# Health Consultation

METALS IN CLAM AND SEDIMENT SAMPLES

FROM SELAWIK, ALASKA

MARCH 25, 2009

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

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HEALTH CONSULTATION

# METALS IN CLAM AND SEDIMENT SAMPLES

# FROM SELAWIK, ALASKA

Prepared By:

Alaska Department of Health and Social Services
Division of Public Health, Section of Epidemiology
Environmental Public Health Program
Under a Cooperative Agreement with the
Agency for Toxic Substances and Disease Registry

***Executive Summary***

*The Alaska Department of Health and Social Services (ADHSS) was asked to evaluate contaminant levels in clams and sediment collected from the Selawik River, Alaska. ADHSS was asked to evaluate this because of a cargo plane that sank in the Selawik River in 1983. Residents feared that the plane was releasing contaminants that were getting into clams and sediment. ADHSS concluded that the amount of manganese in clams may potentially cause a health effect when eaten daily for 30 days. All other clam contaminants were not at levels of concern. ADHSS also concluded that sediment metal levels are not a cause for concern.*

## Background and Statement of Concerns

In May 1983 a cargo airplane sunk beneath the ice of the Selawik River within a mile of the community of Selawik (Fig. 1). Even though eyewitness reports indicate that all fuel and fluids were drained from the plane prior to sinking, recent concern has surfaced that the plane may be leaching heavy metals, petroleum, and petroleum by-products into the river (1).

Fig. 1 Cargo plane (Fairchild C-119F, Flying Boxcar) sinking into Selawik River.
Photo courtesy of Raven Sheldon and Anthony Cravalho

Local residents are concerned about the safety of subsistence resources gathered from the river. In response, the Maniilaq Association, the local Alaska Native agency which provides health-related services to this region, instructed local residents of Selawik to gather clams and sediment samples from the Selawik River and have them tested for contaminants. Upon receipt of sample results, a person from the Maniilaq Association requested the help of the Alaska Department of Health and Social Services (ADHSS), Environmental Public Health Program to determine the public health significance of the results.

The requestor had specific concerns that arsenic and cadmium were elevated in clams from the Selawik River and asked if these concentrations were out of the ordinary (1). Further consultation with the requestor revealed that the community is interested in finding out if any contaminant (whether environmental or caused by human activities) is at a concentration of concern in Selawik clam and sediment samples. People in the Selawik community have expressed concern that clams may be contaminated with metals, polychlorinated biphenyls (PCBs) or polyaromatic hydrocarbons (PAHs). As a whole, community members have stopped eating clams, but would like to know if their concerns about potential health effects from eating clams are warranted.

This health consultation addresses concerns of the requestor and community by evaluating the clam ingestion, sediment--dermal contact and ingestion pathways of exposure. Acute (up to 14 days) and chronic (greater than 364 days) duration exposures are evaluated for metal contaminants observed in Selawik sediment and clams. Exposures from pesticides, PCBs, and PAHs in clams and sediments were not evaluated as part of this health consultation because the laboratory data provided to ADHSS were not reliable. Laboratory analytical procedures caused difficulties in accurately determining the concentration of pesticides, PCBs, and PAHs in the sediment and clam samples.

Selawik is an isolated village located in the Northwest Arctic region of Alaska (Fig. 2), about 90 miles east of Kotzebue and 670 miles northwest of Anchorage. The community of Selawik encompasses 2.5 square miles of land and 0.9 square miles of water. Temperatures average -10 to -15 degrees Fahrenheit (F) during winter and 40 to 65 degrees F during summer. Snowfall averages 35 to 40 inches, with 10 inches of total precipitation per year (2). Approximately 55% of Selawik homes have water and sewer services.

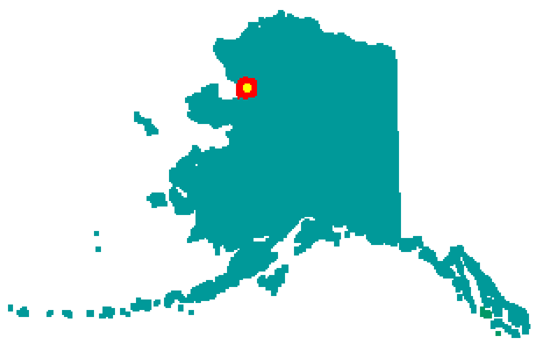

Fig. 2. Selawik location within Alaska (2)

As of the 2000 census, Selawik was a federally recognized tribe with a population of 828 individuals, of which 266 were children (2). The population of the community consists of 95.3% Alaska Native or part Native people. Selawik is an Inupiat Eskimo community active in traditional subsistence fishing and hunting. Inhabitants of Selawik subsist mainly on whitefish, sheefish, caribou, moose, ducks, ptarmigan and berries. Occasionally, bartered seal and beluga whale supplement the diet (2).

