Health Consultation

Evaluation of Soil Contamination
Dallas Avenue Soil Removal Site
Seattle, King County, Washington

September 21, 2005

Prepared by

The Washington State Department of Health
Under a Cooperative Agreement with the
Agency for Toxic Substances and Disease Registry

Washington State Department of Health

DOH 333-112 September 2005

Foreword

The Washington State Department of Health (DOH) has prepared this health consultation in cooperation with the Agency for Toxic Substances and Disease Registry (ATSDR). ATSDR is part of the U.S. Department of Health and Human Services and is the principal federal public health agency responsible for health issues related to hazardous waste. This health consultation was prepared in accordance with methodologies and guidelines developed by ATSDR.

The purpose of a health consultation is to identify and prevent harmful human health effects resulting from exposure to hazardous substances in the environment. Health consultations focus on specific health issues so that DOH can respond to requests from concerned residents or agencies for health information on hazardous substances. DOH evaluates sampling data collected from a hazardous waste site, determines whether exposures have occurred or could occur, reports any potential harmful effects, and recommends actions to protect public health. The findings in this report are relevant to conditions at the site during the time of this health consultation, and should not necessarily be relied upon if site conditions or land use change in the future.

For additional information or questions regarding DOH or the contents of this health consultation, please call the health advisor who prepared this document:

Elmer Diaz
Washington State Department of Health
Office of Environmental Health Assessments
P.O. Box 47846
Olympia, WA 98504-7846
(360) 236-3357
1-877-485-7316
Website: www.doh.wa.gov/consults

For more information about ATSDR, contact the ATSDR Information Center at 1-888-422-8737 or visit the agency's Web site: www.atsdr.cdc.gov/.

Glossary

Acute	Occurring over a short time [compare with **chronic**].
Agency for Toxic Substances and Disease Registry (ATSDR)	The principal federal public health agency involved with hazardous waste issues, responsible for preventing or reducing the harmful effects of exposure to hazardous substances on human health and quality of life. ATSDR is part of the U.S. Department of Health and Human Services.
Cancer Risk Evaluation Guide (CREG)	The concentration of a chemical in air, soil or water that is expected to cause no more than one excess cancer in a million persons exposed over a lifetime. The CREG is a *comparison value* used to select contaminants of potential health concern and is based on the *cancer slope factor* (CSF).
Cancer Slope Factor	A number assigned to a cancer causing chemical that is used to estimate its ability to cause cancer in humans.
Carcinogen	Any substance that causes cancer.
Chronic	Occurring over a long time (more than 1 year) [compare with **acute**].
Comparison value	Calculated concentration of a substance in air, water, food, or soil that is unlikely to cause harmful (adverse) health effects in exposed people. The CV is used as a screening level during the public health assessment process. Substances found in amounts greater than their CVs might be selected for further evaluation in the public health assessment process.
Contaminant	A substance that is either present in an environment where it does not belong or is present at levels that might cause harmful (adverse) health effects.
Dermal Contact	Contact with (touching) the skin (see route of exposure).
Dose (for chemicals that are not radioactive)	The amount of a substance to which a person is exposed over some time period. Dose is a measurement of exposure. Dose is often expressed as milligram (amount) per kilogram (a measure of body weight) per day (a measure of time) when people eat or drink contaminated water, food, or soil. In general, the greater the dose, the greater the likelihood of an effect. An "exposure dose" is how much of a substance is encountered in the environment. An "absorbed dose" is the amount of a substance that actually got into the body through the eyes, skin, stomach, intestines, or lungs.
Environmental Media Evaluation Guide (EMEG)	A concentration in air, soil, or water below which adverse non-cancer health effects are not expected to occur. The EMEG is a *comparison value* used to select contaminants of potential health concern and is based on ATSDR's *minimal risk level* (MRL).

Environmental Protection Agency (EPA)	United States Environmental Protection Agency.
Exposure	Contact with a substance by swallowing, breathing, or touching the skin or eyes. Exposure may be short-term [**acute exposure**], of intermediate duration, or long-term [**chronic exposure**].
Hazardous substance	Any material that poses a threat to public health and/or the environment. Typical hazardous substances are materials that are toxic, corrosive, ignitable, explosive, or chemically reactive.
Indeterminate public health hazard	The category used in ATSDR's public health assessment documents when a professional judgment about the level of health hazard cannot be made because information critical to such a decision is lacking.
Ingestion	The act of swallowing something through eating, drinking, or mouthing objects. A hazardous substance can enter the body this way [see route of exposure].
Ingestion rate	The amount of an environmental medium that could be ingested typically on a daily basis. Units for IR are usually liter/day for water, and mg/day for soil.
Inhalation	The act of breathing. A hazardous substance can enter the body this way [see **route of exposure**].
Inorganic	Compounds composed of mineral materials, including elemental salts and metals such as iron, aluminum, mercury, and zinc.
Media	Soil, water, air, plants, animals, or any other part of the environment that can contain contaminants.
Minimal Risk Level (MRL)	An ATSDR estimate of daily human exposure to a hazardous substance at or below which that substance is unlikely to pose a measurable risk of harmful (adverse), noncancer effects. MRLs are calculated for a route of exposure (inhalation or oral) over a specified time period (acute, intermediate, or chronic). MRLs should not be used as predictors of harmful (adverse) health effects [see **reference dose**].
Model Toxics Control Act (MTCA)	The hazardous waste cleanup law for Washington State.

Oral Reference Dose (RfD)	An amount of chemical ingested into the body (i.e., dose) below which health effects are not expected. RfDs are published by EPA.
Organic	Compounds composed of carbon, including materials such as solvents, oils, and pesticides that are not easily dissolved in water.
Parts per billion (ppb)/Parts per million (ppm)	Units commonly used to express low concentrations of contaminants. For example, 1 ounce of trichloroethylene (TCE) in 1 million ounces of water is 1 ppm. 1 ounce of TCE in 1 billion ounces of water is 1 ppb. If one drop of TCE is mixed in a competition size swimming pool, the water will contain about 1 ppb of TCE.
Reference Dose Media Evaluation Guide (RMEG)	A concentration in air, soil, or water below which adverse non-cancer health effects are not expected to occur. The EMEG is a *comparison value* used to select contaminants of potential health concern and is based on EPA's oral reference dose (RfD).
Route of exposure	The way people come into contact with a hazardous substance. Three routes of exposure are breathing [inhalation], eating or drinking [ingestion], or contact with the skin [dermal contact].
Volatile organic compound (VOC)	Organic compounds that evaporate readily into the air. VOCs include substances such as benzene, toluene, methylene chloride, and methyl chloroform.

Summary and Statement of Issues

The Washington State Department of Health (DOH) conducted this health consultation at the request of the Washington State Department of Ecology (Ecology). The purpose of the health consultation is to evaluate whether the contaminants found in soil at the Dallas Avenue South Soil Removal site pose a health concern to residents in the community. DOH prepares health consultations under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR).

Background

The Dallas Avenue South Soil Removal site is located in a mixed residential, commercial, and industrial area in the South Park community of Seattle, Washington (Figure 1). The site includes Dallas Avenue South to approximately 14th Avenue South, 17th Avenue South between Dallas Avenue South and South Donovan Streets, South Donovan Street between 17th Avenue South and Dallas Avenue South as well as some residential properties (Figure 2). Portions of South Donovan Street, 17th Avenue South, and Dallas Avenue South were unpaved until December 2004. The northern portion of Dallas Avenue South and 16th Street had some pavement but the road shoulder was not well maintained (Figure 3). These areas are now covered under asphalt as part of the interim remediation activities performed by Seattle Public Utilities in November, 2004.

Polychlorinated biphenyls (PCBs), metals, and petroleum compounds were discovered in surface and/or subsurface soils on and adjacent to the site streets. Some contaminants were also found on residential properties. The source of these contaminants has not been identified, but some possible sources are the former Malarkey Asphalt Company where these types of contaminants were detected during past environmental investigations, the former Basin Oil facility where waste petroleum products were handled, and the City of Seattle, which may have applied oil to the unpaved streets in the past.[1]

The city conducted interim actions in December 2004 to eliminate the community's potential exposure to the soil contaminants. Storm water control measures were taken to prevent contaminated street soils from being transported along the streets. This work was followed with the placement of asphalt onto the unpaved streets.[2] In June 2005, Seattle Public Utilities (SPU) removed PCBs found in two residential front yards on 17th Avenue South and also removed gravel recently found to have elevated PCBs in the roadway shoulder on 16th Avenue South between Dallas Avenue South and South Cloverdale Street. Crews replaced the road shoulder gravel with clean gravel.[3]

Some community members are concerned about the possibility of PCB contaminated soil having been tracked into their homes over the years and posing a possible health threat.

