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Memorandum

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Re: First Phase Support Information for PCB Portion of Taking Action for Clean Water Grant

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The purpose of this memorandum is to provide information and recommendations to support the process of making several key decisions in the first phase of the polychlorinated biphenyls (PCBs) portion of the Taking Action for Clean Water Grant (Grant Project). The grant, which was awarded by the California State Water Board to the San Francisco Estuary Project (SFEP), anticipates a collaboration among the Bay Area Stormwater Management Agencies Association (BASMAA), the San Francisco Bay Water Board, and other agencies (such as U.S. EPA) to develop and pilot a program to reduce PCBs releases to surface water by improving management practices for PCBs in historic building materials.[1]

This memorandum was prepared by a team of consultants that are familiar with the project and related scientific, engineering, and regulatory issues. The team, led by Applied Marine Sciences, also includes the San Francisco Estuary Institute, Larry Walker Associates, and TDC Environmental. It represents work conducted through two separate, related tasks both assisting with refining proposed implementation actions for the proposed plan to reduce PCBs levels in San Francisco Bay (the PCBs "Total Maximum Daily Load" or "TMDL"). Alameda Countywide Clean Water Program (ACCWP) Task MS-3.1-06a provided start-up support to assist the Grant Project in identifying key issues requiring resolution to inform the programmatic sampling and analysis program. The San Francisco Bay Area Clean Estuary Partnership (CEP) Task #4.50 has continued activities initiated through the ACCWP Task to support continued development of technical information to support the process of making decisions in the first phase of the Grant Project and to initiate the grant-related stakeholder process.

[1] In the context of this project, "building materials" applies to all types of structures, including parking garages, highway structures, and possibly other types of structures as well as buildings.

This memorandum is organized into three main sections. The first section contains project background information. The second section provides technical information that addresses each of the key first phase Grant Project decisions. The third section summarizes the consulting team's recommendations. This memorandum also includes two appendices. Appendix A provides a description of an approach that may be used to estimate quantitatively the importance to San Francisco Bay water quality of managing PCB-containing building materials. Appendix B provides information about PCBs chemical analysis methods.

1. Context

1.1 History of PCBs Use

Polychlorinated biphenyls were manufactured in the U.S. by the Monsanto Chemical Company between 1929 and 1977. They were incorporated into many products over this period. As awareness grew that PCBs in products were being released into the environment and posed a threat to humans and wildlife, various restrictions were imposed on the types of products that could contain PCBs.

Before 1957, Monsanto manufactured PCBs for use in a wide variety of products, including "open system" products such as inks, papers, paints, adhesives, and caulking, which were directly exposed to the air. Such products were designed to involve one-time PCBs uses—the PCBs were not intended to be recovered at the end of the products' life. Most PCBs were used in capacitors and transformers, which are "closed systems," from which PCBs would only be released in unusual circumstances (e.g., an accident).

In 1957, due to concerns about PCBs in the air, Monsanto limited use of its PCBs products to closed systems—this was defined to include "nominally closed systems," such as plasticizers and lubricants. These products were considered "nominally closed" because it was incorrectly assumed that the chemical structures of these products would allow only minimal quantities of PCBs to be released to the environment. In late 1970, Monsanto discontinued production of nominally closed systems. By 1972, new public use in the U.S. was completely within closed systems. Finally, in 1977 Monsanto terminated manufacture of PCB-containing products.

In 1978, U.S. EPA restricted manufacture and distribution of products containing more than 500 parts per million (ppm) PCBs to strictly "closed systems," with some exceptions. The final rule, which was published in 1979, restricted products that were more than 50 ppm PCBs (U. S. EPA, 1987). In 1984, the U.S. EPA banned manufacture or distribution of any material that contained detectable levels of PCBs except for a limited number of authorized uses (U.S. EPA, 1999).

1.2 PCBs in San Francisco Bay

Elevated PCB levels threaten the heath of people and wildlife consuming fish from San Francisco Bay.[2] A Total Maximum Daily Load (TMDL) to address PCB impairment of

[2] The Water Board recently released a staff report that describes the water quality problem and the TMDL

all segments of San Francisco Bay is in development. The San Francisco Bay PCBs TMDL Project Report (RWQCB, 2004) reviewed the past and present sources of PCBs in the Bay and found that urban runoff was one of the major sources of PCBs loads to the Bay. The report concluded that controlling PCBs sources in urban runoff was a priority for TMDL implementation.

Based on this conclusion, the Clean Estuary Partnership (CEP) evaluated available data on sources of PCBs in urban runoff and recommended approaches for addressing past PCBs releases that have contaminated soil and sediments and PCB-containing historic building materials—specifically uncontained materials like sealants, caulking and paint (LWA et al., 2006). The Grant Project builds on the building materials portion of the CEP report.

1.3 PCBs in Building Materials

The literature review completed for the CEP report found that caulking, grout, paint, and other coating and sealants are potentially significant uncontrolled sources of PCBs in urban environments. For example, a survey by the Swiss government of joint sealants in 1,348 buildings constructed between 1950 and 1980 (Kohler et al., 2005) found that:

- almost half of the surveyed buildings had PCB-containing joint sealants;
- almost 10% contained sealants with PCB concentrations exceeding 10% by weight; and
- the total PCBs reservoir in building joint sealants in Switzerland was an estimated 50-150 metric tons.[3]

A less rigorous study was conducted in Boston with similar findings (Herrick et al., 2004); however, no such evaluation is known for California.

The CEP report found that when PCB-containing building materials like joint sealants, caulking, and paint fail, or when structures that contain these materials are remodeled or demolished, PCBs are released onto the ground and can be washed off by urban runoff. While few data on runoff quantities are available, a Swedish study found that significant quantities of PCBs were released into soil and water runoff during remodeling of a building with PCB-containing joint sealants (Astebro et al., 2000).

Management practices have been developed that can prevent PCBs releases from structural materials into urban runoff. Both the Swiss and Swedish governments have developed active programs to manage PCB-containing building materials in response to public health concerns (related both to direct exposures and to the adverse effect of PCBs on Europe's fisheries). The U.S. does not have any similar program, likely because there has never been a requirement to identify the presence of PCB-containing building materials that remain in structures today.

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proposed to address the problem (RWQCB, 2007). This report is available on the Internet: http://www.waterboards.ca.gov/sanfranciscobay/TMDL/sfbaypcbstmdl.htm

[3] Note that the population of Switzerland (7.3 million) is similar to that of the Bay Area (6.8 million); however, building construction dates and methods may differ.

1.4 Grant Project Overview

The goal of the Grant Project, as described in the grant application is:

> "To develop Bay Area-specific best management practices (BMPs) to prevent release of PCBs from building materials into urban runoff during renovation, maintenance and demolition of structures."

The Grant Project is designed in four phases. In the first phase (the data-collection phase), the Grant Project team will obtain Bay Area specific information on the presence of PCBs in historic building materials. In the second phase, the Grant Project team will develop Bay Area-specific BMPs and a model implementation process to prevent release of PCBs from unregulated, uncontained building materials into urban runoff. Next, BMPs will be piloted in 3-5 municipalities. Subsequently, region-wide phased implementation will be pursued.

1.5 Grant Project Data-Collection Phase

As the grant application stated, the goal of the first phase of the Grant Project is:

> "To obtain Bay Area-specific information about the presence of PCBs in building materials, so that management actions can be targeted specifically to the structures most likely to contain PCBs that threaten water quality."

The scope of work for the Grant Project envisions that this first phase will consist of a data-collection effort that includes a sampling and analysis program.

