PCBs in Urban Watersheds—A Challenge for TMDL Implementation

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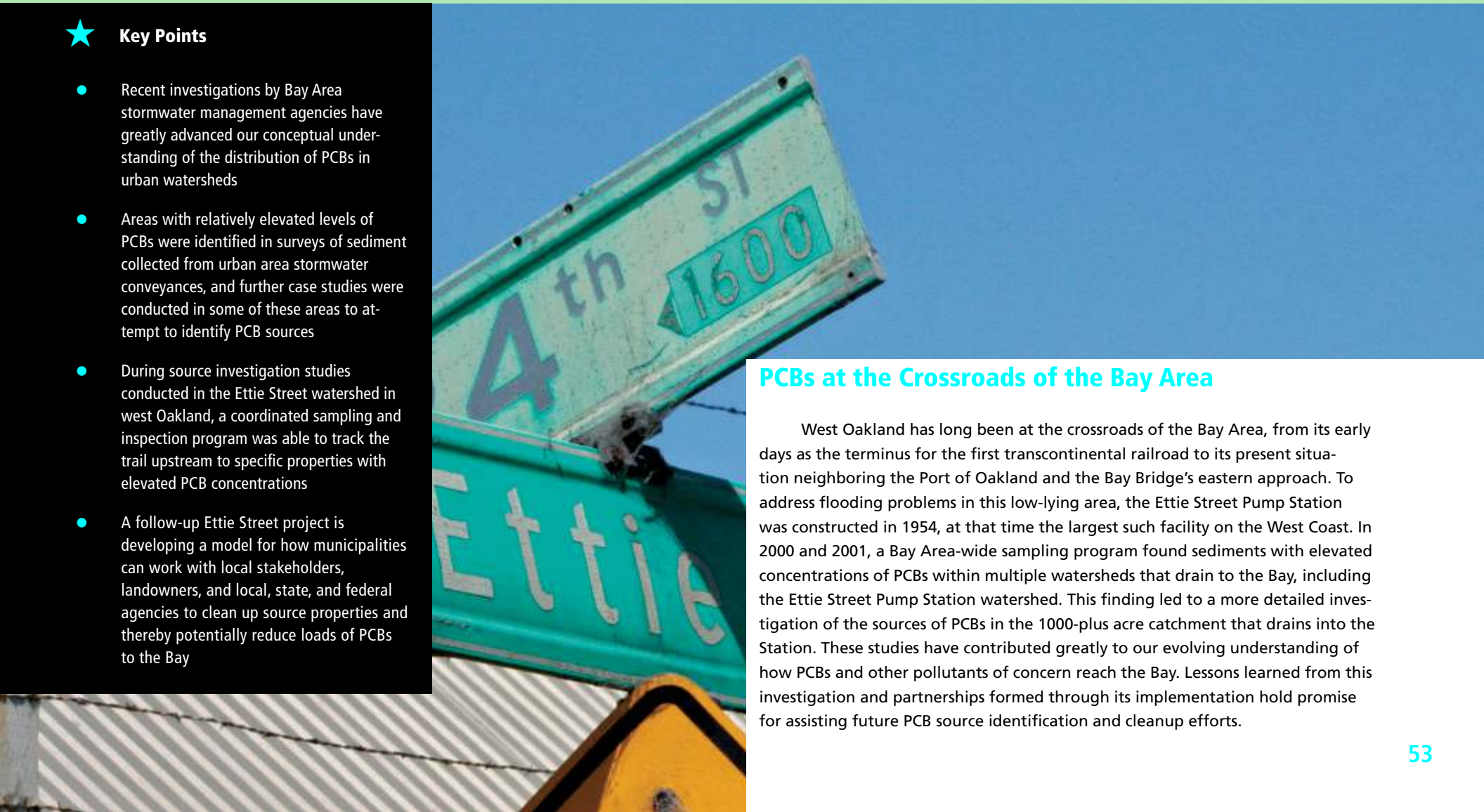
Key Points

- Recent investigations by Bay Area stormwater management agencies have greatly advanced our conceptual understanding of the distribution of PCBs in urban watersheds
- Areas with relatively elevated levels of PCBs were identified in surveys of sediment collected from urban area stormwater conveyances, and further case studies were conducted in some of these areas to attempt to identify PCB sources
- During source investigation studies conducted in the Ettie Street watershed in west Oakland, a coordinated sampling and inspection program was able to track the trail upstream to specific properties with elevated PCB concentrations
- A follow-up Ettie Street project is developing a model for how municipalities can work with local stakeholders, landowners, and local, state, and federal agencies to clean up source properties and thereby potentially reduce loads of PCBs to the Bay