Environmental Investigations

City of Seattle

The City of Seattle (City) collected surface soils samples (1 to 6 inches) on and adjacent to the site streets, and analyzed them for diesel and oil range petroleum hydrocarbons, polychlorinated biphenyls (PCBs), and some metals in July 2004. A number of the samples contained diesel and oil range petroleum hydrocarbons and PCBs (Aroclor 1260) above the Model Toxics Control Act (MTCA) Method A soil cleanup levels.[4,5]

The city conducted additional surface soil sampling in September through December 2004 to continue characterizing the extent of the soil contamination. Some soil samples were also collected from 6-inches to 5-feet below ground surface (bgs) to determine the vertical extent of contamination. The samples during these additional sampling rounds were predominantly analyzed for Aroclors. Some additional petroleum analysis was also conducted in November 2004. No reports are available at this time for the November petroleum sampling rounds. Consequently, there is some uncertainty about the quality of these data. Aroclor 1260 was the only Aroclor detected during these additional sampling rounds, and some of the detected Aroclor levels were above the MTCA Method A soil cleanup levels.[4,5] However, it should be noted that some of the Aroclor detection limits were elevated so it is possible that other Aroclor compounds could be present.[4]

The only data validation summaries available for the data collected by the city are for the July, September, October, and November 2004 sampling rounds. Consequently, there is some uncertainty surrounding the December data quality. The data validation summary for the July 2004 data set indicates that the "data are of known quality and acceptable for use as qualified." [6] The data validation summary for the second round of samples indicates that the "PCB Aroclor data are acceptable for use, as qualified." It should be noted, however, that there were some low matrix spike and laboratory control samples recoveries of Aroclor 1016, which may indicate a low bias of these results.[7]

Tables A1 and A2 in Appendix A provide a summary of the City of Seattle soil sampling results for the site. Figure 3 shows a map of the City of Seattle's soil sample locations at the site.[8]

Public Health – Seattle & King County (PHSKC)

PHSKC collected soil samples on October 27, 2004, from the two residential yards and gardens located along 17th Avenue South located near Dallas Avenue South where elevated levels of PCBs were detected adjacent to the street. The samples were collected from one-inch and four-inch bgs. These soil samples were also analyzed for Aroclor compounds. Like the City of Seattle samples, Aroclor 1260 was the only reported Aroclor compound. [4] Four of the six samples collected in the two residential yards exceeded the Washington State Model Toxics Control Act (MTCA) Method A cleanup level for PCBs (1.0 mg/kg) (Table 2). One of the garden samples was slightly below the MTCA cleanup levels.[5]

PHSKC collected some additional surface soil samples in the nearby community on November 17, 2004. These samples were also analyzed for Aroclors.[9] Aroclor 1260 was the only Aroclor detected but none of the results exceeded the MTCA Method A soil cleanup level.[9,4,5]

No data validation report is available for the October PHSKC data set, so there is some uncertainty about the data quality, which could result in the over or under-estimation of risk.[2] DOH did review the chromatograms associated with the October PHSKC data and found that low levels of Aroclor 1254 might also be present. [9] However, the Aroclor 1254 concentration is likely small and would not significantly affect the total PCB levels. [10] No data validation report was provided for the November 2004 data. Figures 2 and 4 show a map of the street and yard sample locations at the Dallas Avenue South site. [8] Appendix A, Tables (A1 and A2) shows a summary of contaminants found in soil.

PHSKC collected six surface wipe samples on February 24, 2005, inside the homes where elevated levels of PCBs were detected in the residential soil and front yards. These wipe samples were also analyzed for Aroclor compounds. No PCBs were detected in the house dust.[11]

Discussion

PCBs, lead, arsenic, and total petroleum hydrocarbons (TPHs) have been found in street soils and rights-of-way in the vicinity of Dallas Avenue. PCBs were also detected in residential soils at levels of potential health concern (Table 1). The following discussion will address the exposure and potential health hazards associated with these contaminants at the Dallas Avenue site.

Selecting contaminants of Concern

To choose a contaminant of concern (COC), DOH selected the maximum contaminant concentrations and compared them with health comparison values (Appendix A, Table A1). ATSDR considers site-specific exposure factors to ensure selection of appropriate health comparison values. If the maximum concentration for a chemical was greater than the health comparison value, the chemical was selected for additional data review, as a COC. Other factors included in the selection of the COCs included the number of samples above the minimum detection limit, the number of samples with detections above an acute or chronic health comparison value, and the potential for exposure at the sampling location. Aroclor 1260 was the only COC found at the different locations in the residential yards and garden soils at the Dallas Avenue site (Table, 1). Other COCs such as TPHs (diesel and oil), lead and arsenic were not considered for further evaluation because the affected areas such as the Dallas streets and road shoulders were covered with asphalt and gravel, respectively.

Table 1. *2004 Aroclor 1260, TPH-Diesel, and TPH-Oil field screening data, Dallas, Avenue, Seattle, Washington.*

Location	Contaminant	Sample Depth	Maximum Concentration (ppm)	COC chosen (residential scenario)
Street Soil	Aroclor 1260	Surface Subsurface	480 NA	No
	TPH - Diesel	Surface Subsurface	4,600 NA	No
	TPH - Oil	Surface Subsurface	9,500 NA	No
Right-of-Way Soil	Lead	Surface Subsurface	897 NA	No
	Arsenic	Surface Subsurface	200 NA	No
Residential Properties	Aroclor 1260	Surface Subsurface	46.0 NA	**Yes**

NA: not available
COC: Contaminants of concern

Exposure Pathways

The public health implications associated with a site depend on two factors: the contaminants of concern and how people come into contact with the contaminant (i.e., exposure pathways). Contaminants of concern are chemicals found at a site in high enough concentration to warrant further evaluation. Not all chemicals found at a site become a chemical of concern and not all chemicals of concern represent a health hazard.

In order for an exposure to a contaminant of concern to occur, all the elements of an exposure pathway must be in place. Exposure pathways are divided into completed and potential pathways and can be current, past, or future exposures. A completed exposure pathway consists of five elements: a contaminant source; environmental media that transport contaminants from the source (e.g., soil, groundwater, air); a point where people contact contaminated media (e.g., garden soil, tap water); route of exposure by which a contaminant enters the human body (e.g., inhalation, ingestion, dermal contact or absorption); and a receptor population that is exposed to contaminants. A potential exposure pathway exists when some, but not all, of the five elements are present and the potential exists that the missing element(s) have been present, are present or will be present in the future.

A completed exposure pathway for soil currently exists at the Dallas Avenue site. Although several contaminants such as TPH-diesel, TPH-oil, lead and arsenic were found at levels of concern on road shoulders, composite areas, right-of-ways (ROWs) and catch basins at Dallas Avenue site (Table 1 and Appendix A, Table A1), exposure to these contaminants is not evaluated in this document because affected areas were covered with asphalt. It is much more likely for frequent and long-term exposure to contaminants in soil occurring in yard soils than in road soils. Furthermore, interim actions have not yet been undertaken in impacted residential yards. Therefore, this document will focus on potential health impact related to exposures to PCBs in residential soils.

Residential Soils

Comparison values used in this document included the Washington's hazardous waste cleanup law, the Model Toxics Control Act (MTCA), ATSDR's Cancer Risk Evaluation Guide (CREG), and ATSDR's Environmental Media Evaluation Guide (EMEG) (Table 2). These comparative values are very conservative levels, at which ATSDR believes is safe for exposure. PCBs levels in soils were compared to ATSDR CREGs which are based on continuous lifetime exposure (75 years).

Some of the levels of PCBs detected were above ATSDR's (CREGs) comparison values for cancer which is 0.4 ppm. Table 2 describes the maximum concentration of contaminants found in residential soil in relation to their comparison values.

Aroclor 1260 is the only contaminant of concern found in residential yards and garden soils at the Dallas Avenue site. Table 2 lists Aroclor 1260 as the contaminant of concern found at the different locations in the residential yards and garden soils at the Dallas Avenue site. Other COCs were not analyzed by the City of Seattle and PHSKC at the residential properties where high levels of PCBs were found. These contaminants might be present in residential soil but it is uncertain since no information was available to address this concern.

Twenty-five properties were tested for PCBs in soil. There were 23 properties with PCB levels lower than 0.4 ppm.[12] Two residential properties had PCBs in soil at levels of health concern (Table 2).

Exposure Routes and Pathways at Dallas Avenue Site

Although everyone is exposed to small levels of PCBs, certain people may have higher levels of PCB exposure because of their eating habits or activities. Most human exposure comes from dietary sources. For example, people who eat more fish than the general population may be exposed to more PCBs because fish are a common dietary source of PCBs.

Humans can also be exposed to PCBs in soil through the dermal, inhalation, and ingestion routes of exposure. Aroclor 1260, the PCB mixture found at the Dallas Avenue South Soil Removal site, is considered a heavy PCB compound and would not be expected to be found in the vapor phase.[13] Consequently, the people who live near the Dallas Avenue Soil Removal site could be exposed to PCBs through direct contact in which PCBs can be absorbed through the skin, or inadvertently ingested through hand-mouth-contact. PCBs in yard and garden soils might also be tracked into the homes where exposure may continue through direct contact with housedust.

Table 2. *Concentration of PCBs detected in residential yards and their comparison values at Dallas Avenue, Seattle, Washington.*

Yard Sample (YS)	Aroclor 1260 Concentration (ppm)	Non-Cancer Comparison Value (ppm)	Cancer Comparison Value (ppm)	EPA Cancer Group	MTCA Method A Cleanup level (ppm)
YS1 – yard soil	**3.4**	1.0[a]	0.4[b]	B2	1.0
YS2 – yard soil	**1.4**				
YS3 – yard soil	**0.85**				
YS4 – yard soil	**0.53**				
YS1 - garden	**0.99**				
YS2 - garden	0.17				
YS5 – yard soil	**37**				
YS6 – yard soil	**46**				

Note: Bold contaminants indicate that the maximum concentration exceeds comparison values and therefore is considered a contaminant of concern
a- ATSDR's – Child EMEG Environmental Media Evaluation Guide
b- ATSDR's – CREG Cancer Risk Evaluation Guide
EPA Environmental Protection Agency: B2 Probably Human Carcinogen
MTCA (A) – Model Toxics Control Act Method A – Soil Cleanup Level for Unrestricted Land Use
* Aroclor 1254 ATSDR comparison value was used as a surrogate for Aroclor 1260

Currently, there are no children living at the two residences where PCBs were found at high levels in yard soils. This implies that children are not currently likely to be frequently exposed to PCBs in soil at these two yards, but children may live in these residences in the future, so it is very important to consider their exposure.

