Health Consultation

COEUR d'ALENE BASIN

SPOKANE RIVER SEDIMENTS

SPOKANE, WASHINGTON

APRIL 26, 2006

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

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SPOKANE RIVER SEDIMENTS

SPOKANE, WASHINGTON

Prepared by:

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

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 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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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.
Bioavailability	The fraction of lead that is absorbed and enters the blood by whatever portal-of-entry compared with the total amount of lead acquired.
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).
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].
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.
Media	Soil, water, air, plants, animals, or any other part of the environment that can contain contaminants.
Model Toxics Control Act (MTCA)	The hazardous waste cleanup law for Washington State.
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.
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].

Purpose

The Washington State Department of Health (DOH) conducted this health consultation to evaluate whether contaminants found in beach sediments along the Spokane River pose a health hazard to people who use the River for wading, swimming, picnicking, and other recreational activities. This health consultation is directed to the community of Spokane and others who use the shoreline Common Use Areas (CUAs) of the Spokane River for recreation. DOH prepares health consultations under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR).

Background and Statement of Issues

More than 100 years of mining, milling, and ore processing in the area of the upper Coeur d'Alene basin, known as the Silver Valley, [1] have contributed to concentrations of contaminants such as lead, arsenic and cadmium at levels of health concern in the Spokane River basin. Mining in the Silver Valley disbursed more than 700 million tons of contaminated mine waste mixed with native materials.[2] As a result, contamination from the upper Coeur d'Alene basin has traveled downstream and been deposited along the shoreline of the Spokane River.[3] A concentration gradient has been identified, with higher levels upstream near the upper Coeur d'Alene Basin and lower levels downstream near the city of Spokane. Despite this overall gradient, there is some local variation in contaminant levels from site to site along the river that does not follow this trend. Contaminants are expected to continue to move downstream into the Washington section of the Spokane River and redistribute along the CUAs as an ongoing process. Because of this dynamic process, and the public's unpredictable pattern of use of the shoreline, this health consultation evaluates the Spokane River CUAs as a group instead of individual sites.

The Spokane River is a major recreational area frequently used by residents and non-residents of the state of Washington. The Spokane River Centennial Trail is a 37 mile paved path running along the Spokane River from the Idaho State line to Nine Mile Falls.[4] The trail is used by people of all ages and physical capabilities and has open access in many locations to the Spokane CUAs and beaches along the river. In addition to other river accesses, the Centennial Trial is the primary way people access the river and beaches. Potential for direct human contact with lead- and arsenic-contaminated sediment through recreational and other types of activities exists at the shorelines of the Spokane River. Exposed populations may include adults and/or children, residents and/or visitors, trespassers, and others such as fishers, swimmers, and those who play on the shoreline.

In February of 2001, the Spokane Regional Health District (SRHD) issued health advisories for all CUAs of the Spokane River east of the Upriver Dam to the Washington/Idaho border (Figure 1, page 22). The advisories alert the public to elevated levels of lead and arsenic in the beach soils and to describe ways to minimize the risk of lead exposure. Various health advisories are currently in place for the entire Spokane River corridor.

Appendix A, Tables A1 – A3, and Appendix D, Table D1 list the levels of contaminants found at Spokane River CUAs evaluated by the U.S. Environmental Protection Agency (USEPA). Lead and arsenic contaminated sediments were discovered at CUAs located on public and private lands along the banks of the Spokane River from the Washington/Idaho border to the confluence with the Columbia River. In general, all CUAs are shoreline locations and beaches where people play and swim at the water's edge.

In 1998 and 1999, the U.S. Geological Survey (USGS) collected sediment samples in the Spokane River from the north end of Coeur d'Alene Lake in Idaho to the confluence with the Spokane Arm of Lake Roosevelt in Washington (Figure 2, page 23). Additional sampling along the Spokane River was conducted by USEPA in the fall of 2000 to further evaluate CUAs; [5] a total of 126 sediment samples were collected from beaches at 18 CUAs (Appendix A, Tables A1 – A3). Seven sediment sampling locations were established at each CUA site and analyzed for total metals.[3] Composite samples of one to five grab samples of the upper 12 inches of beach sediment were collected from shoreline areas above the water line where digging type of recreational use is expected [a].[2] Samples were sieved to produce particles < 175µm in diameter.[6] This particle size fraction represents the portion of sediments most likely to adhere to skin and be ingested.[7]

Sediment samples were analyzed using a standard laboratory method [EPA-Contract Laboratory Program (CLP)] for total metals.[8] Maximum lead concentrations ranged from 12 mg/kg to 2,360 mg/kg at the CUAs, maximum arsenic levels ranged from 7.7 mg/kg to 45.6 mg/kg, and maximum cadmium levels ranged from 0.1 to 21 mg/kg at the 18 CUAs sampled (Appendix A, Tables A1 and A2, and A3).

EPA developed risk-based screening concentrations (RBCs) that represent estimates of concentrations of contaminants in beach sediments that are expected to adequately protect people engaged in recreational activities along the Spokane River. The RBCs are based on the assumption that children are the most vulnerable population group and may be exposed to beach sediment through ingestion and dermal contact. Levels of lead, arsenic and cadmium were compared to risk-based screening concentrations (RBCs) to evaluate the potential hazards for people who spend time at the CUAs. Lead and arsenic levels at some CUAs exceed the RBCs for lead (700 mg/kg) and arsenic (10 mg/kg) respectively (Appendix A, Tables A1 and A2).

Arsenic concentrations also exceeded the Washington State Model Toxics Control Act (MTCA) Method B cleanup level of 0.67 mg/kg at all CUAs (Appendix A, Table A3). This cleanup level is based on the MTCA goal of allowing no more than one-in-a-million cancer risk. However, since 0.67 mg/kg is below natural background levels, MTCA allows higher cancer risks as long as they do not exceed those associated with exposure to background levels [9,10] (which, for the Spokane River has been determined to be 10 mg/kg). At four CUAs, cadmium concentrations exceeded the MTCA Method A cleanup level of 2 mg/kg.

The presence of contaminants above risk-based screening levels does not necessarily represent a threat to public health. People must have sufficient exposure to the contaminants before they will be harmed. In the following sections, the potential for harm from chemicals that exceeded

[a] Grab sample is a method for collecting random sediment samples at the subsurface of the soil

screening levels is evaluated further using all CUAs. River Road 95 and Barker Road North CUAs contain the highest lead and arsenic concentrations sampled. Figure 3, page 24, shows the River Road 95 at Starr Road as an example CUA site.

Discussion

Contaminants such as lead, arsenic, and cadmium were found in beach and shoreline sediment at levels that exceed EPA's calculated RBCs (i.e., 700 mg/kg for lead and 10 mg/kg for arsenic) (Table 1, page 8, and 2, page 12) and above the MTCA Method A cleanup level for cadmium (2 mg/kg) (Appendix A, Table A3). Therefore, lead, cadmium and arsenic were investigated as the contaminants of potential concern (COPC) at the River Road 95 and Barker Road North CUAs along the Spokane River (Appendix D, Table D1).

Potential exposure routes for these contaminants are through inhalation, ingestion, and dermal (skin) absorption. Ingestion is the primary route of exposure for lead, arsenic and cadmium in soils and sediments. Young children tend to have more exposure than adults because they tend to put things such as toys and fingers in their mouths. Contaminants in dust or soil can be ingested accidentally by this typical hand-to-mouth activity and some children exhibit pica behavior (i.e., swallowing non-food items on purpose) that could lead to higher exposures. Dermal exposure is not a significant concern because lead, arsenic and cadmium are not readily absorbed into the body through the skin and are not expected to cause a dermal reaction at levels found in the sediments. Inhalation of sediments is unlikely. Therefore, the following evaluation will focus on the potential health hazard to children by ingestion of contaminated sediments. For recreational use of the river beaches, it was assumed that exposure occurred two days per week from June through September, for a total of 35 days per year.