PCBs at the Crossroads of the Bay Area

West Oakland has long been at the crossroads of the Bay Area, from its early days as the terminus for the first transcontinental railroad to its present situation neighboring the Port of Oakland and the Bay Bridge's eastern approach. To address flooding problems in this low-lying area, the Ettie Street Pump Station was constructed in 1954, at that time the largest such facility on the West Coast. In 2000 and 2001, a Bay Area-wide sampling program found sediments with elevated concentrations of PCBs within multiple watersheds that drain to the Bay, including the Ettie Street Pump Station watershed. This finding led to a more detailed investigation of the sources of PCBs in the 1000-plus acre catchment that drains into the Station. These studies have contributed greatly to our evolving understanding of how PCBs and other pollutants of concern reach the Bay. Lessons learned from this investigation and partnerships formed through its implementation hold promise for assisting future PCB source identification and cleanup efforts.

Reducing PCB Loads in Stormwater

The Ettie Street Pump Station.

Relatively elevated concentrations of PCBs remain in our urban watersheds - focusing cleanup efforts on these areas may be one cost-effective approach to reducing PCB loads to the Bay

Bay Area stormwater programs have been working with the San Francisco Bay Regional Water Quality Control Board (Water Board) to improve our understanding of PCB occurrence in local watersheds and develop effective strategies to control ongoing discharges to the Bay. PCB concentrations in the Estuary ecosystem continue to pose risks to human and wildlife health despite the federal ban on the sale and production of PCBs in 1979 (see page 40). Continuing inputs of PCBs to the Bay appear to be an important factor contributing to the persistence of PCBs in the Bay. The Total Maximum Daily Load (TMDL) for PCBs in San Francisco Bay (SFRWQCB 2004) proposes a 38 kg reduction in the annual load of PCBs from urban runoff, or a 95% reduction from the existing estimated annual load of 40 kg. An initial predictive model for PCBs in the Bay (Davis *et al*. 2006) suggests that continuing inputs on the order of 20 kg/yr could delay recovery of the Bay by decades. While future research is expected to resolve some of the uncertainties in this simple model, stormwater programs are working on strategies for addressing the identified TMDL load reduction needs.

Two primary options for implementing stormwater load reductions are *source control*, in which sources of PCBs are identified and cleaned up before they reach conveyances that connect to the Bay, and *treatment control*, in which structures or landscape features remove pollutants from the conveyance pathway before reaching receiving waters. During the past several years, Bay Area stormwater agencies have conducted a series of investigations that have greatly advanced our conceptual understanding of the abundance and distribution of PCBs in our urban watersheds. The results of these investigations suggest that areas with relatively elevated concentrations of PCBs remain, and that focusing cleanup efforts on these areas may be one cost-effective approach to reducing PCB loads to the Bay.

Legacy PCBs in the Landscape

Growing concern about PCBs in the Bay in the late 1990s led to the formation of a RMP work group – the Chlorinated Hydrocarbon Workgroup (SFEI 1999) – to consider how regional monitoring could be used to improve our understanding of sources of PCBs and other chlorinated hydrocarbons. As part of the group's deliberations, two hypotheses were proposed regarding current loadings of PCBs to the Bay: (1) that PCBs discharged from our watersheds originate mainly from diffuse sources such as atmospheric deposition; and (2) an alternative hypothesis that discrete sources of PCBs that are possibly controllable still exist in certain watersheds. If the second hypothesis is true, greater opportunities will exist for cost-effective control of loads as part of the TMDL implementation process.

One way to test these hypotheses is to look at the distribution of PCBs in sediments from stormwater conveyances. If PCB sources are primarily diffuse throughout the region, then the expected outcome would be that sediments from watersheds of varying sizes and land use characteristics would show fairly uniform concentrations. If large variations in concentrations were observed, these findings would be more consistent with the hypothesis that discrete PCB sources remain in certain locations. In 2000 and 2001, stormwater management agencies implemented two related investigations that surveyed PCB concentrations in bottom sediments collected in creeks, flood control channels, and storm drains within a number of Bay Area watersheds:

- The Joint Stormwater Agency Project (JSAP), a collaborative effort of the Contra Costa County, Fairfield-Suisun, Marin County, San Mateo County, Santa Clara County, and Vallejo stormwater management agencies. This study focused on sampling engineered storm drain facilities above tidal influence throughout urbanized watersheds.

