Health Consultation

PHILLIPS RESIDENTIAL PROPERTY

TACOMA, WASHINGTON

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U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Agency for Toxic Substances and Disease Registry
Division of Health Assessment and Consultation
Atlanta, Georgia 30333

Health Consultation: A Note of Explanation

An ATSDR health consultation is a verbal or written response from ATSDR to a specific request for information about health risks related to a specific site, a chemical release, or the presence of hazardous material. In order to prevent or mitigate exposures, a consultation may lead to specific actions, such as restricting use of or replacing water supplies; intensifying environmental sampling; restricting site access; or removing the contaminated material.

In addition, consultations may recommend additional public health actions, such as conducting health surveillance activities to evaluate exposure or trends in adverse health outcomes; conducting biological indicators of exposure studies to assess exposure; and providing health education for health care providers and community members. This concludes the health consultation process for this site, unless additional information is obtained by ATSDR which, in the Agency's opinion, indicates a need to revise or append the conclusions previously issued.

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HEALTH CONSULTATION

PHILLIPS RESIDENTIAL PROPERTY

TACOMA, WASHINGTON

Prepared By:

Washington State Department of Health
under cooperative agreement with the
Agency for Toxic Substances and Disease Registry

Forward

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 this 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 changes 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:

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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/.

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Glossary

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	A theoretical risk for developing cancer if exposed to a substance every day for 70 years (a lifetime exposure). The true risk might be lower.
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.
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**].
Groundwater	Water beneath the earth's surface in the spaces between soil particles and between rock surfaces [compare with surface water].
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.
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.
Lowest Observed Adverse Effect Level (LOAEL)	The lowest tested dose of a substance that has been reported to cause harmful (adverse) health effects in people or animals.
Maximum Contaminant Level (MCL)	A drinking water regulation established by the federal Safe Drinking Water Act. It is the maximum permissible concentration of a contaminant in water that is delivered to the free flowing outlet of the ultimate user of a public water system. MCLs are enforceable standards.
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), noncancerous 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.
No apparent public health hazard	A category used in ATSDR's public health assessments for sites where human exposure to contaminated media might be occurring, might have occurred in the past, or might occur in the future, but where the exposure is not expected to cause any harmful health effects.
No Observed Adverse Effect Level (NOAEL)	The highest tested dose of a substance that has been reported to have no harmful (adverse) health effects on people or animals.
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.
Plume	A volume of a substance that moves from its source to places farther away from the source. Plumes can be described by the volume of air or water they occupy and the direction they move. For example, a plume can be a column of smoke from a chimney or a substance moving with groundwater.
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 RMEG 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].

Surface Water	Water on the surface of the earth, such as in lakes, rivers, streams, ponds, and springs [compare with **groundwater**].
Time Weighted Approach (TWA)	The exposure concentration of a contaminant during a given period.
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) has prepared this health consultation at the request of the Tacoma-Pierce County Health Department (TPCHD). The purpose of this health consultation is to evaluate the potential health hazard posed by lead contamination in soil, at the Phillips Residential Property in Pierce County, Tacoma, Washington. DOH prepares health consultations under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR).

Background

The Phillips Residential Property is located in Tacoma, Washington. The property is a 0.14-acre parcel in a residentially zoned area of the city. It includes a one and a half-story, 1320 square foot house constructed in 1908 and a detached garage constructed in 1918. Prior to renting the property, the owner lived at this location. The owner reportedly has been melting lead down into blocks at this property for reuse, and has been doing so for at least a few years. This operation continued while tenants occupied the property.

In March 2007, a family moved into the property and in November 2007, their blood lead levels were tested. The results indicated all of the children had elevated blood lead levels ((EBLL) = 10≥ μg/dl), with the youngest child having the highest concentration. TPCHD notified DOH of the EBLL of the children, a standard protocol whenever a child in Washington State has an EBLL.

In January 2008, TPCHD staff conducted a site visit and observed numerous 5-gallon buckets stacked along the south side of the driveway with metal pieces and debris inside (see photos 1 - 4). The back yard contained metal debris and a large propane tank. TPCHD collected two surface (0 -3 inch) soil samples from the backyard area immediately adjacent to the concrete driveway, where the lead melting occurred. These samples are likely hot spots or a worst-case scenario because they were taken from a location adjacent to the melting area that had been recently washed down. Table 1 shows the maximum concentration of contaminants in the surface soil.