Ingestion Exposure (Swallowing)

People who live near the Dallas Avenue site where PCBs have been detected may be exposed by ingesting contaminated soil. Children playing near this site or adults working near this site may be exposed to additional PCBs by ingesting contaminated soil from their unwashed hands. Young children often put hands, toys, pacifiers, and other things in their mouths, and these may have dirt or dust on them that can be swallowed. Soil sticking to homegrown vegetables will be swallowed when the produce is eaten. Adults may ingest soil and dust through activities such as gardening, mowing, construction work, and dusting.

Pica is a behavior in young children (ages 1 to 3 years) who intentionally eat non-food substances (such as dirt or paper). The amount of soil that a pica child consumes can be on the level of 5 to 10 grams per day more than typical children (~100 mg/day). Children who swallow large amounts of contaminated soil may have added risks from short-term exposure.

Consumption of PCBs in produce grown in contaminated soil is another way that PCBs can be ingested. Briefly, PCBs accumulate in plants by two mechanisms: 1) vapor-to-plant transfer; and 2) air-to-gas transfer. The primary uptake mechanism for total PCBs in plants is by vapor-to-plant transfer.[14] The lighter PCB compounds which are found at highest concentrations in the atmosphere are easily transferred by plants (e.g., lettuce and grass). On the other hand, heavier PCBs can also be adsorbed by plants in the vapor-to-plant transfer mechanism. Strong sorption of PCBs to soil organic matter and clay inhibits the uptake of PCBs in plants through the roots.[13] At the Dallas Avenue site it is unlikely that Aroclor 1260 (a heavy form of PCBs) is incorporated by plants by the vapor-to-plant transfer mechanism.

Inhalation Exposure (Breathing)

The majority of PCBs in air results from volatilization of PCBs from soil and water. PCBs at the Dallas Avenue site are not thought to be highly volatile, so exposure to PCBs through inhalation is thought to be relatively minor. Although people can inhale suspended soil or dust, airborne soil usually consists of relatively large particles that get trapped in the nose, mouth, and throat and are then swallowed, rather than breathed into the lungs.

Skin Exposure (Dermal)

People may be exposed to additional PCBs by dermal contact with PCB-contaminated soils. Experiments have shown that PCBs from contaminated soil/sediment in prolonged contact with the skin can be absorbed by the body.[15]

Evaluating Exposures

Exposure to PCBs can have numerous toxicological impacts depending on how much a person is exposed to and how long they are exposed to it (see following section for more details). The toxicological impacts of most concern for non-occupational, low-level environmental exposures to PCB such as the Dallas Avenue site are neurodevelopmental effects on children, immunologic effects, and increased lifetime cancer risk.

Noncancer

In order to evaluate the potential for *noncancer* adverse health effects that might result from exposure to PCBs in Dallas Avenue soils, estimated doses for child, older child, and adult exposures were calculated. These estimated doses were then compared to EPA's oral reference dose (RfD). An RfD is a dose below which non-cancer adverse health effects are not expected to occur (so called "safe" doses).[16] RfDs are derived from toxic effect levels obtained from human population and laboratory animal studies. This toxic effect level is divided by multiple "safety factors" to give the lower, more protective RfD. A dose that exceeds the RfD indicates only the potential for adverse health effects. The magnitude of this potential can be inferred from the degree to which this value is exceeded by the exposure dose. If the estimated exposure dose is only slightly above the RfD, then that dose will fall well below the toxic effect level. The higher the estimated dose is above the RfD, the closer it will be to the toxic effect level.

Two residential properties had detections of PCBs at levels above 1 ppm. The maximum concentration ranged from about 1.4 ppm – 46 ppm (Table 2).[17] The maximum concentration of PCBs found at the residential properties was used to estimate exposures because the site was not thoroughly characterized. The City of Seattle is planning to conduct more sampling at different depths in these properties to determine remediation activities.[18] Remediation of soils includes confirmation sampling to ensure that PCB levels have been reduced to 1 ppm or less.

The levels found in these properties exceed EPA's RfD of 0.02 µg/kg/day. The estimated dose for a child (0-5 years old) exposed to 46 ppm of PCBs in soil is 0.31 µg/kg/day, and for an older child (5-15 years old) exposed to the same levels is 0.067 µg/kg/day. The estimated exposure doses use conservative assumptions in the calculations – it assumes a fairly consistent exposure. Considering the exposure and toxicity data, there is a potential for increased risk of adverse health effects for residents on these properties from past and present exposure.

PCB exposure from ingesting soil in these properties at low levels (less than 1 ppm) is not expected to cause an increased risk of adverse health effects for a child.

Cancer Risk

Cancer risk is estimated by calculating a dose similar to that described above and multiplying it by a cancer potency factor, also known as the cancer slope factor. Some cancer potency factors are derived from human population data. Others are derived from laboratory animal studies involving doses much higher than are encountered in the environment. Use of animal data requires extrapolation of the cancer potency obtained from these high dose studies down to real-world exposures. This process involves much uncertainty.

Current regulatory practice suggests that there is no "safe dose" of a carcinogen and that a very small dose of a carcinogen could give a very small cancer risk. Cancer risk estimates are, therefore, not yes/no answers but theoretical measures of chance (probability). Such measures, however uncertain, are useful in determining the magnitude of a cancer threat because any level of a carcinogenic contaminant carries an associated risk. The validity of the "no safe dose" assumption for all cancer-causing chemicals is not clear. Some evidence suggests that certain chemicals considered to be carcinogenic must exceed a threshold of tolerance before initiating cancer. For such chemicals, risk estimates are not appropriate. More recent guidelines on cancer risk from EPA reflect the potential that thresholds for some carcinogenesis exist. However, EPA still assumes no threshold unless sufficient data indicate otherwise.[19]

This document describes cancer risk that is attributable to site-related contaminants in qualitative terms like low, very low, slight and no significant increase in cancer risk. These terms can be better understood by considering the population size required for such an estimate to result in a single cancer case. For example, a low increase in cancer risk indicates an estimate in the range of one cancer case per ten thousand persons exposed over a lifetime. A very low estimate might result in one cancer case per several tens of thousands exposed over a lifetime and a slight estimate would require an exposed population of several hundreds of thousands to result in a single case. DOH considers cancer risk to be not significant when the estimate results in less than one cancer per one million exposed over a lifetime. The reader should note that these estimates are for excess cancers that might result in addition to those normally expected in an unexposed population. Cancer risks quantified in this document are an upper-bound theoretical estimate. Actual risks are likely to be much lower.

Cancer risk associated with a chronic exposure to PCBs in Dallas Avenue soil was estimated using the maximum residential soil PCB concentration and lifetime exposure (see appendix B for exposure equations and assumptions). The cancer potency factor for ingestion used for this analysis corresponds to the upper-bound slope factor of 2 per mg/kg-day. This value is appropriate for food chain exposure, sediment or soil ingestion, and dust or aerosol inhalation.[20] Cancer risk associated with this exposure is very low (approximately equal to 7 in 100,000, or 7 excess cancers in 100,000 people exposed) (Table B3).

Housedust data

Children may be exposed to PCBs from both soil and housedust at the Dallas Avenue site. To confirm the presence of PCBs in housedust, DOH conducted sampling data at these two residential properties on May 2005. The analysis of these data will be addressed in an exposure investigation health consultation.

PCBs – General Occurrence and Toxicity

PCBs are a mixture of man-made organic chemicals. There are no known natural sources of PCBs in the environment. The manufacture of PCBs stopped in the U.S. in 1977 because of evidence that it could build up in the environment and cause toxic health effects. Although no longer manufactured, PCBs can still be found in certain products such as old fluorescent lighting fixtures, electrical devices or appliances containing PCB capacitors made before PCB use was stopped, old microscope oil, and old hydraulic oil. Prior to 1977, PCBs entered the environment (soil, water, air) during the manufacture and use of PCBs. Today, although no longer manufactured, PCBs can still enter the environment from poorly maintained hazardous waste sites, illegal or improper dumping of PCB wastes such as old hydraulic oil, leaks from electrical transformer that contain PCB oils, and disposal of old consumer products that contain PCBs.[13]

PCBs enter the environment as mixtures of individual components known as congeners. There are 209 structural variations of PCBs, which differ on the number and location of chlorine atoms on the chemical structure. Once in the environment, PCBs do not easily breakdown and can be transferred between air, water, and soil. As a result, PCBs are found worldwide. PCBs stick to soil and sediment and will not usually be carried deep into the soil with rainwater. They do not easily break down in soil and may stay in the soil for months or years. Generally, the more chlorine atoms that the PCBs contain, the more slowly they break down. Evaporation appears to be an important way by which the lighter PCBs leave the soil. As a gas, PCBs can accumulate in the leaves and aboveground parts of plants and food crops. Small amounts of PCBs can be found in almost all outdoor and indoor air, soil, sediments, surface water, and animals. PCBs bioaccumulate in the food chain and are stored in the fat tissue. The major dietary source of PCBs is fish. PCBs are also found in meats and dairy products.[13]

Most PCBs commercially produced in the U.S. are made up of standard mixtures called Aroclors. The conditions for producing each Aroclor favor the synthesis of certain congeners, giving each Aroclor a unique pattern based on its congener composition. No Aroclor contains all 209 congeners. Traditionally, PCBs analysis has focused on identifying and quantifying Aroclor levels in a sample using Gas Chromatography/Electron Capture Detector (GC/ECD). This method, which was used at the Dallas Avenue Soil Removal site, is quick and relatively inexpensive and provides an estimate of the total PCBs as a sum of the Aroclors. The Aroclor is identified by comparison to Aroclor standards. However, when released into the environment Aroclors undergo weathering, which can alter their physical and chemical composition. Weathering can make it difficult to match an environmental sample with an Aroclor pattern, leading to difficulties in identification and quantification of PCBs.[21]

Exposures to these chemicals usually occur from mixtures rather than from individual PCBs. PCBs were analyzed in the environmental media (e.g., soil) as total PCBs. PCB congener analysis was not addressed in this investigation, because PCB congener analysis is complex and expensive. Therefore, in the absence of this information DOH did focus its evaluation in the results provided by the analytical laboratory (Analytical Resources Incorporated) in total PCBs, and particularly in Aroclor 1260 which was the predominant PCB mixture found at the Dallas Avenue site.