- The Alameda Countywide Clean Water Program (ACCWP). This effort sampled bottom sediments above tidal influence at the base of County watersheds, in waterways that drain the majority of Alameda County.

While the majority of Alameda County watersheds appeared to have sediments with relatively low PCB concentrations, several watersheds contained sediments with elevated concentrations (Salop *et al*. 2002a). The JSAP (KLI and EOA 2002) also found that concentrations were highly variable in urban areas, ranging from below limits of detection to 27,000 ng/g (parts per billion) (Figure 1). In a few instances concentrations were detected that were 1,000 – 10,000 times higher than Bay sediment samples measured by the RMP; one of these occurred in the Ettie Street watershed in northwest Oakland. These results supported the hypothesis that certain watersheds potentially contain important ongoing sources of PCBs to the Bay.

But where were the detected PCBs coming from? And if sources could be identified, were they controllable? Stormwater programs used results of these sediment surveys to set priorities for focused case studies investigating potential sources of PCBs. From 2001 to 2003, BASMAA member agencies conducted 17 different source investigation projects in areas where the initial JSAP or ACCWP sediment surveys found elevated concentrations of PCBs (Figure 1 and Sidebar page 56). The most extensive of the investigations performed to date is a series of studies in the Ettie Street Pump Station watershed, a mixed use watershed that is the most industrialized of those sampled by the ACCWP. This watershed was initially targeted for further investigation by the ACCWP because of its elevated concentration of PCBs relative to other Alameda County watersheds sampled. The investigation has expanded to include other partners and follow-up on progress made. The findings from this investigation illustrate some of the lessons and uncertainties of the source control approach.