The United States Environmental Protection Agency (USEPA) Record of Decision for Operational Unit 2 of the Bunker Hill Mining and Metallurgical Complex identifies 10 shoreline recreational locations along the Spokane River to undergo clean up. This current health consultation is supplemental to an ATSDR Bunker Hill Public Health Assessment currently under revision and will focus only on further evaluation of potential health impacts related to recreational exposure to lead, arsenic and cadmium in the sediments of all CUAs. River Road 95 CUA (Starr Road) and the Barker Road North CUA contains the highest lead and arsenic concentrations sampled (Tables 1, page 8, and 2, page 12 and Appendix A, tables A1, A2, and A3 and Appendix D, table D1). Some of these CUAs will be re-sampled and further characterized because there is much uncertainty about physical sediment modification, natural attenuation processes, variations in soil and sediment characteristics at sampling locations, and the potential for future contaminant migration along the Spokane River corridor.[11]

Lead

Lead is a naturally-occurring element normally found at low levels in soils. Site-specific background concentrations for lead are not available for Spokane River sediments. Background soil concentrations from the upper Coeur d'Alene basin are higher than Spokane River area background concentrations reported by Ecology because natural mineral formations in the basin are higher in metals than the Spokane River area soil.[3] Background soil lead concentrations in the Spokane Area range between 2 mg/kg and 16 mg/kg.[12] Natural background sediment concentrations are likely influenced by both Spokane area soils and materials transported from the upper Coeur d'Alene basin that are deposited on Spokane River beaches.

Children six years old and younger are particularly vulnerable to the effects of lead. Compared with older children and adults, they tend to ingest more dust and soil, and absorb more of the lead they swallow. Because children's brains are developing rapidly, they may be more sensitive to the neurological effects of lead than adults. Pregnant women and women of childbearing age should also be aware of lead in their environment because lead ingested by a mother can affect her unborn fetus.

Health effects

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.[13]

Exposure to lead can be monitored by measuring the level of lead in the blood. One estimate suggests that blood lead rises 3-7 micrograms of lead per deciliter (µg/dl) for every 1,000 mg/kg lead increase in soil or dust concentration.[14] 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 µg/dl (10 µg/dl is defined as a toxicological level of concern by the CDC).[15] However, evidence is growing that damage to the central nervous system resulting in learning problems can occur at blood lead levels less than 10 µg/dl.[16,17,18] About 2.2 % of children (ages 1-5 years old) in the United States have blood lead levels greater than 10 µg/dl.[19]

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.[13] These have usually been associated with BLLs greater than 30 µg/dl and are unlikely to occur from exposure to Spokane River sediments.

In the 11th Report on Carcinogens (2004), the National Toxicology Program (NTP) of the U.S. National Institutes of Health concluded that "lead and lead compounds are reasonably anticipated to be human carcinogens".[20] In arriving at its conclusion, the NTP relied upon studies on laboratory animals and workers exposed to high levels of lead. The laboratory animals developed brain, kidney, and lung cancer. The workers inhaled high levels of lead fumes or accidentally ingested lead dust. The worker studies did not account for diet and smoking and exposure to other cancer-causing agents. The worker study showed weak evidence for increased risk for lung, stomach, or bladder cancer. The workers were exposed to lead at 50 to 5000 micrograms per cubic meter (µg/m3) in air and had 40 to 100 micrograms lead per deciliter (µg/dl) in blood. For the Spokane River, these above exposures do not fit the types and amounts of exposures for recreational users of CUAs.

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 substantial rise in blood lead level.[21] Understandably, most if not all of these conditions would not apply to recreational users of the Spokane River.

Table 1. Summary of average values and maximum levels of lead detected in sieved sediments (diameter less than 175 µm) for CUAs that exceeded the RBCs, at Spokane River, Washington (from USEPA 2000).[3]

Common Use Area (CUA) ID *	Lead (mg/kg)		Non-Cancer CV (mg/kg)	Cancer C V (mg/kg)	RBC (mg/kg)
	Avg.	Max.			
River Road 95 †	1,410	2,360	NA	NA ‡	700
Harvard Road South	367	1,070			
Barker Road North	478	822			
North Flora Road	706	1,040			
Harvard Road North	424	534			

Note: † The mean CUA River Road 95 was used to evaluate lead exposure in children
RBC: EPA's Risk-Based Screening Concentration
Max: Maximum value
Avg: Average value
NA – No available
‡ Lead and lead compounds are reasonably anticipated to be human carcinogen. [20]
* Seven sediment sampling locations were established at each CUA site.

Health risk evaluation – The IEUBK model

To evaluate the potential for harm, public health agencies often use a computer model that can estimate blood lead levels in children younger than seven years of age who are exposed to lead-contaminated soil. This model (developed by EPA and called the Integrated Exposure Uptake Biokinetic Model, or IEUBK model) uses the concentration of lead in soil to predict blood lead levels in children.[22] It is intended to help evaluate the risk of lead poisoning for an average group of young children who are exposed to lead in their environment. The IEUBK model can also be used to determine what concentration of lead in soil could cause an unacceptable number of elevated BLLs in a group of young children. It is often used in this way to set soil cleanup levels for lead.

The IEUBK model was designed to estimate the probability of distribution of BLLs in children 0 to 84 months of age, based on estimates of these parameters:

- Intake of all potential sources of lead including air, water, diet, and soil at the CUA added to incremental intakes of lead at home.
- Uptake of lead from those media into the bloodstream.
- Distribution of lead to tissues and organs.
- Excretion of lead.

It is important to note that the IEUBK model is not expected to predict accurately the BLL of a child (or a small group of children) at a specific time. In part, this is because an individual child (or group of children) may behave differently than the group of children the model uses to calculate BLLs and therefore have different amounts of exposure to contaminated soil and dust. 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 it can provide reasonable estimates about the hazards of environmental lead exposure.

Soil lead concentration and estimated blood lead level

The IEUBK model was used to estimate the percentage of children that could have elevated blood lead levels if they play frequently in areas that have lead contamination and exhibit typical behaviors that result in soil ingestion. These percentages were calculated using the arithmetic mean as the central tendency estimate (CTE) of the soil lead concentrations measured at the CUA River Road 95. Studies have shown good agreement between BL concentrations predicted by the IEUBK model and observed BL concentrations at Superfund sites when the inputs to the model are arithmetic means of the concentrations in the exposure units.[23,24]

The average concentration of lead detected in the sediment at the River Road 95 CUA (0-12 inches) was 1,410 mg/kg. DOH used a beach sediment exposure scenario to account for lead intake resulting from exposure to soil and dust. The following assumptions were considered as reasonable to run the IEUBK Model:

1. Children may be exposed to lead in soil and dust at both at the river as well as at home (located outside the CUA).
2. The mean concentration of lead in the beach sediment at the CUA is 1,410 mg/kg.
3. A child plays at the beach 2 full days/week from June through September (for a total of 35 days of exposure) and stays at home 5 days per week. The soil ingestion rate equals to 100% of residential soil and dust. The soil beach ingestion rates were set at 85 – 135 mg/day, and the total ingestion rates were set at 85 – 196 mg/day.
4. The residential soil concentration was set at the IEUBK default value of 200 mg/kg, and the soil and dust ingestion rates were set at 45% in the soil for 5 days and 55% in dust for 7 days. The total ingestion rates were set within the range of 85 – 135 mg/day.

Exposure frequency

The exposure is assumed to occur for 2 days/week for 16 weeks (for a total of 35 days of exposure) as a typical frequency of seasonal contact with the CUAs. This estimate is reasonable and consistent with the outdoor activity patterns of children in the upper basin and EPA's Exposure Factors Handbook.[25,26]

Ingestion rates for beach sediment

On the 2 days/week that children visit the beach, the daily ingestion rates for beach sediment were set to equal the default age-specific values for daily residential soil plus dust ingestion (e.g., 100 mg/day for age 0 to 84 months). To account for the 5 days that children are not at the beach, the model was run in the default mode.

Estimation of PbB values

Blood lead levels were estimated for children exposed 2 days/week to the weighted soil lead concentration of 377.93 mg/kg in beach sediment (see Appendix B) and to background levels of lead at home (assumed to be 200 mg/kg). The model predicts an approximate 11 percent risk that a 12 to 24 month old child exposed to the conditions listed above will have a BLL greater than 10 µg/dl. Appendix B, Table B2 summarizes blood lead concentration values that exceed 10µg/dl within different age ranges at the CUA River Road 95, Spokane, Washington.