Paint samples were reportedly field tested by a contractor for the presence of lead and positive results were obtained for three areas: a tan under-layer of paint visible in a chipped edge of a kitchen wall; a cream topcoat in good condition on the upstairs bedroom door; and the same cream topcoat on top of the furnace door. In addition, carpet samples were analyzed for the presence of lead. Another possible source of lead in the home could be the drinking water. Older homes often have lead pipes or lead soldering, which leaches lead into the drinking water. Lead contaminated soil may also have been tracked into the home. Melting of lead is also a source for airborne lead that can be inhaled.

Table 1. Maximum concentrations of inorganic contaminants detected in the site's soil relative to comparison values .

Compounds	Maximum Concentration (ppm)	Comparison Value (ppm)	EPA Cancer Class	Comparison Value Reference	Contaminant of Concern
Arsenic	**200**	0.5 20	A	CREG EMEG	**Yes** (cancer) **Yes** (non-cancer)
Barium	160	4,000	D	RMEG	No
Cadmium	3.3	10	B1	EMEG	No
Chromium	51	200 [a]	A	RMEG	No
Lead	**75000**	250	B2	MTCA	**Yes**
Mercury	ND	1	D	MTCA	No
Selenium	ND	300	D	EMEG	No
Silver	4.0	300	D	RMEG	No

RMEG - ATSDR's Reference Dose Media Evaluation Guide (child)
CREG - Cancer Risk Evaluation Guide for $1x10^{-6}$ excess cancer risk
EMEG - ATSDR's Environmental Media Evaluation Guide (child)
A - EPA: Human carcinogen
B1 - EPA: Probable human carcinogen (limited human, sufficient animal studies)
B2 - EPA: Probable human carcinogen (inadequate human, sufficient animal studies)
D - EPA: Not classifiable as to health carcinogenicity
MTCA – Washington State Department of Ecology: Model Toxics Control Act
[a] - chromium hexavalent RMEG value was used as a surrogate
NA – Not available
ND – Not Detected at practical quantitation limit

Discussion

Contaminants of Concern

Contaminants of concern (COC) in soil were determined by employing a screening process. Maximum soil contaminant levels were screened against health-based comparison values. Several types of health-based comparison or screening values are used during this process [see the glossary for descriptions of "comparison value," "cancer risk evaluation guide (CREG)," "environmental media evaluation guide (EMEG)," and "reference dose media evaluation guide (RMEG)"]. Comparison values such as the CREG and EMEG offer a high degree of protection and assurance that people are unlikely to be harmed by contaminants in the environment. 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. With the exception of lead, the comparison values for chemicals that do not cause cancer represent levels that are not expected to cause any health problems. For lead, comparison values are usually based on the goal of keeping blood lead levels in most children below 10 micrograms per deciliter (μg/dl). These types of comparison values often form the basis for cleanup. In general, if a contaminant's maximum concentration is greater than its comparison value, then the contaminant is evaluated further.

Comparisons may also be made with legal standards such as the cleanup levels specified in the Washington State toxic 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, or natural background levels.

The following evaluation addresses lead and arsenic as contaminants of concern in soil. In order for any contaminant to be a health concern, the contaminant must be present at a high enough concentration to cause potential harm, and there must be a completed route of exposure to people.

Human use patterns and site-specific conditions are considered in the evaluation of exposure to lead and arsenic through the following pathways and routes:

- Inadvertent soil ingestion, dust particles inhalation and dermal absorption of contaminants in soil during play.

Exposure to contaminants in soil can occur by swallowing it (ingestion exposure), breathing it (inhalation exposure) or getting it on the skin (dermal exposure).

Ingestion exposure (swallowing)

Most people inadvertently swallow small amounts of sediments, soil and dust (and any contaminants they contain). 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. Adults may ingest sediments, soil and dust through activities such as gardening, mowing, construction work, dusting and in this case recreational activities.

Pica behavior is a persistent eating of non-food substances (such as dirt or paper). In a small percentage of children, pica behavior has been found to result in to the ingestion of relatively large amounts of soil (one or more grams per day). Compared to typical children, those who swallow large amounts of contaminated soil may have added risks from short-term exposure. Some adults may also exhibit pica behavior.

Inhalation exposure (breathing)

Although people can inhale suspended soil or dust, airborne soil usually consists of relatively large particles that are trapped in the nose, mouth, and throat and are then swallowed, rather than breathed into the lungs.