The data-collection effort will be designed to inform all subsequent project phases. Therefore, it is important that the data collection—including the sampling and analysis program—be designed to support timely and effective completion of the overall Grant Project. In order to avoid negatively affecting remaining project phases, this means that the first phase will need to be essentially complete by the end of 2007.

The funding source, budget, and design of the Grant Project create certain limitations on the planned sampling and analysis program:

- The sampling and analysis program will not be designed to look at stormwater loads due to degradation of in-place materials or loads from previous maintenance / renovation / demolition projects (though some background may be gathered that will add to understanding of this topic—see Appendix A).
- The sampling and analysis program will not be designed to evaluate current or past PCBs releases through pathways other than urban runoff.

Neither the Grant Project nor the planned sampling and analysis program to be conducted in association with the project would be designed to address human health endpoints. The sampling design would not provide the type of information used to gauge human health impacts from ambient conditions or during demolition/renovation.[4] Nevertheless,

[4] Appropriate precautions will, of course, be implemented to protect human health during sampling.

information may be obtained through the sampling program that could be used to improve understanding of human exposures to PCBs in building materials. Recognizing the relationship of the project to human health, the grant application notes "[s]ince occupants of buildings constructed with uncontained PCBs may be exposed to PCBs in the air and soil around their buildings, this project will benefit human health as well as water quality."

1.6 Purpose of this Memorandum

The purpose of this memorandum is to identify key decisions that need to be made to design and implement the data-collection phase of the Grant Project, to provide technical information relevant to each decision, and—for technical decisions—provide the consulting team's recommendations. The recommendations in this memorandum are based on the information collected by the team and best professional judgment. The recommendations herein are intended only for the purpose of assisting SFEP and the project stakeholder group in preparing for the stakeholder discussion of the data collection program.

The consulting team identified three main areas of investigation: (1) selection of materials and structure types for inclusion in the project; (2) identification of sampling and analysis methods appropriate for various project phases; and (3) development of methodologies for estimating the inventory of PCBs within building materials and their likelihood for transport to San Francisco Bay via urban runoff. Each of these topics addresses questions where information compiled and interpreted by the project team would help SFEP and stakeholders make key, time-critical decisions for the first phase of the project.

Areas 1 and 2 are obvious precursors to development of the planned sampling and analysis program. Area 3 is not necessarily a driver for the sampling and analysis program. It is necessary, however, to ensure that any data collected through the sampling and analysis program is appropriate for evaluating what BMPs might be effective in minimizing stormwater loads of PCBs emanating from building materials. As this topic is different in many ways from the preceding two topics, and may be reviewed through a different stakeholder process (e.g., a subset of Grant Project stakeholders with specific interest or relevant technical expertise), item 3 is presented in Appendix A to this memo.

It should be noted that published information detailing presence and concentrations of PCBs in specific building materials is limited. Of more importance to the Grant Project, there is very little known information on their usage in Bay Area structures. This memo cites the best information identified by the consulting team, and categorizes the uncertainty where appropriate.

Below in Section 2, we summarize background information on different factors that would shape the Grant Project data collection phase, suggest alternatives for consideration where appropriate, provide the consulting team's recommendations, and identify areas for potential follow-up investigation. In Section 3, we list the key questions for the Grant Project data collection phase and summarize the consulting team's recommendations.

2. Technical Background Information

2.1. Selection of Materials for Inclusion in the Project

As described in Section 1, PCBs were contained in building materials—either through intentional use of PCBs in their formulation or through inadvertent contamination—that were used in construction and maintenance of various types of structures prior to the ban of manufacturing and most uses of PCBs in the late-1970s (U.S. EPA, 1979). In the late 1990s, the U.S. EPA reviewed available literature to compile information on what is known regarding the presence and abundance of PCBs in building materials. This effort identified the following "open system" building materials as potentially containing PCBs, and provided what little was known about product usage and associated PCB concentrations where available, much of it garnered from applications within US military facilities (U.S. EPA, 1999):

- Insulation (e.g., wool felt, foam rubber and fiberglass) and sound dampening materials;
- Plastics, small foam rubber and rubber parts, adhesive tape, and insulating materials used in electrical cabling;
- Paint formulations;
- Fluorescent light ballast potting materials;
- Gaskets in heating, ventilation and air conditioning (HVAC) and other duct systems;
- Coatings for ceiling tiles;
- Flooring and floor wax/sealants;
- Roofing and siding materials;
- Caulking and grout;
- Waterproofing compounds, antifouling compounds, and fire retardant coatings; and
- Coal-tar enamel coatings for steel water pipe and underground storage tanks.

The best available data identified by the project team regarding the content of PCBs in open system building materials are shown in Table 1. The subject of the study is given so that the reader can judge the applicability of these data to Bay Area buildings. Clearly there are wide ranges of values given, even within studies of similar materials.

Table 1. Reported Percentages by Weight of PCBs in Building Materials

PCB containing material	Observed PCB levels	Source	Subject
Caulking	In 1/3rd, >0.005% by weight, mean 1.5645%, maximum 3.6%	Herrick et al., 2004	24 Greater Boston Buildings built in 70s
Caulking	17%	Mengon and Schlatter, 1993	Buildings 1962-1970
Caulking	≤ 30%	Ljung, 2002	Buildings pre-80s
Caulking	Of 1348 buildings: 21% of buildings: >1% 10% of buildings: >10%	Kohler, 2005	1348 public buildings in Switzerland
Caulking	≤ 30%	Government of Western Australia, 2002	Office buildings, bridges, parking structures, and water storage tanks
Coating on concrete	0.07% to 8.7%	Montana Fish, Wildlife and Parks, 2004	Fish Hatchery w/ concrete sealed in '60 and again in unknown year
Coatings for metal and concrete	40%	Davies, 1968 and Parker, 1967	Considered optimum content for production
Masonry sealed with PCB sealant	PCBs detected up to 2 inches beyond surface	Chang et al., 2002	1970s University building
Paint and Coatings	<0.001% to 9.7%	U.S. EPA 1999a	
Paint	0% to 7.4%	Gill, C. G. et al., 1997; Dept. of National Defense, 1997	1930-1970 paints in Canada
PVC and chlorinated rubber paint	5% to 8%	Jensen, 1972	
Roofing and siding material	<0.0002% to 3%	U.S. EPA 1999a	

In the recent review conducted for the CEP, LWA, et al. (2006) identified two categories of building materials as potentially the most significant uncontrolled sources of PCBs in urban environments:

> *Caulking and sealants - PCB-containing sealants were used to seal joints between masonry units and around windows in various types of concrete structures, including buildings, dams, water tanks, and bridges. The literature survey suggests that this may have been a common practice in the 1950s, 1960s, and 1970s;*
>
> *Paint and coatings - PCBs were a component of paint and coatings from the 1930s until the late 1970s…coatings included waterproofing compounds, anti-fouling compounds, and fire retardant coatings. The literature suggests that the most common applications were on concrete surfaces, industrial equipment, surfaces requiring waterproofing, metal structures (including pylons and bridges), and military buildings (constructed of any material, including wood and metal).*

2.1.1. Materials Recommendations

Based on literature review findings, we recommend limiting usages to be investigated through the Grant Project to those of: (1) caulking and sealants, and (2) paint and coatings, with the category of caulking and sealants being the higher priority of the two. Regarding paint and coatings, we recommend conducting a brief survey of painting maintenance practices to inform the amount of effort to dedicate toward this category by estimating the likelihood of PCB-containing paints to still be present in Bay Area buildings.