Default values for the EPA IEUBK Model versus the Box Model

Appendix E, Table E1 summarizes the IEUBK default and box assumptions used in the Coeur d'Alene River Basin.

Use of the IEUBK default assumptions versus site-specific *assumptions*

In its report entitled "Superfund and Mining Megasites," the National Academy of Sciences (NAS) reviewed the way the IEUBK model was used to evaluate hazards of exposure to environmental lead contamination in the Coeur d'Alene River Basin.[27] The report indicates that when reliable site-specific information is available, it should be used instead of default assumptions. The DOH considered the possibility of using the IEUBK model with site-specific information instead of default parameters.

The NAS report discussed the use of non-default parameters to better predict BLLs in the "Box," a 21-square mile area in the Coeur d'Alene basin. Some blood testing had been performed for people living in the Coeur d'Alene Basin (within the Box as well as east and west of the Box), and the results of these tests were compared with BLLs predicted by the IEUBK model to see how well the model worked. For children within the Box and east of the Box, running the model with default values for the parameters resulted in higher predicted geometric mean BLLs and greater percentages of children with BLLs exceeding 10 µg/dL than was found by testing the children. However, using default parameters caused the model to predict geometric mean BLLs and percentage of children with BLLs exceeding 10 μg/dL that were slightly lower than the measured values for children west of the Box (i.e., in the direction of the Spokane River sites that are the subject of this health consultation). In order to have the model provide more accurate predictions for children within the Box, the EPA adjusted two of the input parameters for the model. Bioavailability of lead from soil was lowered from 30% to 18%, based on a plausible assumption that much of the lead present in soils within the Box is present as galena which has a relatively low bioavailability in swine studies. [28,29] Also, the fraction of exposure attributed to neighborhood soils was increased compared to the default parameter. Running the IEUBK model with these Box-specific parameters resulted in better agreement between measured and predicted BLLs for children within and east of the Box. However, for children west of the Box, these adjustments caused the model to more severely underestimate the geometric means and percentage of children with BLLs greater than 10 μg/dL.

A discussion cautioning the use of Box-specific parameters when using the IEUBK model to estimate BLLs in children west of the Box is found on page 260 of the NAS report: "Disparate model performance in the lower basin may be related to differing exposure profiles. For example, shoreline recreation in the lower basin may lead to significant exposure to exposed materials with high lead content and bioavailability. Neighborhood soils therefore may be a poor surrogate in the lower basin leading to box model underprediction. As described in the Operable Unit-3 Human Health Risk Assessment (OU-3 HHRA), follow-up studies of children with high levels of lead in their blood in the lower basin suggest strongly that riverbank material may be an important source of lead exposure (TerraGraphics et al. 2001). The Coeur d'Alene River Basin might also exhibit spatial variation in soil lead bioavailability. Smaller particles are transported further downstream in watersheds and generally exhibit higher lead bioavailability (Mushak 1991) than larger particles." [30]

Based on this information, it seems inappropriate to use the Box-specific input parameters for the purpose of modeling BLLs for sites along the Spokane River. Studies to evaluate site-specific bioavailability or chemical speciation of lead at the Spokane River sites have not been conducted. Available data indicate that using the IEUBK model with default parameters provides good estimates for BLLs in children living west of the Box.

Uncertainties related to the IEUBK model and lead toxicity

The IEUBK model relies on many input parameters to estimate BLLs in children exposed to environmental sources of lead. Several of these parameters (such as soil ingestion rate, lead bioavailability, frequency of exposure, and concentrations of lead where exposure occurs) can be difficult to measure accurately and can vary from person to person and from location to location within a contaminated site. EPA developed default values for all of the parameters to allow the model to be used easily without having to perform potentially costly and time-consuming studies at every site. A few studies comparing BLLs predicted with the IEUBK model with those measured in children suggest that the model can provide reasonable estimates of BLLs in children when using default parameter values. However, there are some conditions, such as those within and east of the Coeur d'Alene Basin Box, where predictions can be improved by changing some of the default parameters.

Without adequate study data, there will be uncertainty about how well the default IEUBK parameter values reflect true conditions at a site, and it is possible that use of the default parameter values could lead the model to overpredict or underpredict actual BLLs. At this time there are no site-specific data from the Spokane River beach sites to use in place of the default parameters and no basis for changing the default parameters.

For this health consultation, the IEUBK model was used to estimate the percentage of children who would have elevated blood lead levels, defined by the Centers for Disease Control and Prevention as those exceeding 10 µg/dL.[31] As mentioned before, evidence is growing that deficits in cognitive and academic skills associated with lead exposure occur at blood lead concentrations lower than 5 µg/dL.[32,17,18] This suggests that using the IEUBK model to calculate the percentage of children with blood lead levels greater than 10 µg/dL may cause the hazards from lead at the Spokane River sites to be underestimated. For exposures at the beach, children are assumed to potentially ingest greater amounts of soil/sediment than they would do at home; therefore, children are more likely to increase BLLs because riverbank material may be an important source of lead exposure.[27]

Mean values at CUAs that exceed RBCs and BLLs in children exposed to lead in the Spokane River Sediment

Table 2. **Mean values for CUAs with levels that exceed children's BLLs greater than 10 µg/dL.**

Common Use Area (CUA) ID *	**Lead (mg/kg)**		**Non-Cancer risks**	**Cancer Risks in CUAs**	**Exceed EPA's 5 % goal of BLLs in children (age 6 – 48 months) > 10 µg/dL**	**RBC (mg/kg)**
	Avg.	**Max.**				
River Road 95 †	**1,410**	2,360	Yes	‡	Yes [a]	700
North Flora Road †	**706**	1,040				

Note: † The mean CUA River Road 95 and North Flora Road were used to evaluate lead exposure in children
RBC: EPA's Risk-Based Screening Concentration
Max: Maximum value
Avg: Average value
‡: Lead and lead compounds are reasonably anticipated to be human carcinogen.[20]
* Seven sediment sampling locations were established at each CUA site.
[a] 5 % refers to the percentage of children that exceeds EPA's target cleanup goal of having no more than 5 % of the community with BLLs above 10 µg/dL.

Table 2 shows mean values for River Road 95 and North Flora Road CUAs that exceed children BLLs. Appendix B, Tables B2 and B4 show BL concentration values that exceed 10 µg/dL for different age ranges.

Arsenic

Arsenic is a naturally occurring element in the earth's soil. Natural background soil arsenic concentrations for the greater Spokane area have been reported to range from approximately 1 mg/kg to 10 mg/kg.[12] A background value identified by the Washington State Department of Ecology for sediments in the upper Spokane River has been established at 10 mg/kg for the purpose of CUA cleanup planning (USEPA ROD).

The main route of exposure for arsenic at the Spokane River sites is expected to be through ingestion of contaminated sediments. Dermal contact with sediments is unlikely to result in harmful exposure because arsenic is poorly absorbed through the skin. Ingestion of inorganic arsenic has been shown to cause cancer and many other health problems in people, including cardiovascular disease, stroke, diabetes, liver damage, nerve damage and changes in the skin.[33]

For the hazard evaluations below, the upper 95% confidence limit (UCL) of the mean arsenic concentration at a site will be used as the reasonable maximum exposure (RME) estimate.[34] Using the UCL 95% as the RME helps ensure that exposures are not underestimated due to spatial or temporal variability and measurement error. Table 3, page 14, lists the UCL 95% values found at the CUAs that exceeds RBCs, MTCA Method B and ATSDR comparison values.