Skin exposure (dermal)

Dirt particles that can adhere to the skin may cause additional exposure to contaminants through dermal absorption. Although human skin is an effective barrier for many environmental contaminants, some chemicals can move easily through the skin. Metals, such as those contaminants of concern, do not pass easily through the skin.

Chemical Specific Toxicity

Below are general summaries of health effects of the COCs, the public health implications of exposure to these COCs from the soil are discussed later.

Lead – *Occurrence, Health Concerns, and Risks*

Lead is a naturally occurring chemical element that is normally found in soil. In Washington, normal background concentrations rarely exceed 20 ppm [1]. However, the widespread use of certain products (such as leaded gasoline, lead-containing pesticides, and lead-based paint) and the emissions from certain industrial operations (such as smelters) has resulted in significantly higher levels of lead in many areas of the state.

Elimination of lead in gasoline and solder used in food and beverage cans has greatly reduced exposure to lead. Currently, the main pathways of lead exposure in children are ingestion of paint chips, contaminated soil, house dust, and drinking water in homes with old plumbing.

Children less than seven years old are particularly vulnerable to the effects of lead. Compared to older children and adults, they tend to ingest more dust and soil, absorb significantly more of the lead that they swallow, and more of the lead that they absorb can enter their developing brain. Pregnant women and women of childbearing age should also be aware of lead in their environment because lead ingested by a mother can affect the unborn fetus.

Health effects

Exposure to lead can be monitored by measuring the level of lead in the blood. In general, blood lead rises 3-7 µg/dl for every 1,000 ppm increases in soil or dust concentration [2]. For children, the Centers for Disease Control and Prevention (CDC) has defined an elevated blood lead level (BLL) as greater than or equal to 10 micrograms of lead per deciliter of blood (µg/dl) [3]. However, there is growing evidence that damage to the central nervous system resulting in learning problems can occur at blood lead levels less than 10 µg/dl. About 2.2 percent of children in the U.S. have blood lead levels greater than 10 µg/dl.

Lead poisoning can affect almost every system of the body and often occurs with no obvious or distinctive symptoms. Depending on the amount of exposure a child has, lead can cause behavior and learning problems, central nervous system damage, kidney damage, reduced growth, hearing impairment, and anemia [4].

In adults, lead can cause health problems such as high blood pressure, kidney damage, nerve disorders, memory and concentration problems, difficulties during pregnancy, digestive problems, and pain in the muscles and joints [4]. These have usually been associated with blood lead levels greater than 30 µg/dl.

Because of chemical similarities to calcium, lead can be stored in bone for many years. Even after exposure to environmental lead has been reduced, lead stored in bone can be released back into the blood where it can have harmful effects. Normally this release occurs relatively slowly. However, certain conditions, such as pregnancy, lactation, menopause, and hyperthyroidism can cause more rapid release of the lead, which could lead to a significant rise in blood lead level [5].

Arsenic

Arsenic is a naturally occurring element in the earth's soil. Background soil arsenic concentrations in Puget Sound Basin range from about 1.5 to 17.1 ppm [1]. However, the widespread use of arsenic-containing pesticides and the emissions from certain smelters has resulted in significantly higher levels of arsenic on many properties in the state. There are two forms of arsenic, organic and inorganic. The EPA established reference dose (RfD) for arsenic is 0.0003 mg/kg/day based on skin color changes and excessive growth of tissue (human data) [6]. EPA classifies the inorganic form of arsenic as a human carcinogen.

Evaluating non-cancer hazards

Exposure assumptions for estimating contaminant doses from soil exposure are found in Appendix A Table A1. In order to evaluate the potential for non-cancer adverse health affects that may result from exposure to contaminated media (i.e., air, water, soil, and sediment), a dose is estimated for each COC. These doses are calculated for situations (scenarios) in which a residents might be exposed to the contaminated media. The estimated dose for each contaminant under each scenario is then compared to EPA's oral reference dose (RfD). RfDs are doses below which non-cancer adverse health effects are not expected to occur (so-called "safe" doses). They are derived from toxic effect levels obtained from human population and laboratory animal studies. These toxic effect levels can be either the lowest-observed adverse effect level (LOAEL) or a no-observed adverse effect level (NOAEL). In human or animal studies, the LOAEL is the lowest dose at which an adverse health effect is seen, while the NOAEL is the highest dose that did not result in any adverse health effects.