When BMP development is initiated, we recommend evaluation of whether "contained PCBs" sources should be included in the project. For example, a common contained PCBs source that is not always identified prior to remodeling or demolition is PCBs-containing potting materials in fluorescent light ballasts. Identification and management of these ballasts is relatively straightforward, so it may be worthwhile to include them in the BMP development phase.

2.2. Selection of Structure Types for Inclusion in the Project

To make BMP implementation as cost-effective as possible, the Grant Project envisioned the use of available information—including sampling and analysis data—to prioritize selection of specific structures for inclusion in the program. This section presents technical and other practical factors that can be considered in conducting this prioritization exercise.

2.2.1. Technical Factors

Several key technical factors to consider when prioritizing building materials for possible inclusion in the project are presented below. Where information from the literature is available in relation to the identified factor, it is included in the summary.

Structure Types – Due to the specific properties of PCBs that led to their incorporation into building materials, PCB-containing materials are likely to be associated with distinct types of structures in the Bay Area. Information in the literature (some of which is colloquial in nature) suggests that common uses of PCB-containing caulking and sealants were around windows, at building/walkway interfaces, and in expansion joints (with the exception of window caulking, these would generally be only on building exteriors). While windows appear in all construction types, caulked expansion joints are most commonly designed into concrete and masonry structures. Most of the structures reflected in Table 1 were of concrete or masonry construction.

Building/walkway interfaces that are caulked are those where a concrete walkway directly abuts a structure. While this may occur in any construction type, it will be more common in land uses that have high percentages of impervious surface (e.g., industrial, commercial, and institutional), because when impervious surface fractions are high, pavement—rather than landscaping—is more likely to directly abut a structure.

PCB-containing paints have anecdotally been associated with applications where durability, flexibility, and water resistance are desirable factors in paint formulation. In some cases, this may be associated with specific structure types, such as masonry and concrete buildings and swimming pools, and in others will be associated with uses common to many building types, such as floor and steel paints (e.g., Schmidt et al., 2000).

Additionally, PCB-containing materials have been identified in many buildings, but they are not limited to buildings. In addition to human-occupied building types of specific interest, there are many examples of other structures with PCB-containing materials, such as bridges, parking garages, athletic facilities, public transportation infrastructure, and dams (e.g., Sykes and Coate, 1995). In these types of structures, PCB-containing sealants have most often been found in sealants in expansion joints between two abutting pieces of concrete.

Lifespan of PCB-containing material – Some of the uses for known and suspected PCB-containing materials are associated with products with recommended short-term life spans (e.g., paints and coatings, sealants around windows, expansion joints) and may therefore have been replaced since phase-out of PCBs was initiated. However, it should be noted that recommended replacement cycles are not always followed and material failure is often the trigger for maintenance activities.

Likelihood of being abated through existing mechanism – There are many building materials that, during the remodel / demolition process, are commonly surveyed, tested, and abated for presence of non-PCB hazardous materials, most commonly asbestos and lead. For example, window glazing compounds that may also contain some mass of PCBs may currently be abated for the purpose of asbestos removal. Similarly, some lead-based paints that may also contain PCBs may be removed through current lead abatement activities.

Age of Original Construction – Structures constructed or remodeled prior to 1977 have greatest potential for PCB-containing materials. Different groupings of years of construction can be developed to attempt to discern differences in PCB concentrations associated with changing regulatory environment or building construction practices. Based upon the history of PCB manufacturing and regulation in the U.S., it would be logical to divide structures into age class groupings as follows:

- Pre-1929—Unlikely to contain PCBs (construction prior to first manufacture)
- 1929 to 1957—May contain PCBs (early manufacturing era)
- 1957 to 1977—Most likely to contain PCBs (era of highest use prior to phase-out)
- 1977 to 1984—May contain PCBs (phase out period prior to final ban)
- Post-1984—Unlikely to contain PCBs (construction after ban)

Data from the literature suggests that that 1957 to 1977 era highlighted above is likely the most important—and that an even narrower range of building construction dates could identify where the highest PCBs concentrations occur. The Swiss study of joint sealants in buildings constructed between 1950 and 1980 described in Section 1.3 and referenced in Table 1 (Kohler et al., 2005) broke down the concentration of PCBs in caulking by the year of building construction. The Swiss scientists found that 48% of sampled sealants contained PCBs. Almost 10% of the samples contained more than 10% PCBs by weight. As shown in Table 2, the sealants most commonly appeared in buildings constructed between 1955 and 1975. The highest frequency was in buildings constructed between 1966 and 1971—more than one third of these buildings contained sealant with PCB concentrations exceeding 1% PCBs by weight. Table 2 contains a complete break down by year of buildings with caulking containing greater than 1% PCBs.

Table 2. PCB Concentration in Caulking as Compared to Year of Building Construction

Building Construction Year	Number of Samples	Percent of Samples Containing >1% PCBs
Before 1950	1	0
1950-1954	6	0
1955-1959	46	7
1960-1961	27	11
1962-1963	50	24
1964-1965	52	25
1966-1967	91	37
1968-1969	114	36
1970-1971	176	32
1972-1973	257	13
1974-1975	195	2
1976-1977	28	11
1978 and later	33	0
Unknown age	272	28
Total	*1348*	*21*

Source: Kohler et al. 2005.

2.2.2. Other Factors

In addition to the technical factors mentioned above, there may be inherent logistical or practical considerations that should be considered if sampling and analysis is pursued. These factors may affect translation of technical factors into selection of actual sampling sites. A few of these are discussed below:

Relevance to BMP Implementation – Material types for which there is not likely to be an effective BMP, or for which a BMP effectiveness evaluation would prove problematic, may garner a lower relative priority. We are currently unaware of any usages that are precluded by this requirement.

Ownership – Although privately-owned buildings far outweigh the number of publicly-owned buildings in the Bay Area, access for sampling personnel may be easier to obtain for publicly-owned buildings. Therefore, the stakeholders may need to consider whether targeting the sampling sites predominantly or exclusively in publicly-owned buildings will affect the likelihood of achieving project goals. We have no reason to believe that limiting it in this manner will affect validity of the investigation.

Geography – Ideally, sampling sites would be selected from a wide enough range of sites to represent target ages and types of structures. However, this may only be achieved through increases in project administrative effort or unacceptable lengthening of the sampling timeframe. The stakeholder group may also need to balance the need for geographic scope with the available pool of structures made accessible by municipalities or agencies.

Feasibility – Any other mitigating factors that would prevent sampling personnel from accessing a particular site within the project budget or timeline would generate a lower relative priority for that site.

2.2.3. Structure Type Selection Recommendations

We recommend that the Grant Product focus its efforts on buildings constructed or substantially remodeled between 1957 and 1977. If sampling and analysis is done, we recommend including structures built prior to 1957 and until 1984 for confirmation purposes. If sufficient samples can be taken, breaking down the 1957 to 1977 into smaller age classes should be considered, as this could provide information that could help more effectively target BMPs. We also recommend considering geographical representativeness when selecting sampling locations.

Although data on structure construction type and PCB-containing material uses are relatively limited, we recommend an initial focus on exterior caulking and sealants used in concrete and masonry structures (of all types). Additional information collection and consideration of structure construction type in the sampling and analysis program are recommended. Additional information collection would involve at least the following steps:

- Additional literature review;
- Contact with academic and agency researchers;
- Contact with product manufacturers and construction trades organizations.

Additional information would reduce the uncertainty that this focus is appropriate (i.e., that it does not omit a significant fraction of structures of concern). Additional research may be able to answer several outstanding questions that could allow more efficient targeting of BMPs. For example, it may be possible to identify more clearly where PCB-containing sealants and caulking were commonly used. Similarly, it may be possible to estimate whether sufficient windows from the PCBs era remain in use to justify addressing window caulk.