Table 3. Summary of the UCL 95% of arsenic detected in sieved sediments (diameter less than 175 µm) for CUAs that exceeded the RBCs screening at Spokane River, Washington (from USEPA, 2000).[3]

Common Use Area (CUA) ID	Arsenic (mg/kg) UCL 95%	Non-Cancer CV (mg/kg)	Cancer C V (mg/kg)	MTCA Method B (mg/kg)	RBC (mg/kg)
River Road 95	**29.3**	20[a]	0.5[b]	0.67[c]	10
Harvard Road North	20.2				
Harvard Road South	15.1				
Barker Road North	**36.2**				
North Flora Road	21.4				
People's Park	16				
Jackson Cove	15.6				

Note: Bold CUAs with the highest concentration values were evaluated in this health consultation
a. EMEG – ATSDR's Reference Dose Media Evaluation Guide (child)
b. CREG – ATSDR's Cancer Risk Evaluation Guide (child)
c. Ecology's Cleanup Levels and Risk Calculations under the Model Toxics Control Act (MTCA) Cleanup Regulation (CLARC).[9]
RBC: EPA's Risk-Based Screening Concentration

Hazard Evaluation for Arsenic - Non-cancer Effects

In order to evaluate the potential for non-cancer adverse health affects that may result from exposure to arsenic-contaminated soil and sediment, an exposure dose was estimated for children who might come into contact with the contamination during seasonal beach recreation. The estimated arsenic dose for this scenario was then compared to ATSDR's minimal risk level (MRL) and EPA's oral reference dose (RfD) which, for arsenic, have the same values. MRLs and RfDs are doses below which non-cancer adverse health effects are not expected to occur and, for arsenic, are based on effects seen in people. A level of uncertainty exists when defining an MRL or RfD because of uncertainty about the quality of data on which it is based. To account for this uncertainty, "safety factors" are used to set RfDs and MRLs below toxic effect levels (e.g., Lowest Observed Adverse Effect Level [LOAEL]) that have been observed in relevant studies. This approach provides an added measure of protection against the potential for adverse health effects to occur. For chronic oral exposure to arsenic, the MRL and RfD is 0.0003 milligrams of arsenic per kilogram of body weight per day (mg/kg/day).

The calculated soil arsenic concentration at the 95 % UCL is 36.2 mg/kg at Barker Road North and 29.3 mg/kg at River Road 95 (Table 3, page 14, Appendix A, table A1, and Appendix D, table D1). An exposure scenario of two days per week for 16 weeks (June through September) at these sites with exposure to 36 mg/kg or 29.3 mg/kg was used in dose calculations in Appendix C, tables C2 and C3. A child (age 3-6) would receive an exposure dose of 0.0000577 and 0.0000465 respectively, which is lower than the chronic MRL of 0.0003 mg/kg/day.

Estimated doses for children and adults are below the acute and chronic MRLs indicating that non-cancer health effects are unlikely to occur from exposures at the CUAs of the Spokane River sediment.

Hazard Evaluation for Arsenic - Cancer

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 a theoretical risk estimate to result in a single cancer case. For example, a low theoretical increase in cancer risk is about one additional contaminant-related cancer case per ten thousand persons exposed over a lifetime. A very low theoretical risk is about in one additional cancer case per several tens of thousands exposed over a lifetime and a slight risk 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 theoretical excess cancers that might result in addition to those normally expected in an unexposed population. The actual risks are likely to be lower and may even be zero.

Exposure to arsenic has been strongly linked to increased risk of bladder cancer, lung cancer, skin cancer, liver cancer, and kidney cancer in people. EPA classifies arsenic as a Group A (known human) carcinogen by the oral and inhalation routes.

Uncertainty

There is some controversy with respect to assessing potential risks associated with exposure to arsenic. Both the RfD and the Cancer Slope Factor (CSF) are based on human ecological studies that have recognized uncertainties. Such studies may have errors in assigning people to specific exposure groups. Also, EPA's current CSF considers only skin cancer, while quantitative estimates of bladder and lung cancer are now available. To adjust for these uncertainties, DOH used early-life exposure scenarios and a range of other CSFs that consider lung and bladder cancer slope factors to adjust for cancer risks associated with arsenic-contaminated soils. Cancer risks are generally higher from early-life exposures than from similar exposure durations later in life. Therefore the following adjustments were used in this evaluation (Appendix C, Table C4).[35]

- For exposures before 2 years of age (i.e., spanning a 2-year time interval from the first day of birth up until a child's second birthday), a 10-fold adjustment.

- For exposures between 2 and <16 years of age (i.e., spanning a 14-year time interval from a child's second birthday up until their sixteenth birthday), a 3-fold adjustment.

- For exposures after turning 16 years of age, no adjustment.

The 95% UCL for arsenic in the soil at the Barker Road North site (36.2 mg/kg) and at the River Road site (29.3) exceed the ATSDR Cancer Risk Evaluation Guide (CREG) of 0.5 mg/kg. Exposure doses were calculated for a child over a 5-year exposure period with 35 days of exposure per year (specifically, two days per week exposure from June through September). The calculated theoretical lifetime cancer risk for such an exposure at either the Barker Road North site or the River Road site is estimated at about 8 and 6 additional cancers in a population of 100,000 people respectively (Appendix C, Table C5 and C6). The risks listed here are calculated estimates that are somewhat uncertain and could overestimate or underestimate the actual cancer risk.

UCL 95% values at CUAs that exceed RBCs and cancer risk for children exposed to arsenic in the Spokane River Sediment

Table 4, below, shows all CUAs that exceed 1 in a million theoretical cancer risks for children exposed to arsenic-contaminated sediment along the shorelines of the Spokane River. The risk from arsenic at these sites is very low (10^{-5} cancer risk), but exceeds the Washington state goal for public health protection of one in a million cancer risk from environmental contaminants. Appendix C, Table C7 shows values that exceed one in a million cancer risks as a result of exposure to arsenic-contaminated sediment from the Spokane River CUAs in the Spokane River, Washington.

Table 4. **UCL 95% arsenic values for CUAs with levels at RBCs values and that exceeds theoretical cancer risks of 2 in 100,000 people to recreational users of the Spokane River.**

Common Use Area (CUA) ID	Arsenic (mg/kg) UCL 95%	Exceeds Human Cancer Risks (2 in 100,000 people)	RBC (mg/kg)	MTCA Method B (mg/kg)
River Road 95	29.3	Yes	10	0.67[a]
Harvard Road North	20.2			
Harvard Road South	15.1			
Barker Road North	36.2			
North Flora Road	21.4			
People's Park	16			
Jackson Cove	15.6			
Plante Ferry Park	14.5			
Riverside Park	11.75			
Wynecoop Landing	10.4			
Coyote Spit	9.9			
The Docks	9.7			
Porcupine Bay	10.8			
"No name" Campground	10.5			
Horseshoe Point	13.9			

a. Ecology's Cleanup Levels and Risk Calculations under the Model Toxics Control Act (MTCA) Cleanup Regulation (CLARC).[9]

Cadmium

Cadmium is a naturally occurring element in the earth's soil. Background soil cadmium concentration ranges between 0.1 and 5.0 mg/kg, statewide in Washington State.[36]
The EPA classified cadmium as a probable human carcinogen based on animal studies. Cadmium contaminated soil can accidentally be ingested by hand to mouth activity. Cadmium is stored in the liver and kidneys and slowly leaves the body in the urine and feces.[37] Dermal exposure is not normally an important pathway because very little cadmium enters through the skin.

For the hazard evaluations below, the upper 95% confidence limit (UCL) of the mean cadmium concentration at a site will be used as the reasonable maximum exposure (RME) estimate.[34] Using the UCL 95% as the RME helps ensure that exposures are not underestimated due to spatial or temporal variability and measurement error.

Non-cancer effects

In order to evaluate the potential for non-cancer adverse health affects that may result from exposure to cadmium-contaminated soil, and sediment, an exposure dose was estimated for children who might come into contact with the contamination during seasonal beach recreation. The estimated cadmium dose for this scenario was then compared to ATSDR's (MRL) or EPA's (RfD). MRLs and RfDs are doses below which non-cancer adverse health effects are not expected to occur.

A level of uncertainty exists when defining an MRL or RfD because of uncertainty about the quality of data on which it is based. To account for this uncertainty, "safety factors" are used to set RfDs and MRLs below toxic effect levels (e.g., Lowest Observed Adverse Effect Level [LOAEL]) that have been observed in relevant studies. This approach provides an added measure of protection against the potential for adverse health effects to occur. 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. The higher the estimated dose is above the MRL or RfD, the greater the likelihood that the chemical will cause health problems. This comparison is known as a hazard quotient (HQ) and is given by the equation below:

Equation 1

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

The chronic oral MRL for cadmium is 0.0002 mg/kg/day. It is assumed that the body rapidly absorbs about 5 % of the cadmium ingested in water and about 2.5 % of the cadmium ingested in food. The estimated NOAEL for chronic cadmium exposure is 0.005 and 0.01 mg/kg/day from water and food, respectively.[38] Chronic exposure studies in humans indicate that the NOAEL is 0.0021 mg/kg/day and the LOAEL is 0.0078 mg/kg/day.