Our understanding of the adverse human health effects of exposure to PCBs is limited by available animal research data and occupational exposure. Concerns about health effects from PCB exposure arose from studies of wildlife communities that showed reproductive, developmental, endocrine, immunological and carcinogenic effects.[22,23,13]

If PCBs get into a person's body, some of the PCB might be changed by the body into other related chemicals called metabolites. Because PCBs bioaccumulate as person ages, the blood PCB levels tend to increase with age. Some metabolites of PCBs have the potential to be as harmful as the PCBs to which the person was originally exposed. Some of the metabolites may leave your body in the feces in a few days; others may remain in your body fat for months. Unchanged PCBs may also remain in your body and be stored for years mainly in the fat and liver, but smaller amounts can be found in other organs as well. PCBs collect in milk fat and can enter the bodies of infants through breast-feeding.[13]

It is difficult to predict how PCBs will affect someone. Different types of PCBs may produce effects by different mechanisms. Amounts that cause serious health problems for some people may have no effect on others. Other factors such as diet, genes, lifestyle, preexisting illness, or exposure to other chemicals can influence how people get sick. Certainly, exposure to the PCB-contaminated soils in the Dallas Avenue site can increase the health risks of residents that live in this area.

Little is known about the long-term health effects of PCBs in humans, so it is important to keep our exposure to these chemicals as low as possible. Most of what is known about the possible human health risks of PCBs comes from animal studies and accidental exposure at the workplace with high levels of these chemicals. Health effects have been observed in humans accidentally exposed to high levels of PCBs, by consumption of contaminated rice oil in Japan and Taiwan, by consumption of contaminated fish, and via general environmental exposure.[13]

Because the health effects of environmental mixtures of PCBs are difficult to evaluate, most of the information provided in ATSDR's toxicological profile is about seven types of PCB mixtures (i.e., Aroclors) that were commercially produced in the U.S.[13]

Chronic and acute exposure to PCBs has shown to produce a wide array of toxic effects in animals including:

- Neurobehavioral, immunological and developmental deficits have been reported in newborns exposed to PCBs in utero.[24,13]

Other toxic effects in humans include:

- Swelling of the upper eyelids
- Numbness in the arms and/or legs
- Weakness
- Discoloring of the nails and the skin
- Muscle spasm
- Chronic bronchitis
- Problems with the nervous system and thyroid metabolism

The PCBs levels found at the Dallas Avenue site are not likely to produce these health effects. However, if the exposure to these compounds is high and persistent, it is likely that the health risks associated with PCB exposure are increased over a lifetime.

Child Health Considerations

Children's residential exposure scenarios were evaluated in this document to determine if children's (the most vulnerable population) exposure was of public health concern. Children may be exposed to PCBs by a variety of exposure pathways. The most common pathway for PCB contamination includes the consumption of contaminated food, particularly meat, fish, and poultry.[25] Infants are potentially vulnerable to PCB exposure through breast feeding. Babies whose mothers eat large amounts of highly contaminated fish are more susceptible to lose weight and have shorter attention spans than babies whose mothers do not eat fish.[26] Exposed children tend to do poorly in intellectual functioning and other developmental skills such as attention span and developmental tests.[27] Chronic PCB exposure, particularly dioxin-like congeners induces dermal alterations in infants.[13]

There is evidence of soil PCB contamination at Dallas Avenue and children may have been exposed to PCBs at levels above ATSDR health comparison values. Soil levels in residential areas and the streets of Dallas Avenue are reported to contain PCBs. PCBs are a suspected human carcinogen and early life exposures to PCBs require special consideration.[28] Information related to the exposure of children living near contaminated soils with PCBs is needed. In particular, quantitative information regarding the bioavailability and amount of PCBs that children are exposed to through contact with contaminated PCB soils are unavailable.[13]

The unique vulnerabilities of infants and children demand special attention in communities with contamination of their water, food, soil or air. The potential for exposure and subsequent adverse health effects are often increased for younger children as opposed to older children or adults. ATSDR and DOH recognize that children are susceptible to developmental toxicity that can occur at levels much lower than those causing other types of toxicity.

Conclusions

Based on a thorough evaluation of available environmental information, DOH has reached the following conclusions:

1. Adults currently living at two residences where PCBs are present in soil at levels of health concern may be exposed to PCBs through gardening, yard work, or other activities in the yard. Exposure scenarios show that these adults are potentially exposed to PCBs at doses slightly higher than "safe" doses. Although adverse health effects are not likely to occur in these adults, they may also be exposed to PCBs in housedust. Therefore, an *indeterminate health hazard* exists for residents who might be exposed to PCBs transported into their homes from contaminated yard soil. This does not indicate that these adults will suffer adverse health effects, only that the potential for such impacts is slightly increased.

    - These adults may also be exposed to PCBs in house dust; dust samples taken by DOH using a Nilfisk dust vacuum will be evaluated in a follow up exposure investigation health consultation.

2. Although no children currently live in the homes where the highest PCB levels were found in yard soil*, a future public health hazard* may exist for these residences if children were to be exposed to PCBs.

    - Although it is not likely for Dallas Avenue resident's long-term exposures to PCBs in soil to result in adverse health effects, the potential remains as long as PCBs are present in residential surface soils.

        - No PCBs were detected in dust samples collected using surface wipes at the residential homes at the Dallas Avenue site.

3. Due to the fact that sampling was limited to two residential properties at the Dallas Avenue site where high levels of PCBs were detected, the evaluation may overestimate or underestimate health risks.

4. DOH has determined that there is not future health risk exposure to PCBs contaminated soils at Dallas Avenue streets because contaminated soils were removed or paved as part of the

City of Seattle's interim cleanup actions in 2004. The city plans a project that will take place next year to permanently protect the public from exposure.

5. Not all potential sources of PCBs have been identified yet at Dallas Avenue site. The former Basin Oil location and Malarkey Asphalt Company where waste petroleum products were handled might be sources of contamination.

Recommendations

1. The Department of Ecology should sample potential sources of PCBs as mentioned in the background section (e.g., the Basin Oil location and Malarkey asphalt) where potential levels of PCBs could be found.

2. Seattle Public Utilities and Public Health Seattle King County should determine the nature and extent of soil contamination on the two residential properties where high levels of PCBs were found.

3. DOH should sample indoor dust at the two properties where high levels of PCBs were found in soil.

Public Health Action Plan

The following steps will limit the exposure to PCBs in residential yards and garden soils at Dallas Avenue site:

- Wash your hands after playing or working, especially before eating.
- Avoid muddy soil that cling to clothing, toys, shoes, hands or feet.
- Wash anything that has come in contact with soils before entering your home.
- Implement regular damp mopping to avoid breathing indoor housedust.
- Vacuum carpets and rugs frequently, plus wet/damp mop and/or wet/damp dust all other surfaces in your home (i.e., hardwood floors), and dispose mop and cleaning solution.
- Take off your shoes before entering your home to avoid tracking soil into your house.
- Wear gloves while gardening and wash vegetables before eating them.
- To reduce exposure, try growing grass/vegetation on bare soil or cover with objects or mulch.
- Because pets may track in or bring in contaminants from yards, clean your pet first before allowing inside e.g., clean paws, legs, etc.

This information was distributed to the residents of Dallas Avenue site where high levels of PCBs were found. DOH notified them in a written letter about these simple steps to reduce and limit exposure to soils while gardening in their yards. In addition, the city of Seattle urged the residents of Dallas Avenue site to follow these precautions to prevent contact with the contaminated soil.

Actions Completed

1. In January 2005, staff from DOH attended the South Park Tour public meeting at the Dallas Avenue site, Seattle, Washington. It was demonstrated that:

    - SPU cleaned at 6 inches and placed new gravel in the road shoulders along **Dallas Avenue South between 14th Avenue South and 17th Avenue South where PCBs were above 1 ppm.** Crews also graded and paved the triangle bounded by **Dallas Avenue South, 17th Avenue South and South Donovan Street**.

    - SPU installed a temporary storm water collection and treatment system to control runoff from the newly-paved roads. This work included digging trenches and installing catch basins and drainage pipes on Dallas Avenue South between 17th Avenue South and South Donovan Street, and on South Donovan Street between Dallas Avenue South and 17th Avenue South. The pipes collect street runoff and convey the runoff to the temporary treatment system. Treated runoff is then discharged to the combined sewer system on South Donovan Street.

2. PHSKC completed wipe sampling on February 24, 2005.

3. DOH did complete housedust sampling in May 2005 on the two residential properties with high levels of PCBs.

4. In June 2005, SPU removed PCBs found in two residential front yards on 17th Avenue and replaced with sod, and also removed gravel recently found to have elevated PCBs in the roadway shoulder along the west edge of 16th Avenue South between Dallas Avenue South and South Cloverdale Street (Figure 5).