Because of uncertainty in these data, the toxic effect level is divided by "safety factors" to produce the lower and more protective RfD. If a dose exceeds the 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 RfD, then that dose will fall well below the observed toxic effect level. The higher the estimated dose is above the RfD, the closer it will be to the actual observed toxic effect level. This comparison is called a hazard quotient (HQ) and is given by the equation below:

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

Estimated exposure doses, exposure assumptions, and hazard quotient is presented in Appendix A for arsenic found in soil. Estimated doses from exposure to arsenic in soil resulted in a hazard quotients in excess of one for a child and an older child.

Evaluating exposure to lead

The biokinetics of lead are different from most toxicants because it is stored in bone and remains in the body long after it is ingested. Children's exposure to lead is evaluated through the use of the Integrated Exposure Uptake Biokinetic Model for Lead in Children (IEUBK) developed by the EPA. The IEUBK predicts blood lead levels in a distribution of exposed children based on the amount of lead that is in environmental media (e.g. soil) [7]. It is important to note that the IEUBK model is not expected to accurately predict the blood lead level of an individual child (or a small group of children) at a specific point in time. In part, this is because an individual (or group of children) may behave differently, and therefore have different amounts of exposure to contaminated soil and dust, than the average group of children used by the model to calculate blood lead levels. For example, the model does not take into account reductions in exposure that could result from community education programs. Despite this limitation, the IEUBK model is a useful tool to help prevent lead poisoning because of the information it can provide about the hazards of environmental lead exposure. For children who are regularly exposed to lead-contaminated soil, the IEUBK model can estimate the percentage of young children who are likely to have blood lead concentrations that exceed a level that may be associated with health problems (usually 10 μg/dl). The EPA also has an adult lead model used to predict adolescents and adults blood lead. However, only the IEUBK model will be used in the evaluation of lead because children are the most susceptible population to lead.

Soil lead concentrations and estimated blood lead levels

The IEUBK model was used to estimate the percentage of children that could have elevated blood lead levels if they play frequently in areas with lead contamination and exhibit typical behaviors that result in ingestion of soil. The maximum soil lead concentration (75,000-ppm) was used as a screen to estimate children's exposure to soil lead. Except for the soil lead concentration, model default parameters were used [7].

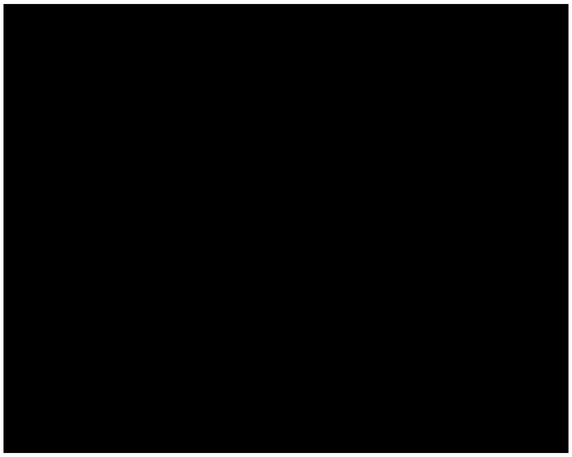
The IEUBK model has not been validated for blood lead concentration greater than 30.0 ug/dl, which correlates with soil lead concentration of 6000-ppm. In addition, the IEUBK model would not allow house dust fraction from outdoor soil to be greater than 27,000-ppm, which correlates with soil lead concentration of 38,557-ppm. At this maximum allowable soil lead concentration of 38,557-ppm, the model predicts 100 % of children will have blood lead levels greater than 10 μg/dl and average blood lead concentration of 87.3 ug/dl. For children less than seven years old who have daily exposure to soil containing 75,000-ppm lead, IEUBK model calculations (win Version 1.0 build 255) predicts average blood lead concentration 129.4 ug/dl.

Evaluating Cancer Risk

Some chemicals have the ability to cause cancer. 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 assumes that there is no "safe dose" of a carcinogen. Any dose of a carcinogen will result in some additional cancer risk. Cancer risk estimates are, therefore, not yes/no answers but 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 [8].

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 insignificant 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 is a common illness and its occurrence in a population increases with age. Depending on the type of cancer, a population with no known environmental exposure could be expected to have a substantial number of cancer cases. There are many different forms of cancer that result from a variety of causes; not all are fatal. Approximately 1/4 to 1/3 of people living in the United States will develop cancer at some point in their lives [9].