The 95% upper confidence limits of cadmium of 17.6 mg/kg in the subsurface soil (0-12 inch interval) at River Road and 13.1 mg/kg at Barker Road North were used to calculate hazard quotients for a person exposed to beach sediment for two days a week from June through September (35 days/year).

The calculated hazard quotients are about 0.027 and 0.02 respectively (see Appendix C – Tables C2 and C3) for both sites (ages 3-6). Exposure for children (ages 3 to 6 years old) is estimated to be about 0.0000267 and 0.0000199 milligrams of cadmium per kilogram of body weight per day and is not expected to result in non-cancer health problems.

Cancer effects

The calculated theoretical lifetime cancer risk for such an exposure is estimated at about 1 additional cancer in a population of 1 million people (Appendix C, Table C6). DOH considers this to be a very low theoretical increased cancer risk over a short period of time.

Child Health Considerations

Exposure scenarios for children's play activities, such as digging, that involve contact with beach sediment along the Spokane River were evaluated in this document to determine if children's exposures were of public health concern. ATSDR and DOH recognize infants and children are susceptible to developmental toxicity that can occur at levels much lower than those causing other types of toxicity. Infants and children are also more vulnerable to exposures than adults. The following factors contribute to this vulnerability at this site:

- Children are more likely to play in ways that involve close contact with soil and sediment in contaminated outdoor areas.
- Children often bring food into contaminated areas, resulting in hand-to-mouth activities.
- Children are smaller and receive higher doses of metals exposure per body weight.
- Children are shorter than adults; therefore they have a higher possibility to breathe in dust and soil.
- Fetal and child exposure to lead can cause permanent damage during critical growth stages.

These unique vulnerabilities of infants and children demand special attention in communities with 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 kids as the most sensitive population being exposed. Reducing children's exposure to lead is an important public health activity. The U.S. government in general, and the CDC in particular, have established a goal of eliminating lead poisoning (specifically, blood lead levels exceeding 10 μg/dL) in children by 2010.
(http://www.whitehouse.gov/omb/expectmore/summary.10003508.2005.html
http://www.cdc.gov/nceh/lead/about/fedstrategy2000.pdf)

It is expected that children will be playing and digging in contaminated sediment at the CUAs from June through September. Children's activities on the beach and residential homes may result in frequent, significant exposure to soil contaminants. Health Advisories and/or signs posted at the contaminated CUAs along the Spokane River can help reduce children's exposure to lead and arsenic that is present.

Conclusions

Potential for direct human contact with lead- and arsenic-contaminated sediment through recreational and other types of activities exists along the shoreline at CUAs of the Spokane River. Exposed populations may include adults and/or children, residents and/or visitors, trespassers, and others such as fishers, swimmers, and those who play on the shoreline.

The mean lead concentrations at two of the CUAs exceeded the RBC, indicating that uncontrolled exposure at the sites could result in an unacceptable risk of lead poisoning for young children.

The estimated additional theoretical cancer risk from exposure to the 95% UCL arsenic concentrations at each of the sampled CUAs is greater than one in one hundred thousand. While the theoretical risks are considered very low (10^{-5} cancer risk), they exceed the Washington state goal (one in a million excess cancer risks) by a factor of ten or more.

Sediment and contaminants are migratory in the river system. Current sampling results from any one CUA cannot accurately predict future levels.

Patterns of human use may change. A majority of this river segment is accessible from the Centennial Trail. Contaminant levels of new areas that people choose to use in the future is unknown.

Based on this information, DOH concludes that the Spokane River, and its CUAs, from the state line to the upriver dam is a past and current public health hazard. Due to the dynamic nature of the river system and its sediments, and plans for cleanup, an indeterminate health hazard exists in the future.

This health consultation supports the use of health advisory signs along portions of the Spokane River, as well as remedial efforts proposed by the U. S. Environmental Protection Agency (EPA) and the Washington Department of Ecology to reduce or eliminate the contamination for local and non-local residents who visit the shoreline and beach common-use areas for recreational purposes. The determination of public health hazard for this segment of the river indicates that there is an expectation of impact to public health. Cleanup of individual CUAs, or segments of the river, where contaminant levels are currently below those that warrant this determination is a prudent health protection measure for future users of these sites.

Available environmental sampling data at the CUAs suggest that there is some variation in contaminant levels from site to site along the river. CUAs with lower concentrations of contaminants will generally be associated with lower degrees of hazard when people’s exposures are the same. However, the true risk to the public is difficult to assess accurately and depends on the number of people who use each site, each person's exposure-related behaviors, and other site-related factors. Site-specific information about soil ingestion rates, frequency of visitation, and bioavailability of contaminants could improve the accuracy of this health evaluation but is not available. Further, sedimentation trends are difficult to predict and how the levels will change over time.

Recommendations

1. Maintain current advisory. Children and adults may be exposed to lead and arsenic in the CUAs along the Spokane River. DOH recommends that the current sediment contact health advisory remain in place for the river until remediated. This advisory should recommend simple ways to limit contact and ingestion of contaminated sediments.

2. Progress with cleanup actions. Because lead and arsenic are present in beach sediments along shoreline recreation areas at levels of health concern, DOH recommends that actions be taken to reduce or eliminate exposure to the contaminants. Permanent actions that effectively reduce or eliminate exposure are preferable to actions that are less effective or permanent. Where appropriate removal of contaminated soil is the most effective and permanent method to eliminate exposure. Due to the level of public education about this issue along the river, DOH is more comfortable with an extended cleanup timeline of 24 months.

Public Health Action Plan

1. The Spokane Regional Health District (SRHD) is responsible for maintaining the health advisory signs posted along the Spokane River up stream of Upriver Dam to avoid human exposure to contaminants that remain on-site.

2. DOH will consult with EPA, the Washington Department of Ecology, and the SRHD on the appropriateness and efficacy of future remedial actions.

3. DOH is prepared to assist the SRHD and Ecology to create updated fact sheets as needed and distribute them to concerned citizens who recreate along the Spokane River. If any citizen has additional information or health concerns regarding the CUAs along the Spokane River, please contact the Spokane Regional Health District at 509-324-1500 or DOH, Office of Environmental Health Assessments, at 1-877-485-7316.

ATTENTION

LEAD AND ARSENIC IN SHORELINE SOILS

Frequent contact with shoreline soils along the Spokane River from State Line to Plantes Ferry Park may be unsafe, particularly for young children. Follow these steps to limit your exposure to lead and arsenic in these soils.

- **Avoid muddy soil that might cling to clothing, toys, or hands or feet.**
- **Wash your hands and face, especially before eating.**
- **Avoid dry, loose, or dusty soils that you might breathe.**
- **Wash anything that has come in contact with shoreline soils before entering your home.**

For more information contact the Spokane Regional Health District at:

(509) 324-1574

Figure 1. Health Advisory Sign for lead and arsenic contamination along the Spokane River, Spokane, Washington.