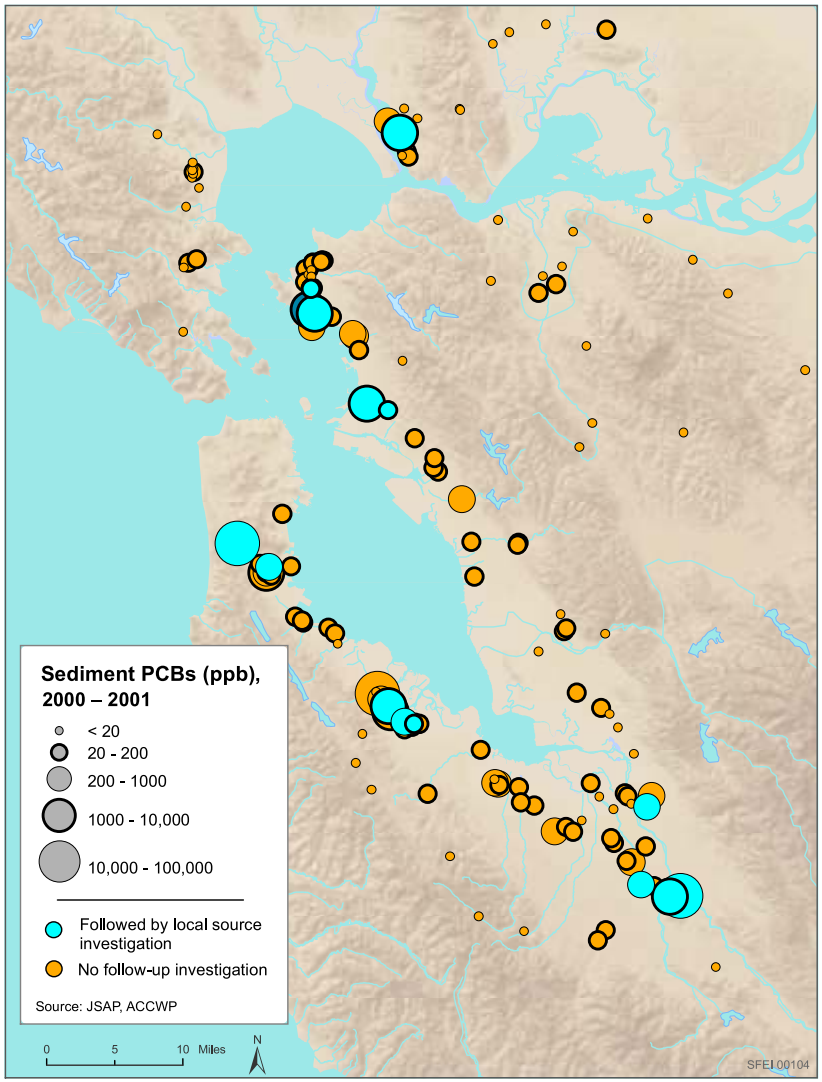


Figure 1. In 2000 and 2001, stormwater management agencies conducted baseline surveys of PCB concentrations in sediments collected in Bay Area creeks, flood control channels, and storm drains. High concentrations observed in some locations supported the hypothesis that certain watersheds potentially contain important ongoing sources of PCBs to the Bay. From 2001 to 2003, source investigations at the contaminated locations provided confirmation and more detailed information on the extent of the contamination.

Identifying Sources of PCBs via Case Studies in Urban Drainages

In addition to the Ettie Street investigations, other less extensive but important studies have been conducted in several Bay Area cities, including San Jose, South San Francisco, Richmond, San Carlos, Redwood City, San Pablo, and Vallejo. These studies developed methods to identify sources of PCBs within contaminated drainages. The studies generally included historical and current land use research, identification of known PCB use or release sites within the study drainage, additional sediment sampling, and analysis of PCB congener patterns. The results of the studies varied widely.

- Some investigations did not repeat the findings of elevated PCB concentrations from the regional surveys. For example, PCB concentrations at the industrial Monterey Highway site in San Jose were 90% lower in the follow-up case study.
- Some investigations confirmed regional survey results of elevated concentrations of PCBs, but were unable to identify suspected PCB sources. For example, investigations within a primarily residential area in the City of Vallejo found concentrations of PCBs in sediments up to 1700 ng/g (ppb), but source properties could not be identified.
- In other cases, the investigations revealed properties that are suspected PCB source areas and potential responsible parties. For example, PCBs were detected at concentrations up to 11,500 ppb in sediments from the Pulgas Creek Pump Station drainage, located in an industrial part of San Carlos. Two potential sources of PCBs were identified: an electrical substation and a soil and groundwater contamination cleanup site.
- Similarly, relatively elevated concentrations of PCBs (as high as about 20,000 ppb) were consistently found in sediments collected from the storm drain line beneath Leo Avenue in an industrial part of San Jose. The spatial distribution of PCB concentrations coupled with an analysis of PCB homolog patterns suggested that a specific property adjacent to Leo Avenue was a major source of PCB-containing sediments.

The PCB case studies have shown promise for identifying suspect source areas and potential responsible parties, but have also revealed that finding PCB sources is often a considerable challenge. Identifying PCB sources will require very intensive investigations such as those conducted around the Ettie Street Pump Station.

Following the Trail

The Ettie Street Pump Station drains a mixed land-use section of west Oakland that extends south and east into downtown Oakland and discharges its runoff into the Bay (Figure 2). The areas closest to the Pump Station are mainly mixed residential and industrial, passing through more commercial areas, and transitioning to mainly residential areas farther upstream. The storm drain system of the watershed is underground for its full extent.

In 2001, the Alameda Countywide Clean Water Program used the Ettie Street watershed to test a pilot methodology for identifying potential source areas of pollutants accumulating at the Pump Station

In 2001, the ACCWP used the Ettie Street watershed to test a pilot methodology for identifying potential source areas of pollutants accumulating at the Pump Station. The first phase of the investigation sampled the five main storm drain lines that drain to the Pump Station. Although detectable concentrations of PCBs were found at or near the base of all five catchments, the northernmost catchment was selected for further study based upon the magnitude of PCB concentrations found (Figure 2).

In this catchment, targeted sampling was conducted on sediments accumulating within 39 stormdrain inlets (Figure 3). Based upon PCB concentrations and comparisons of congener patterns to those of downstream sediments, Salop *et al.* (2002b) identified multiple small areas within the catchment that appeared to be associated with potentially important sources of PCBs (Figure 4).