Cancer risk from exposure to soil was calculated for arsenic only as no other carcinogenic COC was identified in soil (see Appendix A- Table A3). The recent EPA IRIS review draft presented a slope factor for combined lung and bladder cancer of 5.7 per mg/kg-day [10]. The slope factor calculated from the work by the National Research Council is about 21 per mg/kg/day [11]. These slope factors could be higher if the combined risk for all arsenic-associated cancers (bladder, lung, skin, kidney, liver, etc.) were evaluated. For this Health Consultation, DOH used a slope factor of 5.7 per mg/kg-day, which appears to reflect EPA's most recent assessment. The lifetime increase of cancer risk associated with exposure to arsenic found in soil at the maximum concentration is moderate (2×10^{-3}) or (2 in 1,000).

Children's Health Concerns

The potential for exposure and subsequent adverse health effects often increases for younger children compared with 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. The following factors contribute to this vulnerability:

- Children are more likely to play outdoors in contaminated areas by disregarding signs and wandering onto restricted locations.
- Children often bring food into contaminated areas, resulting in hand-to-mouth activities.
- Children are smaller and receive higher doses of lead exposure per body weight.
- Children are shorter than adults, therefore they have a higher possibility of breathing in dust and soil.
- Fetal and child exposure to contaminants such as lead can cause permanent damage during critical growth stages.

These unique vulnerabilities of infants and children demand special attention in communities that have contamination of their water, food, soil or air. Children's health was considered in the writing of this health consultation and the exposure scenarios treated children as the most sensitive population being exposed.

Conclusions

A public health hazard exists for residents exposed to lead and arsenic in soil at this residential property.

- Young children, under the age of seven are the most susceptible to such exposure.

- Another possible source of lead in the home could be the drinking water. Older homes often have lead pipes or lead soldering, which leaches lead into the drinking water. Lead contaminated soil may also have been tracked into the home. Melting of lead is also a source for airborne lead that can be inhaled. However, since melting of lead was carried out on the property, this has likely contributed to the source of lead in the soil and possibly to the increase in the children's EBLL due to inhalation of lead in soil dust and lead fumes.

Recommendations

1. Children should not be permitted access to the property until the contaminated areas have been remediated. Signs should be posted to indicate potential health hazards from lead paint in the home and lead and arsenic in soils.

2. DOH recommends that the drinking water from the tap be tested for lead.

3. The screening level based on the maximum concentration for lead exceeded the five percent for blood lead levels and the risk for arsenic falls within the moderate range for exposure. DOH recommends additional soil sampling to obtain a statistically valid number to use in the model as the central tendencies.

4. DOH recommends that replacement soil meet MTCA cleanup standards for lead and arsenic of 250 and 20 ppm, respectively.

5. Additional, soil sampling in the neighborhood for lead should be conducted.

Public Health Action Plan

Action Planned

1. DOH will coordinate with TPCHD and Ecology to provide a fact sheet of educational materials for the owner and nearby residents regarding the hazards posed by exposure to lead.

2. DOH will provide copies of this health consultation to the concerned parties, TPCHD and Ecology.

3. Medical follow up with physician education for children with EBLL.

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Appendix A

This section provides calculated exposure doses and assumptions used for exposure to chemicals in soil. Three different exposure scenarios were developed to model exposures that might occur. These scenarios were devised to represent exposures to a child (0-5 yrs), an older child, and an adult. The following exposure parameters and dose equations were used to estimate exposure doses from direct contact with chemicals in soil

Exposure to chemicals in sediments 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

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

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

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

Inhalation of Particulate from Soil Route

$$\text{Dose}_{\text{non-cancer (mg/kg-day)}} = \frac{\text{C x SMF x IHR x EF x ED x 1/PEF}}{\text{BW x AT}_{\text{non-cancer}}}$$

$$\text{Cancer Risk} = \frac{\text{C x SMF x IHR x EF x ED x CPF x 1/PEF}}{\text{BW x AT}_{\text{cancer}}}$$

Table A1. Exposure Assumptions for exposure to contaminants in soil from residential property, in Tacoma, Washington.