Actions Planned

- The City of Seattle is working with Public Health – Seattle and King County and the Washington State Department of Ecology to develop long-term actions to remove the PCBs permanently.

Preparer of Report

Elmer Diaz
Washington State Department of Health
Office of Environmental Health Assessments
Site Assessment Section

Designated Reviewer

Wayne Clifford, Manager
Site Assessment Section
Office of Environmental Health Assessments
Washington State Department of Health

ATSDR Technical Project Officer

Alan Parham
Division of Health Assessment and Consultation
Agency for Toxic Substances and Disease Registry

References

1. (Dan Cargill, Washington State Department of Ecology, personal communication, 11-9-2004)

2. (Dan Cargill, Washington State Department of Ecology, personal communication, 12-22-2004)

3. Seattle Public Utilities. South Park Soil Remediation Project. 2004; http://www.seattle.gov/util/About_SPU/Drainage_&_Sewer_System/Projects/South_Park Soil_Project/index.asp.

4. Public Health - Seattle and King County. Laboratory analytical data sheets concerning soil contamination in residential yards and garden near the Dallas Avenue South soil removal project. 11-8-2004.

5. Washington State Department of Ecology. Model toxics control act cleanup regulation. 2-12-2001. Chapter 173-340 WAC.

6. Pyron Environmental Inc. Data validation report, Lower Duwamish Waterway source samples, Seattle Public Utilities. 10-20-2004.

7. Pyron Environmental Inc. Data validation report, Lower Duwamish Waterway source samples, Seattle Public Utilities. 11-5-2004.

8. Dallas Avenue Site and Vicinity Street and Yard Sample Location. The City of Seattle. 12-8-2004.

9. Public Health - Seattle and King County. Laboratory analytical data sheets concerning soil contamination in residential yards and garden near the Dallas Avenue South soil removalproject. 11-4-2004.

10. (Lenford O'garro, Washington State Department of Health, personal communication, 11-9-2004)

11. Seattle Public Utilities. Laboratory analytical data report concerning wipe sampling in residential properties at the Dallas Avenue South soil removal project. Seattle, Washington. 3-7-2005.

12. City of Seattle. Laboratory analytical data sheets concerning soil contamination in residential properties at the Dallas Avenue South soil removal project. Seattle, Washington. 11-17-2004.

13. ATSDR. 2000. Toxicological Profile for Polychlorinated Biphenyls (PCBs). http://www.atsdr.cdc.gov/toxprofiles/tp17.html.http://www.atsdr.cdc.gov/toxprofiles/tp17.pdf

14. Bohme F, Welsch-Pausch K McLachlan MS. 1999. Uptake of airborne semivoatile organic compounds in agricultural plants: Field measurements of interspecies variability. Environ Sci Technol. 33:1805-1813.

15. Duff, R. M. and Kissel, J. C. 1996. Effect of soil loading on dermal absorption efficiency from contaminated soils. J Toxicol.Environ Health. 48:93-106.

16. Integrated Risk Information System (IRIS), U. S. EPA. 10-1-1994. Aroclor 1254, CASRN 11097-69-1. http://www.epa.gov/iris/subst/0389.htm

17. Public Health - Seattle and King County. Laboratory analytical data sheets concerning soil contamination in residential yards and garden near the Dallas Avenue South soil removal project. 10-27-2004.

18. (Beth Schmoyer, Seattle Public Utilities, personal communication, 1-25-2004)

19. Environmental Protection Agency. 3-29-2005. Guidelines for Carcinogenic Risk Assessment. http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=116283.www.epa.gov/cancerguidelines.

20. Freed, J. A. PCB Contamination in Residential Soil. General Electric Company/General Electric Rome. 10-5-2004.

21. Rushneck, D. R., Beliveau, A., Fowler, B., Hamilton, C., Hoover, D., Kaye, K., Berg, M., Smith, T., Telliard, W. A., Roman, H., Ruder, E., and Ryan, L. 2004. Concentrations of dioxin-like PCB congeners in unweathered Aroclors by HRGC/HRMS using EPA Method 1668A. Chemosphere. 54:79-87.

22. Colborn, T., vom Saal, F. S., and Soto, A. M. 1993. Developmental effects of endocrine-disrupting chemicals in wildlife and humans. Environ.Health Perspect. 101:378-384.

23. Tryphonas, H. 1998. The impact of PCBs and dioxins on children's health: immunological considerations. Can.J.Public Health. 89 Suppl 1:S49-7.

24. Agency for Toxic Substances and Disease Registry (ATSDR) and US Environmental Protection Agency (EPA). Public health implications of exposure to polychlorynated biphenyls (PCBs). Atlanta: US Department of Health and Human Services 1998.

25. Gunderson, E. L. 1988. FDA Total Diet Study, April 1982-April 1984, dietary intakes of pesticides, selected elements, and other chemicals. J.Assoc.Off Anal.Chem. 71:1200-1209.

26. Jacobson, J. L., Jacobson, S. W., and Humphrey, H. E. 1990. Effects of exposure to PCBs and related compounds on growth and activity in children. Neurotoxicol.Teratol. 12:319-326.

27. Jacobson, J. L. and Jacobson, S. W. 9-12-1996. Intellectual impairment in children exposed to polychlorinated biphenyls in utero. N.Engl.J.Med. 335:783-789.

28. Cogliano, V. J. 1998. Assessing the cancer risk from environmental PCBs. Environ.Health Perspect. 106:317-323.

29. Washington State Department of Ecology Toxics Cleanup Program and The Ecology Environmental Laboratory. Analytical Methods for Petroleum Hydrocarbons. 1997. ECY 97-602.

30. Environmental Protection Agency. 1996. EPA Method 6010B. http://www.epa.gov/epaoswer/hazwaste/test/6_series.htm.

31. Environmental Protection Agency. 1994. EPA Method 7471A. http://www.epa.gov/epaoswer/hazwaste/test/7_series.htm.

32. Environmental Protection Agency. 1996. EPA Method 8270C. http://www.epa.gov/epaoswer/hazwaste/test/8_series.htm.

33. Environmental Protection Agency. 1996. EPA Method 8082. http://www.epa.gov/epaoswer/hazwaste/test/8_series.htm#8_series.

34. National Center for Environmental Assessment. 1997. Exposure Factors Handbook Volume 1. Washington, D.C.: Office of Research and Development, U.S. EPA.

35. Environmental Protection Agency. 2004. Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment). http://www.epa.gov/oswer/riskassessment/ragse/pdf/2004_1101_part_e.pdf

36. Environmental Protection Agency. 2001. Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. http://www.epa.gov/superfund/resources/soil/ssgmarch01.pdf

37. Maroni, M., Colombi, A., Cantoni, S., Ferioli, E., and Foa, V. 1981. Occupational exposure to polychlorinated biphenyls in electrical workers. I. Environmental and blood polychlorinated biphenyls concentrations. Br.J.Ind.Med. 38:49-54.

38. Maroni, M., Colombi, A., Arbosti, G., Cantoni, S., and Foa, V. 1981. Occupational exposure to polychlorinated biphenyls in electrical workers. II. Health effects. Br.J.Ind.Med. 38:55-60.

39. Emmett, E. A., Maroni, M., Schmith, J. M., Levin, B. K., and Jefferys, J. 1988. Studies of transformer repair workers exposed to PCBs: I. Study design, PCB concentrations, questionnaire, and clinical examination results. Am.J.Ind.Med. 13:415-427.

40. Orloff, K. G., Dearwent, S., Metcalf, S., Kathman, S., and Turner, W. 2003. Human exposure to polychlorinated biphenyls in a residential community. Arch.Environ.Contam Toxicol. 44:125-131.

