within the urban landscape and stormwater conveyance system.

The San Francisco Bay PCB and Hg total maximum daily loads (TMDLs) established by the San Francisco Bay Regional Water Quality Control Board (Water Board) call for stormwater agencies to achieve wasteload allocations by 2028 for Hg and 2030 for PCBs (Assuming EPA approval in 2010). The allocations are implemented through NPDES permits, and permit requirements are based on an updated assessment of best management practices (BMPs) and control measures to reduce PCBs or Hg in urban stormwater runoff to the maximum extent practicable during each permit term (five years). Consistent with these requirements, the recently completed municipal regional stormwater NPDES permit (MRP) Order No. R2-2009-0074 contains many provisions that aim to directly address PCBs and Hg and many other provisions where multiple benefits are recognized that include PCBs and Hg. This tool box provides a resource for permitees to address these provisions.

Guide to this document

This BMP tool box for reducing Polychlorinated biphenyls (PCBs) and Mercury (Hg) in stormwater is organized in the following manner:

Section 2 – Provides a brief review of the history and ongoing use of Hg and PCBs in urban areas and a review of relevant environmental and regulatory issues,

Section 3 – Provides key definitions, a conceptual model of sources and pathways of PCBs and Hg in urban areas, and provides our best estimates of proportions of each mass found in each source in the Bay Area,

Section 4 – Reviews different categories of BMPs for reducing PCB and Hg stormwater loads including institutional and treatment control BMPs, discusses multiple benefits for other pollutants, and options for measuring programmatic effectiveness, and

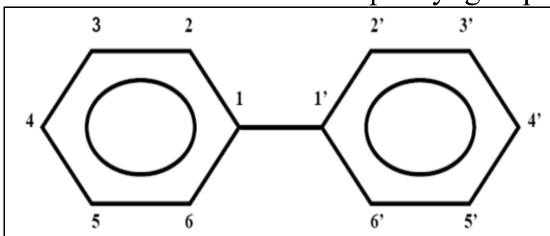
Section 5 – Provides technical information and fact sheets for a range of BMPs applicable to improving water quality in the Bay Area in relation to PCBs and Hg.

SECTION 2: INTRODUCTION

Polychlorinated biphenyl's (PCBs) and mercury (Hg) have been identified as the primary contaminants of concern for San Francisco Bay by local stakeholders amongst a wider range of "normal" urban runoff pollutants. PCBs and Hg are the focus of this document, but at a practical level, it is recognized that many new best management practices (BMPs) for PCB and Hg have multiple benefits for other contaminants and many elements of existing urban programs are applicable for managing PCBs and Hg. Where appropriate, these relationships are highlighted throughout this tool box.

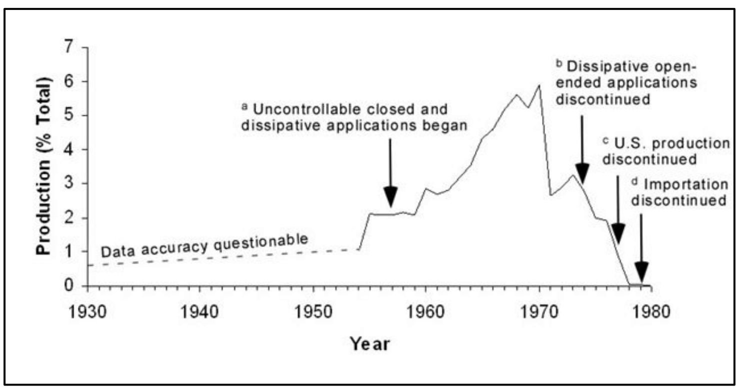
History and on going sources and use of PCBs and mercury

Mercury (Hg), a naturally occurring element primarily found as cinnabar in the earth crust and polychlorinated biphenyl's (PCBs) (a commercially synthesized oily compound) are legacy pollutants. Their peak production and use occurred decades ago, and new uses of both Hg and PCBs has largely been banned, and efforts to eliminate the remaining uses are ongoing. PCBs are a family of chlorinated organic compounds formed by two benzene rings linked by a single carbon-carbon bond. Various degrees of substitution of chlorine atoms for hydrogen are possible on the remaining 10 benzene carbons and there are 209 possible arrangements of chlorine atoms on the biphenyl group.



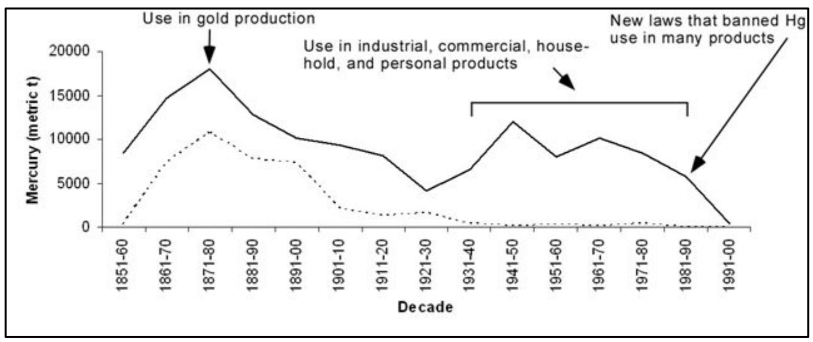
Chemical structure of a PCBs. Chlorine is attached where the numbers are in any one of 209 possible configurations.

Although not produced currently, PCBs can occur as minor byproducts in a number of chemical industrial processes, during drinking water chlorination and from thermal degradation during some industrial processes. The U.S. production of PCBs reportedly totaled approximately 640,000 metric t. Production peaked in 1970. Overall approximately 73% of the U.S. production occurred between 1955 and 1977. About 60% of the PCBs commercially sold in the U.S. were used in controllable closed systems[a] as coolants and insulating fluids in electrical transformers and capacitors, and fluorescent light ballasts. About 10% were used in uncontrollable closed systems[b] such as hydraulic fluids and lubricants and the remaining 20% were used in dissipative products[c] where the PCBs were in direct contact with the environment and with no way of recovering them when the product reached the end of its life. For example, PCBs were used in plasticizers - the additives in plastics that maintain softness and pliability, stabilizers in flexible PVC coatings of electrical wiring and electronic components, pesticide extenders, reactive flame retardants, paints, inks, sealants (caulking in public buildings such as schools and other, non-residential buildings), wood floor finishes (such as *Fabulon* and other products



of Halowax in the U.S.) and carbonless copy paper. The USEPA banned the production and new use of PCBs in 1979, with exceptions for totally enclosed applications (intact, non-leaking electrical equipment i.e. industrial scale transformers and capacitors), which are responsible for an undetermined amount of PCBs that are still in use (known to be at least 580,000 lb in 2009, 30 years after the production ban).

The first Hg mining peak occurred during and after the gold rush in California some 125 years ago when mercury was used to extract gold (Note the dotted line on the diagram below is the production from the New Almaden mines in San Jose alone). A second peak in production occurred before and during World War II when a number of new industrial mercury uses and products began to appear. At the close of the war, many products developed or perfected during WWII were introduced into the consumer market, for example, cameras, videos, TVs, and hearing aids. The advancement of battery technology in the 1950s, including the NiCad battery, and ongoing use of mercury batteries and mercury in printed circuit boards in these kinds of products lead to a third peak in use in the late 1960s. Beginning in 1990, a series of environmental laws banned mercury use in paint (1990/1991) and battery producers reduced mercury in common batteries from an average of 0.5% by weight to just 0.025% by weight in 1991. Laws were also introduced to control or reduce mercury in the other larger uses (thermostats and switches, fluorescent lighting, dental fillings, and instruments such as thermometers). Despite these efforts, Hg is still used in new devices such as LCD TVs, cell phones, and in laboratory applications. Presently we estimate about 14,400 lb of Hg is being consumed in the Bay Area annually in consumer electronics and laboratory applications and a further 330 lb falls on urban surfaces from local or global atmospheric sources.



Adverse impacts to San Francisco Bay Area fish, wildlife, and humans

Mercury is a persistent, bioaccumulative, toxic metal that exists and passes between elemental, inorganic, and organic forms but cannot be destroyed. The organic form, methylmercury, is the most toxic. Small aquatic organisms take in methylmercury, allowing it to enter the food web of the Bay. As methylmercury moves through the food web, it accumulates and concentrates in organisms, increasing at every step of the food web. High levels of mercury have been found in San Francisco Bay fish, including many fish humans and wildlife eat. In humans, mercury is neurotoxic, affecting the brain and spinal cord, and interfering with nerve function. Pregnant women and nursing mothers can pass mercury to their fetuses and infants through the placenta and breast milk. Children are most susceptible to mercury exposure, particularly those under age six, who can suffer from decreased brain size, delayed physical development, impaired mental abilities, abnormal muscle tone, and coordination problems.

Mercury also poses hazards to birds, mammals, and other wildlife. Birds and mammals that consume fish and other aquatic organisms can be exposed to significant quantities of mercury. In birds, mercury can adversely affect survival through effects on cell development and reproductive success, even at sub-lethal concentrations. More acute effects include reduced feeding, weight loss, lack of coordination, hyperactivity and hypoactivity, and liver and kidney damage. The embryos of birds and other vertebrates are more sensitive to mercury exposure than adults. In marine mammals, mercury can reduce speed and agility, making it more difficult to obtain food and avoid predation.

Similar to Hg, small aquatic organisms take up PCBs which then bioaccumulate in larger organisms throughout the food web. Consumption of PCBs-contaminated fish is also considered a primary source of human and wildlife exposure in the Bay Area either through direct consumption or infant exposure in breast milk. Exposure risks are greater for moderately chlorinated PCBs that are retained more efficiently in muscle tissue. Observed effects in humans have ranged from mild reactions to serious health consequences including hepatotoxicity (liver damage), developmental toxicity, immunotoxicity (weakened immune response), neurotoxicity (damage to nervous system and nerve tissue), and carcinogenicity (cancer causing). Piscivorous birds (those that eat fish such as terns and comorants) are also at risk.

TMDL targets and waste load allocations

TMDLs have been completed for both mercury and PCBs in San Francisco Bay. They allow for wasteload allocations of 82 kg Hg and 2 kg of PCBs in urban stormwater with the objective of improving water quality in the Bay in 20 years (2028 for Hg and 2030 for PCBs). These represent estimated reductions of 50% and 90% over the present load estimates of 160 kg of Hg and 20 kg of PCBs. The Hg TMDL also calls for an interim loading target of 50% reduction in 10 years. The PCBs TMDL provides specific guidance for each county (Table to the right). In order to measure success towards these targets, stormwater agencies get credits when they can show mass removed (load avoided) through source control or maintenance activities. Alternatively, if stormwater agencies make measurements in creeks or storm drains, they might be able to get credit by showing a loading trend in stormwater (e.g. a reduction in a 5 year running average or a reduction in sediment concentrations in flowing stormwater measured in mass of either Hg or PCBs decreasing on particles). In the case of Hg, they can also demonstrate that concentration on particles in stormwater is less than or trending towards a concentration of 0.2 mg Hg per kg of sediment (0.2 ppm Hg).

County	Population	PCB Stormwater Load Allocations (Kg / year)
Alameda	1,440,000	0.5
Contra Costa	790,000	0.3
Marin	240,000	0.1
Napa	120,000	0.05
San Francisco	630,000	0.2
San Mateo	600,000	0.2
Santa Clara	1,600,000	0.5
Solano	290,000	0.1
Sonoma	110,000	0.05
Total		2

Interested in further reading?

McKee, L. Mangarella, P., Williamson, B., Hayworth, J., and Austin, L., 2006 (Section 1). Review of Methods to Reduce Urban Stormwater Loads: Task 3.4. A Technical Report of the Regional Watershed Program: SFEI Contribution #429. San Francisco Estuary Institute, Oakland, CA.

SFRWQCB, 2008. Total Maximum Daily Load for PCBs in San Francisco Bay: Final Staff Report for Proposed Basin Plan Amendment. California Regional Water Quality Control Board San Francisco Bay Region, Clay Street, Oakland, CA94612. February 13, 2008. 136pp.
http://www.waterboards.ca.gov/sanfranciscobay/water_issues/programs/TMDLs/sfbaypcbs/Staff_Report.pdf

SFRWQCB, 2009. California Regional Water Quality Control Board San Francisco Bay Region Municipal Regional Stormwater NPDES Permit, Order R2-2009-0074, NPDES Permit No. CAS612008. Adopted October 14, 2009. 279pp.
http://www.waterboards.ca.gov/sanfranciscobay/board_decisions/adopted_orders/2009/R2-2009-0074.pdf

SECTION 3: SOURCES AND PATHWAYS OF PCBs AND HG IN URBAN AREAS

In the broadest sense, society and people's demand for products and services that are enabled by the use of PCBs and Hg are the ultimate source of all legacy and ongoing contamination associated with these substances. Therefore institutional controls, that is, a change to civic behavior and institutional management or operations, are part of the solution for reducing urban sources and loads of PCBs and Hg. However, at a more practical everyday level, specific sources, release, and transport processes must be known to facilitate the broadest array of effective management actions. These are illustrated for PCBs in Figure 3-1 and for Hg in Figure 3-2. Although many of the transport processes are similar, for example urban stormwater and vehicular and foot traffic, in many cases the sources of PCBs and Hg are quite different (introduced in Section 2 and explained more below).

In this section we assist stormwater managers, municipal officials, and other stakeholders by:

- Developing key definitions and core terms to aid communication between urban managers, technical staff, regulatory agencies, and other stakeholders
- Building upon the general introduction of history of uses and regulatory drivers (Section 2) by presenting conceptual models of sources and pathways of PCBs and Hg in urban areas
- Introducing lists of products and locations of sources in the Bay Area (provided in detail in the Appendix)
- Providing our best estimates of proportions of PCBs and Hg found in each source in the Bay Area as context for optimal and cost effective control measures.

Defining key definitions and core terms

Polychlorinated biphenyls (PCBs): PCBs belong to a family of man-made organic chemicals called chlorinated hydrocarbons. PCBs have a range of toxicity and vary in consistency from thin, light-colored liquids to yellow or black waxy solids. Due to their non-flammability, chemical stability, high boiling point, and electrical insulating properties, PCBs were used in hundreds of industrial and commercial applications including electrical, heat transfer, hydraulic equipment, pigments, dyes, and carbonless copy paper and as plasticizers in paints, plastics, and rubber products. Although PCB manufacture was banned in 1979, today PCBs can still be released into the environment due to poor management at hazardous waste sites, illegal dumping of materials containing PCBs, leaks or releases from electrical transformers still in use, and disposal of PCB-containing materials and devices in landfills not designed to handle hazardous waste. PCBs may also be released into the environment during incineration. These releases lead to contamination of sediments, soils, and water in the urban environment. In practice, urban managers are being asked to improve management of all these forms and uses of PCBs (discussed in detail in Section 4).

Figure 3-1. A conceptual model of PCB sources and pathways in Bay Area urban areas. True source categories include factories, and atmospheric deposition. Source categories include old industrial areas, PCBs still in use, illegal disposal, recycling facilities, road deposits, the home and work place, building demolition and remodeling. Transport pathways include runoff from impervious surfaces, vehicle tracking, foot tracking, and wind.

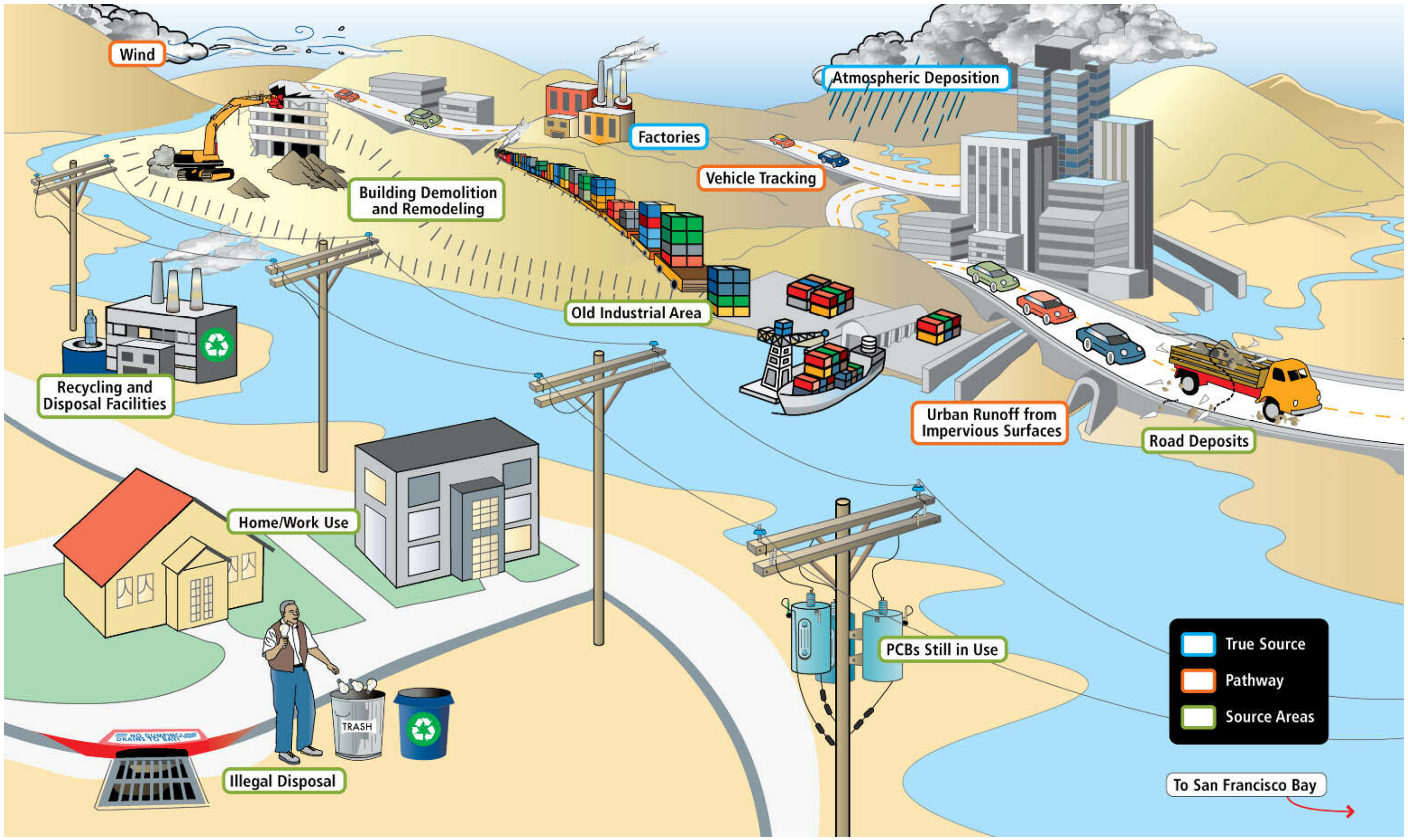
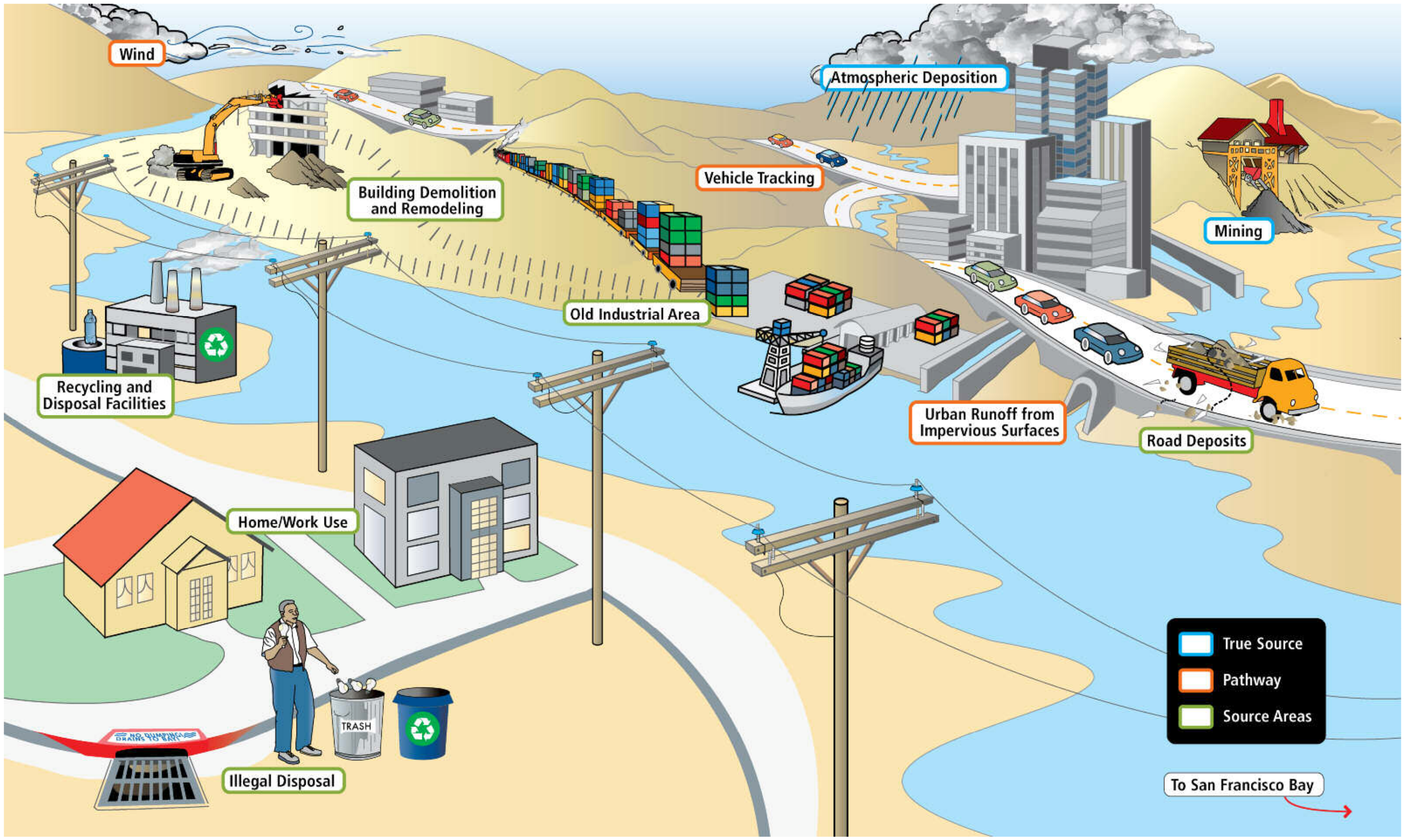


Figure 3-2. A conceptual model of Hg sources and pathways in Bay Area urban areas. True source categories include mining and atmospheric deposition. Source categories include old industrial areas, illegal disposal, recycling facilities, road deposits, the home and work place, building demolition and remodeling. Transport pathways include runoff from impervious surfaces, vehicle tracking, foot tracking, and wind.