Parameter	Value	Unit	Comments
Concentration (C)	Variable	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	100	mg/day	Exposure Factors Handbook [12]
Ingestion Rate (IR) – older child	100		
Ingestion Rate (IR) - child	200		
Exposure Frequency (EF)	350	Days/year	Two weeks vacation
Exposure Duration (Ed)	30 (5, 10,15)	years	Number of years at one residence (child, older child, adult yrs).
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	Exposure Factors Handbook
Surface area (SA) – older child	2900		
Surface area (SA) - child	2900		
Averaging Time$_{non\text{-}cancer}$ (AT)	1825	days	5 years
Averaging Time$_{cancer}$ (AT)	27375	days	75 years
Cancer Potency Factor (CPF)	5.7	$mg/kg\text{-}day^{-1}$	Source: Draft EPA data
24 hr. absorption factor (ABS)	0.03	unitless	Source: EPA (Chemical Specific) Arsenic
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
Inhalation rate (IHR) - adult	15.2	m^3/day	Exposure Factors Handbook
Inhalation rate (IHR) – older child	14		
Inhalation rate (IHR) - child	8.3		
Soil matrix factor (SMF)	1	unitless	Non-cancer (nc) / cancer (c) - default
Particulate emission factor (PEF)	1.45E+7	m^3/kg	Model Parameters

Soil Exposure Route–Non-cancer

Table A2. Non-cancer hazard calculations resulting from exposure scenario to contaminants in soil samples from residential property in Tacoma, Washington.

Contaminant	Max Concentration (ppm)	Scenarios	Estimated Dose (mg/kg/day)			Total Dose	RfD (mg/kg/day)	Hazard quotient
			Incidental Ingestion of Soil	Dermal Contact with Soil	Inhalation of Particulates			
Arsenic	200	Child	2.56E-3	2.22E-4	8.85E-8	2.78E-3	0.0003	9.3
		Older Child	4.68E-4	8.14E-5	5.46E-8	5.49E-4		1.8
		Adult	2.66E-4	3.19E-5	3.38E-8	2.98E-4		0.99

Soil Exposure Route –Cancer

Table A3. Cancer risk resulting from exposure to maximum arsenic concentration in soil samples from residential property in Tacoma, Washington.

Contaminant	Max Concentration (ppm)	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	Inhalation of Particulates	
Arsenic	200	A	5.7	Child	9.72E-4	8.45E-5	3.36E-8	1.06E-3
				Older child	3.55E-4	6.19E-5	4.15E-8	4.17E-4
				Adult	3.04E-4	3.63E-5	3.85E-8	3.40E-4

Lifetime cancer risk: 1.06E-3 + 4.17E-4 + 3.40E-4 = 1.81E-3

Photo 1. Driveway and yard area. Not visible in this photo are stack of buckets on the right side, some containing metal debris.

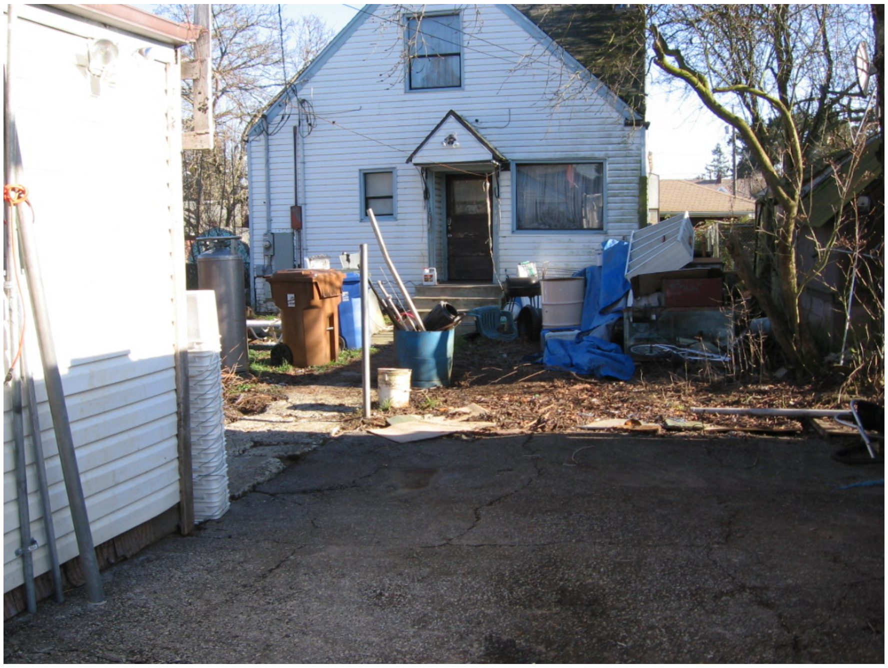


Photo 2. Buckets containing metal debris in the back yard.