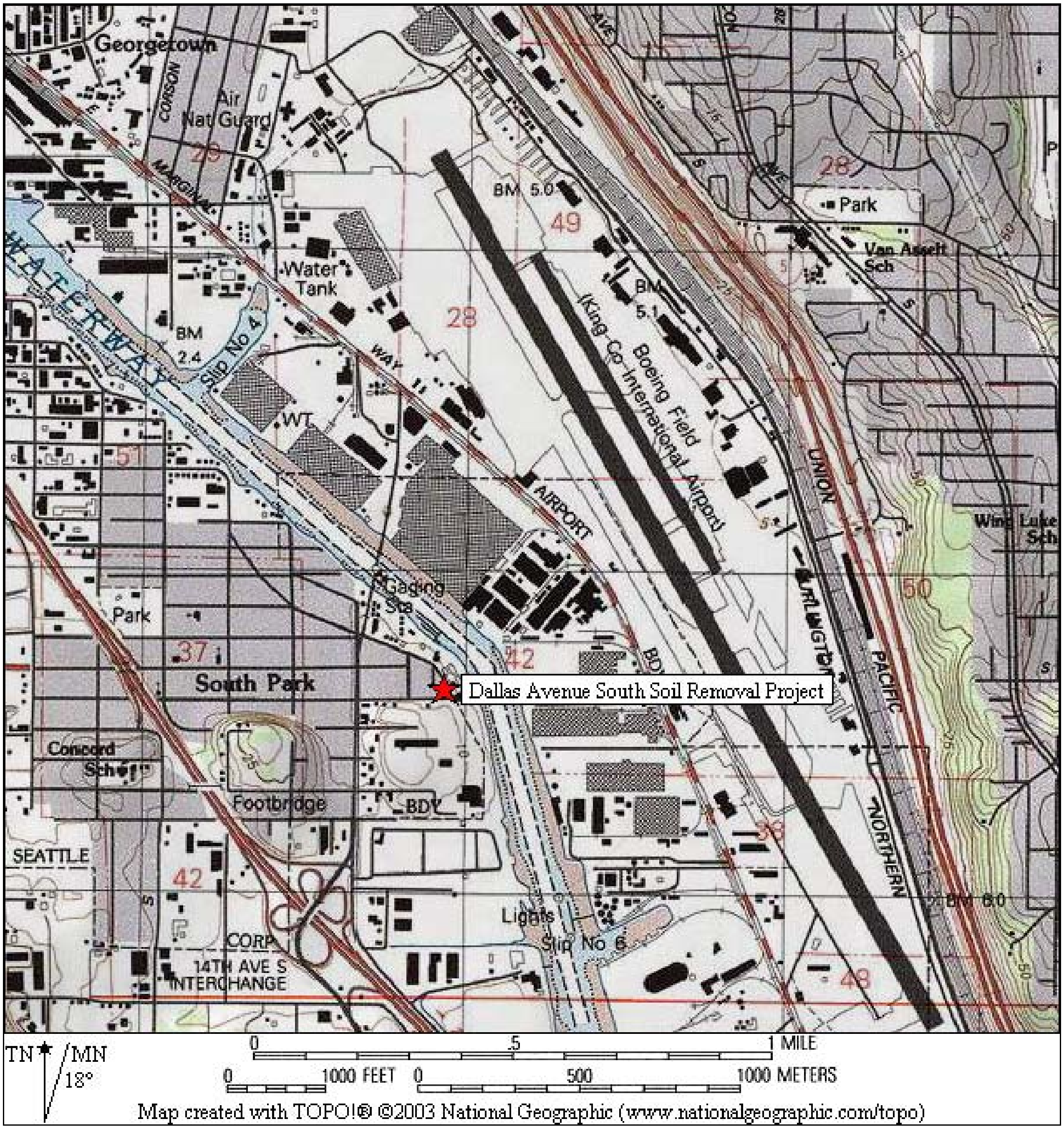

Figure 1 – Vicinity Map
Dallas Avenue South
Soil Removal Site
Seattle, Washington

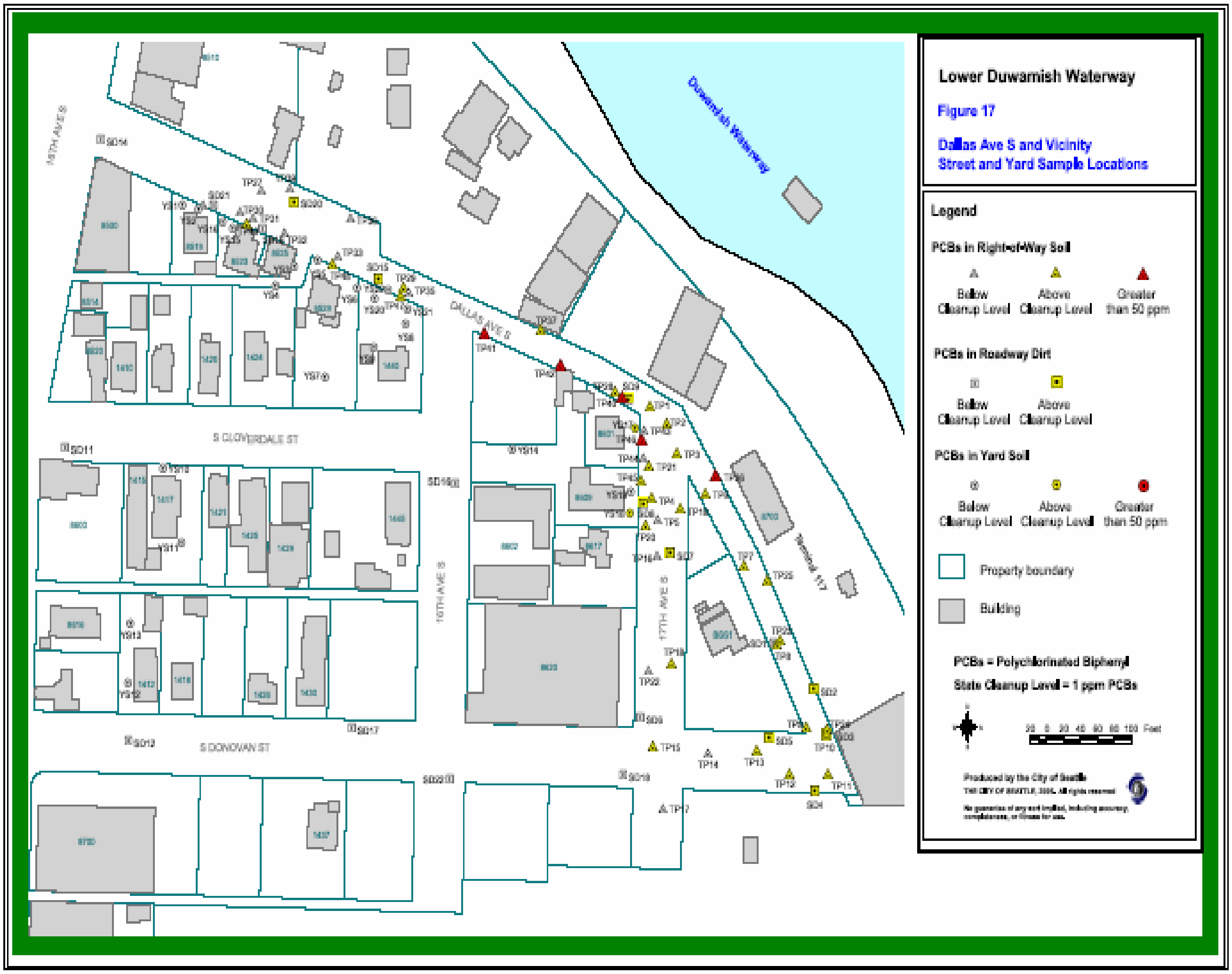

Figure 2 – Street/Yard Sampling Locations: Dallas Avenue South Soil Removal Site. Seattle, Washington

Figure 3. Dallas Avenue South and 16th Street,
Dallas Avenue South Removal Site,
Seattle, Washington

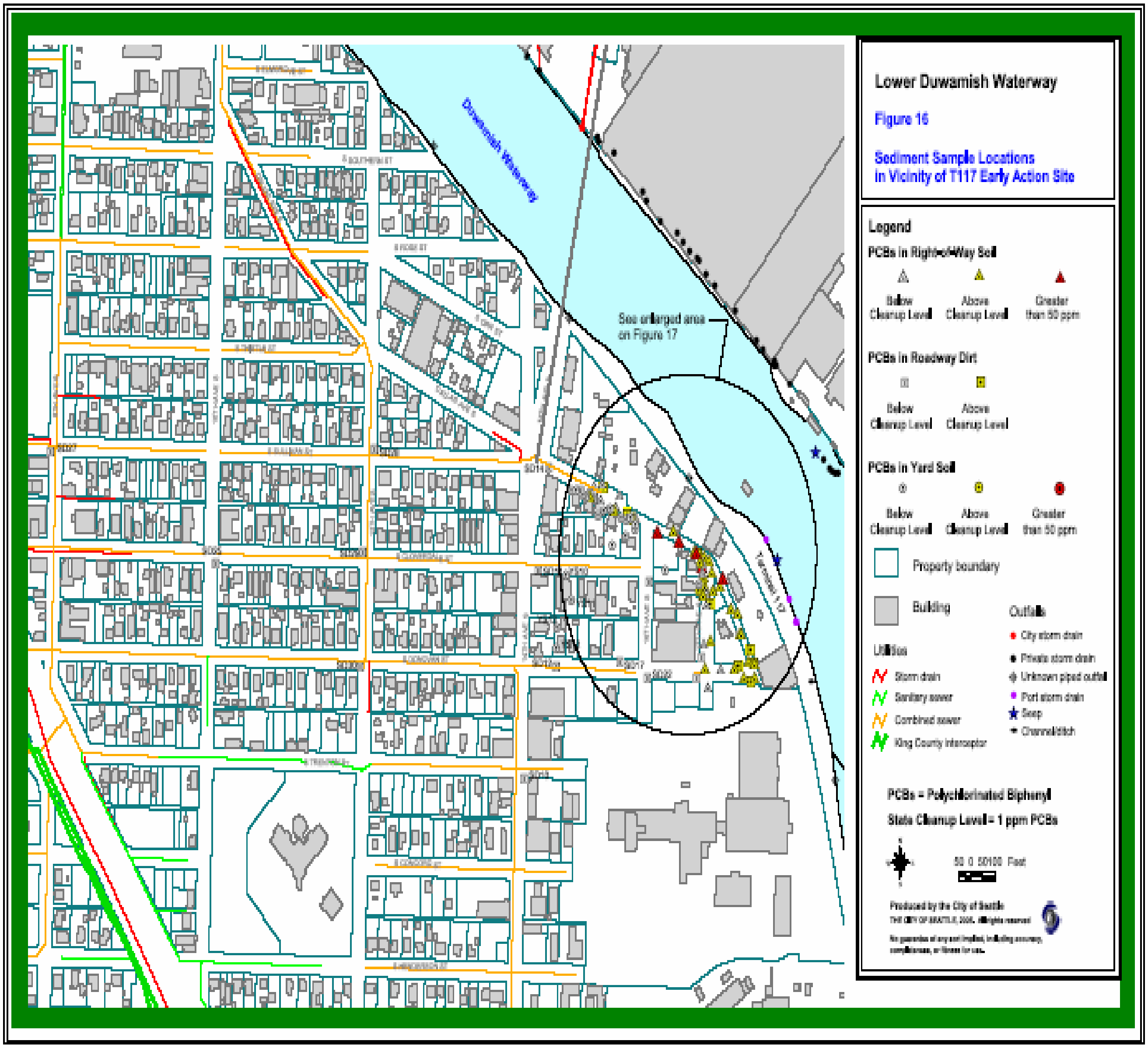

Figure 4 – Soil Sample Location Dallas Avenue South Soil Removal Site Seattle, Washington

Figure 5 – Street/Yard Soil Interim Cleanup, Locations: Dallas Avenue South Soil Removal Site Seattle, Washington

Appendix A

Media-specific health comparison values are contaminant concentrations in specific media (i.e., soil, water and air) used to select contaminants of concern for further evaluation. If the concentration of a chemical exceeds the health comparison value, it does not mean that a public health threat exists but rather signifies that the chemical be further evaluated.