## Methods

### *Sample Collection and Analysis*

No sampling plan was recorded for the Selawik effort. Through personal correspondence, Ninel Shestakovich (previously of Maniilaq Assoc), described the details of the Selawik sampling. On July 17, 2007 local residents working with Maniilaq Association collected clams and sediment samples. Samples were collected from the site where the plane sank (accident site) and a control site that was 0.5 miles upriver of the accident location. The clams were collected in freshwater (Selawik River) but were not identified as to type or species though it is known that pea clams (*Pisidium idahoensis*) are common to this area (3). Two clam and two sediment samples were collected in each location (control and accident site). A local subsistence method for clam harvesting was used to collect these samples. This harvest method uses a steel pipe that is plunged into the sediment and then drawn back up where sediment and clams may be collected. Harvesting in this manner is usually done from a boat and not on land. Multiple uses of the pipe may have been necessary to collect the 5-10 clams necessary to create a clam sample for analysis. However, a sediment sample was collected in only 1 pipe deployment.

Clam samples were of clam meat so the shells were removed (likely by insertion and prying and removal of the shell with a knife) in Selawik. The use of a knife during sampling may have introduced contamination, specifically of manganese. Many knives have manganese in the steel blade or as a rust protectant on the blade (4). Without a sampling plan, ADHSS could not evaluate whether a knife without manganese was used for removing clams from their shells. The lack of these details is critical in making a public health decision on whether clam ingestion may cause an ill effect.

The community was able to have the samples analyzed because of a small grant from the Environmental Network for Indigenous People. Samples were kept frozen and shipped to the University of Alaska, Anchorage (UAA) laboratory for analysis of metals, pesticides, PCBs, and PAHs. Standard methods were used for extracting and analyzing the metals from the clams. The UAA laboratory chose to analyze only two sediment (1 control and 1 accident site) and three clam (1 control and 2 accident site) samples. The metal concentrations were reported in parts per million (ppm) or milligrams per kilogram (mg/kg). Samples that were analyzed for pesticides, PCBs, and PAHs had substances that interacted with each other and this made it impossible to determine the amount of these contaminants.

### *Identifying Contaminants of Potential Concern*
A contaminant of potential concern (COPC) is a substance that is present at levels that might cause harmful (adverse) health effects. The highest site-specific contaminant concentration (level) in sediment and clams were judged against comparison values (CVs) to represent a worst-case scenario for exposure. CVs are values that are below levels known or expected to cause harmful health effects. CVs include large safety factors (3 to 1,000) to protect people from the potential of an ill health effect.

Only clam and sediment contaminants that were above analytical detection limits (Table 1, bold) and/or a soil CV (Table 2, bold) were considered COPC. There are no CVs for clam tissue so any detected level was further evaluated. Also when a site-specific value is higher than a CV or if no CV exists (i.e. calcium in sediments), the substance is further evaluated. Contaminants found at levels below CVs are not considered a public health risk, and no harmful effects are expected from exposure. Contaminants that are below detection limits are sufficiently low that these are also not considered a public health risk and ill effects are unlikely from exposure.

## Pathway Analysis
An exposure pathway is used to describe conditions and circumstances by which a contaminant travels from its source to the human body. At the Selawik site, people may be exposed to metals and other compounds due to naturally occurring contaminants or contaminants that have resulted from human activities. Contaminants may be in (but are not limited to) clams and sediments. People contact sediments and clams when harvesting and eating clams and this action makes a completed exposure pathway. The contaminants in the clams and sediments may be eaten or absorbed through the skin. The potentially exposed population with completed pathways of exposure would consist of adults and children eating clams and/or contacting or ingesting sediment

during harvest activities (Table 3). Exposures are likely ongoing (present and future) and may have also occurred in the past.

**Health Considerations**

The likelihood of ill effects from a contaminant is dependent upon the contaminant amount, the amount a person is exposed to, and how often a person is exposed to the contaminant. Often this information varies and has to be assumed. For instance, one assumption is how many calms a person would normally eat.