2.3. Sampling and Analysis Methods

Studies investigating PCBs in building materials have primarily quantified the PCB content of elastic joint sealants (i.e., caulking) used in concrete buildings built between 1950 and 1980. Polysulfide sealants used during this time have been reported to contain percent level PCBs, which were added as a plasticizer and used in both indoor and outdoor applications (e.g., between concrete blocks and around windows).

Two studies have been conducted in Switzerland, where concentrations of PCBs in joint sealants ranged from 47,000-81,000 ppm (4.7-8.1%; Sundahl et al. 1999) and 20-550,000 ppm (maximum 55%; Kohler et al. 2005). In the two studies conducted in the United States, joint sealants from buildings in the Boston area contained concentrations ranging from 0.6-36,200 ppm (maximum 3.6%; Herrick et al. 2005) and an elementary school in New York State contained joint sealants with PCB concentrations up to 60,000 ppm (maximum 6%; Whitaker 2005). PCBs have also been detected in plaster (maximum 290 ppm) and paint (maximum 1940 ppm) on the exterior of buildings in Norway (Andersson et al. 2004). Other building materials that have been suspected to contain PCBs include grout and flame retardant coatings on ceiling tiles; however reports documenting this are not readily available.

Actual sampling methods used in these previous investigations were not well-documented in publications. Personal communications with investigators suggest that methods, in general, comprised a traditional sampling and analysis design with removal of a small amount of sealant by cutting directly into the sealant with a sharp knife and placing sample material in laboratory-supplied vials for subsequent analysis (R. Herrick, personal communication, June 2007). The Boston and European studies determined total PCB content using either gas chromatography-electron capture detection (GC-ECD) or gas chromatography-mass spectrometry (GC-MS). A discussion of possible screening and analytical methods for consideration for use in the Grant Project follows.

2.3.1. Screening Methods

Screening methods are tools that could be used to suggest a presence / absence of PCBs in targeted materials in the field. Screening methods could be used as a stand-alone technology, or considered in combination with a laboratory analysis component of a more traditional sampling and analysis program.

A screening method that is potentially appropriate for the Grant Project is use of portable X-ray fluorescence analysis (XRF). XRF is a rapid, non-destructive screening method that can provide a surrogate measure of PCBs in building materials by determining the percent chlorine (Cl) in the material. An XRF analyzer, which has historically been used to test for the presence of lead in paint, illuminates a sample with high energy photons generated by a low-power x-ray source. Upon hitting an atom, photons dislodge electrons in inner orbitals. The vacancy is filled by outer orbital electrons, which then release a fluorescent x-ray pattern that is unique for each element. By measuring the scattered x-rays, the XRF can estimate density and calculate a concentration of chlorine within the sampling media.

XRF is available in a portable form, such that the instrument can be carried to the location to be examined. The equipment is not inexpensive—the cost to purchase: $30,000; rental prices are estimated as $575/day, $1900/week, or $4900/month. The detection limit is relatively high – when translated to PCBs concentrations, it would represent about 0.1-0.5% PCBs by weight.

The primary advantage of the XRF analyzer is that it provides rapid, on-site screening of materials containing high concentrations of chlorine and may therefore indicate which materials contain high concentrations of PCBs. After initial purchase or rental, an unlimited number of samples can be quantified. In addition to chlorine, more than twenty other elements can be quantified in a single analysis, which takes from ten seconds to five minutes to complete. An XRF analyzer would allow sampling personnel to survey a wide variety of materials in each building or structure and provide information on the variation in concentration within a material type without taking a large number of samples for laboratory analysis. In short, the XRF analyzer would suggest, but not confirm, which materials contain the highest PCB concentrations. For example, if PCBs were only used in polysulfide-based rubber sealants and not the oil-based sealants; XRF analysis could potentially distinguish between the two types. If technically feasible, XRF analysis of sulfur compounds could be used as a qualitative field confirmation of the presence of polysulfide caulking.

Possible disadvantages of XRF analysis include high detection limits and potential false positive results. Detection limits for chlorine are highly dependent on the matrix and range from 1000-5000 ppm for soil (0.1-0.5%).[5] Detection limits for sealants are expected to be similar but cannot be verified without further investigation. PCB concentrations in joint sealants are expected to be ≥ 1% when present, thus XRF analysis would detect PCBs (as percent chlorine) in these materials. The effectiveness for detecting PCBs in other materials is not known since PCB concentration data are not available. Since the XRF analyzer only quantifies chlorine composition, false positives may result from the detection of chlorinated paraffins or other chlorine additives commonly used as plasticizers in joint sealants. Chlorinated paraffins were frequently detected in a Swiss study of PCBs in joint sealants (Kohler et al. 2005). In this same study, XRF analysis was used to estimate PCB concentrations on a subset of sealant samples. The authors concluded that XRF analysis is a good screening tool for PCBs in sealants when a low percentage of samples containing chlorine is expected, though the specificity may be impaired by the presence of non-PCB chlorine additives (M. Kohler, personal communication, June 2007).

XRF may not be as useful a technology for screening of paint. Relative to uses of sealants in structures, paints can be expected to be used in higher volumes but likely at lower PCB concentrations. For example, an application that used 300 gallons of paint containing PCBs at 100,000 ppm (at a possible XRF detection limit of 0.1%) may not be detected by XRF technology, but could still contain more than 1 kg of PCBs. Further investigation of the use of portable XRF technology for this project is ongoing.

2.3.2. Traditional Sampling and Analysis Methods

Traditional sampling techniques would, like the studies discussed from the literature above, involve removal of a small amount of target material using a small cutting tool (the location would be re-sealed). The sample material would be delivered to an appropriate chemical laboratory for analysis of PCBs concentration. As explained in

[5] Innov-X-Systems α-4000 model.

detail in Appendix B, quantification of PCBs can be conducted via a variety of U.S. EPA approved analytical methods and can be reported in one of two formats, as sum of Aroclors or congeners.[6]

2.3.3. Sampling and Analysis Recommendations

Selection of a sampling and analysis program will require consideration of both technical and non-technical factors. On the technical side, both XRF and traditional sampling and laboratory analysis offer great promise for reducing the uncertainty surrounding what little is known about the mass of PCBs contained within Bay Area building materials. XRF technology has much faster turnaround than traditional laboratory methods, and may allow analysis of more sites compared with traditional sampling and analysis methods.

XRF does have drawbacks, as discussed above, that introduce uncertainty in the interpretation of data. Both false negatives (i.e., the potential for PCBs to be present in a material, but not at a concentration high enough to be detected by the XRF) and false positives (i.e., a measurable chlorine concentration that is due to something other than PCBs) are possible outcomes of XRF screening. While traditional sampling and analysis methods are more time-consuming and costly on a per sample basis, there is a much higher degree of certainty associated with the reported results compared with XRF. From a technical standpoint, a combination of field screening with XRF and confirmation sampling with PCBs measurements by an analytical laboratory would be the preferred sampling design. Prior to development of a sampling and analysis plan, further investigation of XRF is recommended in order to determine the appropriate role of XRF, level of confirmation sampling needed, and extent to which expected chlorine content within targeted building materials would be detectable by XRF.

Use of the XRF analyzer allows for identification of chlorinated compounds of interest within each building sampled. This approach may allow for a larger number of structures, buildings, locations on buildings, and building materials to be screened for concentrations of PCBs. XRF may be particularly valuable for surveying structures other than buildings (e.g., parking garages, bridges) since less is known about PCB contamination in such structures.