Source identification efforts were facilitated by several features of the watershed: collection of all runoff at the Pump Station, forebays acting as sediment-accumulation traps within the Pump Station itself, and numerous local sediment accumulation points throughout the watershed in main drainage culverts and in older, catch-basin type inlets at street intersections. Some watersheds of interest lack such features, and therefore are not as conducive to performing this type of source identification work. However, the watershed is likely representative of other older industrial mixed-use watersheds in that there are likely to be multiple source areas discharging PCBs to stormwater conveyances at different concentrations.

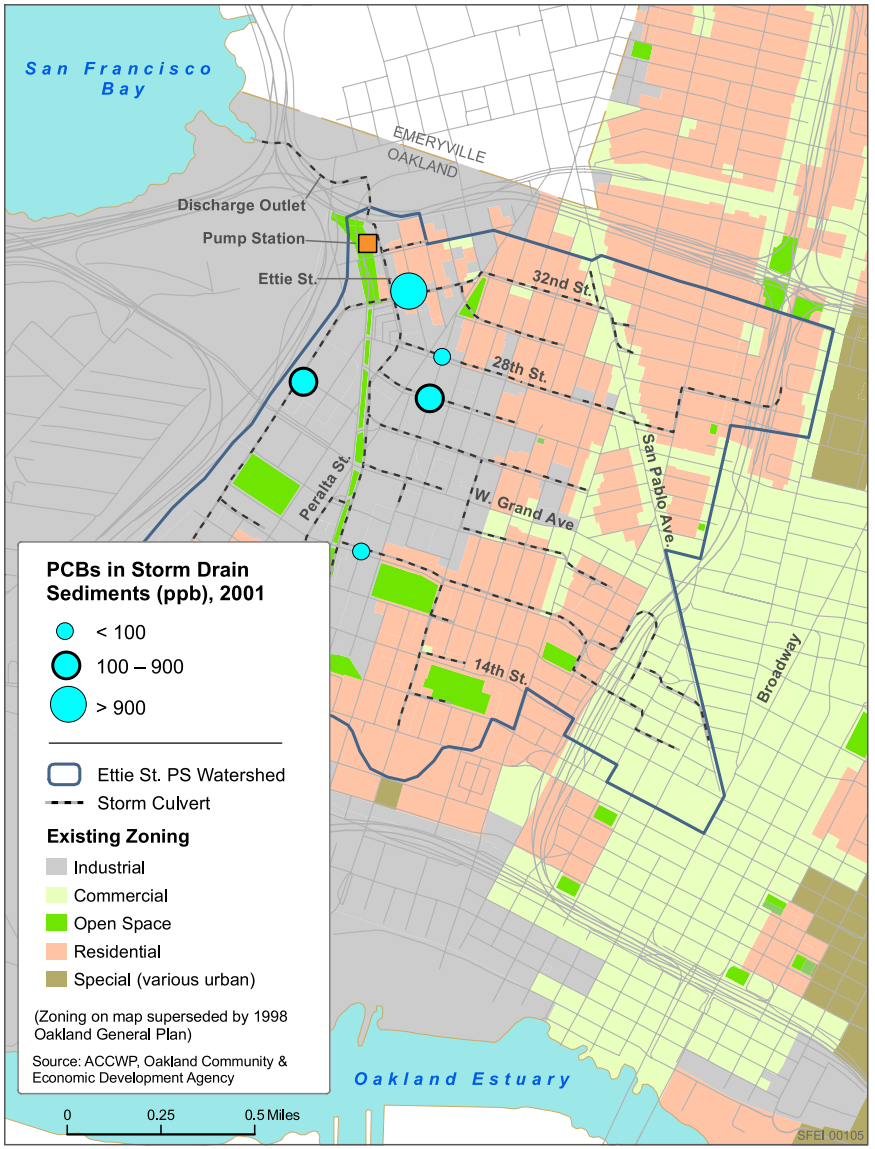


Figure 2. The most extensive of the source investigations performed to date is a series of studies in the Ettie Street Pump Station watershed in west Oakland. The first phase of the investigation sampled the five main storm drain lines that drain to the Pump Station. The northernmost catchment was selected for further study based upon the magnitude of PCB concentrations.

Photo courtesy of Steve Miller

Figure 3. Further investigation of the northernmost subcatchment of the Ettie Street watershed included sampling of 39 storm drain inlets. associated with potentially important sources of PCBs. Sampling of one of the inlets is shown here.