Mercury: Mercury (chemical symbol Hg), also known as quicksilver, is a silver colored metal that is liquid at room temperature. Hg exists and passes between elemental, inorganic, and organic forms and occurs naturally in rocks, soils and water usually in very low concentrations and is emitted into the atmosphere as gas or dust when rocks erode, volcanoes erupt, and soil decomposes. Humans have enhanced releases of Hg through mining and associated waste debris, commercial products with poor end-of-life disposal practices, soil disturbance during urban development and redevelopment, and soil cultivation for food and fuel production. Mercury was, and still is, used in many household and commercial products, as well as industrial processes, because it is liquid at room temperature, combines easily with other metals, and expands and contracts evenly with temperature and pressure changes. The main uses include lighting, switches, batteries, and electronics but there were and are very many uses. In practice, urban managers are being asked to improve management of all forms and sources of Hg (discussed in detail in Section 4).

True sources: Most recently, the term "true sources" has been applied to a subset of sources, the real origin of the contaminant such as a factory in the case of synthetic compounds such as PCBs or a mine in the case of Hg. Many true sources have been identified and have or are being cleaned up through the USEPA superfund or brown fields programs or by responsible parties such as private companies, military or public agencies. Atmospheric deposition (see more discussion below) is a special true source that is deposited on the urban landscape mostly from sources outside local jurisdictional control.

Source areas: Source areas are defined as the places in the landscape where contaminants were used, inadvertently released, systematically discarded or accumulated. Source areas usually have greater concentrations of PCBs and Hg in soils and/or water and air than in surrounding areas.

Pathways: A pathway differs from a source or true source and is defined as a conduit or process that delivers water, sediment, and/or contaminants from the source or true source to an urban storm drain, creek and ultimately to the Bay. The pathways considered in the Bay Area PCB and Hg TMDLs are atmospheric deposition (direct to the Bay surface), local urban stormwater runoff, local non-urban runoff, municipal wastewater, industrial wastewater, the Sacramento and San Joaquin Rivers, in-Bay dredge material disposal, and in-Bay erosion and re-suspension of buried sediments. Here we focus on pathways in the urban system itself including vehicle tracking (road deposits), wind dispersal, and surface runoff (mainly from impervious surfaces) that feed storm drains and creek.

PCB and Hg true sources in the Bay Area

The conceptual models for PCBs and Hg identify three true source categories in Bay Area urban areas. A definition of each is provided below and shown graphically for PCBs in Figure 3-1, and for Hg in Figure 3-2.

1. Factories
2. Mines

3. Atmospheric deposition on urban areas

1. Factories

PCBs are not naturally occurring. PCBs were commercially produced (synthesized) in factories in mixtures of PCBs called aroclors containing specified amounts of chlorine by mass. The common aroclors in the U.S. were aroclor 1242 (52% of U.S. production), 1254 (16%), 1016 (13%), 1260 (11%), and 1248 (7%). These common aroclors total 99% of all U.S. manufacture but there were many others making up that last 1% (Appendix A). Aroclors 1248, 1254, and 1260 are most commonly detected in the environment perhaps because the lighter (lower chlorinated) compounds found in the 1016 and 1242 mixtures can degrade more rapidly, are less persistent and less subject to bioaccumulation. There are many trade names for these substances commonly in use in the U.S. such as aroclor (used by Monsanto Company), asbestol, askarel, bakola131, chlorextol (Allis-Chalmers trade name), hydol, inerteen (used by Westinghouse), noflamol, pyranol/pyrenol (used by General Electric), saf-t-kuhl, and therminol but there were many more (Appendix B). That we are aware of, none of these factories were located in the Bay Area. However, it is important to keep these technical details in mind since drums and other containers used for transporting and storing PCBs may be identified by labels containing these numbers and trade names. Drums like these have been found in at least three industrial areas in the Bay Area.

Photo courtesy of Trish Eliasson

2. Mines

Mercury was mined from the California Coast Range mainly from source rocks called serpentinite (the state rock of California). In some areas, the serpentine geology was so enriched with mercuric sulphide (HgS, called cinnabar) that extracting it was economically profitable. The most famous and profitable of the mining areas was called the New Almaden Mining District and consisted of eight mines located in the Santa Clara Valley south of San Jose. However, there were a total of 22 mines in the Bay Area located in the Counties of Marin, Solano, Contra Costa, Alameda, Santa Clara, and San Mateo (See appendix C for details). Urban creeks and stormwater conveyances downstream from these mining areas may be contaminated with this legacy true source.

3. Atmospheric deposition on urban areas

Both PCBs and mercury are transported globally in the atmosphere and are found in lakes, glacial ice, and soils far from manufacturing, mining or urban areas. Some of this global circulating mass of PCBs and Hg is continually deposited in the Bay Area each year, more or less as an even blanket. This nearly continuous source results in about 1.3 $\mu g/m^2$ of PCBs and about 23 $\mu g/m^2$ of Hg (equivalent to 20 lb of PCBs and 330 lb of Hg) falling on the surfaces of the nine-county Bay Area annually. In addition, there is an unknown extra quantity derived from local sources and source areas through off-gassing from contaminated sites and as soils decompose, from dust rising into the atmosphere, vegetation fires, from industrial fires (PCBs and Hg), combustion of fossil fuels (coal, gas, gasoline, diesel, and oil) for heating, manufacturing cement, oil refining etc (Hg), and from incineration (PCBs and Hg), and cremation (Hg). Some of the PCB and Hg released from these local sources is deposited locally down wind and the rest is lost to the Central Valley area further east or to the global cycle. A list of known PCB users in the Bay Area in found in Appendix D and a map of local atmospheric Hg air source are found in Appendix E. There is international evidence and limited local evidence that soils and water bodies in urban areas and stormwater conveyances near these kinds of use and release areas have higher concentrations of PCBs and Hg.

PCB and Hg sources areas

The conceptual models for PCBs and Hg identify a number of source areas in Bay Area urban areas. A definition of each is provided below and shown graphically for PCBs in Figure 3-1, and for Hg in Figure 3-2. It is interesting to note that there is some cross over between definitions. This is due to a particular true source, source, or use occurring in many locations in the urban environment.

1. Old industrial areas
2. PCBs still in use
3. Illegal disposal
4. Recycling and disposal facilities
5. Road deposits
6. In the home and work place
7. Building demolition and remodeling

1. Old industrial areas

In the context of PCBs and Hg, the term old industrial area refers to any industrial area that was active during the period of peak use of PCBs and Hg (1950-1990). PCBs were used in a variety of industrial and large scale commercial products. For example, the manufacture of transformers and large capacitors, the use of large electrical equipment in industrial facilities that used a lot of electric power, heavy electrical wires, electric motors, in heat transfer devices, and hydraulic equipment. For example, there are many old transformer units still on power poles on private property in industrial areas. Plasticizers, plastics, and rubber products were also manufactured in these old industrial areas. In addition caulking compounds and industrial grade paint were both manufactured and used in old industrial areas. Used oil containing PCBs was also used for dust suppression in industrial yards and along railway lines.

In a similar way, products containing Hg such as batteries, fluorescent lights, pressure and heat sensing devices, switches and thermostats, and paint were all manufactured or used in old industrial areas. Many of the factories and large commercial facilities found in old industrial areas were fitted with fluorescent lights that, prior to 1991, contained both PCBs (in the ballast) and Hg (in the light tube). Spillage and inadequate disposal practices left a legacy of water and soil contamination in old industrial areas that have not yet been cleaned up or redeveloped.

2. PCBs still in use

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 (last update February 2010). Appendix D provides a table of PCBs still in use in the Bay Area. Presently at least 260,000 kg (580,000 lb) of PCBs are reported as still in use in the Bay Area. In California, Pacific Gas and Electric (PG&E) has and ongoing program to voluntarily decommission much of the electrical equipment associated with power transmission and changed out transformer oils in serviceable equipment. However, in some cases, legacy contamination in soils is still present on PG&E properties at concentrations that while legal, may be slowly being dispersed off site by wind, water, wheel- and foot-tracking and entering the local stormwater conveyance.

3. Illegal disposal

PCBs and mercury are still found in many items in factories, commercial areas, work places and homes. In some instances people who don't know or understand the laws, or who don't recognize end-of-life products and waste materials as hazardous, may choose improper disposal methods. This category includes both illicit dumping along creek and riparian corridors, in industrial or less populated urban areas, and illegal or improper disposal in trash receptacles such as dumpsters and waste bins. Unfortunately illicit dumping is still common place and often occurs after dark or on weekends when the chances of being witnessed are not as great. Illegal disposal occurs sporadically and often attracts repeated offences by others who seize the opportunity causing a growing temporary dumping area to grow. Some kinds of "trash" in these illegal dumping areas contain PCBs (e.g. demolition and remodeling waste, heavy electrical wiring and motors, used gear box and hydraulic oil) and Hg (old TVs, computers, VCRs, home and office remodeling wastes (fluorescent light tubes, thermostat controls), refrigerators, microwaves, stoves, old paint, batteries). Many of these types of electrical equipment can also be improperly disposed of in dumpsters and waste bins and often if the equipment is smashed either during the act of dumping or at a later time, some of the mercury can leak out on the ground and flow to a storm drain or creek when it next rains.

4. Recycling and disposal facilities

There are many forms of legal recycling and disposal in our urban environments including both municipal and private facilities. These include auto dismantlers, white goods recyclers, transfer stations, landfills, metal recyclers, and computer and electronics recyclers. For the most part, most of these facilities are obeying recent environment laws that guide the removal and correct disposal or reuse of components during the act of recycling. However, older facilities that were operating before 2000 may have legacy contamination in soils and waters. In addition, many auto wrecking and auto-refurbishing enterprises operate below the radar and are ephemeral (that is they come and go for various reasons including economic pressures and legal actions). In addition, the EPA estimates that about 15% of the material in the recycling stream is lost during the act of recycling. For example, some of it leaks out of trucks on the way to the facility. In addition, some of the waste that should have gone to recycling ends up in the mixed trash stream that is disposed of in municipal land fills not designed to receive hazardous waste. Further more, a special kind of waste called auto shredder fluff is used daily to cover land fills. This fluff contains PCBs and often some Hg. Road and other impervious surfaces, soils, water, and air in areas surrounding and down wind of recycling and disposal facilities are likely to have higher concentrations than areas further distant.

5. Road deposits

Gasoline, diesel, transmission fluids, and motor oils contain trace amounts of Hg that are deposited on road surfaces as unburned residues and exhaust products. Streets in industrial areas and poorer neighborhoods have greater levels of these deposits due to older vehicles and greater emissions. There is some evidence that roads in older urban areas may have higher concentrations of Hg perhaps because of decades of buildup and from a time of lower emissions standards for cars and home heating. In addition, roads receive trash and debris that leak out of vehicles during haulage that can contain PCBs and Hg. Roads servicing recycling areas and municipal or private landfills and disposal areas likely receive a greater share of the burden of inadvertently deposited PCBs and Hg.

6. Use in the home and work place

PCBs and Hg were used in many very practical applications in the home and work place. In older homes that were either remodeled or built during the peak period of PCB and Hg usage (1950-1990) many of these products may still be in use. For example, PCBs can be found in older appliances such as TVs, refrigerators, and washing machines and other appliances containing single phase motors, in fluorescent light ballasts, old bottles of ink and glues and carbonless copy paper, flame retardants (old synthetic furniture, bedding, wall coverings and sealing tiles), old cans of floor wax, floor finish (that bowling lane

looking polyurethane coating), and in caulking around windows. Hg was also used in thousands of products in the home and office including switches in appliances (e.g. any old appliance that has a light that turns on automatically when you open the door), thermostats (e.g. ovens and clothing irons), thermometers, manometers (e.g. medical blood pressure gauges), and barometers (weather indicators), latex paints manufactured before 1992 (to prevent fungus), batteries (particularly button cells but any battery manufactured before 1991), disinfectants, antiseptics, makeup (skin whiteners), diuretics and preservatives. Old chemistry sets and children's toys were once sold with liquid mercury (e.g. a mercury maze). In general, any of these sorts of products that predate the early 1990s should be used and disposed of thoughtfully. For example, a single medical blood pressure gauge from the 80s could contain over 1 lb of Hg.

7. Building demolition and remodeling

PCBs and Hg are present in homes offices, businesses and factories incorporated into the building materials, fixtures, wiring, heating, elevators, flooring, finishings, roofing. Even after all of the mobile equipment, such as items described in the home and work place section above, is removed, many other products still remain. Prior to 1979, PCBs were used in fluorescent light ballasts, electric motors and heavy electrical wiring (e.g. in building lifts), well pumps, switch boards and switch gear, flame retardants (wall coverings and sealing tiles), floor wax, floor finish (that bowling lane looking polyurethane coating), industrial heavy duty paints, resins, synthetic rubber, and waterproofing compounds. Many people may already be familiar with concern raised about PCB use in caulking around windows, doors and between concrete slabs in the walls of tilt-slab buildings and between concrete slabs in concrete floor buildings and external foot paths. With the exception of Hg in electrical switch boards and circuits, and in paint, most of the Hg in buildings older than 1990 slated for demolition or full scale remodeling is associated with thermostats, switches, and fluorescent lighting. As buildings are demolished or remodeled, it is possible for some of these materials to leave the work site and settle on impervious surfaces or enter directly into a local storm drain or creek.

PCB and Hg pathways to urban stormwater conveyances

The conceptual models for PCBs and Hg (Figures 3-1 and 3-2) describe how these chemical substances can get from their true sources and source areas to urban storm drains and creeks. These routes or modes of transport are called pathways. There are three main pathways:

1. Wind dispersal
2. Vehicle and foot tracking
3. Buildup and wash off from impervious surfaces

PCBs and Hg attach strongly to soil and sediment particles. PCB and Hg mass that is rained out, settled, leaked, spilled, or discarded from true sources or products used in source areas can find its way to local soils and sediments. Although there is some evidence that PCBs are attached most commonly to slightly larger particles than Hg is, in general, the majority of the mass of PCBs and Hg in contaminated soils and sediments is in the fine sand, silt, and clay fractions.

1. Wind dispersal
In the climate enjoyed by Bay Area residents, soils and sediment dry out completely in the summer months leaving them exposed to wind dispersal. Wind is a strong vector for transporting PCBs and Hg away from old industrial areas or soils and sediment in other kinds of source areas onto local impervious surfaces where, during the next rainfall, runoff, along with the build up of PCBs and Hg, can escape to the storm drain. Management of dust and maintenance of impervious surfaces offers a control option for this kind of pathway (discussed more in section 4).

2. Vehicle and foot tracking
Vehicles that drive on and off unpaved lots and roads in industrial areas can track soils and sediment contaminated with PCBs and Hg to local feeder and arterial streets. During winter months, the volume of sediment transported off site is greater due to the sticky nature of clay loam soils in the Bay Area. In general much of this soil is spun off within a city block or two with the remainder being dispersed at greater distances. In the same manner, soils (and associated contaminants) attached to work boots can be dispersed into work trucks during the day, and passenger vehicles at the end of the work day and find their way into people homes. During the summer months, less soil sticks to the tires and work boots, but a cloud of dust often follows trucks off unpaved lots carrying with it any contaminants. Installing sediment traps (grates and water baths) at gateways for winter months and encouraging employees to change footwear before leaving a work site, and keeping speeds low during summer months will help to reduce offsite transport of PCBs and Hg to roads, homes, and ultimately to the storm drain or creek system (see chapter 4 for more details).

3. Buildup and wash off from impervious surfaces
PCBs and Hg that fall on impervious surfaces from global or local atmospheric sources gradually build up on impervious surfaces. As described above, wind, vehicle and foot traffic moves PCBs and Hg from source areas onto impervious surfaces. Once on impervious surfaces, rain storms in the winter and wind (mainly vehicle related) move it into the stormwater system or local creek. Maintenance activities such as street sweeping (if they capture fine sands, silts and clays particles less than 250 µm) and inlet cleaning are examples of management methods with multiple benefits for other substances (discussed more in Chapter 4) that could be enhanced to reduce PCB and Hg mass getting to the stormwater system or local creek.

Estimated proportions of each PCBs and Hg derived from each category

PCBs and Hg arrive in the urban environment from a variety of true sources, source areas (uses), and pathways. Although the balance of each category varies substantially for differing land uses such as old industrial areas versus urban residential areas, presently there is no knowledge about this for any particular watershed, city, or county in the Bay Area. But we have made estimates for the Bay Area as a whole region as shown in Figure 2-3 for PCBs and 2-4 for Hg.

For PCBs, Figure 3-3 shows the following general ideas. The largest sources impacting stormwater are estimated to be building demolition and remodeling, PCBs still in use in industrial areas, contaminated soils underneath and near where transformers and large capacitors that contained PCBs used to be installed, atmospheric deposition, and general soil and water contamination in industrial areas. Together it is estimated that these source are responsible for about 83% of the load of PCBs getting into stormwater in the Bay Area. What is not shown so well is that confidence is higher for the estimates for the some categories (PCBs still in use, contaminated soils near transformers and large capacitors, small capacitors, other dissipative uses, plasticizers, auto-recycling, and general industrial contaminated areas), and much lower for others (building demolition and remodeling, lubricants, landfills, contaminated soils around railway lines, and atmospheric deposition).

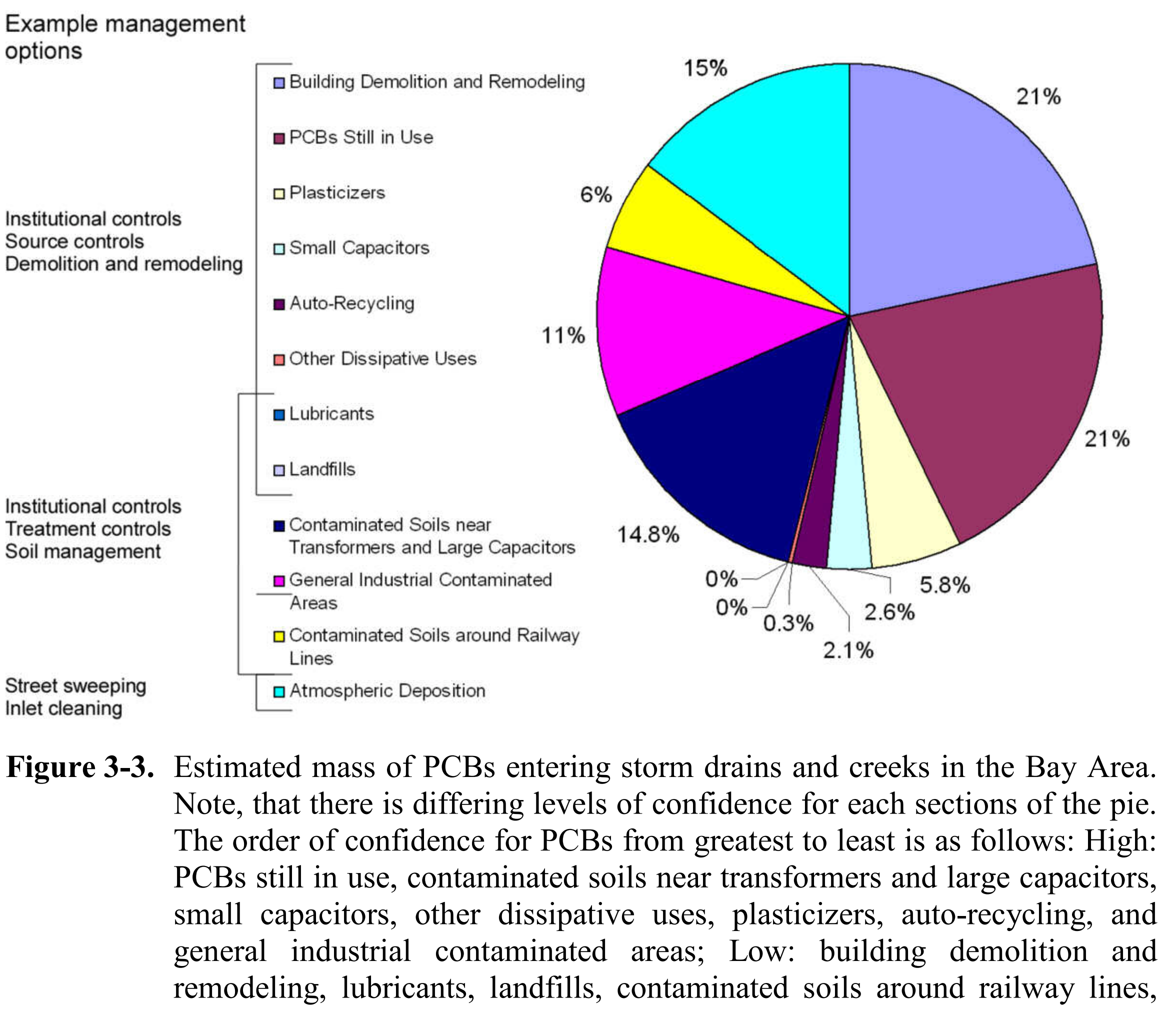


Figure 3-3. Estimated mass of PCBs entering storm drains and creeks in the Bay Area. Note, that there is differing levels of confidence for each sections of the pie. The order of confidence for PCBs from greatest to least is as follows: High: PCBs still in use, contaminated soils near transformers and large capacitors, small capacitors, other dissipative uses, plasticizers, auto-recycling, and general industrial contaminated areas; Low: building demolition and remodeling, lubricants, landfills, contaminated soils around railway lines, and atmospheric deposition.