Non-technical factors, however, are just as important to consider as technical ones for this project. For example, if there is concern about the management consequences of measuring actual PCBs concentrations, the uncertainties associated with XRF could actually be viewed as advantageous. Also, the level of disclosure of site-specific results may be an important consideration for some stakeholders. Non-technical factors like these should be evaluated by SFEP and stakeholders in their consideration of an appropriate sampling and analysis method for this project.

[6] PCBs can occur in 209 chemical configurations called congeners. Most uses in the US were of manufactured congener mixtures marketed under the trade name of Aroclors, with numerical suffixes reflecting chemical properties of individual Aroclor mixes.

For XRF data to be meaningful, a way to validate the results will need to be developed; however, the consulting team believes there are methods that hold potential for providing this validation. . The following steps are recommended prior to making a final decision about how to best incorporate use of XRF in a sampling and analysis program:

- Review a portable XRF unit. Determine exactly how portable it is, how it works, and what types of sampling program designs might be possible given its level of portability;
- Verify XRF detection limits against reported chlorine content within building materials of interest;
- Explore options for validating measurements. These might include a tracer (i.e., another element that would commonly be present in PCB-containing materials) and obtaining validation samples (i.e., known PCB-content materials) to measure with the XRF. Several options for obtaining validation samples are available, including: obtaining local samples,[7] obtaining samples from current PCBs cleanup sites, or collaborating with investigators elsewhere to use their archived samples.

We also recommend that stakeholders discuss how to create a sampling design that would incorporate sites where traditional sampling and chemical analysis for PCBs can be performed. If a traditional sampling and analysis component is incorporated into the project sampling and analysis program, we recommend that all such samples be analyzed for PCB content using low resolution GC-MS (see Appendix B, which explains this recommendation in detail).

3. Recommendations

This section summarizes the key questions identified by the consulting team for the first phase of the Grant Project, and summarizes the consulting team's recommendations for each question. <u>Stakeholder input is particularly important for consideration of the final two questions below.</u>

1. *What building materials types should be included in the Grant Project?*

   We recommend that the Grant Project initially focus on the building materials within the categories of: (1) caulking and sealants, and (2) paint and coatings, with the category of caulking and sealants being the higher priority of the two. Information collected during the first phase of the project should be used to determine whether to include paints and coatings in latter project phases.

   When BMP development is initiated, we recommend evaluation of whether "contained PCBs" sources like PCB-containing fluorescent light ballasts should also be included in the project.

2. *What field sampling and chemical analysis approaches are appropriate?*

[7] A relatively small number of samples may be sufficient to provide validation of XRF method.

The consulting team recommends a combination of field screening with XRF and confirmation sampling with PCBs measurements by an analytical laboratory. Use of the XRF analyzer allows for identification of chlorinated compounds of interest within each building sampled. There is a possibility that XRF can be validated sufficiently to provide meaningful information without confirmatory chemical analysis of every sample. Prior to making a final decision about how to best incorporate use of XRF in a sampling and analysis program, a portable XRF unit should be reviewed, detection limits should be compared to PCB-related chlorine concentrations in historic sealants and paints, and options for validating measurements should be examined.

If a traditional sampling and chemical analysis component is incorporated into the project sampling and analysis program, we recommend that all such samples be analyzed for PCB content using low resolution GC-MS (see Appendix B, which explains this recommendation in detail).

3. *How can structures that are most likely to contain PCBs in their building materials be identified?*

We recommend that the Grant Project initially focus its efforts on exterior caulking and sealants used in concrete and masonry structures constructed or substantially remodeled between 1957 and 1977. We recommend that sampling and analysis be designed to confirm and possibly narrow the construction date range, to ensure appropriate structure types are included in the project, and to ensure that BMPs can be designed to address PCB-containing material usages in the structures (e.g., types of locations where PCB-containing sealants and caulking were specifically used).

We recommend including paints within the sampling and analysis program to the extent that their investigation does not interfere with meeting data collection objectives for caulking and sealants. Additional literature investigation is recommended to determine whether paints can be included within follow-on phases of the Grant Project. It is unlikely that there will be reliable indicators that will allow for distinguishing between PCBs and non-PCBs paint based upon appearance, integrity, or age of building construction; however, there is a chance that use, or other characteristics that are highly correlated with PCB-containing paint can be identified.

4. *What other data collection approaches can be taken to meet the Grant Project's data gathering phase goals?*

We recommend additional information collection through methods other than sampling. Additional data collection offers the opportunity to improve and target BMP design and to assist with interpretation of XRF findings and narrow the uncertainty associated with XRF data. Potential areas of additional research should be fully framed out before proceeding—our initial recommendations include exploration of the following topics:

- Use Patterns. Seek to identify more clearly historic PCBs-containing building materials use patterns (e.g., where within a structure PCB-containing sealants and caulking were commonly used, what applications were common for PCB-containing coating).
- Formulations. PCBs containing building materials, particularly sealants and caulk, may have been formulated in manners that would allow them to be traced through the presence of other elements. General caulking formulation information would provide information that would allow better interpretation of XRF data (e.g., potential for false positives).
- Shorter Lifespan Materials. It may be possible to estimate whether sufficient windows from the PCBs era remain in use to justify addressing window caulk. Additional investigation could allow the Bay Area to benefit from the rapidly growing experience elsewhere with these materials.
- Building types. Literature and construction experts may be able to assist with determining which construction types should be included in BMPs.

Additional information collection would involve at least the following steps:

- Additional literature review;
- Contact with academic and agency researchers;
- Contact with product manufacturers and construction trades organizations.

5. *Can the data collection phase improve our estimates of the potential inventory of PCBs contained within Bay Area structures and the importance of building materials PCBs relative to other controllable sources of PCBs in urban runoff?*

The sampling and analysis and other data collection recommended above would definitely improve estimates of the potential quantity of PCBs in building materials in the Bay Area—and could reduce the uncertainty as to the relative importance of building materials as a source of PCBs in urban runoff. To address these questions within the context and budget of the project, additional research on building inventories is recommended.

Estimating the inventory of PCBs in Bay Area structures can best be accomplished through methods that gather data on the inventories of structures in the age and construction type categories where PCBs are most commonly present. Data sets assembled for other reasons, including hazard assessment or tax records, may be useful in the development of these inventories.

Although sampling and analysis of runoff from sites affected by PCBs in building materials would be valuable for creating urban runoff load estimates, the project budget and regulatory context effectively preclude collection of sufficient samples to prepare higher confidence level estimates. However, literature values in combination with information on building inventories should be useful in identifying the more likely significant sources and framing the significance of building materials as a PCB source to runoff. In addition, estimates that allow comparisons of different building types may help to inform BMP development that can be effective in mitigating PCB releases from building materials.

6. *What would be the downsides if sampling and analysis were not conducted during the data collection phase?*

   Uncertainty would remain regarding the presence of PCBs-containing building materials in San Francisco Bay Area structures. Very limited information would necessarily be the basis for selecting which types of structures to include in the BMP program. This would increase chances of omitting structures with significant quantities of PCBs and/or creating an unnecessary burden on owners of structures that are unlikely to contain PCBs. Uncertainties related to data limitations could restrict public officials' willingness to participate in the Grant Project's voluntary BMP implementation program.

7. *Under what conditions would it be possible to identify locations for sampling and analysis?*

   This question can be answered on the basis of interests and views of the organizations of participating stakeholders. In preparing to discuss this question, stakeholders should consider their interests (e.g., interests in water quality and human health protection), the logistics of their potential participation, and the potential management issues that might arise (e.g., public concerns about the presence of PCBs in building materials, potential for regulatory agency attention, other risks).