During the evaluation of PCBs in residential soils at Dallas Avenue, the DOH used several health-screening values specifically for children. Comparison values used in this document included the Washington's hazardous waste cleanup law, the Model Toxics Control Act (MTCA), ATSDR's Cancer Risk Evaluation Guide (CREG), ATSDR's Environmental Media Evaluation Guide (EMEG), and EPA Region 9 Preliminary Remediation Goals (PRGs).

Tables in appendix A (Table A1 and A2) describe the maximum concentration of contaminants found in soil in relation to their comparison values. Comparison values offer a high degree of protection and assurance that people are unlikely to be harmed by contaminants in the environment. The EMEG soil comparison value is designed to be protective of a child. Chronic exposure to a contaminant in soil at levels below the EMEG is unlikely to result in noncancer adverse health effects. For chemicals that cause cancer, the comparison values represent levels that are calculated to increase the risk of cancer by about one in a million.

Appropriate analytical methods and adequate quality assurance and quality control measures were followed with regarding to sampling procedures, chain-of-custody, laboratory procedures, and data reporting. Ecology's NWTPH-Dx analytical method was used to analyze for diesel and oil range hydrocarbons.[29] EPA Method 6010B was used to analyze for total arsenic, copper, lead, and zinc.[30] EPA Method 7471A was used to analyze for total mercury.[31] EPA method 8270C was used to analyze Semi-Volatile Organic Compounds (SVOCs).[32] PCBs were analyzed for Aroclor compounds using U.S. Environmental Protection Agency (EPA) Method 8082.[33]

Comparisons may also be made with legal standards such as the cleanup levels specified in the Washington State hazardous waste cleanup law, the Model Toxics Control Act (MTCA). Legal standards may be strictly health-based or they may incorporate non-health considerations such as the cost or the practicality of attainment.

There are hundreds of chemicals for which little toxicological information is available for either animals or humans. These chemicals may in fact be toxic at some level, but risks to humans cannot be quantified because of uncertainty. Uncertainty with regard to the health assessment process refers to the lack of knowledge about factors such as chemical toxicity, human variability, human behavior patterns, and chemical concentrations in the environment. Therefore, contaminants that lack of toxicological information are difficult to compare and quantify in terms of human health risk assessment.

Aroclor 1260 was the predominant PCB mixture that was detected in the soil and residential samples at Dallas Avenue site (Table 2). However, other Aroclor compounds had levels above health comparison values (Appendix A, Table A1). The chromatogram analysis show consistent results on the presence of Aroclor 1260 and the levels of this compound are consistently higher than other Aroclors. The presence of other Aroclors in a mixture of Aroclors was over masked by the presence of Aroclor 1260. The high levels for other Aroclor compounds were drawn from a dilution factor due to high levels of Aroclor 1260.

There are not comparison values specific for Aroclor 1260. Comparison values are derived from ATSDR studies on Aroclor 1254. In the absence of information on Aroclor 1260, the surrogate Aroclor 1254 was used for screening and dose calculations in this document.

Table 1 describes surface (0 – 6 inches) and subsurface (> 6 inches) concentrations of contaminants found at the Dallas Avenue site. PCBs comparison values and maximum levels of contaminant of concern in residential yards and street soils at the Dallas Avenue site are shown on Tables 2, A1 and A2, respectively.

Table A1. *Maximum levels of contaminants of concern in soil and human health comparison values found at Dallas Avenue streets, Seattle, Washington.*

Contaminant	Soil Maximum Concentration (ppm)	Non-Cancer Comparison Value (ppm)	Cancer Comparison Value (ppm)	EPA Cancer Group	MTCA Method A Cleanup level (ppm)
PCBs					
Aroclor 1016	0.03U - 4.5	1.0[a]	0.4[b]	B2	1.0
Aroclor 1242	0.03U - 4.5	1.0[a]	0.4[b]	B2	1.0
Aroclor 1248	0.03U - 4.5	1.0[a]	0.4[b]	B2	1.0
Aroclor 1254	0.03U - 4.5	1.0[a]	0.4[b]	B2	1.0
Aroclor 1260	0.02 - 480	1.0[a] *	0.4[b]	B2	1.0
Aroclor 1221	0.03U - 4.5	1.0[a]	0.4[b]	B2	1.0
Aroclor 1232	0.03U - 4.5	1.0[a]	0.4[b]	B2	1.0
TPH					
Diesel	0.02 - 4,600	N/A	N/A		2,000
Oil	0.04 - 9,500	N/A	N/A		2,000
Metals					
Copper	57 - 819	2,000[c]		D	NA
Lead	18 - 897			B2	250
Mercury	0.05U -1.67			D	2.0
Zinc	123 - 444	20,000[c]		D	NA
Arsenic	10U - 200	20[a]	0.5[b]	A	20

Note: Bold contaminants indicate that the maximum concentration exceeds comparison values and therefore considered a contaminant of concern
a- EMEG - ATSDR's Environmental Media Evaluation Guide (child)
b- CREG - ATSDR's Cancer Risk Evaluation Guide (child)
c- IM EMEG – ATSDR's Intermediate Environmental Media Evaluation Guide (child)
U – Data qualifier: The analyte was analyzed for but not detected
B2 – EPA: Probably human carcinogen (inadequate human, sufficient animal studies)
D – EPA: Not classifiable as to health carcinogenicity
MTCA (A) – Model Toxics Control Act Method A – Soil Cleanup Level for Unrestricted Land Use
* Aroclor 1254 ATSDR comparison value was used as a surrogate for Aroclor 1260
N/A: Not available

Table A2. *Maximum concentration of organic compounds detected in soil and their respective comparison values at the Dallas Avenue site in Seattle, Washington.*

Contaminant	Maximum Concentration (ppm)	Comparison Value (ppm)	EPA Cancer Class	Comparison Value Reference	Contaminant of Concern
1,2,4-Trichlorobenzene	0.02U - 0.34	62	D	Region 9	No
1,4-Dichlorobenzene	0.02U - 0.27	3.4	C	Region 9	No
2-Chlorophenol	0.02U - 0.42	63	D	Region 9	No
2,4-Dinitrotoluene	0.09U - 0.28	120	B2	Region 9	No
4-Chloro-3-methyl phenol	0.04U - 0.54	20*	C	EMEG	No
4-Nitrophenol	0.1U - 0.53	100*	D	RMEG	No
Acenaphthene	0.02U - 0.31	3,000		RMEG	No
Benzo (b) fluoranthene	0.029U - 0.03	0.62*	B2	Region 9	No
Benzo (k) fluoranthene	0.03U	6.2*	B2	Region 9	No
Benzo (g,h,i) perylene	0.02U - 0.38	0.62*	D	Region 9	No
Bis (2-ethylexyl) phthalate	0.02U – 1.0	50	B2	CREG	No
Chrysene	0.02U - 0.09	62	B2	Region 9	No
Di-n-octyl phthalate	0.02U - 0.34	2,400	D	Region 9	No
Fluoranthene	0.02U - 0.03	2,000	D	RMEG	No
N-nitroso-di-n-propylamine	0.04U - 0.26	690	B2	Region 9	No
Pentachlorophenol	0.03U - 0.47	3.0	B2	Region 9	No
Phenanthrene	0.02U - 0.06	2,000*	D	RMEG	No
Phenol	0.02U - 0.47	18,000	D	Region 9	No
Pyrene	0.06U - 0.41	2,000	D	RMEG	No

EMEG - ATSDR's Environmental Media Evaluation Guide (child)
CREG - ATSDR's Cancer Risk Evaluation Guide (child)
IM EMEG – ATSDR's Intermediate Environmental Media Evaluation Guide (child)
RMEG – ATSDR's Reference Dose Media Evaluation Guide (child)
B2 – EPA: Probably human carcinogen (inadequate human, sufficient animal studies)
C – EPA: Possible human carcinogen (no human, limited animal studies)
D – EPA: Not classifiable as to human carcinogenicity
Region 9 – EPA: Preliminary Remediation Goals
MTCA (A) – Model Toxics Control Act Method A – Soil Cleanup Level for Unrestricted Land Use
*4-Chlorophenol EMEG (pica child) value was used as a surrogate for 4-chloro-3-mehtyl phenol
* Fluoranthene RMEG value was used as a surrogate for Phenanthrene
* Benzo (a) Pyrene CREG values was used as a surrogate for Benzo (b) fluoranthene and Benzo (k) fluoranthene
* Benzo (a) anthracene Region 9 value was used as a surrogate for Benzo (g,h,i) perylene
* 2,4-dinitrophenol RMEG value was used as a surrogate for 4-nitrophenol
U – Data qualifier: The analyte was analyzed for but not detected

Tables A3 and A4 summarize the status of sampled streets and residential yards at the Dallas Avenue site. DOH evaluated two residential properties where levels of PCBs were above one ppm. The maximum PCB concentration was chosen because there were not enough samples to characterize better the data on these residential properties.