The second general concept that can be gleaned from Figure 3-3 is that it is estimated that a combination of institutional controls (change to civic behavior and institutional management or operations), source controls including correct disposal of raw PCBs or products containing PCBs, as well as careful application of BMPs during demolition and remodeling have the potential to capture about 54% of the load of PCBs presently entering stormwater.

In the case of Hg, Figure 3-4 shows the following general ideas. The largest single source of Hg to the watersheds of the Bay Area and stormwater itself is atmospheric deposition. The other large sources impacting stormwater are estimated to be Hg derived from instruments, switches and thermostats, and fluorescent lighting that together make up 38% of the estimated annual average load going to stormwater. However, what is not shown on the figure is the current confidence around these estimates. Luckily (and differing for PCBs), there is relatively good confidence for the largest estimated sources (switches and thermostats, and fluorescent lighting, and instruments).

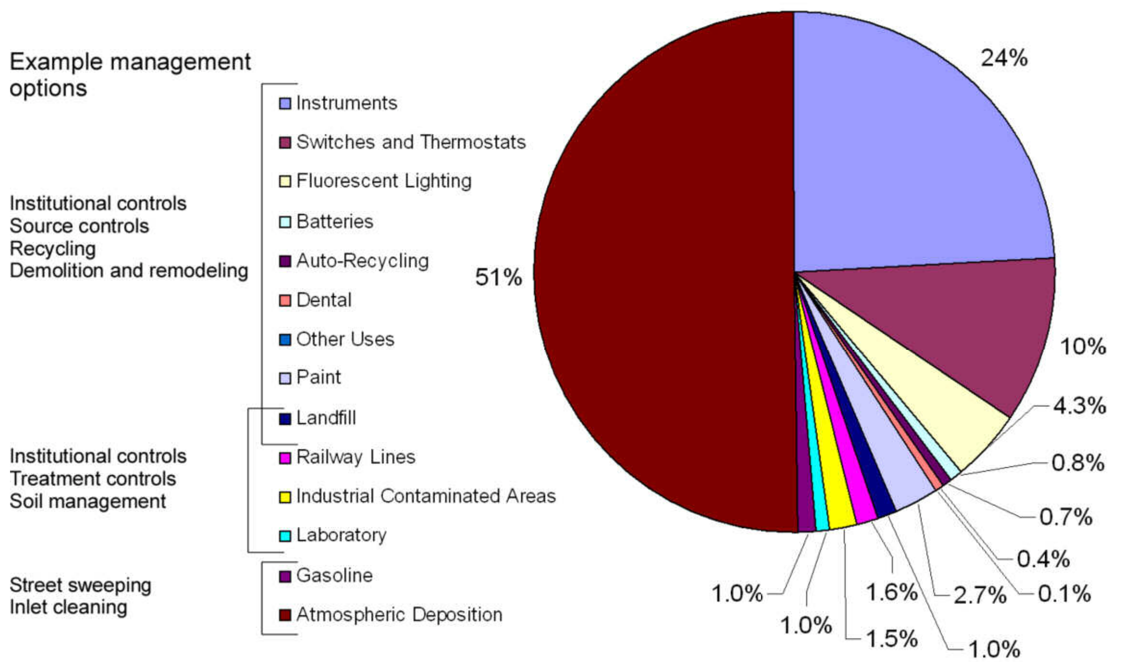


Figure 3-4. Estimated mass of Hg entering storm drains and creeks in the Bay Area. Note that the example management options will be discussed more in Section 4 of this tool box. In addition, note, that there are differing levels of confidence for each sections of the pie. The order of confidence for Hg from greatest to least is as follows: High: switches and thermostats, and fluorescent lighting, and instruments): Medium: dental, landfill, paint, laboratory, atmospheric deposition, batteries, gasoline, other uses (mainly cell phones, LCD TVs and other modern use devices), and railway lines; Low: Industrial contaminated areas and auto-recycling.

There is medium confidence for the categories of dental, landfill, paint, laboratory, atmospheric deposition, batteries, gasoline, other uses (mainly cell phones, LCD TVs and other modern use devices), and railway lines. Confidence is low for industrial contaminated areas and auto-recycling. The second general concept that can be gleaned from Figure 3-4 is that it is estimated that a combination of institutional controls, source controls including correct disposal of products containing Hg, as well as careful application of BMPs during demolition and remodeling have the potential to capture about 45% of the Hg load presently entering stormwater.

Interested in further reading?

McKee, L. Mangarella, P., Williamson, B., Hayworth, J., and Austin, L., 2006 (Chapter 2). Review of Methods to Reduce Urban Stormwater Loads: Task 3.4. A Technical Report of the Regional Watershed Program: SFEI Contribution #429. San Francisco Estuary Institute, Oakland, CA.

SFRWQCB, 2008. Total Maximum Daily Load for PCBs in San Francisco Bay: Final Staff Report for Proposed Basin Plan Amendment. California Regional Water Quality Control Board San Francisco Bay Region, Clay Street, Oakland, CA94612. February 13, 2008. 136pp.
http://www.waterboards.ca.gov/sanfranciscobay/water_issues/programs/TMDLs/sfbaypcbs/Staff_Report.pdf

SFRWQCB, 2009. California Regional Water Quality Control Board San Francisco Bay Region Municipal Regional Stormwater NPDES Permit, Order R2-2009-0074, NPDES Permit No. CAS612008. Adopted October 14, 2009. 279pp.
http://www.waterboards.ca.gov/sanfranciscobay/board_decisions/adopted_orders/2009/R2-2009-0074.pdf

SECTION 4: BEST MANAGEMENT PRACTICES FOR CONTROL OF PCB AND HG IN MUNICIPAL STORMWATER

PCBs and Hg are still found in many types of legacy products and, in some cases, products still in use (See Section 3 for details). In addition, contaminated soils and water vary in location, extent, and connectivity relative to the stormwater conveyance system. The historic and ongoing uses differ between the two substances and, unlike Hg, it is illegal to recycle or reuse PCBs. Therefore, although there are many advantages with managing these (mostly) legacy substances as a pair, no single set of best management practices (BMPs) will suffice. To achieve the loads reductions called out in the San Francisco Bay PCB and Hg TMDLs and meet the requirements described by the municipal regional stormwater NPDES permit (MRP) Order No. R2-2009-0074 (SFBRWQCB, 2009), stormwater managers will need to develop and implement an integrated, watershed-scale strategy for each substance. Each strategy could consist of a combination of institutional BMPs (that change civic behavior and municipal operations including source control and pollution prevention activities), soil remediation approaches, and treatment control BMPs. Strategies will need to be implemented at a variety of scales and locations from higher up in a watershed (far from the Bay) right down to the Bay margin. Although each strategy will have its unique elements, there will be many components that apply to both PCBs and Hg and many components that achieve multiple benefits for other pollutants of concern. In addition, although there will be many common elements, the effort on each element, and therefore each strategy, will likely be unique to a given jurisdiction depending on land use history, social and economic factors.

This section assists stormwater managers, municipal officials, and other stakeholders by:

- Describing BMP implementation points in relation to the true source, source areas, and pathways of PCBs and Hg described in Section 3 of this tool box
- Summarizing the state of knowledge on the types and applicability of various BMPs in relation to these implementation points
- Illustrating some of the multiple benefits for other pollutants of concern
- Providing an overview of options for assessing effectiveness at a variety of programmatic and environmental levels.

BMP implementation points

As described in Section 3 of this tool box, PCBs and Hg contamination enters stormwater from a variety of true sources, source areas, and pathways. BMPs may be implemented to address the true sources or source areas themselves (e.g. street sweeping or recycling or decommissioning programs) or capture PCB and Hg mass along a transport pathway (e.g. filters, swales, dry weather flow or first flush treatment). Implementation points can be thought of as any feasible and cost effective opportunity to reduce PCBs or Hg in the urban landscape and are diverse in style. The range of implementation points include:

- Institutional approaches implemented within the watershed, in a dispersed manner (in homes, offices and businesses, schools, hospitals, research institutions, on public or private lots), or on the street, or in the stormwater conveyance
- Source control and soil remediation approaches on public or private lots
- Treatment controls at the start of pipe as contaminated water and soils leave those lots or as contaminated water and soils pass into a storm drain from a public space (roads, parking lots, etc)
- Treatment controls within the pipe during transport through the MS4/urban storm drain system
- Treatment controls at the end of pipe that capture contaminated water and soils just before they would otherwise discharge to the Bay.

Figure 4-1 provides a conceptual model of the types of BMPs that might be considered at the various possible implementation points in the urban landscape.

Institutional BMPs

For decades, Bay Area cities and counties have implemented institutional BMPs that have directly or indirectly helped to improve water quality. For example, Figure 4-1 illustrates the role of pollution prevention activities in controlling true sources and wastes that can potentially escape from source areas (areas of high product use where soils, water or air may be contaminated). Pollution prevention can take many forms and includes dispersed effort such as public education and outreach campaigns, recycling facilities, and take back programs. Most of these programs are voluntary but some efforts might also require enforcements. Although there is room for enhancement, these programs are already quite advanced for Hg (for example, community education and fluorescent bulb, thermostat, switch, thermometer, and dental equipment recycling programs). In contrast, fewer pollution prevention efforts for PCBs have been implemented (for more detail please see Section 5 of this BMP toolbox).

Street sweeping on roads and parking lots, although mainly targeted at removing trash and other road related debris, also removes pollutants like PCBs and Hg that strongly attach to particles and that end up on impervious areas due to wind, vehicle- and foot-tracking and atmospheric deposition (Figure 4-1). Although street sweeping is presently optimized for trash, there is an opportunity to enhance street sweeping to remove PCBs and Hg (discussed more in Section 5 of this tool box). Clean up of illegally dumped waste is another potential implementation point to remove PCBs and Hg waste before it reaches the stormwater conveyance system, however, there is currently no record of mass of PCBs and Hg removed in this manner locally.

Institutional BMPs also include changes in public perception and may include changes in state and federal laws. A recent example of a change in state law is provided by the thermostat recycling program. The Mercury Thermostat Collection Act of 2008 (AB 2347, Ruskin), that came into effect on July 1st 2009, requires a contractor who removes

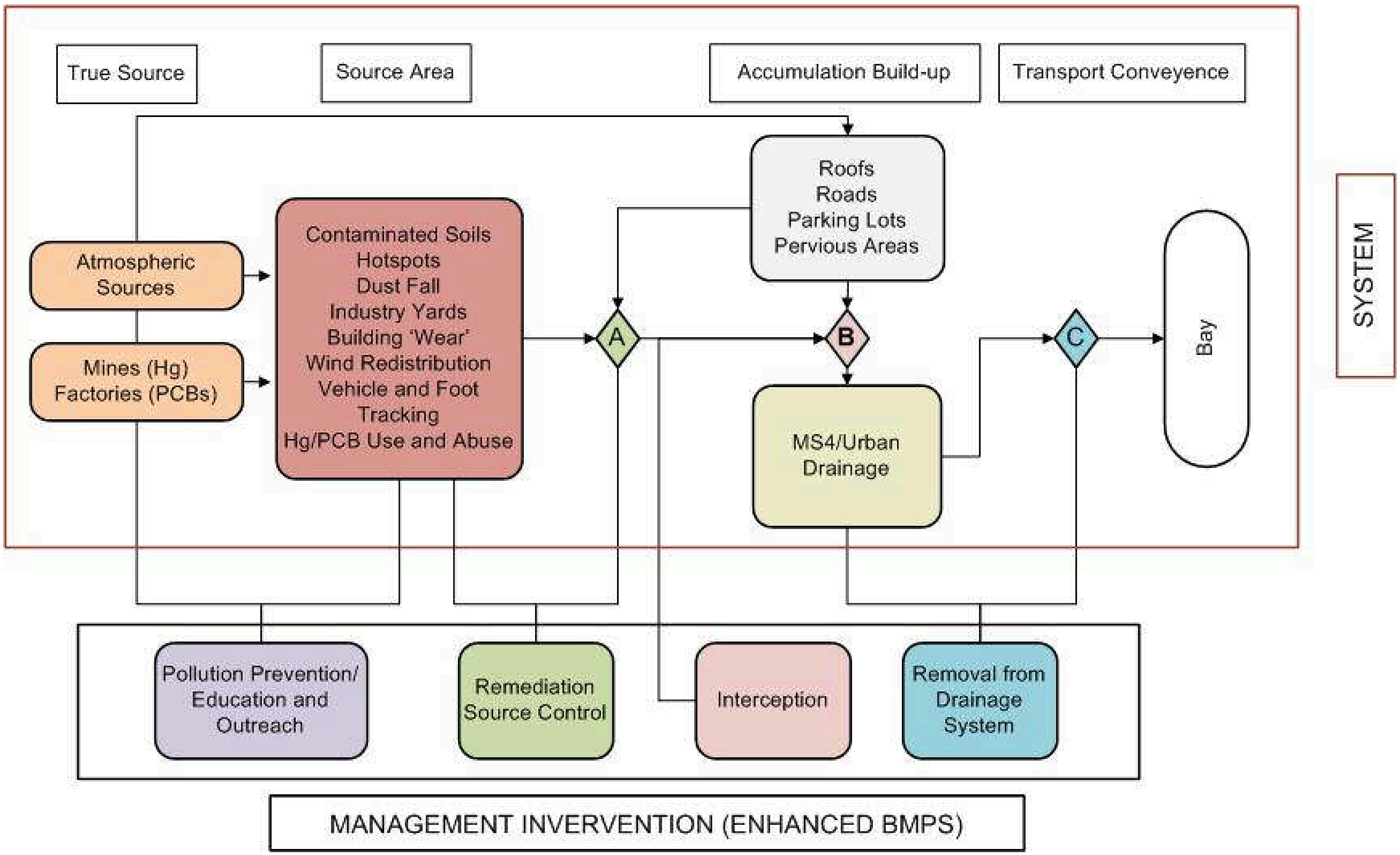


Figure 4-1. Conceptual model of implementation points for reducing Hg and PCB loads to San Francisco Bay.

out-of-service mercury thermostats to take them to a collection location for recycling. There was over 260,000 kg (580,000 lb) of PCBs still legally in use in the Bay Area in 2009, 30 years after the production ban, a situation that could change with new state or federal laws.

These institutional BMPs are examples of intervention that are occurring and could be enhanced before point A on Figure 4-1. The municipal regional stormwater NPDES permit (MRP) Order No. R2-2009-0074 calls for managers to implement a variety of institutional BMPs in relation to Hg (provision C.11) and PCBs (provision C.12) to enhance recycling through enhanced public awareness (for Hg only), pilot studies to investigate enhanced street sweeping to remove PCBs and Hg, remove contaminated sediment during maintenance activities in stormwater collection systems, pipes and channels (these last few are examples of Implementation Point C on Figure 4-1).

Source control and soil remediation BMPs on public or private lots

Soil remediation and source control for PCBs and Hg is another example of an institutional control when it is related to an enforcement action, but it can also be carried out as a volunteer effort, or during redevelopment. It refers to remediation of soil pollution in areas where past practices have resulted in elevated concentrations in soils that could potentially be mobilized and transported into the storm drain system during all flow conditions but particularly during wet weather. This control option also includes the identification and elimination of storage or use of Hg or PCBs that could potentially contribute to loads on both public and private lands (see remediation source control on Figure 4-1).

Over the past decade stormwater agencies in the Bay Area have been carrying out sediment characterization studies in stormwater conveyance systems to identify watersheds with higher concentrations of PCBs and Hg. Where higher concentrations have been identified, follow up "case" studies were carried out at a greater local intensity to test soils and water upstream and identify areas for cleanup and abatement. In some instances this has lead to successful removal of PCB mass from private lots (barrels of raw PCB oil), and clean up of contaminated soils and sediment along roadsides. These kinds of sites tend to be areas where large amounts of PCBs were used for manufacture of products such as transformers or large capacitors or where recycling or re-packaging left legacy contamination.

Another example of on-site source control specific to PCBs is the effort underway to improve building remodeling or demolition BMPs for removal of caulking installed before 1979 that contains PCBs. This could be in addition to identifying and disposing of light ballasts and other PCB containing materials and equipment in buildings (see Section 3 of this tool box for further details). This BMP is relevant for any building or structure that was tilt-slab constructed and where caulking containing PCBs was used to seal up gaps between slabs and around windows and doors. Many public buildings found at schools, hospitals, universities, fire houses, police stations, government offices, military sites, as well as many private buildings fit this description.

On-site source control is also applicable to reducing Hg. For example, there are locations in the Bay Area where concentrations of Hg in collection systems range between 1-12 mg/kg (very high local concentrations that can only be from a concentrated source). In addition, legacy contamination may be found on lots that were formerly used for manufacture of paint, batteries, lighting equipment, thermostats, switches, or pesticides, or where recycling or refurbishing of any of these products, home appliances, and vehicles has left soil or water contamination.

Another area for consideration for both PCBs and Hg is soils near railway lines or areas of high goods transport where PCBs may have been used for dust suppression, where PCBs and Hg were used in infrastructure for electric trains, or where damage and spillage may have occurred during the act of loading and unloading goods.

Provision C.12 (PCBs) of the MRP calls for enhanced identification of contaminated soils on-land and PCB containing equipment during industrial inspections (examples of activities that can occur before Implementation Point A on Figure 4-1).

Treatment control BMPs

Treatment controls may be implemented by both counties and municipalities (institutional), or on private lots during new- and re-development. Treatment controls are engineered devices or environments that can be installed or built in place to enhance the capture of an undesirable constituent such as sediment, PCBs, or Hg. Any treatment control designed to capture PCBs and Hg will likely have multiple benefits for fine sediments and other substances like other metals and other organic compounds that strongly attached to soils and sediments. Treatment control BMPs have a variety of modes of operation including those that slow down the movement of water, remove sediment and associated contaminants through filtering, settling, or otherwise separating sediment from flowing water, or adsorb and incorporate the substance into some kind of media (e.g. carbon, resin, or living plant material). Treatment controls usually require regular inspection and maintenance that may include repair, removal of accumulated sediments and trash, replacement of media, or harvesting vegetation. Presently there is little specific guidance for design requirements, maintenance schedules, or costs to treat PCBs and Hg (discussed more in Section 5 of this BMP toolbox).

1. Start of pipe

Treatment controls can be installed just upstream from the point of collection (start of pipe). These can intercept PCBs and Hg before they enter the conveyance (See Point B on Figure 4-1). They are installed to stop sediment and pollutants from leaving a public or private lot, or to stop pollutants as they runoff impervious surfaces such as roofs, roads, and parking lots. These types of treatment BMPs include infiltration trenches, basins, retention and reuse (e.g. rain barrels or underground tanks), ponds, detention basins, swales, buffer strips, and bioretention. There are many examples of projects in the Bay Area that have already been implemented (e.g. the rain gardens at City of Burlingame municipal building and City of El Cerrito Municipal building, and the sub-grade gardens and vegetated swales at the Walmart complex parking lot, Oakland). The MRP calls for ten green street pilot projects in the next five years (Provision C.3).

Table 4-1. Applicability of specific BMPs for controlling PCBs and Hg in urban areas in relation to sources (true sources and source areas), and transport pathways. Note, for the definitions of true sources, source areas, and pathways, the reader is referred to Section 3 of this BMP toolbox).