   Sampling program design is likely to affect stakeholder consideration of this question. The purposes of the sampling are (1) to obtain information by structure type (e.g., age, construction materials) and (2) to screen for general presence of potential PCB-containing building materials. The project scientific purposes can readily be met through implementation of a survey that is completed based solely upon the basis of structure attributes—in other words, there is no scientific need for a design that entails presentation of chemical analysis results for individual sampling locations grouped by physical location. Instead, results will need to be evaluated by material and/or structure type. (The acceptability of various potential designs to the grant manager will also be a non-technical consideration.)

   We recommend that stakeholders discuss how to create a sampling design that would incorporate sites where traditional sampling and chemical analysis for PCBs can be performed. Additional information is needed to determine whether use of the XRF method alone would provide meaningful information without subsequent laboratory confirmation.

Since it is non-destructive, for XRF analysis to be conducted the sampling team would only need permission to access the site. Most sampling locations of interest are on the exterior of structures. If available, providing approximate construction dates for buildings would be helpful. For collection of samples for traditional chemical analysis, the sampling team would need permission to access the site and approval of the proposed procedure to obtain samples and reseal the location from which the material was collected.

8. *On the basis of the above information, should the project include field sampling and chemical analysis of materials from Bay Area structures? Three options that can be considered are:*
   a) *Should the sampling program take a traditional sampling approach of removal of a small amount of a building material of interest and subsequent analysis for PCBs by a qualified laboratory?*
   b) *If a traditional sampling approach is not possible but some sampling component is, should the sampling program comprise a non-destructive field screening program capable of indicating—but not proving—PCBs presence?*
   c) *If no sampling component is possible, what alternative approaches can be used to meet the Grant Project's goals for the first phase of the project?*

   The consulting team recommends a combination of options (a) and (b)—field screening with XRF and confirmation sampling with PCBs measurements by an analytical laboratory. Further investigation of the XRF method (as discussed above) is needed to determine whether XRF can be validated sufficiently to provide meaningful information without confirmatory chemical analysis of every sample. The consulting team further recommends that this sampling be supplemented by additional investigation into methods of identifying and/or inventorying Bay Area structure types in classes likely to contain PCBs, historic PCBs-containing building materials use patterns, and the growing experience elsewhere with these materials (as reflected by interviews and additional literature reviews).

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APPENDIX A - Methodology for Gauging Importance of Building Materials as a Source of PCBs

A.1 Introduction

The purpose of this appendix is to summarize methods that may be used to estimate the total PCB mass loading in buildings, and lay the framework to model PCB loadings to urban runoff from historic building materials.

A.2 Estimating the Inventory of PCBs in Building Materials in Bay Area Structures

Without sampling, conducting an inventory of PCBs in Bay Area structures is a significant challenge. Suggested steps for the process are:

- Estimate the amount of PCBs in building materials used in the Bay Area;
- Determine how these materials were used in different building designs;
- Divide structures into groups with similar PCB-containing material use;
- Estimate the number of structures in the Bay Area belonging to each group.

A.2.1 Estimate the Amount of PCBs in Building Materials Used in the Bay Area

As discussed in Section 2.1, there are literature studies available containing analysis of PCBs levels in caulking, sealants, paints and coatings. These values can be used to estimate the PCBs levels in building materials used in the Bay Area.

It is also worth noting that studies of paints and coatings often do not take into consideration that PCBs leach into the surface below. An article comparing Swedish building studies (Ljung, 2002) showed that PCBs seeped up to 200 mm into concrete. A significant decrease in PCB concentration was seen at 2 mm of depth, where three studies showed that PCB concentrations were 4% to 0.18% of the surface PCB content. In renovating buildings that contain PCBs, therefore, a slightly greater concentration of PCBs may be exposed and susceptible to entering stormwater than would be estimated using PCB surface concentration data.

A.2.2 Determine How these Materials Were Used in Different Building Designs

Caulking containing PCBs was used in the 1950s through the 1970s to seal window frames, masonry joints, and cement joints. Paints and coatings containing PCBs were used in the 1930s through the 1970s. They were primarily applied to concrete or metal surfaces. The coatings served as waterproofing agents, anti-fouling agents, and fire retardants.

Many of the studies performed examined institutional buildings, but Herrick's study of buildings in Boston suggests that PCBs are also prevalent in residential buildings constructed in the 70s (Herrick et al., 2005). Conducted in the U.S., this study may most closely reflect the PCB content of buildings in the Bay Area.

In Australia, government reports indicate that prior to 1980, PCB-containing caulk was used to seal expansion joints in nearly every concrete structure; for example, PCB-containing caulk was used in office buildings, bridges, parking structures, entertainment facilities, and water storage tanks (Government of Western Australia 2002). Government data indicates that these sealants may contain as much as 30% PCBs.

A.2.3 Divide Building/ Structure Inventory into Groups with Similar PCB-containing Material Use

As many studies focused on institutional buildings, it would be best to first divide buildings into residential and institutional use to apply the appropriate data. Second, buildings should be categorized by their year of construction. The following periods are recommended to reflect changes in PCB regulations (see discussion of manufacturing and regulatory changes in Section 1):

- 1929 to 1957
- 1957 to 1977
- 1977 to 1984

Finally, as Table 1 (in Section 2) contains significant data for sealants and coatings used on concrete and brick, it would be ideal to identify buildings constructed of these materials. This information, however, may prove difficult to obtain for large regions.

A.2.4 Estimate the Number of Buildings in the Bay Area Belonging to Each Group

Building and planning departments for various municipalities were contacted but were unable to offer summary statistics of building types (i.e. concrete, masonry) or number of buildings constructed during a specific time period. It was common for departments in charge of building codes to have individual permits online for buildings dating back in the 1980s. Older permits could be retrieved in hard copy, but considerable time would be required to create summary statistics. In some areas, pre 1950s or pre 1940s records may have been compiled to document historic buildings. Palo Alto, for example, has a survey of older buildings available at their development center. Architectural societies or historic building societies have likely kept records for San Francisco and would be a good source of information to investigate.

A more promising source is County Assessor's Offices, where records are kept that include address, year built, building type or use, and, in some cases, construction type. In general, the information is available online but is not easily searchable. However, there is a service called ParcelQuest (www.parcelquest.com), which provides information to assessors either through online searches or on CDs. The databases can be queried by year and building use for 8 of the 9 Bay Area counties (Santa Clara County does not include information on year built). Construction type is not readily available but in some cases may be inferred by building use codes. Building uses are in several categories including residential, multi-family residential, commercial, industrial, rural, institutional, improved commercial (includes parking garages). CDs can be purchased for 3 counties for approximately $600 or for the 9 Bay Area counties for approximately $1,600.

The Association of Bay Area Governments (ABAG) was also suggested as a source for obtaining information regarding building inventories. ABAG can provide information on public buildings including age and type of construction if the building is insured through ABAG. This information could be useful in identifying individual buildings that may be candidates for test cases.

A.3 Estimating the Runoff of PCBs from Bay Area Structures

Many studies have investigated the indoor air quality of buildings containing PCBs. These studies have found that the concentration of PCBs in air is dependent on the type of PCB mixture used (isomers with lower molecular weights volatize more), the outdoor air temperature, and the amount, surface and position of the PCB-containing material in the room. During cleaning or removal of PCB containing materials the air concentration of PCBs increases. Relatively few studies, however, have tried to measure any deposition as a result of volatized PCBs.