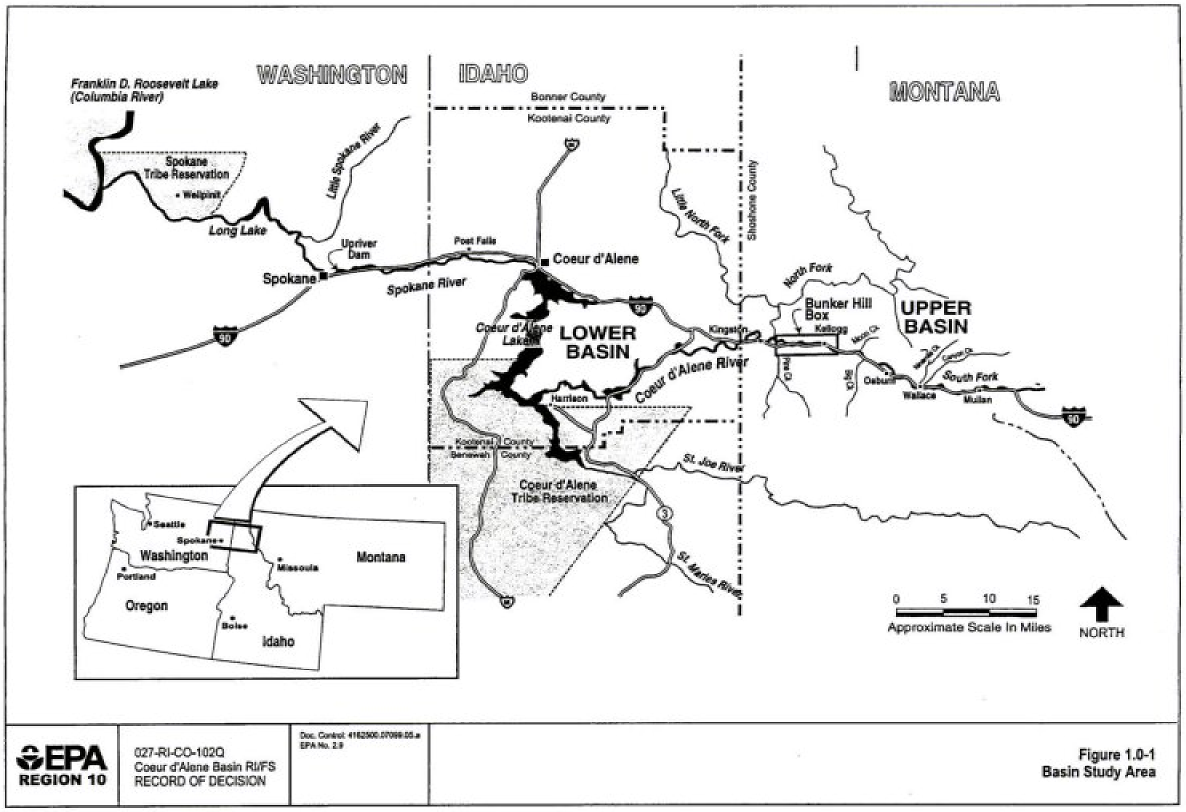

Figure 2. Upper Coeur d'Alene Basin and major tributary rivers.

Figure 3. Common Use Area River Road 95 at Star Road Spokane River, Spokane, Washington.

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Appendix A

Lead and arsenic were investigated as the primary contaminants of concern at the CUAs River Road 95 and Barker Road North respectively, although arsenic and cadmium were present at other CUAs the levels pose sufficiently low health risk to children when they become exposed with an exposure frequency of 2 days/week.

Table A1. Summary of maximum and 95% UCLs levels of arsenic detected in common use areas that exceed MTCA, RBCs and ATSDR comparison values at Spokane River, Washington.

Common Use Area (CUA) ID	Arsenic (mg/kg)		Non-Cancer CV (mg/kg)	Cancer C V (mg/kg)	RBC (mg/kg)	MTCA Method B (mg/kg)
	Max.	UCL 95%				
River Road 95	**35.1**	**29.3**				
Harvard Road North	**23.6**	**20.2**				
Harvard Road South	**31.7**	**15.1**				
Barker Road North	**45.6**	**36.2**				
North Flora Road	**24.8**	**21.4**				
Plante Ferry Park	16.5	14.5				
Boulder Beach	7.7	6.9				
People's Park	**25.2**	**16**				
Riverside Park	9.7	11.75	20[a]	0.5[b]	10	0.67[c]
Wynecoop Landing	11.5	10.4				
Coyote Spit	10.4	9.9				
The Docks	13.3	9.7				
Jackson Cove	**22.9**	**15.6**				
Porcupine Bay	13	10.8				
"No name" Campground	11.1	10.5				
Horseshoe Point	18.3	13.9				
Pierre Campground	12.2	9				
Fort Spokane Park	8.5	6.7				

Note: Bold contaminant indicates that the maximum and UCL 95% concentrations exceeds both MTCA and RBC and therefore is considered a contaminant of concern

a. EMEG – ATSDR's Reference Dose Media Evaluation Guide (child)

b. CREG – ATSDR's Cancer Risk Evaluation Guide (child)

c. Ecology's Cleanup Levels and Risk Calculations under the Model Toxics Control Act Cleanup Regulation (CLARC).[9]

RBC: EPA's Risk-Based Screening Concentration

Max: Maximum value

Table A2. Summary of levels of lead detected in common use areas that exceed MTCA and RBCs at Spokane River, Washington.

Common Use Area (CUA) ID	Lead (mg/kg)		Non-Cancer CV (mg/kg)	Cancer C V (mg/kg)	RBC (mg/kg)
	Avg.	Max.			
River Road 95	**1,410**	**2,360**			
Harvard Road North	**424**	**534**			
Harvard Road South	**367**	**1,070**			
Barker Road North	**478**	**822**			
North Flora Road	**706**	**1,040**			
Plante Ferry Park	107	174			
Boulder Beach	31	55			
People's Park	17	27			
Riverside Park	81	110	NA	NA	700
Wynecoop Landing	16	17			
Coyote Spit	20	25			
The Docks	19	24			
Jackson Cove	15	20			
Porcupine Bay	15	20			
"No name" Campground	14	17			
Horseshoe Point	12	15			
Pierre Campground	11	15			
Fort Spokane Park	9	12			

Note: Bold contaminant indicates that the average and maximum concentrations exceeds both MTCA and RBC and therefore is considered a contaminant of concern
RBC: EPA's Risk-Based Screening Concentration
Avg: Average
Max: Maximum value
NA: No available

Table A3. Summary of levels of cadmium detected in common use areas that exceed MTCA and ATSDR's non-cancer values at Spokane River, Washington.

Common Use Area (CUA) ID	Cadmium (mg/kg)		Non-Cancer CV (mg/kg)	Cancer CV (mg/kg)	MTCA Method A (mg/kg)	RBC (mg/kg)	EPA Region 9 (mg/kg)
	Max.	UCL 95%					
River Road 95	21	**17.6**					
Harvard Road North	13.6	**10.6**					
Harvard Road South	11.4	**7.5**					
Barker Road North	15.5	**13.1**					
North Flora Road	10.1	**8.7**					
Plante Ferry Park	2.5	1.6					
Boulder Beach	<0.26	b					
People's Park	<0.2	b					
Riverside Park	2.5	1.8	10[a]	NA	2	NA	37
Wynecoop Landing	<0.2	b					
Coyote Spit	0.27	c					
The Docks	0.24	0.1					
Jackson Cove	<0.2	b					
Porcupine Bay	<0.12	b					
"No name" Campground	<0.21	b					
Horseshoe Point	<0.2	b					
Pierre Campground	<0.2	b					
Fort Spokane Park	<0.12	b					

Note: Bold contaminant indicates that the 95% UCL concentrations exceeds MTCA and only River Road 95, Harvard Road North, and Barker Road North exceeds non-cancer ATSDR comparison values and therefore are considered a contaminant of concern.
RBC: EPA's Risk-Based Screening Concentration
a. EMEG – ATSDR's Reference Dose Media Evaluation Guide (child)
b. No average or UCL95% was calculated because the chemical was not detected in any sample at this CUA.
c. No average or UCL 95% was calculated because the chemical was detected in only one sample at this CUA.
Max: Maximum value
NA: No available

Appendix B

This section provides inputs for the IEUBK model. The following inputs to the model were used to account for exposures at the CUA River Road 95, Spokane River, Washington.

The fraction of hours the child is exposed for each location (beach and home) was calculated as follows:

Apportioning exposure across locations according to hours of exposure:

$$F_{beach} = \frac{10 \text{ hours/day x 2 days/week}}{14 \text{ hours/day x 7 days/week}} = \frac{20}{98} = 0.204$$

0.204 represents the fraction of seasonal exposure, and 10 hours/day indicates the amount of time a child spends at both the beach an at home (indoor area). The 0.204 fraction is used for seasonal exposure because 1) BLLs are known to increase during the summer; and 2) there is no clear time frame associated with adverse health effects of elevated BLLs.