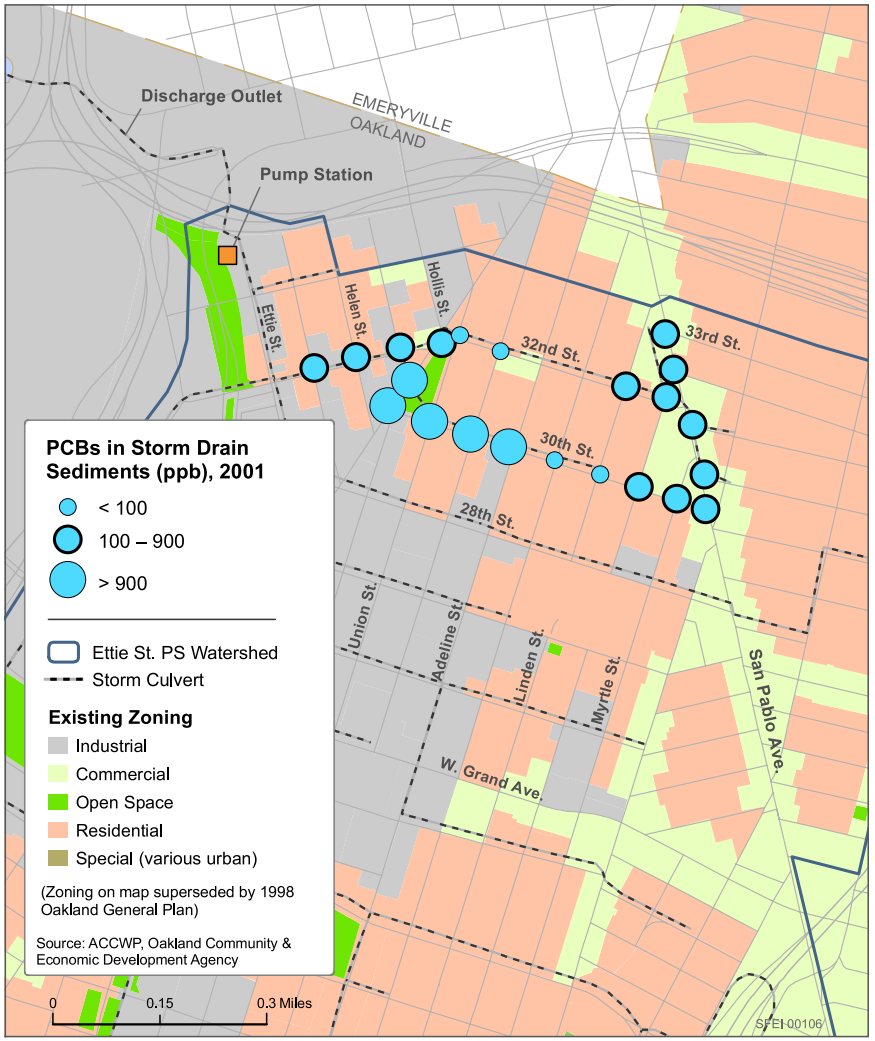


Figure 4. Multiple small areas within the northernmost subcatchment appeared to be associated with potentially important sources of PCBs. Sites with high PCB concentrations were clustered together in areas with similar land use.

Identifying Sources

In 2002 the City of Oakland was awarded a Proposition 13 grant from the State Water Resources Control Board for a PCB Abatement Project focused on finding and abating PCB-containing sediments and sources in the Ettie Street Pump Station watershed. Another goal of this Project, scheduled for completion in late 2006, is to develop a model for how municipal staff can work with local stakeholders, landowners, and local, state, and federal agency staff to clean up source properties and reduce loads to the Bay.

The PCB Abatement Project has piloted several innovative techniques for identifying specific properties acting as sources of PCBs to the Pump Station

The PCB Abatement Project has piloted several innovative techniques for identifying specific properties acting as sources of PCBs to the Pump Station. Various databases, agency files, and other information sources were reviewed in an attempt to identify potential source properties out of more than 1700 businesses located in the watershed (Kleinfelder 2005). City inspectors combined this background research with driving and walking surveys of the entire watershed, using a checklist of attributes associated with past or current use of PCBs to identify potential source properties (see Sidebar).