In the U.S., two studies were found that suggest deposition is a significant pathway of PCB pollution. Herrick's study of residential buildings in Boston measured dust from building ventilation that contained <1 to 81ppm of PCBs. Therefore, sites where no demolition or remodeling was taking place still were polluted with PCBs. A study of the Great Lakes (Eisenreich et al., 1981) found that 60 to 90% of PCBs entered the lake through atmospheric deposition.

In one Swedish study (Astebro, et al., 2000), PCB concentrations in soil were taken after sealant was removed from the concrete walls of a seven-story apartment building. In this case, an oscillating knife was used to remove the sealant and 1 to 2 mm of the concrete below due to leaching as discussed previously. A high efficiency vacuum was attached to the tool to trap PCB vapors. After the sealant was removed the walls were pressure washed clean and drippings were also tested for PCBs. Soil samples contained 90 to 2500 ppb PCBs by dry weight and the drippings contained 94 to 850 ppb PCBs. Soil concentrations decreased significantly 3 meters away from the apartment building.

In the absence of disruptions such as power washing, PCBs have also been measured in soils near buildings with PCB-containing sealants. PCBs were detected in the soil surrounding an eight-story apartment building in Finland (Hellman, 2000) with PCB-containing caulking. The upper layers of soil (0-0.3m deep) contained high concentrations. Distance from the building also affected concentration as shown in Table A-1.

Table A-1. Concentrations of PCBs in Soil at Increasing Distance from Apartment Building with PCB-Containing Caulking

Distance From Building (meters)	Concentration of PCBs at 0.1 meter Depth (ppm)
0.1	6.62
0.5	1.3
1.0	0.71
2.0	0.15
10.0	0.04

Source: Hellman, 2000.

Another US study was conducted in 2006, with the objective of evaluating PCB levels in soil surrounding buildings where PCB-containing caulk was still in place (Herrick, 2007). A university housing unit and two schools were the subject of the study. These building were typical of masonry buildings constructed in the 1960s and 1970s. Samples were collected of caulking from the outside of the buildings and soil from approximately 30 cm away from the building foundations. PCB levels in the caulking ranged from10,000 – 36,000 mg/kg. In the soil, PCB levels ranged from 3.3 – 34 mg/kg.

In the study of sealant removal by Astebro, a total estimate of PCB runoff from the removal of 600m of caulking was 2-20 grams (Astebro et al., 2000). Other known studies have not considered the runoff from removal of PCB containing products. There are also no known studies of runoff from gradual deposition of PCBs on surface near PCB containing materials. Table A-1 suggests that PCB deposition on soil in the absence of cleaning or material removal may be low, but there is insufficient data to estimate the long term impact of regular runoff from this soil. Samples of soil concentrations will be influenced by the timing and the magnitude of the last rainfall, which may have washed away the upper layer of soil.

The initial goals of this project are directed towards estimating the amount of PCBs in buildings in the Bay Area. These goals include classifying buildings in the Bay Area into groups that would have similar types and amounts of PCB containing materials, estimating the number of buildings in each of these groups, and estimating the average amount of PCBs in the materials the buildings contain. With this information, pollutant loads entering the bay from PCB removal and washing could be estimated. Variables that should be considered would be estimates of:

- The percentage of different classes of buildings that are removing PCB containing materials or washing surfaces with PCB-containing paints and sealants;
- The frequency of any washing;
- The number of businesses that remove or wash PCB containing materials which allow particulate matter and water to leave the work site.

Rough estimates of the weight of caulking in a building have been made in multiple studies by measuring the length of a seam and estimating the depth of caulking in the seam. The percentage of different building classes removing or washing PCB containing materials could be quantified by asking the owners of properties suspected to contain PCBs if they have employed people to conduct these activities. Finally, identified businesses could be anonymously surveyed about how they dispose of waste and how they determine if waste may be hazardous.

A.4 Recommendations

This section discusses developing an approach to estimating the inventory of PCBs within building materials and the potential for their conveyance through urban runoff. As discussed in Section 1.6, the purpose of such an approach is to ensure that data collected in this project is appropriate for evaluating the effectiveness of BMPs in reducing PCB load contributions from building materials to runoff. In order to provide a baseline for the investigation of BMPs and to determine which sources may present the greatest opportunities for mitigation through BMPs, we recommend further developing estimates of the inventory of PCBs in building materials in the Bay Area through the following steps:

- Continue to explore approaches to developing inventories of buildings that are likely to have been constructed with PCB-containing materials. This would include obtaining the assessor inventories described above for 2-3 representative Bay Area counties and using them to estimate the number of structures within the county that are likely to contain PCBs.

- Develop approaches to estimating the amount of caulking, sealant, paints and coatings that may be in use in different types of buildings. Using ABAG insurance records, it may be possible to identify a few buildings that could be used to ground truth approaches to determining the amount of materials that have been used within a given building (i.e., number of expansion joints, feet of caulking used, number of windows, etc., per square foot of building space). This would not involve collecting samples for PCB analysis but simply evaluating how much of the types of materials that may contain PCBs are found in the building.

- Use literature values and any results from local sampling that may be conducted to estimate the amount of PCBs in the building materials. These values in combination with the number of buildings in a category and the amount of targeted building materials can be used to estimate quantities of PCBs that may be present in different categories of buildings. These estimates can be used to determine if certain types of buildings are more significant sources of PCBs. The more significant sources would be the focus of future BMP development. In addition, identifying larger sources may inform efforts to develop effective BMPs.

- Literature values may also be useful for estimating the quantities of PCBs released to soil near buildings. These estimates may be useful in informing BMP development.

APPENDIX B – PCB Analytical Methods

Quantification of PCBs can be conducted via a variety of EPA approved analytical methods and can be reported in one of two formats, as sum of Aroclors or congeners. The following discussion describes the benefits and drawbacks of the reporting formats, and references specific analytical methods used to generate the results.

B.1 Aroclor Mixture Analysis

The most simplistic method for quantifying PCBs in the laboratory is accomplished using characteristic Aroclor pattern recognition followed by routine peak quantification with a GC-ECD. Aroclor analysis is appropriate for consideration for this project since, in most cases, PCBs were likely added to building materials as a single Aroclor mixture and interference from other PCB sources to these materials (which would increase uncertainty) is not expected. Aroclor analysis provides an estimate of total PCBs in the material based on its Aroclor content and is the least expensive analytical method for PCBs available.

For this project, potential disadvantages of Aroclor analysis include false negatives and data comparability. False negatives may result if degradation of the PCBs in the material has occurred in the more than 30 years since construction and may prevent accurate identification of the Aroclor profile (R. Herrick, personal communication). Severe degradation also has the potential to increase uncertainty in the concentration by either underestimating or overestimating the PCB content. Use of Aroclor analysis for the quantification of PCBs will also limit comparability to other studies. Congener-specific analysis was used in the previous assessments of PCBs in building materials and in the majority of studies researching PCBs in the environment. Previous studies of PCBs in building materials used congener-specific analysis because it was suspected that the pattern might not be recognizable due to degradation over the 35-55 years since application and because the data were needed for risk assessments (R. Herrick, personal communication, June 2007).

B.2 Congener-Specific Analysis

Determination of PCB content can also be accomplished by summing the concentrations of the individual PCB congeners in each sample. Congener-specific analysis is valuable because it is a more accurate method for total PCB content (particularly if it includes congeners that are not quantified in the Aroclor analysis) and the data can be used to determine if degradation of the Aroclor mixture has occurred. Congener-specific analysis is generally more time-consuming and costly; therefore it is more expensive than Aroclor analysis.