	Implementation Points								Applicable sources and pathways							
	Dispersed								PCBs		Hg		Other organics		Other metals	
Best Management Practice (BMP) category	Private homes	Public lots, schools, hospitals, govt bldgs and research institutions	Private offices and businesses	Other private lots and industrial yards	On the street	Start of pipe	Within pipe	End of pipe	Sources	Pathways	Sources	Pathways	Sources	Pathways	Sources	Pathways
Institutional BMPs																
Education and outreach	√	√	√	√					F,OI,IUP,ID,HW,BDR		M,IUP,ID,HW,BDR		F,IUP,ID,HW		M,IUP,ID,HW,BDR	
Volunteer cleanup efforts	√	√	√	√	√				F,OI,IUP,ID,HW		M,IUP,ID,HW,BDR		F,IUP,ID,HW		M,IUP,ID,HW	
Recycling	√	√	√	√							M,IUP,ID,HW,BDR		OI,IUP,HW		OI,IUP,HW	
Amnesties	√	√	√	√					OI,IUP,HW		M,IUP,ID,HW,BDR		OI,IUP,HW		IUP,HW	
Product Bans / product replacement	√	√	√	√					F,OI,IUP,HW		M,IUP,ID,HW,BDR		F,OI,IUP,HW		OI,IUP,HW	
Enforcement			√	√					F,OI,IUP,ID,HW,BDR		M,OI,IUP,ID,HW,BDR		F,OI,IUP,ID,HW		M,IUP,ID,HW,BDR	
Sweeping		√	√	√	√				A,OI,RF,RD,BDR	RI,VT,FT,W	A,OI,RF,RD,BDR	RI,VT,FT,W	A,OI,RF,RD	RI,VT,FT,W	A,OI,RF,RD,BDR	RI,VT,FT,W
Washing (streets/footpaths)		√	√	√	√				RD,BDR	RI,VT,FT,W	RD,BDR	RI,VT,FT,W	RD,BDR	RI,VT,FT,W	RD,BDR	RI,VT,FT,W
Illicit waste dumping cleanup					√	√	√	√	OI,ID	RI	OI	RI	OI	RI	OI	RI
Stormwater conveyance maintenance				√		√	√	√	A,OI,ID,RF	RI,VT,FT,W	A,ID,RF	RI,VT,FT,W	A,ID,RF	RI,VT,FT,W	A,ID,RF	RI,VT,FT,W
Treatment BMPs																
Infiltration trench		√	√	√		√			A,OI,RF	RI,VT,FT,W	A,OI,RF	RI,VT,FT,W	A,OI,RF	RI,VT,FT,W	A,OI,RF	RI,VT,FT,W
Infiltration basin		√	√	√		√			A,OI,RF	RI,VT,FT,W	A,OI,RF	RI,VT,FT,W	A,OI,RF	RI,VT,FT,W	A,OI,RF	RI,VT,FT,W
Retention and reuse / irrigation	√	√	√			√		√	A,OI,RF	RI,VT,FT,W	A,OI,RF	RI,VT,FT,W	A,OI,RF	RI,VT,FT,W	A,OI,RF	RI,VT,FT,W
Wet Pond		√	√	√		√			A,OI,RF	RI,VT,FT,W	A,OI,RF	RI,VT,FT,W	A,OI,RF	RI,VT,FT,W	A,OI,RF	RI,VT,FT,W
Constructed wetland		√	√	√		√		√	A,OI,RF	RI,VT,FT,W	A,OI,RF	RI,VT,FT,W	A,OI,RF	RI,VT,FT,W	A,OI,RF	RI,VT,FT,W
Extended detention basin		√	√	√		√		√	A,OI,RF	RI,VT,FT,W	A,OI,RF	RI,VT,FT,W	A,OI,RF	RI,VT,FT,W	A,OI,RF	RI,VT,FT,W
Vegetated swale		√	√	√		√			A,OI,RF	RI,VT,FT,W	A,OI,RF	RI,VT,FT,W	A,OI,RF	RI,VT,FT,W	A,OI,RF	RI,VT,FT,W
Vegetated buffer strip		√	√	√		√			A,OI,RF	RI,VT,FT,W	A,OI,RF	RI,VT,FT,W	A,OI,RF	RI,VT,FT,W	A,OI,RF	RI,VT,FT,W
Bioretention (Rain garden / green roof)	√	√	√	√		√			A,OI,RF	RI,VT,FT,W	A,OI,RF	RI,VT,FT,W	A,OI,RF	RI,VT,FT,W	A,OI,RF	RI,VT,FT,W
Media filter		√	√	√			√		A,OI,RF	RI,VT,FT,W	A,OI,RF	RI,VT,FT,W	A,OI,RF	RI,VT,FT,W	A,OI,RF	RI,VT,FT,W
Water quality inlet		√	√	√			√		A,OI,RF	RI,VT,FT,W	A,OI,RF	RI,VT,FT,W	A,OI,RF	RI,VT,FT,W	A,OI,RF	RI,VT,FT,W
Wet vault		√	√	√			√		A,OI,RF	RI,VT,FT,W	A,OI,RF	RI,VT,FT,W	A,OI,RF	RI,VT,FT,W	A,OI,RF	RI,VT,FT,W
Hydrodynamic separation		√	√	√			√		A,OI,RF	RI,VT,FT,W	A,OI,RF	RI,VT,FT,W	A,OI,RF	RI,VT,FT,W	A,OI,RF	RI,VT,FT,W
Drain insert		√	√	√			√		A,OI,RF	RI,VT,FT,W	A,OI,RF	RI,VT,FT,W	A,OI,RF	RI,VT,FT,W	A,OI,RF	RI,VT,FT,W
Flow diversion to wastewater treatment								√	All sources	All pathways	All sources	All pathways	All sources	All pathways	All sources	All pathways

True sources: Mining = M, Factories = F, Atmospheric deposition = A.

Source areas: Old industrial = OI, PCBs and Hg products still in use = IUP, Illegal disposal = ID, Recycling facilities = RF, Road deposits = RD, Home and work place = HW, Building demolition and remodeling = BDR.

Transport pathways: Runoff from impervious surfaces = RI, Vehicle tracking = VT, Foot tracking = FT, Wind = W.

Provision C.3. also calls for permittees to use their planning authorities to include appropriate stormwater treatment measures in new- and re-development projects. The goal is for these projects to address both soluble and insoluble stormwater runoff pollutant discharges and to prevent increases in runoff flows from new- and re-development projects. These provisions are examples of start of pipe treatment controls.

2. Within pipe
Treatment BMPs can be installed in the MS4 stormwater collection system itself (within pipe). These are typically installed just as water passes underground or completely underground and include a range of filters and screens and proprietary devices such as wet vault, media filter (e.g. multi chamber treatment train), and hydrodynamic separations (e.g. vortex separator). These devices usually have high maintenance requirements and can sometimes back up the flow of water when not well maintained.

3. End of pipe
Further downstream, treatment of PCBs and Hg can occur closer to the Bay (Implementation Point C on Figure 4-1). These BMPs include sedimentation basins that enhance settling and trap PCBs and Hg, constructed wetlands that remove pollutants through biofiltration and sedimentation, or diversion of dry or wet weather flow to treatment (perhaps at a local wastewater treatment plant that has excess capacity). Provisions C.11.f. and C.12.f. of the MRP call for feasibility studies of diversion of dry weather flows and first flush flows to publicly owned treatment facilities (POTWs). There are presently two feasibility studies underway in the Bay Area now that addresses these previsions (City of Oakland/ East Bay Municipal Utility District and Contra Costa County/ West County Wastewater District).

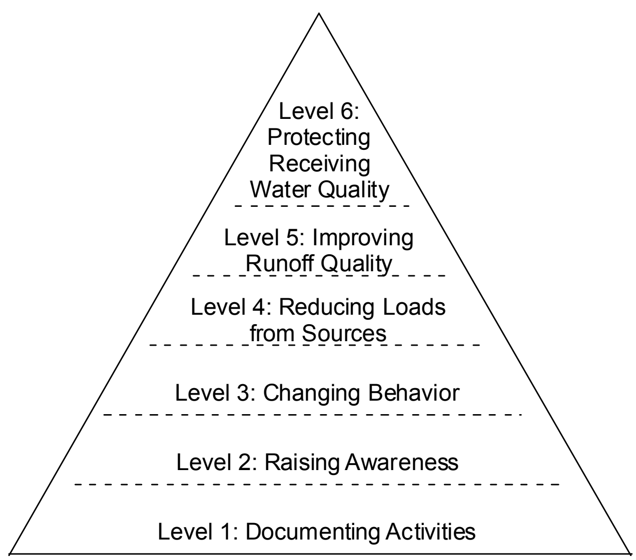
Summary of applicability of BMPs for control of PCBs and Hg

As discussed briefly above, although there are many advantages with managing PCBs and Hg together, as shown by Table 4-1, no single set of best management practices (BMPs) will suffice. Some BMPs are suitable in multiple situations whereas others are limited to very specific scenarios. Stormwater managers will need to develop and implement an integrated watershed-scale strategy for each substance. Table 4-1 provides a starting framework for each strategy, highlighting how successful strategies for PCBs and Hg will likely consist of a combination of institutional BMPs, soil remediation approaches, and treatment control BMPs. Strategies will need to be implemented at a variety of scales and locations from high up in a watershed right down to the Bay margin. Although each strategy will have unique elements, there will be many components that apply to both PCBs and Hg as well as other pollutants of concern as highlighted in the four columns on the right of Table 4-1. In addition, although there will be many common elements, the effort on each element, and therefore each strategy will likely be unique to a given jurisdiction depending on land use history, social and economic factors. At this time, there is no data available on performance, however, in Section 5 of this tool box, some useful guidance is provided on potential performance based on what is known about the physical properties of soils and sediments in the Bay Area, the physical properties of PCBs and Hg, and a range of other reasonable assumptions. Programs that are in a position to report the results of any performance evaluations will provide great benefit to others in the future.

Assessing BMP program effectiveness in relation to PCBs and Hg

Stormwater managers are often challenged by increasing program requirements without seeing similar budget increases. Assessing program effectiveness regularly provides a tool to monitor how well outcomes are matching program objectives. The California Stormwater Quality Association (CASQA) expresses levels of program effectiveness in terms of four programmatic and two environmental outcomes (Figure 4-2). It can be seen by inspecting Figure 4-2, that the measurement of program outcomes increases in effort and costs as you go up each level in the triangle. However, there is benefit gained, as with each level, the relationship between program outcomes and the ultimate program objective (improved environmental quality) grows stronger. For example, it is often very difficult to show any kind of relationship between a BMP such as street sweeping or even suites of BMPs in relation to a Level 6 outcome. In contrast, relationships between Level 3 and Level 4 may be measurable, and between Levels 4, 5, and 6 may be measurable. Another observation that can be made from Figure 4-2, is that spatial and temporal scales also change. Documentation (Level 1 effectiveness measurements) needs to be done at least annually whereas, in some circumstances, higher levels can be assessed less often saving costs. Therefore, one way for individual programs to get around some of these costs, it to measure program effectiveness annually at a minimum at Level 1, 2, and 3, and less often at higher levels. Conversely, the spatial scale of the receiving water body quality may be large enough so that a cost sharing agreement between multiple agencies may facilitate regular cost effective monitoring (This is the case for the Regional Monitoring Program for Water Quality in San Francisco Bay: See SFEI, 2009).

Figure 4-2. Effectiveness assessment outcomes for stormwater programs (CASQA, 2007).



In relation to PCBs and Hg, assessments can be conducted at a variety of outcome levels, depending on the type of BMP implemented as shown in Table 4-2. For example, all BMPs can be assessed for a Level 1 outcome by documenting program activities. This is usually done on an annual basis. Assessments of increased awareness or changed human behavior are great tools for assessing the outcomes of institutional BMPs (such as education campaigns). At the other end of the scale, the outcomes from a number of institutional BMPs may be assessed at outcome Level 4. For the case of PCBs and Hg, BMPs that can be assessed at this level all remove measurable amount of waste (measured in either volume or mass). This is already happening in the Bay Area. For example, the Alameda County Wide Clean Water Program (ACCWP) and the Contra Costa County Clean Water Program (CCCWP) efforts to document mass of PCBs and Hg removed during institutional maintenance activities (e.g. Salop, 2006).

The San Francisco Bay Regional Water Quality Control Board (Water Board) has asked stormwater agencies in the Bay Area to increase programmatic outcome documentation in relation to PCBs and Hg to Levels 4 and higher. For example, Provision C.11.a of the municipal regional stormwater NPDES permit (MRP) Order No. R2-2009-0074 requires that permit holders promote, facilitate and/or participate in region-wide recycling efforts to capture Hg from equipment such as thermometers, thermostats, switches, bulbs, to increase effectiveness and public participation. The MRP calls documentation of mass removed by recycling Hg (a Level 4 outcome). Similarly, for example, provision C.12.c. calls for pilot projects to investigate and abate on-land locations with elevated PCB concentrations. Reporting requirements include documentation of numbers of locations found and site characteristics (Level 1 outcome), responsible parties (Level 2 outcome), and in the forth year, mass removed (Level 4 outcome). Provision C.8. of the permit called for measurement of loads of PCBs and Hg in watersheds of the Bay Area as a baseline for systematically determining trends over time scales of 10-20 years (a Level 5 outcome) that is linked in the TMDLs to improving and protecting the water quality in San Francisco Bay (a Level 6 outcome and the ultimate objective of effort).

One way of determining loading trends is to assess the rate at which sediment concentrations of PCBs or Hg in stormwater during rain events approach a target of 0.005 mg/kg (PCBs) and 0.2 mg/kg (Hg). A study is presently underway to evaluate six years of existing very detailed data collected in the Guadalupe River watershed (San Jose) and a small urban drainage in Hayward by the RMP. The objective of the study is to develop an optimized sampling program (least cost for most information) for measuring loads and trends. In addition, the recent permit has also called for improving estimates of PCB and Hg loads at the regional scale (Provision C.8.) The RMP is presently developing a model to provide a tool for BASMAA to address this provision. These are further examples of evaluating programmatic outcomes at Level 4 and above.

Interested in further reading?

CASQA, 2007. Municipal stormwater program assessment effectiveness guidance. May 2007. www.casqa.org

McKee, L. Mangarella, P., Williamson, B., Hayworth, J., and Austin, L., 2006 (Chapter 4&5). Review of Methods to Reduce Urban Stormwater Loads: Task 3.4. A Technical Report of the Regional Watershed Program: SFEI Contribution #429. San Francisco Estuary Institute, Oakland, CA.

SFEI, 2009. The Pulse of the Estuary: Monitoring and Managing Water Quality in the San Francisco Estuary. SFEI Contribution 583. San Francisco Estuary Institute, Oakland, CA.

Table 4-2. Program assessment effectiveness in relation to PCBs and Hg.

Best management practice (BMP) category	Most applicable effectiveness assessment outcome levels					
	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6
	Documenting activities	Raising awareness	Changing behavior	Reducing loads from sources	Improving runoff quality	Protecting receiving water quality
Institutional BMPs						
Education and outreach	√	√	√			
Volunteer cleanup efforts	√			√		
Recycling	√			√		
Amnesties	√			√		
Product Bans / product replacement	√			√		
Enforcement	√	√	√	√		
Sweeping	√			√		
Washing (streets/footpaths)	√			√		
Illicit waste dumping cleanup	√			√		
Stormwater conveyance maintenance	√			√	√	
Treatment BMPs						
Infiltration trench	√			√	√	
Infiltration basin	√			√	√	
Retention and reuse / irrigation	√			√	√	
Wet Pond	√			√		
Constructed wetland	√			√		
Extended detention basin	√			√		
Vegetated swale	√			√	√	
Vegetated buffer strip	√			√	√	
Bioretention (Rain garden / green roof)	√			√	√	
Media filter	√			√		
Water quality inlet	√			√		
Wet vault	√			√		
Hydrodynamic separation	√			√		
Drain insert	√			√		
Flow diversion to wastewater treatment	√			√	√	√

SECTION 5: TECHNICAL INFORMATION AND FACT SHEETS FOR PCB AND HG BMP DESIGN

San Francisco Bay is listed as impaired for PCBs and Hg and the resulting TMDLs for each describe a plan of action that includes controlling urban runoff. Many provisions in the recently issued municipal regional stormwater NPDES permit (MRP) Order No. R2-2009-0074 aim to directly or indirectly address PCB and Hg loads in urban runoff. In previous sections of this tool box, surmised information has been provided on the history and use and relevant environmental and regulatory issues (Section 2), key definitions, sources and pathways (Section 3), and categories of BMPs for reducing PCB and Hg stormwater loads, multiple benefits for other pollutants, and options for measuring programmatic effectiveness (Section 4).

Organization of this section

This section assists stormwater managers, municipal officials, and other stakeholders by:

- Briefly summarizing key information found in previous sections of the tool box,
- Providing fact sheets that include key technical information relevant for the design and implementation of each BMP or BMP category including both institutional controls (Section 5A) and treatment controls (Section 5B).

Institutional controls	
I-1	Hg recycling
I-2	Building demolition and remodeling
I-3	Local atmospheric sources
I-4	Street sweeping
I-5	Street washing
I-6	Stormwater conveyance maintenance
I-7	Source control and soil remediation
Treatment controls	
T-1	Those that incorporate sediment settling as a primary treatment mode (and in some cases biological uptake) • Wet pond • Constructed wetland • Extended detention basin • Wet vault (proprietary) • Vortex separator (proprietary)
T-2	Those that capture and reuse stormwater • Retention/irrigation • Freshwater wetland restoration • Flow diversion to wastewater treatment

Fact sheet contents

Each fact sheet is organized in the following manner:

- Description,
- Location and applicability,
- Design considerations,
- Information needs / uncertainties,
- References to selected BMP fact sheets where existing specifications are likely to adequate for addressing PCB and Hg loads from key sources and/or pathways.
- Further reading

Summary of key information from other tool box sections

Section 2 summary: PCBs and Hg are classified as legacy contaminants. Although there are ongoing restricted uses of both substances, their main history and peak use was more than three decades ago. Both substances strongly attach to particles making them very persistent in aquatic environments like San Francisco Bay where there is an abundance of fine organic sediment. PCBs and Hg are very toxic to wildlife and humans at very low concentrations and bioaccumulate upwards through the aquatic food chain from phytoplankton to higher trophic level species. People and wildlife that eat fish (particularly the larger species) are at risk for exposure and resulting heath effects. As a result, San Francisco Bay is listed as impaired for PCBs and Hg, and the resulting TMDLs describe plans of action that includes controlling loads of PCBs and Hg urban runoff. The reader may refer to Section 2 of this tool box for more details.

Section 3 summary: Due to a long history of literally thousands of uses and the role of wind and atmospheric processes in dispersion, PCBs and Hg are now spread all over the urban landscape. However, at a more practical level, there are a number of key true sources, source areas, and pathways that provide opportunities where urban managers can focus more attention and capture larger quantities of these toxic substances. For PCBs, the largest sources impacting stormwater are estimated to be building demolition and remodeling, old industrial areas, and thirdly, atmospheric deposition. While there is only low to moderate confidence on some of these estimates, together it is estimated that these sources are responsible for about 83% of the load of PCBs getting into stormwater in the Bay Area. The main pathways are runoff, wheel and foot tracking, dust dispersion from industrial areas, and runoff from impervious surfaces (See Section 3 of this tool box for details). In contrast, the largest single source of Hg to stormwater in Bay Area is atmospheric deposition. In general, confidence for Hg estimates is higher than for PCB estimates. The other large source is the combined impact of Hg derived from instruments, switches, thermostats, and fluorescent lighting that together make up 38% of the estimated annual average load going to stormwater. While the pathways for Hg are very similar to PCBs, the emphasis is a little different because of the differing history of use and the greater role of atmospheric deposition as a true source. The main pathways for Hg are impervious surface runoff but the other pathways listed for PCBs play a lesser, but important, role. For more details, the reader is referred to Section 3 of this tool box.

Section 4 summary: Although there are many advantages with managing PCBs (both mainly legacy substances) as a pair, no single set of best management practices (BMPs) will suffice because the history of uses and transport pathways are slightly different. At a regional scale, strategies will need to have elements unique to each substance as well as more general strategies. These will need to be implemented at a variety of scales and locations from higher up in a watershed right down to the Bay margin. At the scale of a local jurisdiction, each strategy will likely be unique depending on land use history, social and economic factors. A full range of BMP options are relevant and include institutional controls, soil remediation, and treatment controls. Implementation points (any feasible cost effective opportunity to reduce PCBs or Hg in the urban landscape) are therefore also very diverse and include dispersed options, start of pipe, within pipe, and end of pipe. However, the applicability of each implementation point as a suite is unique for PCBs and Hg. Luckily, many stormwater programs have existing experience relevant to PCBs and Hg gained through implementing BMPs that aim to control sediments, other organic compounds, and metals. Controlling PCBs and Hg in most cases can be thought of as an enhancement of these existing programs achieving multiple benefits. In a similar manner, measures of programmatic effectiveness already in place are also relevant for PCBs and Hg. For more details, the reader is referred to Section 4 of this tool box.

SECTION 5A: INSTITUTIONAL CONTROLS

I-1	Hg recycling
I-2	Building demolition and remodeling
I-3	Local atmospheric sources
I-4	Street sweeping
I-5	Street washing
I-6	Stormwater conveyance maintenance
I-7	Source control and soil remediation

Mercury recycling

Description
The Universal Waste Rule mandates recycling of mercury in households and businesses. If mercury containing devices such as fluorescent bulbs, old thermostats, thermometers, switches, gauges, older appliances which contain mercury filled components such as TVs, refrigerators, and microwaves, batteries, and personal devices with liquid crystal displays (e.g. cell phones and TVs) are broken or improperly disposed of, it is possible for some of the mercury to spill on the ground or volatilize and deposit again locally. When this mercury ends up on impervious surfaces, it can build up and easily wash off during wet weather, when it can enter the stormwater system, and be conveyed to the Bay. The MRP calls for implementation and enhancement of recycling through promotion, facilitation, and/or participation in collection and recycling of mercury containing devices and equipment at the consumer level.

Location and applicability
This BMP will mostly be applied in a dispersed manner. There is a permit credit opportunity if mass associated with Hg-containing waste collected at illicit dump sites is documented.

Design considerations
Implementation opportunities include education and outreach to the public, schools, churches, contractors who do remodeling and/or demolition, owners of auto-wrecking, auto-refurbishing, and metals recycling businesses, volunteer clean up efforts, amnesties where Hg-containing devices and products are collected at minimal or no cost to the consumer. Enforcement actions may be necessary and these may lead to prosecution in relation to illegal disposal. Another great opportunity would be to partner with recycling organizations that have already developed outreach materials and have collection infrastructure in place.

Further information needs / uncertainties
Stormwater managers would benefit from improved lists of devices and products containing Hg including manufacture years, and amount of Hg.