City inspectors next conducted modified stormwater inspections within 123 properties identified through the database reviews and surveys. Based on the results of these inspections, the City selected candidate sites in the public right-of-way for follow-up sampling. Properties were characterized as high, medium, or low priority for sampling based upon past and present history of PCB spills or uses, as well as site characteristics or management practices that increased the likelihood of onsite pollutants entering stormwater (Salop 2004). This approach led to one immediate success: a 55-gallon barrel labeled as containing PCBs was found, along with other unlabeled barrels, in the yard of a current asbestos abatement business (Figure 5). The exact contents of this barrel are unknown, but assuming it was full and labeled accurately, proper disposal may have isolated up to 300 kg of PCBs. This mass would be equivalent to over ten percent of the estimated mass of PCBs present in the surface sediment layer of the entire Bay (Davis 2004), and nearly ten times the current estimate of annual stormwater loads of PCBs to the Bay (RWQCB 2004).

Photo courtesy of Trish Eliasson

Figure 5. Through background research and inspections, City inspectors were able to identify properties with a high potential as a PCB source. One of the successes was the discovery of a property with a 55-gallon barrel labeled as containing PCBs. If the contents of a barrel like this one were to enter the Bay through accidental or intentional dumping, the mass of added PCBs could be enough to delay recovery for many decades.

High priority uses or activities associated with PCBs, from checklist for site screening in the PCB Abatement Project in the Ettie Street Pump Station watershed (Salop 2004)

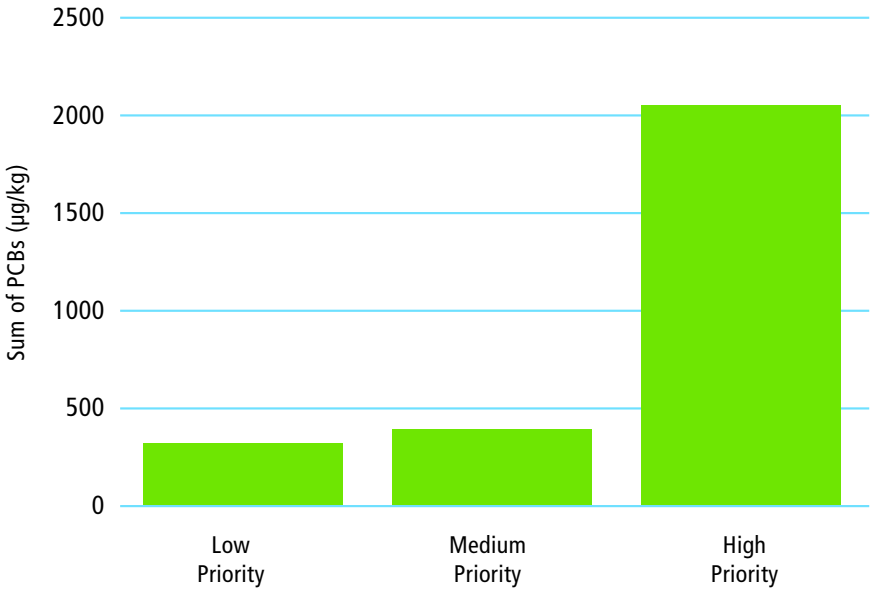
- Manufacture or handling of electrical applications (transformers, appliances, televisions, fluorescent light ballast, motors, etc.)
- Hydraulic fluids (lifts, die-casting machinery, etc.)
- Plasticizers (sealants, caulk, PVC, polyurethanes, polycarbonates, etc.)
- Drum cleaning/recycling*
- Auto recycling/scrap
- Outdoor burning or combustion*
- Miscellaneous (coatings, printing inks, pesticides)

* indicates potential to cause dioxin-like compounds.

Sediments were then sampled from public rights-of-way at points where they were likely to have been washed from high priority properties. Results for these high priority samples ranged from 23 parts per billion (ppb) to over 31,000 ppb, with the maximum concentration found adjacent to the above-mentioned asbestos abatement business (Figure 6). Of the 41 samples collected at 37 high priority sites, 25 exceeded the Water Board's residential Environmental Screening Level (ESL) of 220 ppb, and 33 exceeded the California Department of Toxic Substance Control's California Human Health Screening Level (CHHSL) of 89 ppb (Kleinfelder 2005).

Transferring sediment into jars to be shipped to the analytical laboratories. Photo courtesy of Paul Salop.