Several methods are available for congener-specific analysis and the most common methods are listed in Table B-1. As noted previously, the Swiss and Boston studies of PCBs in building materials used congener-specific analysis to estimate total PCBs. A list of potential sampling scenarios, including both screening and traditional sampling and analysis options, and their estimated costs are listed in Table B-2.[8]

B.3 Recommendations – Traditional Chemical Analysis

If a regional sampling project employing traditional chemical analysis is conducted, we recommend a combination of field screening with XRF technology in combination with confirmation sampling by congener-specific analysis using GC-MS to be conducted in partnership with the analytical laboratory at East Bay Municipal Utility District (EBMUD).

Use of the XRF analyzer allows for identification of chlorinated compounds of interest in each building, which will guide sampling and potentially reduce the number of samples collected per building. Even if detection limits are slightly higher than estimated and the analyzer can only be used in a subset of buildings and structures (i.e., weekly rental), XRF analysis will insure that we are sampling the materials that contain chlorinated compounds in the highest concentrations. Use of this approach may allow for a larger number of structures, buildings, locations within buildings, and building materials to be screened for possible contamination of high concentrations of PCBs. XRF may be particularly valuable for surveying structures (e.g., parking garages, bridges) since less is known about PCB contamination in materials other than those in buildings. It is unclear whether XRF would provide satisfactory screening results for paint, which may have PCBs concentrations that are below XRF detection limits.

[8] Table B-2 does not include field personnel or planning costs associated with different scenarios, such as XRF validation, permitting for sampling access, or resealing and/or inspection of locations where sample material has been removed.

In addition to the XRF field screen, if a regional sampling project is conducted, we recommend that all samples be analyzed for PCB content using low resolution GC-MS. Using EPA method 8270D, congener-specific analysis and Aroclor mixture determination is accomplished in a single instrument run. Congener-specific analysis provides more accurate measurements of PCB content than the Aroclor method and allows for direct comparability with not only previously published studies on PCBs in building materials, but also with PCBs in other environmental matrices (i.e., stormwater runoff, Bay water and sediment, and biological materials). If the 40 congeners measured by the San Francisco Bay Regional Monitoring Program (RMP) are quantified, direct comparisons of the results can be made to the Swiss studies, other RMP data, and many other studies of PCBs in the environment. Comparison of these data to the Boston study will also be feasible (34 of the 55 congeners quantified in the Boston study are included in the 40 RMP congener list). The 40 RMP congeners also include the major congeners in the Aroclor mixtures. Additionally, congener-specific analysis of these materials may be useful for incorporation into human health risk assessments.

Unlike congener-specific analysis using GC-ECD, congener-specific analysis using GC-MS provides positive identification of the PCB congeners and is less subject to potential interferences in the material matrix. In addition, these data can be directly compared to other RMP data, which are also analyzed using GC-MS methods. Correlations between XRF data and congener-specific data will also be beneficial for assessing the effectiveness of XRF as a rapid screening tool for future studies of PCBs in building materials. The disadvantage of this option is that GC-MS methods are higher in cost than Aroclor and congener-specific analysis using GC-ECD. A sufficient sample mass will need to be collected for laboratory analysis (5-25 g) and archives (5-25g).

The estimated cost per sample for GC-MS analysis is $150 through EBMUD. Assuming 9 samples are collected at 34 structures (306 samples) and an XRF analyzer is rented for 2 weeks ($1900/week), the estimated analytical cost using this option is $49,700 (Table B-2). EBMUD has experience with this analytical method and has previously analyzed PCBs in sealants and paints. EBMUD estimates throughput of samples at approximately 60 samples per week.

During implementation of the pilot and region-wide projects, sampling of PCB-containing materials will occur. The information in this memorandum and any new information obtained subsequently should be reviewed as part of the final determination of the appropriate sampling methods to use. Our preliminary recommendation is that all samples be analyzed for PCB content using low resolution GC-MS that quantifies at least the 40 RMP congeners.

Table B-1. Summary of Available Analytical Methods for Determining PCBs in Building Materials

Analytical Method	Total PCB reported as:	Est. Cost	Detection Limits (ng/g or ppb)	Advantages	Disadvantages
X-Ray Fluorescence Spectrometry (XRF)	% Cl	Purchase: $30,000 Rental: $575/day $1900/week $4900/month	1,000,000-5,000,000 (0.1-0.5%)	- Rapid, on-site screening tool - Targets high concentration materials - Can screen large # of samples	- High detection limits - False positives likely - False negatives possible if sampling is not conducted correctly
Standard Aroclor Mixtures EPA 8082 GC-ECD	Aroclor concentration	Per sample $75 (EBMUD) $95 (CAS) $225 (AXYS)*	20 (EBMUD) 10 (CAS) 100-500 (AXYS)	- Least expensive lab method	- Potential for false negatives due to degradation of Aroclor over time - Data comparability may be an issue
'Low-level' Aroclor Mixtures EPA 8082 GC-ECD	Aroclor concentration	Per sample $145 (CAS)**	1.7 (CAS)	- More sensitive than standard Aroclor method	- More expensive than standard Aroclor method
Individual PCB Congeners EPA 8082 GC-ECD	Sum of congeners (May request which PCBs to be quantified)	Per sample $125 (EBMUD; 40 RMP) $175 (EBMUD; 40 RMP and separate Aroclor analysis) $325 (CAS; 59 cong.)**	2-15 (EBMUD) 0.03-0.3 (CAS)	-No data comparability issues -More accurate method for total PCBs	-Higher cost than Aroclor method
Individual PCB Congeners EPA 608A/680 or 8270D GC-LRMS	Sum of congeners	Per sample $150 (EBMUD; 8270D; 40 RMP) $450 (AXYS; 608A/680; 90 cong.)**	500 (EBMUD) 0.1-0.5 (AXYS)	-No data comparability issues -More accurate method for total PCBs -Higher specificity/Positive id of PCBs -Includes Aroclor identification -Less subject to false positives than congener analysis by GC-ECD	-Higher cost
Individual PCB Congeners EPA 1668/A GC-HRMS	Sum of congeners (May request which PCBs to be quantified)	Per sample $700 (AXYS; 40 RMP cong.) $925 (AXYS; 209 cong.)** $1200 (CAS; 209 cong.)**	0.05-0.2 (AXYS) 0.4-50 (CAS)	-No data comparability issues -More accurate method for total PCBs -Higher specificity/Positive id of PCBs -Most sensitive method -Less subject to false positives than congener analysis by GC-ECD	- Higher cost

* The AXYS Aroclor method is only in draft form; detection limits are estimates. ** Cost may be adjusted if more/fewer congeners requested.
AXYS = AXYS Analytical Services; CAS = Columbia Analytical Services; EBMUD = East Bay Municipal Utility District Laboratory (not a contract laboratory, but may be able to provide PCBs analysis for this phase of the Grant Project).

Table B-2. Potential Low Cost Sampling Scenarios for a Regional Sampling Study (Assumes 9 samples/structure)

		XRF	**Aroclors GC-ECD Method 8082**	**Congeners GC-ECD Method 8082**	**Congeners GC-MS Low Resolution (LR) Method 8270D**	**Congeners GC-MS High Resolution (HR) Method 8270D**	
		$3800	$75/sample	$125/sample	$150/sample	$700/sample	
Scenario	*# Structures*		*# Samples*	*# Samples*	*# Samples*	*# Samples*	*Total Cost*
1	34	Yes	0	0	306	0	$49,700
2	37	No	0	0	333	0	$49,950
3	37	Yes	333	167	0	0	$49,588
4	40	No	360	180	0	0	$49,500
5	31	No	279	140	28	0	$42,548
6	27	No	243	122	0	24	$50,423