The home fraction was calculated by subtracting the fraction of hours spent at other locations from 1.0; thus, the remaining time spent at home is:

$$F_{home} = (1.0 - 0.2) = 0.8$$

Deriving a weighted soil concentration from school and home DOH used the following equation:

$$PbS_{w} = EF_{beach} \times [(f_{beach} \times PbS_{beach}) + (f_{home} \times PbS_{home})] + (EF_{home} \times PbS_{home})$$

Where:

PbS_W = Weighted soil lead concentration (ppm).

PbS_{beach} = Average soil lead concentration at an exposure unit on the site (ppm).

PbS_{home} = Average soil lead concentration near home (ppm). (**Default value = 200 mg/kg**)

f_{home} = Fraction of daily outdoor time at local background soil lead concentration (usually near home) = 1-f_{beach} (unitless).

EF_{beach} = Exposure frequency expressed as fraction of the months/year child visits the secondary location during the exposure period.

EF_{home} = Exposure frequency expressed as fraction of the months/year child does not visit the secondary location during the exposure period = 1-EF_{beach}.

f_{beach} = Fraction of daily outdoor time spent at the secondary location on days when the site is visited (dimensionless).

The weighted soil lead concentration results in 377.93 mg/kg (Table B1). This number was used to run the IEUBK Model.

Table B1. IEUBK parameters used to calculate the weighted soil lead concentration from children exposed for 2 days a week for 16 weeks (for a total of 35 days of exposure) as a typical frequency of seasonal contact with the CUAs at the Spokane River.

IEUBK input parameters	Values used for CUA River Road 95	
Derived Weight soil concentration (PbS *W*)		**377.93** [a]
PbS_{beach}	1,410 mg/kg	[b]
PbS_{home}	200 mg/kg	[c]
EF_{beach}	0.204	
EF_{home}	0.796	
f_{beach}	0.204	
f_{home}	0.8	
Exposure period	35 days	

[a] This is the weighted soil lead concentration based on the mean sediment lead concentration (1,410 mg/kg).
[b] Corresponds to the mean sediment lead value.
[c] Corresponds to indoor dust lead levels (constant value).

Table B2. Blood lead concentration values that exceed 10µg/dl within different age ranges at the CUA River Road 95, Spokane, Washington.

IEUBK Output		
Age range (months)	**GM PbB**	**% > 10 µg/dL**
0-84	4.5	4.5
6-12	5.0	**7.0**
12-24	5.6	**10.8**
24-36	5.2	**8.4**
36-48	5.0	**6.9**
48-60	4.2	3.1
60-72	3.6	1.5
72-84	3.2	0.8

GM PbB: Blood lead geometric mean
Bold indicates blood lead concentrations are greater than 5 %.
5 % refers to the percentage of children that exceeds EPA's target cleanup goal of having no more than 5 % of the community with BLLs above 10 µg/dL.

Children's intake of lead from soil and dust sources exhibit blood lead levels greater than 10µg/dl for different age ranges at the CUA River Road 95, Spokane, Washington (Table B2).

Table B3. IEUBK parameters used to calculate the weighted soil lead concentration from children exposed for 2 days a week for 16 weeks (for a total of 35 days of exposure) as a typical frequency of seasonal contact with the CUAs at the Spokane River. The EPA's RBCs value was used to calculate the weighed soil lead concentration.

IEUBK input parameters	Values used for CUAs using RBC value	
Derived Weight soil concentration (PbS *W*)		**348.35** [a]
PbS_{beach}	700 mg/kg	[b]
PbS_{home}	200 mg/kg	[c]
EF_{beach}	0.204	
EF_{home}	0.796	
f_{beach}	0.204	
f_{home}	0.8	
Exposure period	35 days	

[a] This is the weighted soil lead concentration based on the mean sediment lead concentration (700 mg/kg).
[b] Corresponds to the mean sediment lead value.
[c] Corresponds to indoor dust lead levels (constant value).

Table B4. Blood lead concentration values that exceed 10µg/dl within different age ranges at the CUAs using the RBC value, Spokane, Washington.

IEUBK Output		
Age range (months)	**GM PbB**	**% > 10 µg/dL**
0-84	4.4	3.9
6-12	4.9	**6.2**
12-24	5.4	**9.7**
24-36	5.1	**7.5**
36-48	4.8	**6.0**
48-60	4.0	2.7
60-72	3.5	1.2
72-84	3.1	0.7

GM PbB: Blood lead geometric mean
Bold indicates blood lead concentrations are greater than 5 %.
5 % refers to the percentage of children that exceeds EPA's target cleanup goal of having no more than 5 % of the community with BLLs above 10 µg/dL.

Children's intake of lead from soil and dust sources exhibit BLLs greater than 10µg/dl for different age ranges at the CUAs using the RBC value, Spokane, Washington (Table B4).

Appendix C

This section provides calculated exposure doses and assumptions used for exposure to chemicals in soil at Spokane River Sediment. Three different exposure scenarios were developed to model exposures that might occur at the site. These scenarios were devised to represent exposures to 1) a child (0-2 yrs old), 2) an older child (3-15 yrs old) and 3) 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 soil via ingestion, inhalation, and dermal absorption.

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

Ingestion Route

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

$$\text{Cancer Risk} = \frac{C \times CF \times IR \times EF \times CPF \times ED}{BW \times AT_{\text{cancer}}}$$

Dermal Route

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

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

$$\text{Cancer Risk} = \frac{DT \times SA \times EF \times CPF \times ED}{BW \times AT_{\text{cancer}}}$$

Inhalation of Particulate from Soil Route

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

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

Table C1. Exposure assumptions for exposure to contaminants (arsenic and cadmium) in sediment at the Spokane River Sediment – Spokane, Washington.

Parameter	Value	Unit	Comments
Concentration (C)	variable	mg/kg	95% UCL concentration
Conversion Factor (CF)	0.000001	kg/mg	Converts contaminant concentration from milligrams (mg) to kilograms (kg)
Ingestion Rate (IR) – adult	100*	mg/day	Estimated Soil ingestion rate by children for As and Cd. [39]
Ingestion Rate (IR) – older child	300*		
Ingestion Rate (IR) - child	300*		
Exposure Frequency (EF)	35	days/year	Average days exposed to beach sediment
Exposure Duration (Ed)	(4, 9, 15)	years	Number of years at one residence (child, older child, adult years)
Body Weight (BW) - adult	70	kg	Adult mean body weight
Body Weight (BW) – older child	41		Older child mean body weight
Body Weight (BW) - child	19		3-6 year-old child average body weight
Surface area (SA) - adult	5700	cm^2	Risk Assessment Guidance (EPA) [40]
Surface area (SA) – older child	2900		
Surface area (SA) - child	2900		
Averaging Time$_{non-cancer}$ (AT)	3285	days	Child 7-15 years
Averaging Time$_{cancer}$ (AT)	27375	days	75 years
Cancer Potency Factor (CPF)	As: 4.5E+00 Cd: 3.8E-01	$mg/kg\text{-}day^{-1}$	Source: EPA: CPF are presented in Appendix C, Tables C4, C5 and C6
24 hr. absorption factor (ABS)	0.03	unitless	Source: EPA Chemical Specific Arsenic – 0.03 Cadmium – 0.001 Inorganic – 0.001 Organic – 0.01
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 [41]
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

As: Arsenic
Cd: Cadmium
* For Exposures at the beach, children are assumed to potentially ingest greater amounts of soil/sediment than they would at home; consequently, the soil/sediment ingestion rate selected for the 95% UCL concentration and RBC is 300 mg/day, rather than 200 mg/day.[39]

Soil Ingestion Route of Exposure – Non-cancer

Table C2. Non-cancer hazard calculations resulting from exposure to contaminants in soil at the Spokane River CUAs – Spokane, Washington.