I-1 Institutional Control

Applicable sources / pathways

True Sources
- Mining √
- Factories
- Atmospheric

Source Areas
- Old industrial √
- Products still in use √
- Illegal disposal √
- Recycling facilities
- Road deposits
- Home and work place √
- Building demolition and remodeling √

Transport pathways
- Runoff from impervious surfaces
- Vehicle tracking
- Foot tracking
- Wind

Key sources
- Fluorescent lights
- Thermostats
- Thermometers
- Switches
- Batteries
- Cell phones
- Appliances

Implementation points
- Dispersed √
- On the street √
- Start of pipe
- Within pipe
- End of pipe

Examples of existing fact sheets

DTSC 2005a: How to handle mercury in major appliances. California Department of Toxic Substances Control, Sacramento, CA. http://www.dtsc.ca.gov/HazardousWaste/Mercury/upload/HWMP_FS_Merc_Appliances.pdf

DTSC 2005b: BMPs for managing spent fluorescent lights. California Department of Toxic Substances Control, Sacramento, CA. http://165.235.111.242/HazardousWaste/Mercury/upload/HWMP_REP_BMP_Fluorescent-Tubes.pdf

DTSC 2006: New law for recycling cellular phones. California Department of Toxic Substances Control, Sacramento, CA. http://www.dtsc.ca.gov/HazardousWaste/EWaste/upload/HWMP_FS_AB2901.pdf

DTSC 2007a: How to manage mercury switches in vehicles. California Department of Toxic Substances Control, Sacramento, CA. http://www.dtsc.ca.gov/HazardousWaste/Mercury/upload/HWMP_FS_Merc-Vehicles.pdf

DTSC 2007b: Rechargeable battery recycling act. California Department of Toxic Substances Control, Sacramento, CA. http://www.dtsc.ca.gov/HazardousWaste/upload/FactSheet_AB1125.pdf

DTSC 2007c: Changes to the appliance recycling program. California Department of Toxic Substances Control, Sacramento, CA. http://www.dtsc.ca.gov/HazardousWaste/Mercury/upload/CARfactsheet.pdf

DTSC 2009: Mercury thermostat collection act of 2008. California Department of Toxic Substances Control, Sacramento, CA. http://www.dtsc.ca.gov/HazardousWaste/upload/Mercury-Thermostat-Fact-Sheet-June-2009-2.pdf

Interested in further reading?

Mangarella, P., Havens, K., Lewis, W., and McKee, L.J., 2010. Task 3.5.1: Desktop Evaluation of Controls for Polychlorinated Biphenyls and Mercury Load Reduction. A Technical Report of the Regional Watershed Program. San Francisco Estuary Institute, Oakland, CA. 41pp.

McKee, L. Mangarella, P., Williamson, B., Hayworth, J., and Austin, L., 2006. Review of Methods to Reduce Urban Stormwater Loads: Task 3.4. A Technical Report of the Regional Watershed Program: SFEI Contribution #429. San Francisco Estuary Institute, Oakland, CA.

SFRWQCB, 2006. Mercury in San Francisco Bay Proposed Basin Plan Amendment and Staff Report for Revised Total Maximum Daily Load (TMDL) and Proposed Mercury Water Quality Objectives. California Regional Water Quality Control Board San Francisco Bay Region, Clay Street, Oakland, CA94612. August 1, 2006. 116pp. http://www.waterboards.ca.gov/sanfranciscobay/water_issues/programs/TMDLs/sfbaymercury/sr080906.pdf

SFRWQCB, 2009. California Regional Water Quality Control Board San Francisco Bay Region Municipal Regional Stormwater NPDES Permit, Order R2-2009-0074, NPDES Permit No. CAS612008. Adopted October 14, 2009. 279pp. http://www.waterboards.ca.gov/sanfranciscobay/board_decisions/adopted_orders/2009/R2-2009-0074.pdf

Building demolition and remodeling

Description
PCBs were used in caulking prior to 1979 to seal up gaps between slabs and around windows and doors in buildings. In addition, PCBs were also used in light ballasts, wall coverings, ceiling tiles, floor wax, floor finish, heavy electric wiring and lift motors. Hg was used in buildings in fluorescent lights, thermostats, temperature sensing devices, and paint. During building demolition and remodeling inadequate disposal of these products and materials and containment of dust, water, and other liquids can allow some of the Hg and PCBs to disperse either directly into local drains or onto impervious surfaces. When these PCBs and Hg end up on impervious surfaces, they can easily wash off next time it rains, enter the stormwater system, and be conveyed to the Bay. In an effort to further evaluate this kind of pollution, provisions C.12.b and C.11.f of the MRP calls for pilot projects to evaluate the management of PCB- and Hg-containing materials and wastes during building demolition and renovation (e.g., window replacement) activities.

Location and applicability
This BMP will be applied in a dispersed manner. These PCB- and Hg-containing products and fixtures were common in many public buildings such as schools, hospitals, universities, fire houses, police stations, government offices, military sites, as well as many privately owned commercial and residential buildings.

Design considerations
This fact sheet is relevant for any building or structure that was constructed with tilt-slab or that was constructed or remodeled between 1955 and 1979. For Hg, these can be any buildings that have any Hg-containing products, although buildings constructed or remodeled before 1993 are likely to contain larger qualities due to voluntary phase out and the passage of laws governing the use of Hg in switches, paint, thermostats, and concentrations in other products. Implementation opportunities include education and outreach to the public, schools, churches, contractors who do remodeling and or demolition, volunteer clean up efforts, amnesties where PCB- and Hg-containing devises and products can be collected at

I-2 Institutional Control

Applicable sources / pathways

True Sources
- Mining
- Factories √
- Atmospheric

Source Areas
- Old industrial √
- Products still in use √
- Illegal disposal √
- Recycling facilities
- Road deposits
- Home and work place √
- Building demolition and remodeling √

Transport pathways
- Runoff from impervious surfaces
- Vehicle tracking
- Foot tracking
- Wind

Key source areas
- Private homes
- Public buildings
- Private offices/ office blocks, commercial and wholesale / retail centers
- Factories / warehouses

Implementation points
- Dispersed √
- On the street √
- Start of pipe
- Within pipe
- End of pipe

minimal or no cost to the consumer, enforcement actions that may lead to prosecution in relation to illegal disposal, and partnering with recycling or waste disposal organizations.

Further information needs / uncertainties

There is no present way of identifying buildings that contain caulking or other PCB containing fixtures. There are databases that provide information on styles and ages of buildings in cities across the Bay Area (e.g.: Empois: http://www.emporis.com/en/bu/ Emporis manages a worldwide database on construction data and commercial real estate information. The data base contains hundreds of buildings that fit the general profile of risk. XRF has recently been tested as a screening tool however, since many other compounds contain chlorine, XRF is prone to giving false positives.

There is a project presently being completed by the Association of Bay Area Governments (ABAG) funded by the State Revolving Fund under the American Recovery and Reinvestment Act of 2009 (ARRA) that includes a task to characterize the use of PCBs in historic building materials in the San Francisco Bay Area and develop best management practices. This project aims to address some of the existing data gaps in relation to PCBs in building materials. In addition, information gathered during the first permit term of the MRP will also likely provide valuable information.

Existing fact sheets

DTSC 2003: PCBs in schools. California Department of Toxic Substances Control, Sacramento, CA.
http://www.dtsc.ca.gov/Schools/upload/SM_POL_PCB_Schools.pdf

DTSC 2005b: BMPs for managing spent fluorescent lights. California Department of Toxic Substances Control, Sacramento, CA.
http://165.235.111.242/HazardousWaste/Mercury/upload/HWMP_REP_BMP_Fluorescent-Tubes.pdf

DTSC 2009: Mercury thermostat collection act of 2008. California Department of Toxic Substances Control, Sacramento, CA.
http://www.dtsc.ca.gov/HazardousWaste/upload/Mercury-Thermostat-Fact-Sheet-June-2009-2.pdf

EPA, 2009a. Preventing exposure to PCBs in caulking material. United States Environmental Protection Agency. Hazardous Waste Identification Division. http://www.epa.gov/epawaste/hazard/tsd/pcbs/pubs/caulk/caulkexposure.pdf

EPA 2009b. Fact sheet - PCBs in caulk. United States Environmental Protection Agency. Hazardous Waste Identification Division.
http://www.epa.gov/epawaste/hazard/tsd/pcbs/pubs/caulk/caulk-fs.pdf

EPA 2009c. Contractors handling PCBs in caulk during renovation. United States Environmental Protection Agency. Hazardous Waste Identification Division. http://www.epa.gov/epawaste/hazard/tsd/pcbs/pubs/caulk/caulkcontractors.pdf

Interested in further reading?

Mangarella, P., Havens, K., Lewis, W., and McKee, L.J., 2010. Task 3.5.1: Desktop Evaluation of Controls for Polychlorinated Biphenyls and Mercury Load Reduction. A Technical Report of the Regional Watershed Program. San Francisco Estuary Institute, Oakland, CA. 41pp.

McKee, L. Mangarella, P., Williamson, B., Hayworth, J., and Austin, L., 2006. Review of Methods to Reduce Urban Stormwater Loads: Task 3.4. A Technical Report of the Regional Watershed Program: SFEI Contribution #429. San Francisco Estuary Institute, Oakland, CA.

SFRWQCB, 2008. Total Maximum Daily Load for PCBs in San Francisco Bay: Final Staff Report for Proposed Basin Plan Amendment. California Regional Water Quality Control Board San Francisco Bay Region, Clay Street, Oakland, CA94612. February 13, 2008. 136pp.
http://www.waterboards.ca.gov/sanfranciscobay/water_issues/programs/TMDLs/sfbaypcbs/Staff_Report.pdf

SFRWQCB, 2009. California Regional Water Quality Control Board San Francisco Bay Region Municipal Regional Stormwater NPDES Permit, Order R2-2009-0074, NPDES Permit No. CAS612008. Adopted October 14, 2009. 279pp.
http://www.waterboards.ca.gov/sanfranciscobay/board_decisions/adopted_orders/2009/R2-2009-0074.pdf

Local atmospheric sources

Description

Both PCBs and mercury are transported globally in the atmosphere and are found in lakes, glacial ice, and soils far from manufacturing, mining or urban areas. Some of this global circulating mass of PCBs and Hg is continually deposited in the Bay Area each year. In addition, there is an unknown extra quantity derived from local sources including industrial fires (PCBs and Hg), combustion of fossil fuels (coal, gas, gasoline, diesel, and oil) for heating, manifesting cement, oil refining, etc. (Hg), and from incineration (PCBs and Hg), and cremation (Hg). Some of this locally derived air deposition falls on impervious surfaces where it is easily transported to storm drains and to the Bay.

Location and applicability

A list of known PCB users in the Bay Area in found in Appendix D and a map of local atmospheric Hg air sources is found in Appendix E. There is international evidence and limited local evidence that soils and water bodies in urban areas and stormwater conveyances near these kinds of uses and release areas have higher concentrations.

Design considerations

Provision C.12 (PCBs) of the MRP calls for enhanced identification of contaminated soils on-land and PCB-containing equipment during industrial inspections. Although the intent of this provision is to improve management of equipment or contaminated soils, it may also indirectly result in reduced atmospheric sources. To address this permit provision, fruitful outcomes might be gained by focusing on businesses that have in the past or currently use high amounts of electricity. In the case of both Hg and PCBs, if laws were to change in relation to PCB use, fossil fuel combustion, or Hg management during cremation, local atmospheric re-deposition would likely also change.

Further information needs / uncertainties

PCBs: Given there are some notable missing potential users on the current EPA list (Appendix D) including oil refineries, power plants, and PG&E, it would seem likely that the current number of locations and mass is a minimum estimate. It is estimated that about 0.3% of PCBs released during spills enters the atmosphere (see review by McKee et al. (2006)) and an

I-3 Institutional Control

Applicable sources / pathways

True Sources

- Mining √
- Factories √
- Atmospheric √

Source Areas

- Old industrial √
- Products still in use
- Illegal disposal
- Recycling facilities
- Road deposits
- Home and work place
- Building demolition and remodeling

Transport pathways

- Runoff from impervious surfaces √
- Vehicle tracking
- Foot tracking
- Wind

Key source areas

- New Almaden mines
- Gambonini mine
- Refineries
- Cement plants
- Crematorium
- Industrial facilities that burn fossil fuels

Implementation points

- Dispersed √
- On the street
- Start of pipe
- Within pipe
- End of pipe

unknown amount enters the atmosphere when industrial fires occur (a common end of life fate of transformers and large capacitors). There is no local data to show how far PCBs might disperse from in-use sources.

Hg: There is presently just one study of Hg deposition from a local air source for the Bay Area (Rothenberg et al., 2010a and 2010b), focusing on air deposition near the only cement plant in the Bay Area. This provided evidence of local deposition. However, there has been no follow-up survey to determine how much of this locally deposited Hg gets to stormwater and is transported to the Bay and no studies to determine if there are locally elevated fish concentrations in relation to atmospheric Hg that are linked to wildlife effects. There are no local studies of atmospheric deposition in the vicinity of any of the power plants, oil refineries, or crematorium in the Bay Area.

Existing fact sheets

There are no other existing fact sheets that we know of that pertain to better control of local air sources in the Bay Area.

Interested in further reading?

Mangarella, P., Havens, K., Lewis, W., and McKee, L.J., 2010. Task 3.5.1: Desktop Evaluation of Controls for Polychlorinated Biphenyls and Mercury Load Reduction. A Technical Report of the Regional Watershed Program. San Francisco Estuary Institute, Oakland, CA. 41pp.

McKee, L. Mangarella, P., Williamson, B., Hayworth, J., and Austin, L., 2006. Review of Methods to Reduce Urban Stormwater Loads: Task 3.4. A Technical Report of the Regional Watershed Program: SFEI Contribution #429. San Francisco Estuary Institute, Oakland, CA.

Rothenberg, S.E., McKee, L.J., Gilbreath, A., Yee, D., and Conner, M., and Fu, X.,2010a. Wet deposition of mercury within the vicinity of a cement plant before and during cement plant maintenance. Atmospheric Environment 44, 1255-1262.

Rothenberg, S.E., McKee, L.J., Gilbreath, A., Yee, D., and Conner, M., and Fu, X., 2010b. Evidence for short range transport of atmospheric mercury to a rural, inland site. Atmospheric Environment 44, 1263-1273.

SFRWQCB, 2006. Mercury in San Francisco Bay Proposed Basin Plan Amendment and Staff Report for Revised Total Maximum Daily Load (TMDL) and Proposed Mercury Water Quality Objectives. California Regional Water Quality Control Board San Francisco Bay Region, Clay Street, Oakland, CA94612. August 1, 2006. 116pp. http://www.waterboards.ca.gov/sanfranciscobay/water_issues/programs/TMDLs/sfbaymercury/sr080906.pdf

SFRWQCB, 2008. Total Maximum Daily Load for PCBs in San Francisco Bay: Final Staff Report for Proposed Basin Plan Amendment. California Regional Water Quality Control Board San Francisco Bay Region, Clay Street, Oakland, CA94612. February 13, 2008. 136pp. http://www.waterboards.ca.gov/sanfranciscobay/water_issues/programs/TMDLs/sfbaypcbs/Staff_Report.pdf

SFRWQCB, 2009. California Regional Water Quality Control Board San Francisco Bay Region Municipal Regional Stormwater NPDES Permit, Order R2-2009-0074, NPDES Permit No. CAS612008. Adopted October 14, 2009. 279pp. http://www.waterboards.ca.gov/sanfranciscobay/board_decisions/adopted_orders/2009/R2-2009-0074.pdf

Street sweeping

Description

Street sweeping is conducted on roads and sometimes in parking lots by most, if not all, municipalities in the 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 pollutants like PCBs and Hg that strongly attach to particles and that end up on impervious areas due to wind, vehicle and foot tracking and atmospheric deposition. If not collected, these particles may build up and enter the stormwater system during wet weather and be conveyed to the Bay.

Location and applicability

This BMP is presently mainly applied in a dispersed manner across all neighborhood types but focuses on residential and commercial areas. Although street sweeping is presently optimized for trash, there is an opportunity to enhance street sweeping to remove PCBs and Hg. Areas to target are those that are known or suspected to have higher concentrations including old industrial areas, older neighborhoods where longer periods of use has left greater buildup, near recycling and waste management facilities, and as part of routine clean-up in relation to illegal dumped waste. There is also an opportunity to reach out to businesses to increase their stewardship in parking lots, driveways, yards, and loading areas. Work completed or collated by SFEI provides a list of individual sites and patches in industrial areas that might be a starting point for further effort and investigations (Yee and McKee, 2010; see Appendix F for details). The data show that locations and areas where there are elevated concentrations of PCBs and Hg often do not overlap, but there are some areas with moderate to high concentrations of both. This is to be expected given the unique sources and use history of each substance but adds difficulty and costs to a management program.

Design considerations

There are a number of factors to consider when enhancing current sweeping practices. These are 1) utilization of more efficient sweepers that use regenerative air and/or water to ensure greater pick up of fine particles, 2) frequency, 3) location, 4) season, and driver education (5) speed and accuracy). Generally there is a lack of data on how these

I-4 Institutional Control

Applicable sources / pathways

True Sources	√
Mining	
Factories	√
Atmospheric	√
Source Areas	
Old industrial	√
Products still in use	√
Illegal disposal	√
Recycling facilities	√
Road deposits	√
Home and work place	
Building demolition and remodeling	√
Transport pathways	
Runoff from impervious surfaces	√
Vehicle tracking	√
Foot tracking	√
Wind	√

Key source areas

- Roads
- Parking lots
- Industrial yards
- Airport runways

Implementation points

Dispersed	√
On the street	√
Start of pipe	
Within pipe	
End of pipe	

factors affect PCBs, Hg, or even sediment removal, but some general statements can be made. Frequency of sweeping 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 two (Sarter and Boyd, 1971). 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 sweeping (CWA, 2006). 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 and associated contaminants off private and public lots to roads and other nearby impervious surfaces. In general, slower sweeper speeds enhance pick up as does positioning the sweeper closer to the curb where pollutant buildup is greater.

Further information needs / uncertainties

There is disagreement among stormwater practitioners whether pick-up efficiency equates to load reduction (Selbig and Bannerman, 2007). Sweeper technology has advanced considerably over the past 20 years with the emphasis on designing sweepers to remove fine sediments and associated constituents. The last local study of alternative sweeper types was conducted in San Jose in the early-1990s and indicated a significant improvement in pick up efficiency for sediment and copper with regenerative air sweepers compared to broom type sweepers (Woodward Clyde Consultants, 1994). No studies have been conducted since then, so performance of the latest technology in street sweepers in local environments is unknown.

We know of no studies on PCBs or Hg sweeping removal effectiveness, but our recent work (Yee and McKee, 2010) investigating pollutant partitioning in stormwater and stormwater collection facility sediments indicates particles larger than 25 microns account for half the PCBs in stormwater and 90% or more of Hg in sediments accumulated in collection facilities. Accumulated sediments over 25 microns also likely contain a similarly large fraction of PCBs. Equipment that can capture these moderately small particles can therefore potentially remove a large fraction of Hg and PCBs.

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 the design of improved sweeping programs. The MRP calls for permittees to evaluate ways to enhance existing municipal street sweeping and curb clearing parking restrictions. It is anticipated that some data collected locally through these evaluations will provide some of the necessary information for designing enhanced sweeper programs.

Existing fact sheets

CASQA, 2003. Stormwater Best Management Practice Handbook: Municipal. California Stormwater Quality Association. SC70 Road and street maintenance.
www.cabmphandbooks.com

Interested in further reading?

CWP, 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). Center for Watershed Protection.

Mangarella, P., Havens, K., Lewis, W., and McKee, L.J., 2010. Task 3.5.1: Desktop Evaluation of Controls for Polychlorinated Biphenyls and Mercury Load Reduction. A Technical Report of the Regional Watershed Program. San Francisco Estuary Institute, Oakland, CA. 41pp.

McKee, L. Mangarella, P., Williamson, B., Hayworth, J., and Austin, L., 2006. Review of Methods to Reduce Urban Stormwater Loads: Task 3.4. A Technical Report of the Regional Watershed Program: SFEI Contribution #429. San Francisco Estuary Institute, Oakland, CA.

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

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.

SFRWQCB, 2009. California Regional Water Quality Control Board San Francisco Bay Region Municipal Regional Stormwater NPDES Permit, Order R2-2009-0074, NPDES Permit No. CAS612008. Adopted October 14, 2009. 279pp.
http://www.waterboards.ca.gov/sanfranciscobay/board_decisions/adopted_orders/2009/R2-2009-0074.pdf

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

Yee, D., McKee, L.J., 2010. Task 3.5: Concentrations of PCBs and Hg 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.

Street washing

Description

Street washing is rarely conducted in the Bay Area for the purposes of removing pollutants. The traditional purpose of street washing is to remove chewing gum, oils, and other stains that collect on sidewalks lowering aesthetic appeal. However, street washing could also remove very small amounts of pollutants like PCBs and Hg that strongly attach to particles and that end up on impervious areas due to wind, vehicle- and foot-tracking, and atmospheric deposition. That said, a recent analysis suggested that even if effort was stepped up to hundreds of acres per month with a monthly frequency, about 25 g of Hg and about 50 g of PCBs could be removed per year, but at a tremendous cost (Mangarella et al., 2010). While there is no evidence to suggest that street washing would be a cost efficient BMP for removal of PCBs and Hg, any mass inadvertently removed would reduce the pool available for transport to the Bay via the stormwater system.

Location and applicability

For the most part, washing that is conducted is carried out in the central business district or central plaza by city governments or private businesses as part of normal maintenance of aesthetic value. There is an opportunity to use street washing in a targeted manner when PCBs (or Hg) are known to occur in very high concentrations (for example, outside a business that recycles or handles PCBs or Hg routinely or where a spill or illegal dumping occurs). Routine washing may also be effective in extremely high traffic areas near recycling centers or waste management depots. Street washing was performed in the Ettie Street pump station watershed as part of a clean-up and abatement exercise near businesses where PCBs were located. In this case about 8.5 g of PCBs were removed at a cost of $100,000 (Kleinfelder, 2006). The municipal regional stormwater NPDES permit (MRP) calls for permitees to identify five drainage areas that contain high levels of PCBs and conduct pilot projects to investigate and abate these high PCB concentrations. Street washing may be part of the abatement toolbox where impervious surfaces have highly concentrated deposits. Work completed or collated by SFEI provides a list of individual sites and patches in industrial areas that might be a starting point for further effort and investigations (Yee and McKee, 2010; see

I-5 Institutional Control

Applicable sources / pathways

True Sources	√
Mining	
Factories	√
Atmospheric	√
Source Areas	
Old industrial	√
Products still in use	√
Illegal disposal	√
Recycling facilities	√
Road deposits	√
Home and work place	
Building demolition and remodeling	√
Transport pathways	
Runoff from impervious surfaces	√
Vehicle tracking	√
Foot tracking	√
Wind	√

Key source areas

- Spills on impervious pavement
- Illegal dumping areas
- Impervious area receiving excessive contaminated runoff from a local primary source
- Extremely high traffic areas

Implementation points

Dispersed	√
On the street	√
Start of pipe	
Within pipe	
End of pipe	

Appendix F and G for details). The data show that locations and areas where there are elevated concentrations of PCBs and Hg often do not overlap, although there are some locations with moderate to high concentrations of both. This is to be expected given the unique sources and use history of each substance but adds difficulty and costs to a management program.