Collection and consumption of clams from Selawik would historically occur only in July (Clyde Ramoth, USFW RIT and Selawik resident, personal correspondence September 3, 2008). This occurred for two reasons: children would dive for clams in the warmer water temperatures of July and also because the tribe eats foods that are traditionally available by season. Clams were traditionally used for chowder and would not be frozen and eaten at another time of year. ADHSS assumed that a person might eat one meal of clams (defined as 5-10 clams per meal) for each of the 30 days in July. The number of clams in a meal would indicate that the average meal size (amount a person is exposed to) is equal to an 8-ounce portion of meat. Chowder recipes indicate that between 2 to 21 ounces of clams are used per person (Food Network) with the majority of recipes using 3 to 4 ounces of clams per person. Assuming an 8-ounce portion for this health consultation is conservative because it accounts for people that eat meals of clams that are not in chowder. Children from 1-6 years old were estimated to eat 15% of the adult consumption rate (1.2 ounces) whereas 7-19 year olds were estimated to eat 90% of the adult portion (7.2 ounces).

Based on the seasonal nature of harvesting clams in the Selawik area, the amount of exposure to sediments was estimated at 30 days per year. Additionally, clam harvesting (by either pipe or diving) might occur for a probable duration of 45 years. Children less than 7 years old were not considered to be able to dive for or participate in clam harvesting activities and therefore were not assessed for exposure to sediments.

Estimates of theoretical cancer risk are largely dependent on the contaminant amount, the amount a person is exposed to, and how often a person is exposed to the contaminant. Most cancer studies use daily exposure to a substance to see if it will produce cancer. However, exposure to the contaminants in Selawik sediments and clams are not occurring on a daily basis. Sediments in the Selawik River are not likely accessible and clamming activities do not occur year round. The risk of exposure and cancer development is significantly reduced by not coming in daily contact with clams and sediments. Nonetheless, when data was available, excess lifetime cancer risk (ELCR) numbers were calculated for the contaminants that *may* produce cancer from oral exposure. The ELCR is an estimate for excess cancers that *might* result in addition to those normally expected in an unexposed population.

**Toxicological Evaluation**

Estimated doses for the clam ingestion (subsistence food) pathway are located in Table 4 and Table 5. Table 4 estimates doses for a short term exposure (acute) and Table 5 estimates doses for potentially carcinogenic (cancer-causing) contaminants eaten in Selawik clams throughout a lifetime. Estimated doses for barium, iron, and manganese exceeded a CV when eating clams (Table 4, bold).

***Subsistence Food Pathway***

**Metals eliminated as contaminants of concern in Selawik clams**

Clam samples had no detectable concentrations of antimony, beryllium, silver, thallium, thorium, or uranium (Table 1). Since there are no values for these compounds, the doses were not calculated and the potential for health effects were not assessed. However, ill effects are not likely when detection limits are so low.

Aluminum, calcium, cadmium, chromium, cobalt, copper, iron, magnesium, molybdenum, nickel, potassium, selenium, sodium, vanadium, and zinc are normally found at some level in foods (5-14; 21). Site-specific doses or daily rates of aluminum, arsenic, cadmium, calcium, chromium, cobalt, copper, lead, molybdenum, magnesium, nickel, potassium, selenium, sodium, vanadium, and zinc in Selawik clams (Table 4) were below the respective CVs (5-14; 21). It is highly unlikely that aluminum, calcium, cadmium, chromium, cobalt, copper, magnesium, molybdenum, nickel, potassium, sodium or zinc obtained from eating Selawik clams would cause harmful health effects in children or adults. Calcium, chromium, copper, iron, magnesium, molybdenum, potassium, selenium, sodium, and zinc are elements necessary for human bodies to function properly and are considered essential because of this feature.

**Metals ingested in Selawik clams that were at or above CVs**

***Arsenic***

Arsenic is fairly common in shellfish. Previous research indicates average concentrations of arsenic in clams to be 12 ppm, whereas crab levels are 5 ppm (21). Selawik clam samples had a maximum concentration of 1.42 ppm arsenic (Table 1) and this is below the previously reported clam and crab concentrations (21).

Eating a meal a day of Selawik clams result in arsenic doses that are within the range of a non-cancer effect CV (Table 4). However, a 10 fold safety factor is applied to this CV so it is unlikely that there will be ill effects from eating Selawik clams. Lifetime arsenic doses (Table 5) from eating Selawik clams are 10,000 times less than a level (1.1 mg/kg-day) shown to produce cancer (21). The theoretical excess lifetime cancer risks, ELCRs, for arsenic exposure from clams were between 2.2 to 4.3 additional persons per 10,000 individuals (Table 5).This cancer estimate is a worst-case scenario and highly unlikely given the reasoning in the following paragraph. The actual cancer risk from eating Selawik clams with arsenic may be zero or lower than 1 in 10,000 which is considered acceptable by EPA.