Contami_ nant	UCL 95% (mg/kg)	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	29	Child 0-2	6.95E-05	4.03E-06	1.06E-07	7.36E-05	3E-4	0.25
		Older child 3-6	4.39E-05	2.55E-06	6.55E-08	4.65E-05		0.16
		7-15	2.03E-05	1.18E-06	6.55E-08	2.20E-05		0.07
		Adult	3.97E-06	4.76E-07	4.05E-08	4.49E-06		0.015
Cadmium	13.1	Child 0-2	3.14E-05	6.06E-08	4.79E-08	3.15E-05	1.0E-03	0.03
		Older child 3-6	1.98E-05	3.83E-08	1.48E-08	1.99E-05		0.02
		7-15	9.19E-06	1.77E-08	1.48E-08	9.20E-06		0.009
		Adult	1.79E-06	7.16E-09	3.66E-08	1.83E-06		0.002

Table C3. Non-cancer hazard calculations resulting from exposure to contaminants in soil at the Spokane River CUAs – Spokane, Washington.

Contami_ nant	UCL 95% Concen tration (mg/kg)	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	36	Child 0-2	8.63E-05	5.00E-06	1.32E-07	9.14E-05	3E-4	0.31
		Older child 3-6	5.45E-05	3.16E-06	8.13E-08	5.77E-05		0.19
		7-15	2.53E-05	1.47E-06	8.13E-08	2.68E-05		0.09
		Adult	4.93E-06	5.90E-07	5.03E-08	5.57E-06		0.019
Cadmium	17.6	Child 0-2	4.22E-05	8.15E-08	6.44E-08	4.23E-05	1.0E-03	0.04
		Older child 3-6	2.66E-05	5.15E-08	3.98E-08	2.67E-05		0.027
		7-15	1.23E-05	2.39E-08	3.98E-08	1.24E-05		0.012
		Adult	2.41E-06	9.60E-09	2.46E-08	2.45E-06		0.003

Soil Ingestion Route of Exposure - Cancer

Table C4. Theoretical cancer risk resulting from exposure to contaminants of concern in soil samples from Spokane River CUAs – Spokane, Washington.

Contaminant	95% UCL Concentration (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	Inhalation of Particulates	
Arsenic	36	A	15	Child 0-2	4.32E-05	2.50E-06	3.95E-08	4.57E-05
			4.5*	Child 7-15	1.36E-05	7.90E-07	4.88E-08	1.44E-05
			1.5	Adult	1.48E-06	1.77E-07	4.52E-08	1.70E-06

Contaminant	95% UCL Concentration (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	Inhalation of Particulates	
Arsenic	29	A	15	Child 0-2	3.48E-05	2.01E-06	3.18E-08	3.68E-05
			4.5*	Child 7-15	1.10E-05	6.37E-07	3.93E-08	1.16E-05
			1.5	Adult	1.19E-06	1.43E-07	3.64E-08	1.37E-06

***** For exposures between 2 and < 16 years of age, a 3-fold adjustment was used at Barker Road North and River Road 95 to calculate the cancer potency factor. Cancer potency factors (CPF) were used as follows: for child exposures between 0-2, CPF corresponds to 15 mg/kg-day^{-1}, child exposures among 3-6 and 7-15, CPF corresponds to 4.5 mg/kg-day^{-1}, and adult exposures CPF corresponds to 1.5 mg/kg-day^{-1}.

Table C5. Theoretical cancer risk resulting from exposure to contaminants of concern in soil samples from Spokane River CUAs – Spokane, Washington.

Contaminant	UCL 95% Concentration (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	Inhalation of Particulates	
Arsenic	29	A	4.5E+00	Child 0-2	3.48E-05	2.01E-06	3.18E-08	3.68E-05
				Older Child 3-6	1.05E-05	6.11E-07	3.93E-08	1.12E-05
				7-15	1.10E-05	6.37E-07	3.93E-08	1.16E-05
				Adult	1.19E-06	1.43E-07	3.64E-08	1.37E-06
Cadmium	13.1	B1	3.8E-01	Child 0-2	3.98E-07	7.69E-10	1.21E-09	4.00E-07
				Older Child 3-6	4.02E-07	7.77E-10	1.50E-09	4.04E-07
				7-15	4.19E-07	8.10E-10	1.50E-09	4.21E-07
				Adult	1.36E-07	5.44E-10	1.39E-09	1.38E-07

Table C6. Theoretical cancer risk resulting from exposure to contaminants of concern in soil samples from Spokane River CUAs – Spokane, Washington.

Contaminant	UCL 95% Concentration (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	Inhalation of Particulates	
Arsenic	36	A	4.5E+00	Child 0-2	4.32E-05	2.50E-06	3.95E-08	4.57E-05
				Older Child 3-6	1.31E-05	7.59E-07	4.88E-08	1.38E-05
				7-15	1.36E-05	7.90E-07	4.88E-08	1.44E-05
				Adult	1.48E-06	1.77E-07	4.52E-08	1.70E-06
Cadmium	17.6	B1	3.8E-01	Child 0-2	5.34E-07	1.03E-09	1.63E-09	5.37E-07
				Older Child 3-6	5.40E-07	1.04E-09	2.01E-09	5.43E-07
				7-15	5.63E-07	1.09E-09	2.01E-09	5.66E-07
				Adult	1.83E-07	7.31E-10	1.87E-09	1.85E-07

Table C7. EPA's RBCs value for CUAs that exceeds one in a million theoretical cancer risks as a result of exposure to arsenic-contaminated sediment from the Spokane River CUAs – Spokane, Washington.

Contaminant	UCL 95% Concentration (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	Inhalation of Particulates	
Arsenic	10	A	4.5E+00	Child 0-2	1.20E-05	6.95E-07	1.10E-08	1.27E-05
				Older Child 3-6	3.63E-06	2.10E-07	1.36E-08	3.86E-06
				7-15	3.79E-06	2.20E-07	1.36E-08	4.02E-06
				Adult	4.10E-07	4.90E-08	1.26E-08	4.72E-07

Appendix D

Other contaminants of concern found at CUAs, Spokane River, Washington.

Table D1. Maximum and 95% UCL concentration of metals detected in the sediment and their respective comparison values at CUAs in the Spokane River Sediment, Spokane, Washington.

Contaminants	Maximum levels at CUAs (mg/kg)	UCL 95% levels at CUAs (mg/kg)	Comparison Value (mg/kg)	EPA Cancer Class	Comparison Value Reference	RBC (mg/kg)	COC
Antimony	4.1	3.21	20[a]	D	RMEG		No
Cadmium	21	17.6	10	B1	EMEG		Yes†
Iron	49,300	40,571	23,500		Region 9	27,000	No*
Manganese	2,890	2,549	3000	D	RMEG		No
Mercury	0.55	0.38	1	D	MTCA		No
Zinc	4,880	3,809	20,000	D	IM EMEG	4,880	No
Arsenic	45.6	36.2	0.5 20	A	CREG EMEG	10	Yes‡
Lead	2,360	NA+	250		MTCA	700	Yes†

†: Both cadmium and lead values correspond to River Road 95 CUA.
‡: Arsenic value corresponds to Barker Road North CUA.
COC: Contaminant of concern
* Iron is an essential nutrient. The Recommended Dietary Allowance (RDA) is the average daily dietary intake of a nutrient that is sufficient to meet the requirement of nearly all (97-98%) healthy persons. The RDA for iron is 0.36 to 1.11 mg/kg/day for children age 6 months to 10 years. [42] A child exposed to the maximum concentration of iron at a CUA would receive an exposure dose of 0.32 mg/kg/day, which is lower than the RDA.
NA+: No available, the mean lead concentration is 1,410 mg/kg.

Appendix E

TABLE E1. IEUBK Default and Box Assumptions Used in the Coeur d'Alene River Basin

Model	Fraction (%) of Soil/Dust Lead Ingestion Attributed to			Bioavailability of Lead in Soil (%)
	House Dust	Yard Soil	Neighborhood Soil	
Default	55	45	0	30
Box	40	30	30	18

Source: TerraGraphics *et al.* 2001. [43]

IEUBK default values for the EPA IEUBK Model:

Soil lead concentration = dust lead concentration = 200 μg lead per gram of soil/dust.
Soil = 45% of total ingestion, dust = 55% of total ingestion.
Diet and water bioavailability = 50%, soil and dust bioavailability = 30%.
Note: Bioavailability is not constant. Absolute bioavailability decreases as lead intake increases and uptake saturation is reached. [44]

Certification

This Coeur d'Alene Basin - Spokane River Sediment, Spokane, Washington Public Health consultation was prepared by the 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