Design considerations

Street washing is limited to areas where pavements are still in reasonable condition. Areas that are cracked due to age or the weight of heavy vehicles may be further damaged during the act of power washing by steam cleaning. Other considerations include the ability to collect the wash water, the need to limit overspray onto neighboring properties, and the costs of disposal.

Further information needs / uncertainties

There has been only one study to-date in the Bay Area that determined effectiveness and costs associated with removing PCBs under a clean-up and abatement action. Sediment PCBs were found at that location post-abatement (one year later) at concentrations similar to those prior to treatment. Given the fairly aggressive hydroblasting removal effort in 2006, pollutants measured in the follow up sampling are unlikely to have come from within the treated sites, so transport from nearby areas is the more likely cause. However it is not possible to entirely discount the first possibility, as no samples were collected or reported immediately after the abatement actions were taken, so within-site transport might still be a component of the pollutants found in follow-up sampling (Salop 2007). There are no studies in the Bay Area on the use of street washing as a tool for removing Hg mass before it enters stormwater.

Existing fact sheets

There are no existing fact sheets available to guide this BMP. The experience gained by the City of Oakland during the Ettie Street abatement is the most valuable knowledge in the Bay Area.

Interested in further reading?

Kleinfelder, Inc. 2005. Sediment sampling report Ettie Street pump station watershed, Oakland, California. City of Oakland PWA – ESD. July 2005. pp.1-31.

Kleinfelder, Inc. 2006. Final project report Ettie Street pump station watershed, Oakland, California. City of Oakland PWA – ESD. July 2005. pp.1-31.

Mangarella, P., Havens, K., Lewis, W., and McKee, L.J., 2010. Task 3.5.1: Desktop Evaluation of Controls for Polychlorinated Biphenyls and Mercury Load Reduction. A Technical Report of the Regional Watershed Program. San Francisco Estuary Institute, Oakland, CA. 41pp.

Salop, P. (2007). Post-Abatement Sampling and Analysis for PCBs in the Ettie Street Pump Station Watershed, Alameda Countywide Clean Water Program: 12 pp.

SFRWQCB, 2009. California Regional Water Quality Control Board San Francisco Bay Region Municipal Regional Stormwater NPDES Permit, Order R2-2009-0074, NPDES Permit No. CAS612008. Adopted October 14, 2009. 279pp. http://www.waterboards.ca.gov/sanfranciscobay/board_decisions/adopted_orders/2009/R2-2009-0074.pdf

Yee, D., McKee, L.J., 2010. Task 3.5: Concentrations of PCBs and Hg 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.

Stormwater conveyance maintenance

I-6 Institutional Control

Applicable sources / pathways

True Sources
- Mining
- Factories √
- Atmospheric √

Source Areas
- Old industrial √
- Products still in use
- Illegal disposal √
- Recycling facilities √
- Road deposits
- Home and work place
- Building demolition and remodeling

Transport pathways
- Runoff from impervious surfaces √
- Vehicle tracking √
- Foot tracking √
- Wind √

Key source areas
- ➢ Old industrial areas
- ➢ Older neighborhoods
- ➢ Urban areas prone to illegal dumping

Implementation points
- Dispersed √
- On the street √
- Start of pipe
- Within pipe √
- End of pipe √

Description

Municipal agencies are responsible for maintaining the storm drain system so that it functions as designed. Maintenance includes activities that help to avoid the system clogging up with trash, debris and sediment. Deposited material is removed from catch basins, drain inlets, pump station sumps, storm drain pipes, and open channels. The sediment removed contains urban pollutants including trace amount of PCBs and Hg at concentrations dependant on a number of factors including grain size and proximity to sources. In general, concentrations are greater on smaller grain sizes and in industrial areas where PCBs and Hg were used, processed or inadvertently spilled. However, most of the sediment mass that accretes in storm inlets appears to be moderate to large particles (>25 microns), and accounts for ~90% or more of the Hg in storm conveyance inlet sediments. Removing contaminated sediment from the conveyance system ensures that none of this material can be remobilized during larger rain events and find its way to the Bay. The recently adopted Municipal Regional Stormwater NPDES Permit (MRP) calls for evaluation of ways to enhance PCB load reduction benefits of operation and maintenance activities that remove or manage sediment at a pilot scale in five drainages during the first permit term.

Location and applicability

Although the design of sediment maintenance program will undoubtedly need to continue to focus on maintenance of a clean and safe urban environment, there is an opportunity to enhance desilting activities in areas most likely to be contaminated with PCBs and Hg. These include older industrial areas where PCBs and Hg were processed or spilled over many years during their peak use period of 1955-1970 (PCBs) and 1955-1990 (Hg), in older neighborhoods where greater build up has occurred through atmospheric sources, traffic and residential uses over many decades, in areas that are prone to illegal dumping, and near recycling centers or waste management depots where there are higher concentrations associated with ongoing activities. There may also be an opportunity to reach out to private businesses in older industrial areas to encourage better house keeping of inlets and drainage systems within property boundaries. Work completed or collated by SFEI provides a list of individual sites and patches in industrial areas that might be a starting point for further effort and investigations (Yee and McKee, 2010; see Appendix F & G for details). The data show that locations and areas where there are elevated concentrations of PCBs and Hg often do not overlap, but there are some locations with moderate to high concentrations of both. This it to be expected given the unique sources and use history of each substance but adds difficulty and costs to a management program.

Design considerations

Enhancement of sediment desilting operations possibly represents a very cost effective way of removing and documenting PCB and Hg load reductions because it requires relatively little improvement in expertise. A first step may be simply documenting the mass of PCBs and Hg removed during normal desilting exercises in industrial or older neighborhoods. Quantification in these types of land uses may provide a cost effective (cost per mass documented) permit credit, however, permittees should expect and not be disappointed to find that even within higher PCB and Hg contamination risk areas, concentrations will be variable. This is to be expected because the processes that combine to erode and deposit sediment are variable in space and time depending on annual rainfall and land use activities. It is probably less efficient to make laboratory measurements on sediment removed in less polluted areas. In both cases however, thorough compositing of collected sediments from multiple sites can reduce associated lab analytical costs, although with loss of certainty over the exact origin of any contaminated sediments found. With judicious and well documented compositing however, follow-up sampling of uncomposited portions can help pinpoint locations of concern. If samples are composited, care should be taken to ensure that the analytical laboratories have sufficiently sensitive methods to detect down to ambient levels, because if the pollutants cannot be measured, the amount removed cannot be quantified. Enhancement of documentation could proceed through improved characterization of sediment volumes, mass conversion (i.e. mass of sediment per unit volume of clean-out material), and analysis of the bulk sediment at a reputable laboratory.

Further information needs / uncertainties

During the first permit term of the MRP, permitees will implement five pilot studies to evaluate desilting in relation to PCBs and Hg. Knowledge and experience gained should provide a basis for enhanced sediment removal and management practices in subsequent permit terms. Due to challenges with data return below detection limit, laboratories with experience in sediment analysis at low levels should be selected. There is presently no fact sheet for describing the process of recording volume, estimating mass, sub-sampling for chemical analysis, and interpreting results. However, there is local experience to draw upon (e.g. Salop, 2004).

Existing fact sheets

Normal municipal maintenance practices are applicable (see CASQA, 2003 BMP SC-74).

CASQA, 2003. Stormwater Best Management Practice Handbook: Municipal. California Stormwater Quality Association. SC74 Drainage system maintenance.

www.cabmphandbooks.com

Interested in further reading?

Mangarella, P., Havens, K., Lewis, W., and McKee, L.J., 2010. Task 3.5.1: Desktop Evaluation of Controls for Polychlorinated Biphenyls and Mercury Load Reduction. A Technical Report of the Regional Watershed Program. San Francisco Estuary Institute, Oakland, CA. 41pp.

McKee, L. Mangarella, P., Williamson, B., Hayworth, J., and Austin, L., 2006. Review of Methods to Reduce Urban Stormwater Loads: Task 3.4. A Technical Report of the Regional Watershed Program: SFEI Contribution #429. San Francisco Estuary Institute, Oakland, CA.

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

SFRWQCB, 2009. California Regional Water Quality Control Board San Francisco Bay Region Municipal Regional Stormwater NPDES Permit, Order R2-2009-0074, NPDES Permit No. CAS612008. Adopted October 14, 2009. 279pp.
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Yee, D., McKee, L.J., 2010. Task 3.5: Concentrations of PCBs and Hg 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.

Source control and soil remediation

Description

Soil remediation and source control for PCBs and Hg is another example of an institutional control when it is related to an enforcement action, but it can also be carried out as a volunteer effort, or during redevelopment. It refers to remediation of soil pollution in areas where past practices have resulted in elevated concentrations in soils. This control option also includes the identification and elimination of storage or use of PCBs or Hg on both public and private lands. During all weather conditions but particularly during wet weather, some of this contamination can be gradually mobilized and transported into the storm drain system and ultimately to the Bay if it is not cleaned up to environmental standards.

Location and applicability

Given the majority of remaining PCBs known to be still in use are on private lands, this management option appears more suited to PCBs. Appendix D of this BMP tool box contains a list of known PCB users in the Bay Area compiled by the EPA, 2010. During the development of a white paper, McKee and others (2006) queried regulatory databases and built a list of known PCB and Hg spill sites in the Bay Area. In addition, work completed or collated by SFEI provides a list of pollutant concentrations at individual sites in industrial areas; all these lists together might be a starting point for further effort and investigations (Yee and McKee, 2010; see Appendix F and G for details). If combined, these lists might be a starting point for further effort and investigations. These kinds of sites tend to occur on lots where large amounts of PCBs were used for manufacture of products such as transformers or large capacitors, where these types of applications are still in use, or where recycling or repackaging left legacy PCB and Hg contamination. There is evidence of some hotspots associated with Hg, however, these rarely overlap with PCB contaminated sites. Provisions C.11.c. and C.12.c of the Municipal Regional Stormwater NPDES Permit, Order R2-2009-0074, NPDES Permit (MRP) call for pilot projects to investigate and abate PCB and Hg sources. The design focus specified by the Water Board is on PCBs with the primary focus on reducing loads of PCBs to stormwater; reducing loads of mercury is a secondary concern.

I-7 Institutional Control

Applicable sources / pathways

True Sources

Mining	√
Factories	√
Atmospheric	

Source Areas

Old industrial	√
Products still in use	√
Illegal disposal	√
Recycling facilities	
Road deposits	
Home and work place	
Building demolition and remodeling	√

Transport pathways

Runoff from impervious surfaces	
Vehicle tracking	
Foot tracking	
Wind	

Examples

- Superfund sites
- Brown fields
- Abandoned factories where products were synthesized or commercially produced
- Abandoned areas where recycling, repackaging or disposal occurred

Implementation points

Dispersed	√
On the street	
Start of pipe	
Within pipe	
End of pipe	

Design considerations
In a related manner, provision C.12.a of the MRP calls for the development of training materials to train municipal industrial building inspectors to identify, in the course of their existing inspections, PCBs or PCB-containing equipment. Appendix A and B of this BMP toolbox contains tables of the common PCB Aroclors used in the US and the most common trade names as a starting point. Given that some of the sources to soils in public right-of-ways and stormwater systems will be associated with superfund sites, brown fields, privately owned and managed or abandoned industrial lots, and other potentially responsible parties, there are clear opportunities and needs for permitees to partner with state and federal agencies (For example the EPA, DTSC, Water Board, or BAAQMD).

Further information needs / uncertainties
The persistent presence of PCBs at the Ettie Street pump station led to a successful effort to find sources in the watershed and a pilot scale removal project. The pilot abatement project included inspection and removal of PCB wastes from private lots and removal of contaminated soils from road sides on Helen and Hannah streets. As reported by Kleinfelder, a total of 20 tons of sediment were removed from these areas amounting to an estimated mass of PCBs of 8.5 g based on estimates of soil density and laboratory PCB data. The total cost was reported to be $100,000 for removal and disposal or about $12,000 per gram of PCBs. This may seem like a lot of money, however, without comparative cost evaluations of other BMPs and without considering multiple benefits for other contaminants, it is presently not easy to determine just how cost effective this effort was. In addition, based on this one example, it is very hard to determine under what circumstances the methods followed during the Oakland experience may or may not be applicable to other Bay Area locations. Information (including documentation of costs of mass of PCBs and Hg and other contaminants removed or abated) gained by permittees during the first and subsequent permit terms of the MRP will likely provide improved data for assessing the most cost effective soil remediation and source control measures.

Existing fact sheets
There are no existing fact sheets for describing methods, costs, and lessons learned on clean-up and abatement for PCBs and Hg in the Bay Area. The best available resources are the City of Oakland, Kleinfelder, and AMS who lead the Ettie street effort.

Interested in further reading?

Kleinfelder, Inc. 2005. Sediment sampling report Ettie Street pump station watershed, Oakland, California. City of Oakland PWA – ESD. July 2005. pp.1-31.

Kleinfelder, Inc. 2006. Final project report Ettie Street pump station watershed, Oakland, California. City of Oakland PWA – ESD. July 2005. pp.1-31.

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USEPA, 2010. PCB self-reporting data base: http://www.epa.gov/epawaste/hazard/tsd/pcbs/pubs/data.htm

Yee, D., McKee, L.J., 2010. Task 3.5: Concentrations of PCBs and Hg 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.

SECTION 5B:
TREATMENT CONTROLS

T-1	Those that incorporate sediment settling as a primary treatment mode (and in some cases biological uptake) • Wet pond • Constructed wetland • Extended detention basin • Wet vault (proprietary) • Vortex separator (proprietary)
T-2	Those that capture and reuse stormwater • Retention/irrigation • Freshwater wetland restoration • Flow diversion to wastewater treatment

Primary treatment mode – sediment settling

Description
Treatment controls may be implemented by both counties and municipalities, or on private lots during new- and redevelopment. Treatment controls are engineered devices or environments that can be installed or built in place to enhance the capture of an undesirable constituent such as sediment, PCBs, or Hg. These devices have a variety of modes of operation. One of those modes is settling, although it often occurs in conjunction with biological elements such as grasses or reeds that can provide bio-remedial benefits. Familiar examples include wet ponds, constructed wetlands, extended detention basins, wet vaults, and hydrodynamic separators. Settling based treatment controls can be installed at the start of pipe and capture PCBs and Hg before they enter the stormwater conveyance system, within the pipe (e.g. wet vaults, and hydrodynamic separators), or at the end of the pipe or channel close to the Bay margin in the case of a settling basin. Treatment controls usually require regular inspection and maintenance that may include repair, removal of accumulated sediments, and trash that over time reduce performance. Regular removal of sediment ensures that captured PCBs and Hg are disposed of and unable to remobilize during winter rain storms and reach the Bay.

Location and applicability
Given the limited space available in built out areas, on the face of it, there may be limited opportunity to find areas for large treatment controls within existing commercial and residential neighborhoods. The main opportunities appear to be in areas undergoing redevelopment. Given that most PCBs and Hg sources are thought to occur in areas that are or were formerly industrial, as these areas are redeveloped, treatment BMPs can be worked into new urban landscape designs. These include older industrial areas where PCBs and Hg were processed or spilled over many years during their peak use period of 1955-1970 (PCBs) and 1955-1990 (Hg), and near recycling centers or waste management depots where there are higher concentrations associated with ongoing activities. There may also be an opportunity to reach out to private businesses in older industrial areas to encourage better house keeping of sedimentation basins and other treatment control devices

T-1 Treatment Control

Applicable sources / pathways

True Sources

Mining	
Factories	
Atmospheric	√

Source Areas

Old industrial	√
Products still in use	√
Illegal disposal	
Recycling facilities	√
Road deposits	√
Home and work place	
Building demolition and remodeling	

Transport pathways

Runoff from impervious surfaces	√
Vehicle tracking	√
Foot tracking	√
Wind	√

Examples

- Wet pond
- Constructed wetland
- Extended detention basin
- Wet vault (proprietary)
- Vortex separator (proprietary)

Implementation points

Dispersed	√
On the street	
Start of pipe	√
Within pipe	√
End of pipe	√

within property boundaries. Work completed or collated by SFEI provides a list of individual sites and patches in industrial areas that might be a starting point for further effort and investigations (Yee and McKee, 2010; see Appendix F and G for details). The data show that locations and areas where there are elevated concentrations of PCBs and Hg often do not overlap, although there are some sites with moderate to high concentrations of both. This it to be expected given the unique sources and use history of each substance but adds difficulty and costs to a management program. In addition, locations where PCB are known to be still in use (See Appendix D of this BMP tool box) or areas near known Hg emission sites (Appendix E) may also be places to consider.

Design considerations

The recently adopted Municipal Regional Stormwater NPDES Permit (MRP) provides guidance and design criteria for treatment control in the low impact development (LID) sections. Provision C.3. specifies three options: Volume Hydraulic Design Basis (approximately the 85^{th} percentile 24-hour storm runoff event volume), Flow Hydraulic Design Basis (runoff produced by a rain event equal to at least two times the 85th percentile hourly rainfall intensity for the applicable area, based on historical records of hourly rainfall depths), or Combination Flow and Volume Design Basis.

If treatment of PCB and or Hg is part of the objective of a treatment LID project, the properties of PCBs and Hg in stormwater will also need to be considered. PCBs and Hg both strongly attach to particles both in soils and in flowing stormwater. Based on the water settling and soil partitioning experiments completed recently by SFEI, moderate to high amounts of both Hg and PCB can removed with relatively short settling times; an average of ~20% of Hg and ~50% of the PCBs would settle out in 20 minutes or less (Yee and McKee, 2010; see appendix H of this toolbox for details). Thus, management practices that employ settling will likely remove PCBs and Hg from stormwater. These are very encouraging results and suggest that PCBs are associated with coarser particles than Hg (which is logical given the differences in use history and domination of atmospheric sources in the case of Hg). Therefore, it appears that treatment BMPs will perform better for PCBs than for Hg assuming all other things being equal (local site characteristics, starting concentrations, type II settling, etc). Therefore, design of treatment BMPs that aim to capture both PCBs and Hg should be designed to specifications for Hg. In addition, based on the pilot scale work of SFEI, an average grain density of 1.7 g/cm^3 is a reasonable starting assumption for design of treatment BMPs where the primary mode of operation is settling; site specific characteristics and equipment performance can be verified through analysis of the flows leaving installed controls.

Further information needs / uncertainties

Presently the work of SFEI provided pilot level data on settling of PCBs and Hg in urban stormwater from just two locations in industrial land use settings. While the data appear to be consistent from the two locations, it would be prudent to increase the size of the data set to include other land uses and a broader array of flow conditions. In addition, there are even less data in grain density, an important factor for developing improved sizing criteria for maximizing treatment potential of treatment BMPs while minimizing the cost of construction.

Existing fact sheets
Normal municipal treatment control design and maintenance practices are applicable (see CASQA, 2003: TC-20, TC-21, TC-22).

CASQA, 2003. Stormwater Best Management Practice Handbook: Municipal. California Stormwater Quality Association. SC74 Drainage system maintenance. www.cabmphandbooks.com

Interested in further reading?

Mangarella, P., Havens, K., Lewis, W., and McKee, L.J., 2010. Task 3.5.1: Desktop Evaluation of Controls for Polychlorinated Biphenyls and Mercury Load Reduction. A Technical Report of the Regional Watershed Program. San Francisco Estuary Institute, Oakland, CA. 41pp.

McKee, L. Mangarella, P., Williamson, B., Hayworth, J., and Austin, L., 2006. Review of Methods to Reduce Urban Stormwater Loads: Task 3.4. A Technical Report of the Regional Watershed Program: SFEI Contribution #429. San Francisco Estuary Institute, Oakland, CA.

SFRWQCB, 2009. California Regional Water Quality Control Board San Francisco Bay Region Municipal Regional Stormwater NPDES Permit, Order R2-2009-0074, NPDES Permit No. CAS612008. Adopted October 14, 2009. 279pp. http://www.waterboards.ca.gov/sanfranciscobay/board_decisions/adopted_orders/2009/R2-2009-0074.pdf

Yee, D., McKee, L.J., 2010. Task 3.5: Concentrations of PCBs and Hg 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.

Primary treatment mode – capture and reuse

Description

California enjoys an arid climate with warm, dry summers and cool, wet winters where most usable rainfall and water storage occurs over a few brief winter storms (October – April). Due to growing concerns about climate change and water shortage during droughts, there is a movement towards treating stormwater as a valuable resource rather than a nuisance to be conveyed away from urban infrastructure. In addition to providing water security and environmental flows, capturing and reusing stormwater offers the opportunity to remove PCBs and Hg. Since atmospheric deposition is estimated to be the largest source of Hg to stormwater at the regional scale, there is a clear direct connection between water capture and loads reduced. Since both PCBs and Hg do not occur at concentrations in stormwater that are toxic, reuse may even be possible in industrial land use types as long as the primary reuse does not increase the possibility of bio-accumulation in the food web. There are three main capture and reuse BMPs: landscape irrigation, freshwater wetland restoration, and diversion to wastewater treatment. It is this latter category that has received a lot of attention in the recently adopted Municipal Regional Stormwater NPDES Permit (MRP).