Photo 3. Backyard. Soil sample was collected from the area immediately adjacent to the concrete.

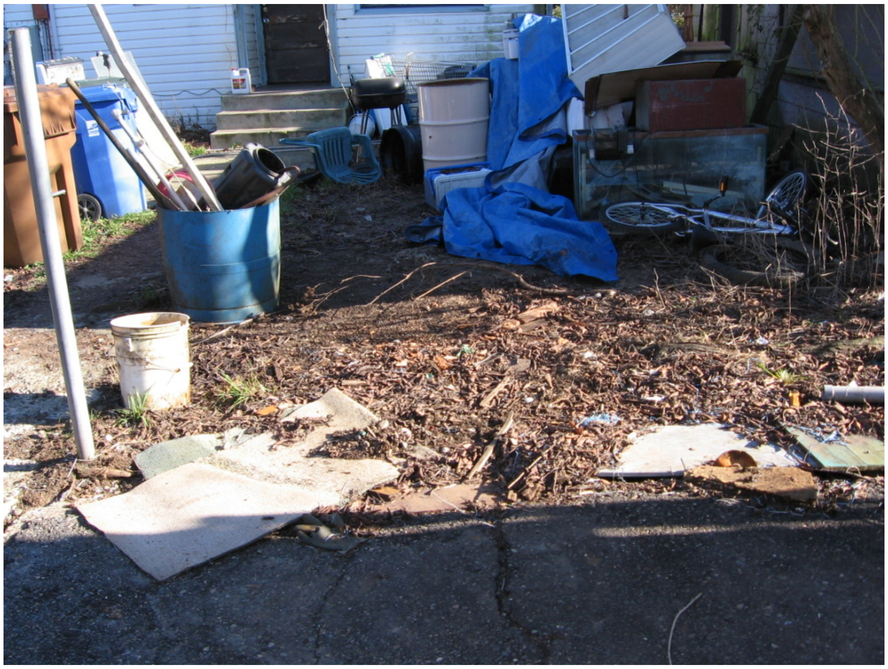
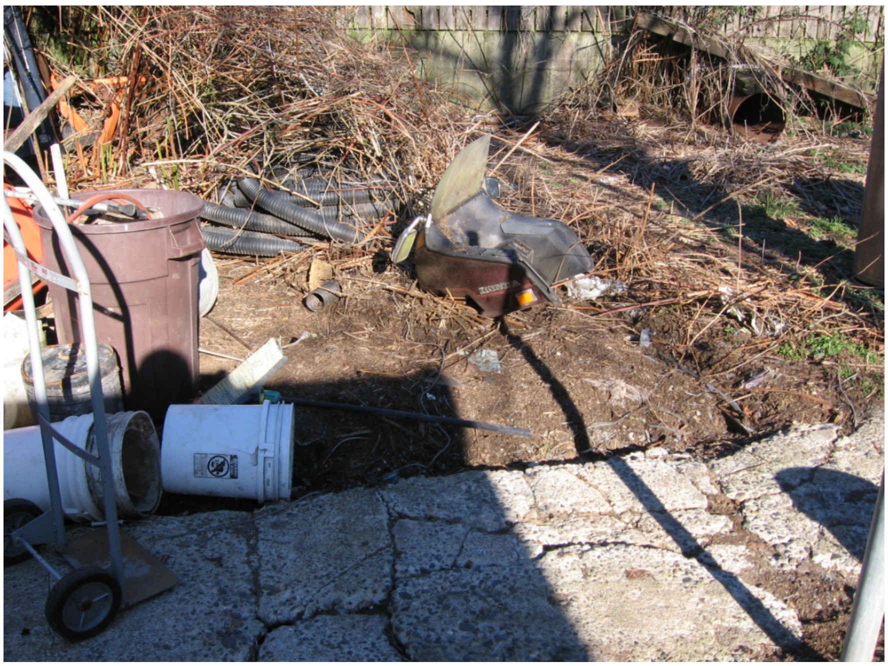


Photo 4. Backyard area between garage and house. Soil sample was collected from the area immediately adjacent to the concrete.



Certification

The Washington State Department of Health prepared this Health Consultation under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). It was completed in accordance with approved methodology and procedures existing at the time the health consultation was initiated. Editorial review was completed by the Cooperative Agreement partner.

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The Division of Health Assessment and Consultation, ATSDR, has reviewed this public health consultation and concurs with the findings.

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