The next phase of the PCB Abatement Project included sampling of sediments collected from 19 private properties (18 industrial sites and one residential site), ranked as high priority potential sources through the right-of-way sampling. Sampling was conducted through the City's annual Certified Unified Program Agency, the local agency certified by California EPA to manage various programs related to control of hazardous materials. Thirteen of the 25 total samples collected exceeded an industrial soil ESL of 740 ppb. A maximum concentration of over 93,000 ppb was found at a marble cutting facility on a property that had previously been involved with disposal of PCB-containing waste (Kleinfelder 2006). This property was one of several at which sediment PCBs were at least 10 times higher than concentrations in the downstream right-of-way.



Footnote: Bars indicate averages.

Figure 6. The PCB Abatement Project then sampled sediments from public rights-of-way at points where they were likely to have been washed from high priority properties. Results for these high priority locations ranged from 23 parts per billion (ppb, µg/kg) to over 31,000 ppb. High priority locations had much higher average concentrations than low or medium priority locations.

Adaptive Management

In addition to the high priority sites sampled through the PCB Abatement Grant Project, in 2005 the ACCWP funded sampling of sixteen additional medium or low priority right-of-way sites as a check on the effectiveness of the prioritization scheme. Although high priority locations had higher concentrations than low or medium priority sites, there was no statistically significant difference between

sites characterized as high versus medium-to-low priority. However, these analyses did point out potential modifications to the prioritization scheme that could change this outcome in future investigations. For example, vacant lots with no indication of previous heavy industrial uses, considered high priority during this effort, were generally not associated with elevated concentrations and may be considered a lower priority for future sampling efforts.

Related concerns for potential direct human exposure in the urban landscape and a request by the Water Board Toxics Cleanup Division led to a related City investigation in 2005 in order to more fully test the effectiveness of the prioritization process. In this investigation, 18 right-of-way sites spread throughout the watershed were identified for sampling and analysis through a randomized selection process. The results of this investigation, when compared with the previous targeted sampling, strongly suggest that the private properties were the source of the PCBs in the right-of-way. For example, an upper bound value for the randomized right-of-way sampling was 680 ppb, compared to 2,500 ppb for the targeted right-of-way sampling and 14,000 ppb for the private property samples.

The elevated concentrations observed in these studies have caused PCB Abatement Project managers to increase their focus on cleaning up identified source areas. As part of this Project, the City initiated pilot abatement efforts in public rights-of-way during spring 2006. The City also has begun the outreach portion of the Project to share its findings and planned activities with local residents and business owners. Additionally, ongoing coordination between USEPA, the California Department of Toxic Substances Control (DTSC), the Water Board, City staff, and individual private property owners is facilitating development and implementation of an abatement program for identified source properties. The City is seeking additional funding to continue abatement work and post-abatement monitoring to gauge effectiveness.

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Inside the Ettie Street Pump Station. Photo courtesy of Applied Marine Sciences.

One question yet to be answered is how the abatement activities in this Project will affect loadings to the Bay. The actual amount of PCB mass that will be removed in the abatement process is not well understood. It is also unclear how much of the PCB mass that is removed from the right-of-way areas, and potentially the private properties, would have actually made it to the Bay. New methods for understanding the mass of PCBs intercepted through abatement activities will need to be developed as abatement activities evolve.

Challenges Ahead

Based on investigations conducted to date, it appears that some, mainly older industrial, watersheds in our region contain relatively large masses of PCBs, and effective isolation or removal of soils and/or sediments with PCBs in these priority watersheds will likely be an important step in reducing loads of PCBs to the Bay. However, a number of challenges lie ahead in the process of identifying and cleaning up important sources.

Identification of priority watersheds and location of specific source areas within them requires a careful combination of measurement and judgment. Previous approaches combining targeted sediment monitoring, land use analysis, and watershed and site inspection hold promise, but these methods are continuing to evolve.

Once source properties are identified, the challenge remains to obtain funding for remediation or identify responsible parties to perform abatement activities. Evaluation of abatement activities will also need to be conducted to determine what works and what does not. The lessons learned during the Ettie Street investigation will inform similar investigations and abatement in other Bay Area watersheds - an important part of the overall effort to reduce the amount of PCBs in the Bay and restore sport fishing and wildlife habitat beneficial uses.