Much of the land immediately surrounding San Francisco Bay, often referred to as the 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 and are often also in close proximity to wastewater treatment facilities. While there are other reasons, it is primarily this proximal relationship between industrial land uses, pump stations, and wastewater treatment facilities that make this option feasible and attractive.

Location and applicability

In the case of Hg, given the small magnitude of atmospheric sources, landscape irrigation could be implemented anywhere in the urban landscape where there are large impervious areas such as warehouse roofs, school buildings, parking lots, or any other area that has a large footprint. There may be, for example, opportunities to partner with schools or local

T-2 Treatment Control

Applicable sources / pathways

True Sources

- Mining
- Factories
- Atmospheric √

Source Areas

- Old industrial √
- Products still in use √
- Illegal disposal
- Recycling facilities √
- Road deposits √
- Home and work place
- Building demolition and remodeling

Transport pathways

- Runoff from impervious surfaces √
- Vehicle tracking √
- Foot tracking √
- Wind √

Examples

- Landscaping irrigation
- Freshwater wetland restoration
- Diversion to waste-water treatment

Implementation points

- Dispersed √
- On the street
- Start of pipe √
- Within pipe
- End of pipe √

businesses to capture water for reuse on baseball parks, golf courses, or cemeteries or any other area that requires green grass or flowering gardens year-round.

In the case of PCBs, primary locations of reuse and/or treatment are mainly located near the tidal marsh areas of the Bay margin, the exception being San Jose. Appendix D of this BMP tool box contains a list of known PCB users in the Bay Area compiled by the EPA, 2010. During the development of a white paper, McKee and others (2006) queried regulatory databases and built a list of known PCB and Hg spill sites in the Bay Area. In addition, work completed or collated more recently by SFEI provides a list of individual sites and patches in industrial areas with high PCB and Hg concentrations (Yee and McKee, 2010; see Appendix F and G for details). A combination of all these lists together might be a starting point for investigations on the feasibility of capture, reuse and/ or treatment.

Design considerations

There are a variety of design challenges associated with any of the capture and reuse BMP options. One challenge of landscape irrigation (no matter the scale) is in finding adjacent areas for capture, storage and reuse elements. In addition, there are concerns about mosquito management. There are similar concerns for reuse of stormwater in freshwater wetlands, with an added concern of the possibility of bioaccumulation in wildlife. The MRP provides guidance and design criteria for treatment control in its low impact development (LID) sections. Provision C.3. specifies three options: Volume Hydraulic Design Basis (approximately the 85^{th} percentile 24-hour storm runoff event volume), Flow Hydraulic Design Basis (runoff produced by a rain event equal to at least two times the 85th percentile hourly rainfall intensity for the applicable area, based on historical records of hourly rainfall depths), or Combination Flow and Volume Design Basis.

In the case of diversion to wastewater treatment for the benefit of reducing PCB and Hg loads, there are many components to the feasibility analysis. These include available treatment capacity and proximity to pump stations, industrial land use, and estimates of loads that could be treated. SFEI has developed a GIS dataset of over 250 pump stations in the Bay Area. These, along with land use maps and evaluations of available capacity during dry weather flow and first flush flow, could be combined with knowledge about soil contamination in older industrial areas, to make initial assessments. Part of the feasibility assessment of stormwater diversion to wastewater treatment could also include the possibility of water reuse. For example, treated wastewater could be routed to a freshwater wetland on the Bay margin or diverted again for use in an industrial application such as cooling water.

Further information needs / uncertainties

At present there is little information in the Bay Area at a regional scale on the amount of water passed through pump stations. SFEI has collected about 25 datasets out of the 250 pump stations in the database. In addition, there is a lack of available knowledge of additional (if any) treatment capacity in wastewater treatment facilities. Presently there are two projects under way in the Bay Area to carryout feasibility assessment of pump station diversion and treatment; an East Bay Municipal Utility District / Alameda County collaboration; and a West County Waste Water District / Contra Costa County collaboration. In addition, provision C.11.f. and C.12.f. of the MRP calls for permittees to implement five pilot projects to divert dry weather and first flush flows to wastewater treatment plants to address these flows as a source of PCBs and Hg to receiving waters. These studies will likely provide valuable additional information on the challenges and costs of implementing these kinds of BMPs.

Existing fact sheets

Normal municipal treatment control design and maintenance practices for design and maintenance of retention / irrigation and constructed wetlands are applicable (see CASQA, 2003: TC-12, TC-21). Presently there are no fact sheets available to guide stormwater diversion to wastewater.

CASQA, 2003. Stormwater Best Management Practice Handbook: Municipal. California Stormwater Quality Association. www.cabmphandbooks.com

Interested in further reading?

Mangarella, P., Havens, K., Lewis, W., and McKee, L.J., 2010. Task 3.5.1: Desktop Evaluation of Controls for Polychlorinated Biphenyls and Mercury Load Reduction. A Technical Report of the Regional Watershed Program. San Francisco Estuary Institute, Oakland, CA. 41pp.

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Yee, D., McKee, L.J., 2010. Task 3.5: Concentrations of PCBs and Hg 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.

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DTSC 2007a: How to manage mercury switches in vehicles. California Department of Toxic Substances Control, Sacramento, CA. http://www.dtsc.ca.gov/HazardousWaste/Mercury/upload/HWMP_FS_Merc-Vehicles.pdf

DTSC 2007b: Rechargeable battery recycling act. California Department of Toxic Substances Control, Sacramento, CA. http://www.dtsc.ca.gov/HazardousWaste/upload/FactSheet_AB1125.pdf

DTSC 2007c: Changes to the appliance recycling program. California Department of Toxic Substances Control, Sacramento, CA. http://www.dtsc.ca.gov/HazardousWaste/Mercury/upload/CARfactsheet.pdf

DTSC 2009: Mercury thermostat collection act of 2008. California Department of Toxic Substances Control, Sacramento, CA. http://www.dtsc.ca.gov/HazardousWaste/upload/Mercury-Thermostat-Fact-Sheet-June-2009-2.pdf

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Rothenberg, S.E., McKee, L.J., Gilbreath, A., Yee, D., and Conner, M., and Fu, X., 2010b. Evidence for short range transport of atmospheric mercury to a rural, inland site. Atmospheric Environment 44, 1263-1273.

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APPENDIX A: PCB AROCLORS

Reference USEPA PCB website:
http://www.epa.gov/epawaste/hazard/tsd/pcbs/pubs/aroclortable.pdf

CASRN	IUPAC Name	Type
12674-11-2	Aroclor 1016	Mixture
147601-87-4	Aroclor 1210	Mixture
151820-27-8	Aroclor 1216	Mixture
11104-28-2	Aroclor 1221	Mixture
37234-40-5	Aroclor 1231	Mixture
11141-16-5	Aroclor 1232	Mixture
71328-89-7	Aroclor 1240	Mixture
53469-21-9	Aroclor 1242	Mixture
12672-29-6	Aroclor 1248	Mixture
165245-51-2	Aroclor 1250	Mixture
89577-78-6	Aroclor 1252	Mixture
11097-69-1	Aroclor 1254	Mixture
11096-82-5	Aroclor 1260	Mixture
37324-23-5	Aroclor 1262	Mixture
11100-14-4	Aroclor 1268	Mixture
12767-79-2	Aroclor (unspecified)	Mixture

CASRN
Chemical Abstracts Service (CAS) Registry Number.
IUPAC Name
The names presented in the table are the IUPAC names.
Type
The type of the PCB entity: Congener, Homolog, Mixture, Category.

APPENDIX B: PCB TRADE NAMES

Reference USEPA PCB website:
http://www.epa.gov/epawaste/hazard/tsd/pcbs/pubs/aroclor.htm#aroclor

Shaded names are those that were most commonly used in the United States. [1]Aroclor - used by Monsanto Company; [2]Chlorextol - Allis-Chalmers trade name; [3]Inerteen - used by Westinghouse; [4]Pyranol/Pyrenol - used by General Electric

Aceclor	Clophen	Hyvol	Polychlorinated diphenyls
Adkarel	Clophenharz	Inclor	Polychlorobiphenyl
ALC	Cloresil	Inerteen[3]	Polychlorodiphenyl
Apirolio	Clorinal	Inertenn	Prodelec
Apirorlio	Clorphen	Kanechlor	Pydraul
Arochlor[1]	Decachlorodiphenyl	Kaneclor	Pyraclor
Arochlors[1]	Delor	Kennechlor	Pyralene
Aroclor[1]	Delorene	Kenneclor	Pyranol[4]
Aroclors[1]	Diaclor	Leromoll	Pyroclor
Arubren	Dicolor	Magvar	Pyronol[4]
Asbestol	Diconal	MCS 1489	Saf-T-Kuhl
ASK	Diphenyl, chlorinated	Montar	Saf-T-Kohl
Askael	DK	Nepolin	Santosol
Askarel	Duconal	No-Flamol	Santotherm
Auxol	Dykanol	NoFlamol	Santothern
Bakola	Educarel	Non-Flamol	Santovac
Biphenyl, chlorinated	EEC-18	Olex-sf-d	Solvol
Chlophen	Elaol	Orophene	Sorol
Chloretol	Electrophenyl	PCB	Soval
Chlorextol[2]	Elemex	PCB's	Sovol
Chlorinated biphenyl	Elinol	PCBs	Sovtol
Chlorinated diphenyl	Eucarel	Pheaoclor	Terphenychlore
Chlorinol	Fenchlor	Phenochlor	Therminal
Chlorobiphenyl	Fenclor	Phenoclor	Therminol
Chlorodiphenyl	Fenocloro	Plastivar	Turbinol
Chlorphen	Gilotherm	Polychlorinated biphenyl	
Chorextol	Hydol	Polychlorinated biphenyls	
Chorinol	Hyrol	Polychlorinated diphenyl	

APPENDIX C: INACTIVE MINE SITES IN THE BAY AREA

Table C.1. Inactive mines in the Bay Area. See Figure C.1 on the next page for locations. Source: San Francisco Bay Basin Plan: http://www.waterboards.ca.gov/sanfranciscobay/water_issues/programs/basin_plan/docs/basin_plan07.pdf

Number	Mine Name	Associated Material	Number	Mine Name	Associated Material
1	Snowflake	magnesite	25	Hillsdale	mercury
2	Palisade	mercury	26	Silver Creek	mercury
3	Silverado	mercury	27	Winegar	manganese
4	La Joya	mercury	28	Fable Manganese	manganese
5	Hastings	mercury	29	Western	magnesite
6	St. John's	mercury	30,31	Maltby	magnesite
7	Borges	mercury	32	Keller	magnesite
8	H. Corda	mercury	33	Queenbee No. 1	manganese
9	Cycle	mercury	34	Blackhorse	manganese
10	Franciscan	mercury	35	Black Eagle	manganese
11	Chileno Valley	mercury	36	Jones Group	manganese
12	Gambonini	mercury	37	Mexican Deposits	manganese
13	Union Gulch	copper	38	Pine Ridge	manganese
14	Leona Heights	pyrite	39	April	mercury
15	Alma	pyrite	40	Cristobal	mercury
16	Black Diamond	coal	41	San Francisco	mercury
17	Buckhorn	manganese	42	San Pedro Pit	mercury
18	Man Ridge	manganese	43	Enriquita	mercury
19	Section 14	coal	44	San Mateo	mercury
20	Newman	chromite	45	Senator	mercury
21	Livermore Coal	coal	46	Guadalupe Mines	mercury
22	Pendarin	coal	47	Hooker Creek	copper
23	Camp 9	manganese	48	Marine Magnes Div.	magnesium salts
24	Challenge	mercury			

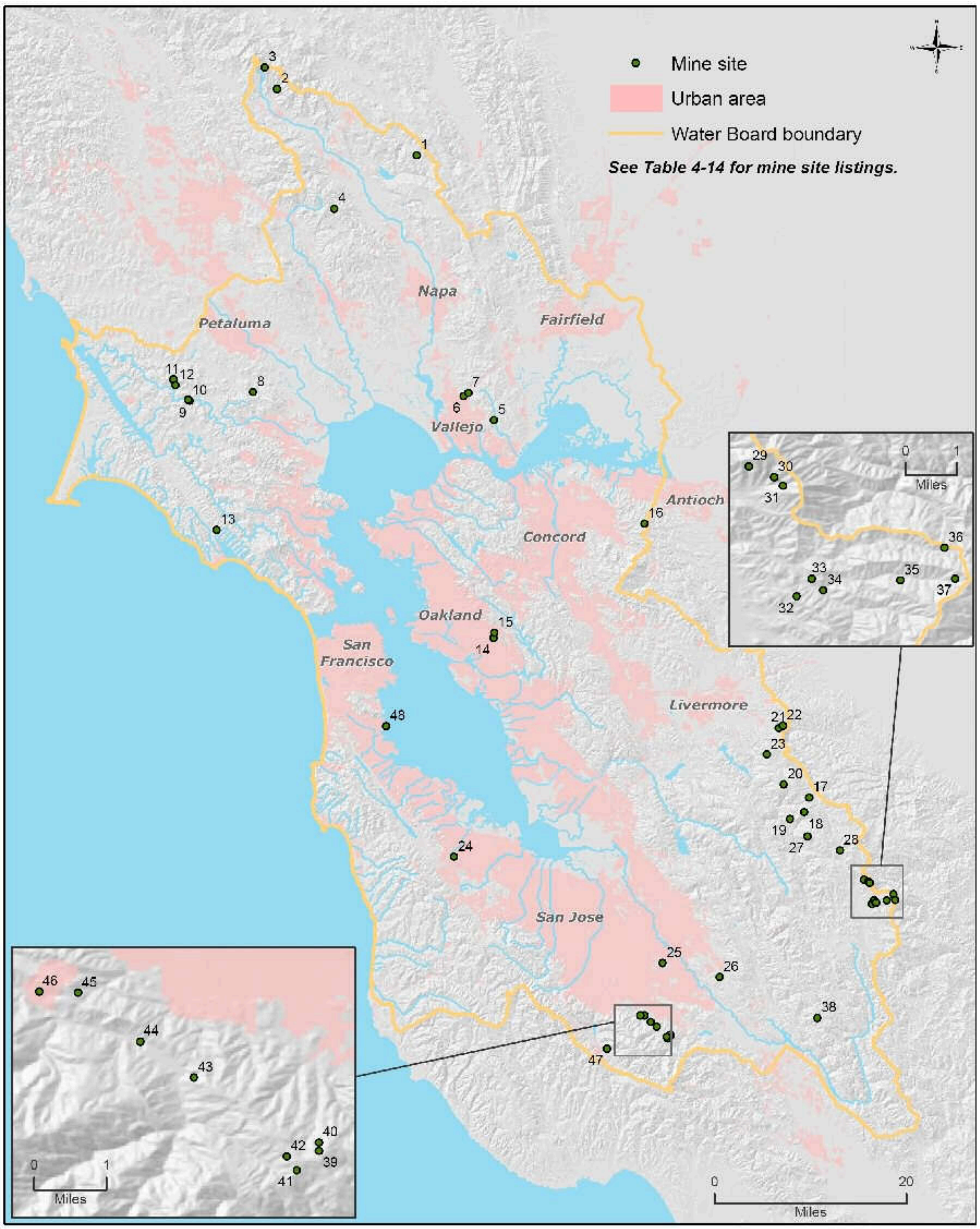


Figure C..1. Map of inactive mines in the Bay Area. See Table C on the previous page for mine names and materials mined at each location. Source: San Francisco Bay Basin Plan: http://www.waterboards.ca.gov/sanfranciscobay/water_issues/programs/basin_plan/docs/basin_plan07.pdf

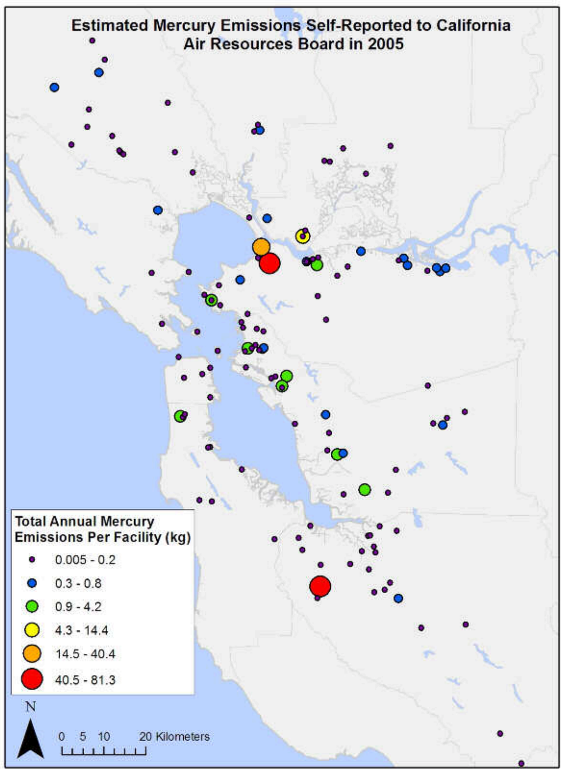
APPENDIX D: SELF REPORTED PCB MASS STILL IN USE IN THE BAY AREA

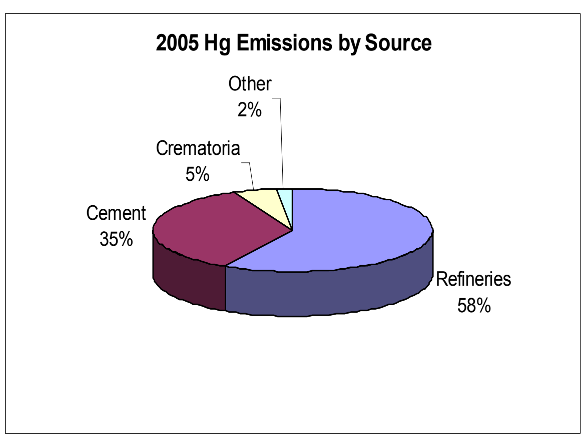
Reference: USEPA PCB self-reporting data base:
http://www.epa.gov/epawaste/hazard/tsd/pcbs/pubs/data.htm

Company	Address	City	Number of transformers	Mass (kg)	Date reported
USS-POSCO Industries	900 Loveridge RD.	Pittsburg	105	203802	13-Sep-05
Quebecor Printing San Jose, Inc.	696 East Trimble Road	San Jose	5	32094	19-Nov-98
NASA	Ames Research Center	Moffett Field	17	7052	23-Dec-98
Gaylord Container Corp	2301 Wilbur Ave.	Antioch	2	6078	07-Dec-98
General Chemical	510 Nichols Road	Pittsburg	3	4800	23-Dec-98
Rhodia Inc.	100 Mococo Road	Martinez	3	2807	28-Aug-00
NASA Ames Research Center	M/S 218-1; Building N229, Room 156	Moffett Field	2	1916	04-Oct-05
Pacific Custom Materials, Inc.	9000 Carquinez Scenic Dr.	Port Costa	2	1590	10-Apr-01
DOT Maritime Administration Suisun Bay Reser	2595 Lake Herman Rd.	Benicia	3	1048	14-Jan-99
Hollywood Park Land Company, LLC	4 Embarcadero Center, Suite 3300; Grandstand Building at Tunnel #4 Inside C-Vault Electrical Room	San Francisco	1	927	24-Jul-06
Hollywood Park Land Company, LLC	1200 Park Place, Suite 200; Grandstand Building at Tunnel #4 Inside C-Vault Electrical Room	San Mateo	1	927	23-Sep-05
Macaulay Foundry, Inc.	811 Carleton St.	Berkley	1	913	02-Dec-98
Naval Weapons Station Seal Beach Detachment Concord	10 Delta Street; R-2 Building	Concord	1	610	20-May-99
National Semiconductor Corporation	2900 Semiconductor Dr.; North side of Building A	Santa Clara	2	275	16-Aug-01
Stanford Linear Accelerator Center	2575 Sand Hill Rd	Menlo Park	1	1	16-Dec-98
Department of the Navy, Naval Facilities Eng	950 West Mall Square, Suite 200; Building 377, 2671 Monarch Street; Transformers	Alameda	1	unknown	07-Dec-99
Department of the Navy, Naval Facilities Eng	950 West Mall Square, Suite 200; Building 552, 1990 Skyhawk Street; Oil Filled Switches	Alameda	2	unknown	07-Dec-99
Department of the Navy, Naval Facilities Eng	950 West Mall Square, Suite 200; Building 552, 1990 Skyhawk Street; Transformers	Alameda	4	unknown	07-Dec-99
Naval Weapons Station Seal Beach Detachment Concord	10 Delta Street; R-3 Building	Concord	0	unknown	09-Aug-99
Rhodia Inc.	100 Mococo Road	Martinez	0	unknown	07-Dec-06
		Total =	>156	>264,840	

APPENDIX E: A MAP OF HG AIR EMMISION POINT SOURCES IN THE BAY AREA

Reference: a) 2005 estimated Hg emissions by location; b) breakdown of 2005 Hg emissions by industry. Hanson's is the only cement manufacturing plant in the Bay Area air district, contributing 35% of estimated Hg emissions. Data from: www.arb.ca.gov/app/emsinv/facinfo/facinfo.php.





APPENDIX F: SAMPLE SITES IN THE BAY AREA WITH TOP 10TH PERCENTILE CONCENTRATIONS OF HG, PCBS, OR BOTH BASED ON ALL DATA COLLECTED TO-DATE IN SOILS AND SEDIMENTS.

Reference: Yee, D., McKee, L.J., 2010. Task 3.5: Concentrations of PCBs and Hg 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. (See Yee and McKee, 2010 for a full list of references listed in this table).