Table A3. *Status of samples collected from roadway surface, catch basins, and right-of-ways at Dallas Avenue, Seattle, Washington.*

General location samples collected	Contaminant Level (PCB)	Number of street dirt samples	Status
Roadway Surface and Catch Basins	Less than 1 ppm	**17**	No further action
	Greater than 1 ppm and less than 10 ppm	**9**	All remediated (Cleaned and placed new gravel on road shoulders)
Right-of-Way	Less than 1 ppm	**57**	No further action
Right-of-Way	Greater than 1 ppm and less than 10 ppm	**35**	All remediated (Cleaned and placed new gravel on road shoulders)
Right-of-Way	Greater than 10 ppm and less than 100 ppm	**16**	All remediated (Cleaned and placed new gravel on road shoulders)
Right-of-Way	Greater or equal than 100 ppm and less than 200 ppm	**2**	All remediated (Cleaned and placed new gravel on road shoulders)
Right-of-Way	Greater or equal than 400 ppm	**1**	All remediated (Cleaned and placed new gravel on road shoulders)

Table A4. *Status of samples collected from residential yards at Dallas Avenue, Seattle, Washington.*

Contaminant Level (PCB)	Number of yard samples in residential properties	Status
Not detected	**2**	No further action
Less than 1 ppm	**30**	No further action
Greater than 1 ppm and less than 10 ppm	**2**	Residential property was remediated on June 2005 by SPU
Greater than 10 ppm and less than 100 ppm	**2**	Residential property was remediated on June 2005 by SPU

Appendix B

This section provides calculated exposure doses and assumptions used for exposure to chemicals in soil at the Dallas Avenue site (Table B1). The levels of PCBs detected were above ATSDR's comparison values for non-cancer and cancer health effects at the two residential properties. Three different exposure scenarios were developed to model exposures that might occur at this site. These scenarios were devised to represent exposures to 1) a child (0-5 yrs), 2) an older child (6-15), and 3) an adult. The following exposure parameters and dose equations were used to estimate exposure doses from incidental ingestion and direct contact with chemicals in soil.

Exposure to chemicals in soil via ingestion, and dermal absorption.

Total dose $_{\text{(non-cancer)}}$ = Ingested dose + dermally absorbed dose

Ingestion Route

$$\text{Dose}_{\text{(non-cancer (mg/kg-day)}} = \frac{\text{C x CF x IR x EF x ED}}{\text{BW x AT}_{\text{non-cancer}}}$$

$$\text{Cancer Risk} = \frac{\text{C x CF x IR x EF x CPF x ED}}{\text{BW x AT}_{\text{cancer}}}$$

Dermal Route

$$\text{Dermal Transfer (DT)} = \frac{\text{C x AF x ABS x AD x CF}}{\text{ORAF}}$$

$$\text{Dose}_{\text{(non-cancer (mg/kg-day)}} = \frac{\text{DT x SA x EF x ED}}{\text{BW x AT}_{\text{non-cancer}}}$$

$$\text{Cancer Risk} = \frac{\text{DT x SA x EF x CPF x ED}}{\text{BW x AT}_{\text{cancer}}}$$

Table B1. *Exposure Assumptions for exposure to chemicals in soil at Dallas Avenue site, Seattle, Washington.*

Parameter	Value	Unit	Comments
Concentration (C)	46 ppm	mg/kg	Maximum detected value
Conversion Factor (CF)	0.000001	kg/mg	Converts contaminant concentration from milligrams (mg) to kilograms (kg)
Ingestion Rate (IR) – adult	50	mg/day	Exposure Factors Handbook [34]
Ingestion Rate (IR) – older child	50		
Ingestion Rate (IR) - child	200		
Exposure Frequency (EF)	350	days/year	Average days in residential scenario
Exposure Duration (ED)	(5, 10, 15)	years	Number of years in residential scenario.
Body Weight (BW) - adult	72	kg	Adult mean body weight
Body Weight (BW) – older child	41		Older child mean body weight
Body Weight (BW) - child	15		0-5 year-old child average body weight
Surface area (SA) - adult	5700	cm^2	Risk Assessment Guidance (EPA) [35]
Surface area (SA) – older child	2800		
Surface area (SA) - child	2800		
Averaging Time$_{non\text{-}cancer}$ (AT)	1825	days	5 years
Averaging Time$_{cancer}$ (AT)	27375	days	75 years
Cancer Potency Factor (CPF)	Variable	$mg/kg\text{-}day^{-1}$	Source: EPA: CPF are presented in Table B3
24 hr. absorption factor (ABS)	Variable	unitless	Source: EPA Supplemental Guidance [36] Inorganic – 0.001 Organic – 0.01 PCBs – 0.14
Oral route adjustment factor (ORAF)	1	unitless	Non-cancer (nc) / cancer (c) - default
Adherence duration (AD)	1	days	Source: EPA
Adherence factor (AF)	0.2	mg/cm^2	Child, older child
	0.07		Adult
Soil matrix factor (SMF)	1	unitless	Non-cancer (nc) / cancer (c) - default

Soil Ingestion and Dermal Route of Exposure – Non-cancer

Table B2. *Non-cancer hazard calculations resulting from exposure to contaminants of concern in soil at Dallas Avenue site – Seattle, Washington.*

Contaminant	Concentration (ppm) (mg/kg)	Scenarios	Estimated Dose (mg/kg/day)		Total Dose	RfD (mg/kg/day)	Hazard quotient
			Incidental Ingestion of Soil	Dermal Contact with Soil			
PCBs	46	Child	2.94E-4	1.71E-5	3.11E-4	2.0E-5 *	15.55
		Older child	5.38E-5	1.36E-5	6.74E-5		3.37
		Adult	3.06E-5	2.66E-6	3.33E-5		1.7

* EPA RfD for Aroclor 1254

Because of uncertainty in these data, the toxic effect level (Total dose) is divided by "safety factors" to produce the lower and more protective MRL or RfD. If a dose exceeds the MRL or RfD, this indicates only the potential for adverse health effects. The magnitude of this potential can be inferred from the degree to which this value is exceeded. If the estimated exposure dose is only slightly above the MRL or RfD, then that dose will fall well below the toxic effect level. The higher the estimated dose is above the MRL or RfD, the closer it will be to the actual toxic effect level. This comparison is known as a hazard quotient (HQ) and is given by the equation below:

Equation 1

$$HQ = \frac{\text{Estimated Dose (mg/kg-day)}}{\text{RfD (mg/kg-day)}}$$

People may be exposed to a variety of exposure pathways. The most important pathway for PCB exposure appears to be the consumption of contaminated foods, particularly fish.[12] At the Dallas Avenue site there are two potential exposure pathways - the incidental ingestion of soil and dermal contact. Incidental ingestion of soil may occur from hand-to-mouth transfer, direct mouth contact, ingestion of soil from contaminated vegetables and fruits, and ingestion of dust from soil. Although dermal (skin) contact is considered as a significant contributor to the accumulation of PCBs in fat tissue from factory workers,[37,38,39] it is likely that this route of exposure also contributes to the accumulation of PCBs in fat tissues for people living at the Dallas Avenue site.

The hazard quotient values shown on Table B2 exceeds one, which it is an indication that a potential adverse health effect might occur if the total ingested dose is not reduced. However, an indication of a hazard quotient above one might not represent a problem considering the uncertainty involved in the absorption and distribution of PCBs as a result of inhalation, ingestion, and dermal exposure. Humans can absorb PCBs by the inhalation, oral, and dermal routes of exposure. PCBs, when administered orally, are well absorbed by experimental animals, but they are absorbed less efficiently when administered by the dermal route.[13]

Unfortunately, few studies on the absorption and distribution of PCBs from soil exist. There is also no information on the link between blood PCB concentration and soil or dust PCB concentrations.[40]

TPH oil and diesel were found above MTCA cleanup levels mainly between the east edges of Dallas Avenue south at the entrance of terminal 117 (T117), on road shoulders, composite areas, right-of-ways (ROWs) and the catch basin. These hot spots might have posed a public health hazard in the past if children have had access to these areas. Because the affected soils and sediments have been removed, these contaminants do not pose a current public health hazard.

Soil Ingestion and Dermal Route of Exposure - Cancer

Table B3. *Cancer risk resulting from exposure to contaminants of concern in soil samples from Dallas Avenue site – Seattle, Washington.*

Contaminant	Concentration (ppm) (mg/kg)	EPA Cancer Group	Cancer Potency Factor mg/kg-day[1])	Scenarios	Increased Cancer Risk		Total Cancer Risk
					Incidental Ingestion of Soil	Dermal Contact with Soil	
PCBs	46	B2	2.0	Child	3.92E-5	2.27E-6	4.15E-5
				Older child	1.43E-5	3.62E-6	1.80E-5
				Adult	1.23E-5	1.06E-6	1.33E-5
				Lifetime	6.58E-5	6.95E-6	7.28E-5

* - Total theoretical cancer risk for a child 0 – 5 years old

Certification

This Evaluation of Soil Contamination at Dallas Avenue Soil removal Site, Seattle, Washington Public Health Consultation was prepared by the Washington State Department of Health under a cooperative agreement with the federal Agency for Toxic Substances and Disease Registry (ATSDR). It was completed in accordance with approved methodologies and procedures existing at the time the health consultation were initiated. Editorial review was completed by the Cooperative Agreement partner.

____

Technical Project Officer, CAT, SPAB, DHAC

The Division of Health Assessment and Consultation (DHAC), ATSDR, has reviewed this health consultation and concurs with its findings.

____

Team Lead, CAT, SPAB, DHAC, ATSDR