Site Name	TOP 10%	Latitude	Longitude	Reference	PCB (mg/kg)	Hg (mg/kg)
HWD08	Hg	37.64664	-122.13564	Yee and McKee, 2010	<MDL	12.54
SJO46	Hg	37.30898	-121.85463	Yee and McKee, 2010	<MDL	6.23
SanLeandroCk	Hg	37.72700	-122.15700	Salop et al., 2002b	0.47	4.29
SCV012	Hg	37.32011	-121.88906	KLI & EOA, 2002	0.12	4.26
HWD04	Hg	37.65281	-122.13822	Yee and McKee, 2010	<MDL	3.31
SJO01	Hg	37.37516	-121.95028	Yee and McKee, 2010	<MDL	3.26
SCV034	Hg	37.36203	-121.90100	KLI & EOA, 2002	0.14	3.04
Decoto-BART	Hg	37.58900	-122.01600	Salop et al., 2002b	0.12	2.70
SJO35	Hg	37.31236	-121.87038	Yee and McKee, 2010	<MDL	2.15
CerritoCk	Hg	37.89800	-122.30600	Salop et al., 2002b	0.30	1.99
CordonicesCk	Hg	37.88300	-122.30000	Salop et al., 2002b	0.05	1.92
SMC025 (FR)	Hg	37.70665	-122.39812	KLI & EOA, 2002	0.24	1.91
SCV031	Hg	37.31387	-121.86013	KLI & EOA, 2002	0.05	1.90
VFC005	Hg	38.09460	-122.24187	KLI & EOA, 2002	0.06	1.86
SMC025	Hg	37.70665	-122.39812	KLI & EOA, 2002	0.14	1.73
EP1 (24th and Wood)	Hg	37.82025	-122.29226	Salop et al., 2002a	0.23	1.58
HWD21	Hg	37.63323	-122.12354	Yee and McKee, 2010	<MDL	1.35
SSO03	Hg	37.65189	-122.39436	Yee and McKee, 2010	<MDL	1.24
GE-1	Hg	37.82500	-122.25154	Salop et al., 2002a	0.31	1.20
SCV006	Hg	37.37017	-121.94653	KLI & EOA, 2002	0.06	1.18
RMD31	Hg	37.91958	-122.36020	Yee and McKee, 2010	0.33	1.05
EP1 (26th and Poplar)	Hg	37.81943	-122.28596	Salop et al., 2002a	0.70	1.02
SJO34	Hg	37.30618	-121.87856	Yee and McKee, 2010	<MDL	1.01
PIT3	Hg	38.03021	-121.86983	Yee and McKee, 2010		0.98
SLO06	Hg	37.72287	-122.19298	Yee and McKee, 2010	<MDL	0.96
EP2-8	Hg	37.82129	-122.27845	Salop et al., 2002a	0.26	0.95
EttieStPS	Hg	37.82600	-122.28900	Salop et al., 2002b	0.76	0.94
VLJ9	Hg	38.09927	-122.27029	Yee and McKee, 2010	0.78	0.94
PORT10	Hg	37.80893	-122.31233	Yee and McKee, 2010	0.03	0.90
EP1 (32nd and Hannah)	Hg	37.82347	-122.28683	Salop et al., 2002a	0.98	0.88
RMD03	Hg	37.95070	-122.36341	Yee and McKee, 2010	<MDL	0.86
UCC3	Hg	38.04856	-122.24789	Yee and McKee, 2010	<MDL	0.86
OAK6	Hg	37.73723	-122.17966	Yee and McKee, 2010	0.54	0.85

Appendix F continued.

Site Name	TOP 10%	Latitude	Longitude	Reference	PCB (mg/kg)	Hg (mg/kg)
SCV028	Hg	37.34572	-121.92558	KLI & EOA, 2002	0.17	0.80
SausalCk	Hg	37.79100	-122.22200	Salop et al., 2002b	0.04	0.78
RMD24	Hg	37.92517	-122.37341	Yee and McKee, 2010	0.82	0.78
SCA36	Hg	37.49967	-122.24462	Yee and McKee, 2010	0.30	0.77
CordonicesCk	Hg	37.88300	-122.30000	Salop et al., 2002b	0.03	0.76
SJO14	Hg	37.35945	-121.94474	Yee and McKee, 2010	<MDL	0.76
ABY02	Hg	37.89597	-122.30885	Yee and McKee, 2010	<MDL	0.73
CCC006	Hg	37.94672	-122.36681	KLI & EOA, 2002	0.17	0.72
OAK33	Hg	37.84819	-122.28519	Yee and McKee, 2010	0.78	0.72
SJO53	Hg	37.31554	-121.86649	Yee and McKee, 2010	<MDL	0.72
GE-2	Hg	37.83097	-122.24566	Salop et al., 2002a	0.29	0.70
SCV001	Hg/PCB	37.31033	-121.85278	KLI & EOA, 2002	26.75	1.08
SMC020	Hg/PCB	37.51757	-122.26382	KLI & EOA, 2002	20.29	1.84
SMC024	Hg/PCB	37.67403	-122.45702	EOA. 2004	16.81	1.31
PORT6	Hg/PCB	37.79733	-122.28159	Yee and McKee, 2010	3.36	0.69
Ettie St PS	Hg/PCB	37.82600	-122.28900	Gunther et al, 2001.	3.26	0.80
RMD28	Hg/PCB	37.92400	-122.36206	Yee and McKee, 2010	1.98	1.39
CCC032	Hg/PCB	37.92538	-122.36910	KLI & EOA, 2002	1.95	0.95
RMD29	Hg/PCB	37.92340	-122.36212	Yee and McKee, 2010	1.54	0.71
SLO02	Hg/PCB	37.71563	-122.18961	Yee and McKee, 2010	1.27	1.19
RMD25	Hg/PCB	37.92534	-122.36906	Yee and McKee, 2010	1.24	1.12
SMC021	Hg/PCB	37.49868	-122.24592	KLI & EOA, 2002	1.22	0.92
RMD27	Hg/PCB	37.92121	-122.36476	Yee and McKee, 2010	1.19	0.74
ETT122	PCB	37.82533	-122.29100	Kleinfelder Inc., 2006	93.41	
ETT66	PCB	37.82633	-122.28633	Kleinfelder Inc., 2005	31.33	
ETT56 South	PCB	37.82217	-122.28633	Kleinfelder Inc., 2006	17.73	
ETT84b	PCB	37.82000	-122.28483	Kleinfelder Inc., 2006	14.73	
SMC-047	PCB	37.50010	-122.24380	STOPPP, 2003.	11.52	
ETT58	PCB	37.82283	-122.28650	Kleinfelder Inc., 2005	11.12	
SMC-047 (FR)	PCB	37.50010	-122.24380	STOPPP, 2003.	10.66	
ETT63-64-65	PCB	37.82633	-122.28667	Kleinfelder Inc., 2006	10.62	
SCV046	PCB	37.31115	-121.86393	San Jose & EOA. 2003	9.20	
ETT84	PCB	37.82017	-122.28733	Kleinfelder Inc., 2006	8.21	
PORT5	PCB	37.79724	-122.28143	Yee and McKee, 2010	7.65	0.03
ETT64-65	PCB	37.82633	-122.28667	Kleinfelder Inc., 2005	7.35	
SMC-023	PCB	37.50483	-122.24915	STOPPP, 2003.	6.19	
ETT38	PCB	37.82217	-122.28183	Kleinfelder Inc., 2006	6.08	
SCV046 (FR)	PCB	37.31115	-121.86393	San Jose & EOA. 2003	5.95	
ETT5	PCB	37.81167	-122.28833	Kleinfelder Inc., 2006	5.70	
SCV059	PCB	37.31032	-121.86520	San Jose & EOA. 2003	5.35	
ETT2	PCB	37.81217	-122.30050	Kleinfelder Inc., 2005	3.81	
ETT85	PCB	37.82067	-122.28567	Kleinfelder Inc., 2005	3.74	
ETT111	PCB	37.82267	-122.28433	Kleinfelder Inc., 2006	3.70	
ETT85	PCB	37.82067	-122.28567	Kleinfelder Inc., 2006	3.63	
Site I	PCB	37.92280	-122.36590	EOA, 2007	2.79	
SMC-040	PCB	37.64435	-122.41720	EOA. 2002	2.72	

Appendix F continued.

Site Name	TOP 10%	Latitude	Longitude	Reference	PCB (mg/kg)	Hg (mg/kg)
ETT8	PCB	37.81433	-122.29250	Kleinfelder Inc., 2005	2.51	
EP2-7	PCB	37.82251	-122.28380	Salop et al., 2002a	2.49	0.58
Site O	PCB	37.92330	-122.36720	EOA, 2007	2.39	
ETT56	PCB	37.82217	-122.28633	Kleinfelder Inc., 2005	2.38	
RMD32	PCB	37.91205	-122.35924	Yee and McKee, 2010	2.26	0.21
SMC023	PCB	37.50483	-122.24915	KLI & EOA, 2002	2.26	0.32
SCA04	PCB	37.49819	-122.24535	Yee and McKee, 2010	2.22	0.24
ETT84b	PCB	37.82000	-122.28483	Kleinfelder Inc., 2005	2.22	
PORT4	PCB	37.79710	-122.28175	Yee and McKee, 2010	2.12	0.04
SCV058	PCB	37.31032	-121.86520	San Jose & EOA. 2003	2.05	
CCC034 (2002)	PCB	37.92528	-122.36827	EOA, 2007	2.05	
ETT56	PCB	37.82217	-122.28633	Kleinfelder Inc., 2005	2.05	
Site N	PCB	37.92310	-122.36220	EOA, 2007	1.99	
ETT8	PCB	37.81433	-122.29250	Kleinfelder Inc., 2006	1.95	
CCC032 - Composite (2001)	PCB	37.92120	-122.36006	EOA, 2007	1.88	
Site M	PCB	37.92400	-122.36340	EOA, 2007	1.84	
SMC-021	PCB	37.49868	-122.24592	STOPPP, 2003.	1.82	
ETT84c	PCB	37.82150	-122.28567	Kleinfelder Inc., 2006	1.78	
ETT50	PCB	37.82540	-122.28865	Kleinfelder Inc., 2006	1.75	
ETT2	PCB	37.81217	-122.30050	Kleinfelder Inc., 2006	1.66	
EP2-6	PCB	37.82272	-122.28472	Salop et al., 2002a	1.59	0.50
ETT63	PCB	37.82600	-122.28650	Kleinfelder Inc., 2005	1.51	
CCC034 (2005)	PCB	37.92528	-122.36827	EOA, 2007	1.40	
SVA08	PCB	37.38101	-122.02473	Yee and McKee, 2010	1.38	0.10
ETT57	PCB	37.82150	-122.28617	Kleinfelder Inc., 2005	1.29	
OAK30	PCB	37.81907	-122.28382	Yee and McKee, 2010	1.29	0.67
OAK24	PCB	37.79231	-122.25330	Yee and McKee, 2010	1.27	0.20
VFC006	PCB	38.11467	-122.25213	KLI & EOA, 2002	1.26	0.17
ETT122	PCB	37.82533	-122.29100	Kleinfelder Inc., 2005	1.22	
SCV033	PCB	37.30902	-121.86680	KLI & EOA, 2002	1.22	0.30
SCV033 (2002)	PCB	37.30902	-121.86680	San Jose & EOA. 2003	1.22	
SFO11	PCB	37.74566	-122.39300	Yee and McKee, 2010	1.16	0.40
CCC031	PCB	37.92123	-122.36107	KLI & EOA, 2002	1.15	0.41
ETT38	PCB	37.82217	-122.28183	Kleinfelder Inc., 2005	1.14	
CCC031 - Composite (2001)	PCB	37.92523	-122.36896	EOA, 2007	1.12	
SCA27	PCB	37.50642	-122.25330	Yee and McKee, 2010	1.09	0.06
SFO12	PCB	37.74386	-122.39320	Yee and McKee, 2010	1.05	0.55

APPENDIX G: PATCH CONCENTRATIONS AND RANKINGS BASED ON ALL DATA COLLECTED IN THE BAY AREA TO-DATE IN SOILS AND SEDIMENTS.

Reference: Yee, D., McKee, L.J., 2010. Task 3.5: Concentrations of PCBs and Hg 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. (See Yee and McKee, 2010 for a full list of references listed in this table).

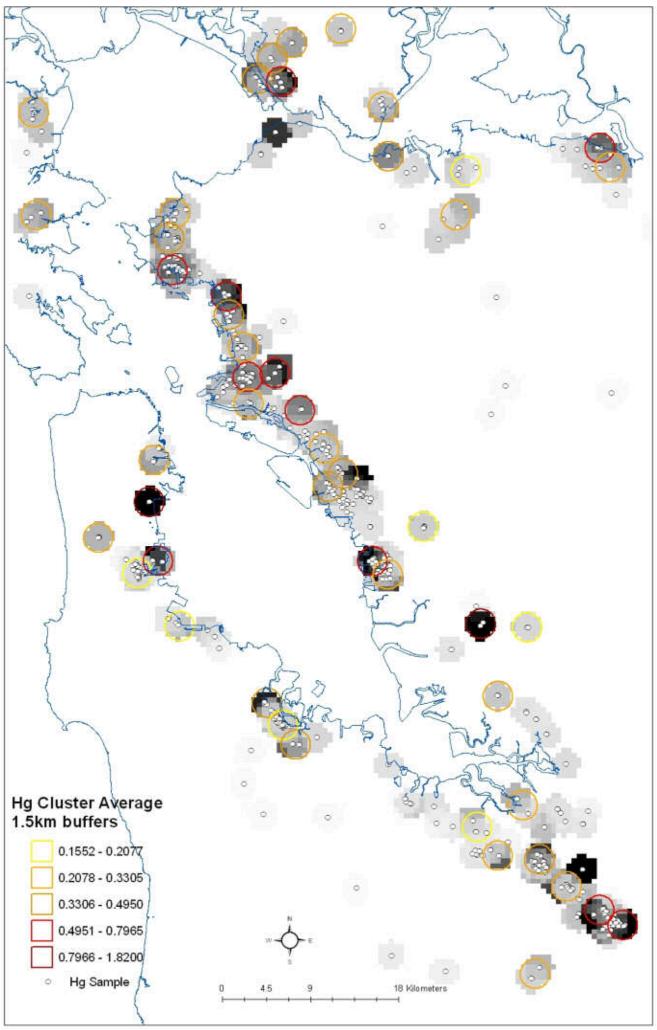


Figure G.1. Map of averaged Hg concentrations in Bay Area soils and sediments (mg/kg).

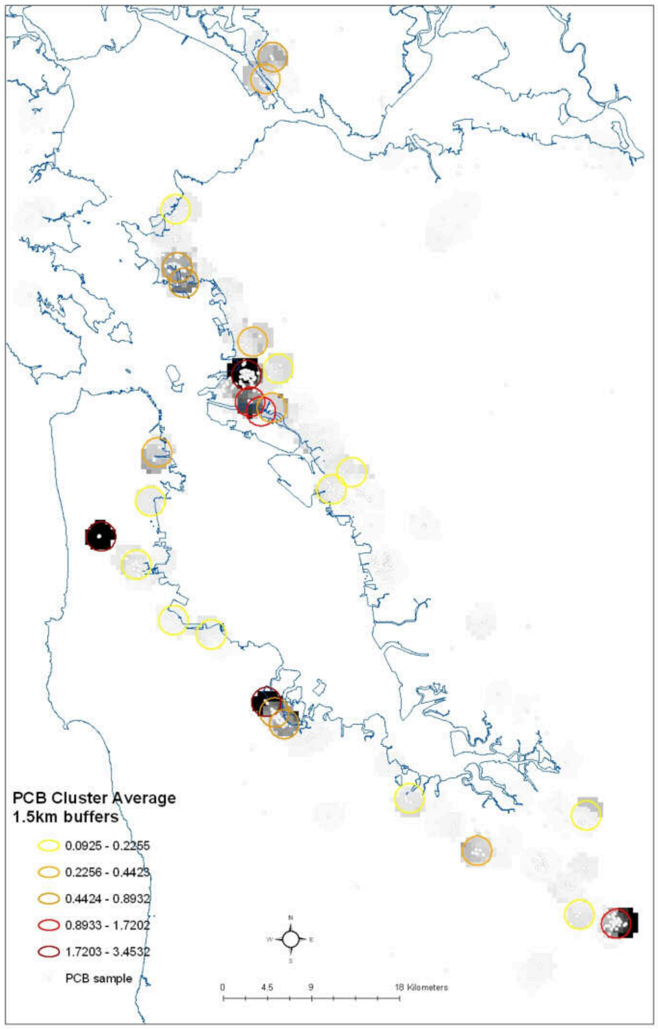


Figure G.2 Map of averaged PCB concentrations in Bay Area soils and sediments (mg/kg).

Table G.1. Patches with highest average Hg concentrations (combined data, this study and others – see Yee and McKee, 2010 and appendix F for references). Patches are 1.5 km radius circular areas over which site results are averaged.

Number of sites in patch	Hg concentration (mg/kg)			Centroid Y	Centroid X	Patch description (centroid x-streets)
	Average	Minimum	Maximum			
2	1.82	1.73	1.91	37.70661	-122.39821	Beatty Ave & Hwy 101 San Francisco
2	1.45	0.20	2.70	37.59104	-122.01551	11th St & Decoto Rd, Union City
2	0.80	0.35	1.24	37.65196	-122.38859	E Grand Ave & Grandview Dr South SF
26	0.78	0.08	12.54	37.65006	-122.14030	Cabot Blvd & W Winton Ave, Hayward
20	0.78	0.09	6.23	37.31025	-121.85541	S 10th St & Burke St, San Jose
6	0.70	0.18	1.99	37.89674	-122.30695	Pierce St & Central Ave, Albany CA
4	0.67	0.15	1.21	37.82512	-122.25132	Glen Ave & Piedmont Ave, Oakland
5	0.62	0.14	1.86	38.09549	-122.24138	Curtola Pkwy & Solano Ave, Vallejo
3	0.56	0.32	0.98	38.03088	-121.87105	E 3rd St & Columbia St, Pittsburg
20	0.56	0.08	1.39	37.92115	-122.36934	S 4th St & Cutting Blvd, Richmond
22	0.56	0.08	1.58	37.82169	-122.28289	Magnolia St & 30th St, Oakland
2	0.54	0.31	0.78	37.79037	-122.22285	26th Ave & E 27th St, Oakland
12	0.54	0.10	4.26	37.32451	-121.88231	S 1st St & Union St, San Jose
2	0.50	0.31	0.68	38.02513	-122.11762	Marina Vista Ave & Shell Ave, Martinez
6	0.46	0.05	1.84	37.51956	-122.26362	Shoreway Rd & Cormorant Dr, Belmont

Table G.2. Patches with highest average PCB concentrations (combined data, this study and others – see Yee and McKee, 2010 and appendix F for references). Patches are 1.5 km radius circular areas over which site results are averaged.

Number of sites in patch	PCB concentration (mg/kg)			Centroid Y	Centroid X	Patch description (centroid x-streets)
	Average	Minimum	Maximum			
6	3.45	0.00	20.29	37.51921	-122.26557	Quarry Rd & Industrial Blvd, San Carlos
5	3.37	0.00	16.81	37.67370	-122.45541	El Camino Real & Collins Ave, Colma
99	2.70	0.00	93.41	37.82235	-122.28555	Helen St & Peralta St, Oakland
9	1.72	0.15	7.65	37.79749	-122.28152	ML King Jr Way & 1st St, Oakland
11	1.49	0.00	7.65	37.78856	-122.26918	Embarcadero Way & Oak St, Oakland
40	1.37	0.00	26.75	37.31046	-121.86425	Leo Ave & S 7th St, San Jose
42	0.89	0.00	20.29	37.50946	-122.25612	Montgomery St & Industrial Rd, San Carlos
49	0.86	0.00	11.52	37.49851	-122.24505	Washington St & Bayport Ave, San Carlos
2	0.80	0.35	1.26	38.11663	-122.25213	Michigan St & Couch St, Vallejo
54	0.74	0.00	2.79	37.92235	-122.36499	S 4th St & Cutting Blvd, Richmond
14	0.65	0.00	2.26	37.90822	-122.35754	S Marina Way & Hall Ave, Richmond
12	0.44	0.03	1.16	37.75115	-122.38986	26th St & Minnesota St, San Francisco
8	0.41	0.00	1.38	37.37960	-122.02375	E California Ave & Morse Ave, Sunnyvale
4	0.36	0.00	1.27	37.79185	-122.25654	E 8th St & 7th Ave, Oakland
10	0.29	0.00	0.92	38.09641	-122.26086	Mare Island Way & Maine St, Vallejo

APPENDIX H: SUMMARY OF HG AND PCB STORMWATER SETTLING REMOVAL EFFICIENCIES BASED ON PILOT SCALE SETTLING EXPERIMENTS.

Reference: Yee, D., McKee, L.J., 2010. Task 3.5: Concentrations of PCBs and Hg 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. (See Yee and McKee, 2010 for a full list of references listed in this table).

The results of the partitioning experiments for stormwater and bed sediment samples highlight some differences in Hg and PCB characteristics that will lead to differences in their environmental mobility and ease of removal. Summaries of settling removal efficiencies, the fractions of Hg and PCBs that are very quickly (<2 minutes at 20 degrees C) and quickly (<20 minutes at 20 degrees C) settled, are shown for stormwater. The data show that PCBs are more easily removed – that is they appear to be associated with slightly coarser factions in flowing stormwater. See Yee and McKee, 2010 for more details.

	Minimum	Maximum	Average
Hg			
<2 min	3%	12%	7%
<20 min	10%	28%	17%
PCB			
<2 min	14%	46%	31%
<20 min	27%	72%	53%