No ill effects are likely from the arsenic in Selawik clams for four reasons. First, much of the arsenic in shellfish is expected to be a less toxic form (organic). Secondly, the clam meal size is a 50% over-estimate of what would normally be eaten in chowder. Third, even with this over-estimate, the doses are less than ones that may cause an ill effect. Lastly, people do not eat clams daily and this reduces the likelihood of an ill effect.

***Barium***

Eggs, organ meat (liver, etc.), and peanut butter are some of the foods that commonly contain barium. Eggs and peanut butter have barium levels of 0.46 to 2.9 ppm (15). The concentration of barium levels normally found in shellfish is unknown. Barium was observed to have a maximum concentration of 372 ppm in Selawik clams.

The estimated doses of barium were within the same range as the CV (Table 4). This MRL is based on a rat study where no observable adverse effect was detected at a level 10 times higher than those observed in Selawik. The dose was then divided by 100 for uncertainty. An ill effect is therefore unlikely for people that eat Selawik clams.

***Iron***
A meal-sized portion of calf liver (3 ounces or 85,000 mg) provides up to 14 mg of iron (16). Selawik clams may provide up to 167 mg (1,966 mg/kg*0.085 kg) of iron, or almost 12 times the amount from a beef liver meal.

Iron is essential for the human body to function. Iron is important for transporting oxygen in the blood and for enzymes to function properly. Iron deficiency is a common problem among many Alaska Native people (17). Iron doses from eating Selawik clams were estimated (Table 4) and translate to rates of 10-67 mg iron/day. Some of these rates were above a CV. An adult dose that is 100 times higher (18) and child dose that is 10 times higher (19) than those in Selawik may lead to ill effects. Doses of iron from eating Selawik clams are lower than those that may cause harmful effects for children and adults.

***Lead***
Lead is common in foods. Fruit may have up to 0.06 ppm of lead and meat may have up to 0.5 ppm of lead (23). The maximum concentration of lead in Selawik clams is 0.12 ppm, below a level that a person may normally be exposed to if eating other types of meat (beef, poultry).

The ingestion of Selawik clams and the exposure created by the lead is extremely small but higher than the California CV (Table 4, see representative calculation for understanding). Agencies differ on the amount of lead that is considered acceptable through ingestion (Table 4). California's CV (24) is the most stringent and the American National Standards Institute (25) and World Health Organizations (26) are higher. Doses for adults and children would fall below the California CV. By eating Selawik clams there may be a slight increase in blood lead levels (Table 7). The estimated total blood lead levels for adults and children were below 2 micrograms per deciliter (µg/dL) from all environmental sources. Estimated blood lead levels would be below the current levels of concern established by the Centers for Disease Control and Prevention (10 micrograms per deciliter of blood, µg/dL) and also below a Finnish worker lead cancer study (>21 µg/dL). No data is available to calculate ELCRs for lead. Health effects, including cancer, are unlikely from the amount of lead ingested Selawik clams. .

***Manganese***
Nuts and meat (including fish) contain 50 and 5 ppm of inorganic manganese, respectively (20). Manganese was observed at a maximum concentration of 4,817 ppm. All three clam samples reportedly had manganese levels above 3,000 ppm. Selawik clams are at least ten times higher in manganese levels than other clams (UAA lab correspondence).

Manganese doses were above the dietary intake (DRI-ULs) and interim health guidance value CVs (Table 4). No acute (≤ 14 days) studies were located on whether the site-specific levels may cause adverse health effects in people. Less serious health effects occurred in rats exposed to 100 times more manganese (20) than that observed from eating Selawik clams.

Sampling and harvesting methods may have contaminated Selawik clams with extra manganese (see methods section). Nonetheless, studies indicate that exposure to high levels of manganese may cause harmful effects. By day 25, a human study using 15 mg manganese/day supplementation (375 mg total manganese; 15 mg/day*25 days) reported an increase in manganese carried in the blood (13). Increased blood levels of manganese may lead to a higher chance of an ill effect, as manganese may then pass into the brain where effects may occur. People in Selawik may obtain 375 mg of manganese by eating 7 (adult at 8 ounces/day), 8 (7-19 yr old at 7.2 ounces/day) and 29 (1-6 yr old at 1.2 ounces/day) clam meals, if the true level of manganese was reported in these clams. The clam weight may affect how many total clams may be eaten. An ill effect, from manganese, may happen after eating 21 to 72 clams. Ill effects, such as behavioral or cardiovascular changes, may be possible for children and adults that eat too many Selawik clams. Poor muscle coordination, lack of balance, tremors, and possible changes to the nervous system are symptoms of too much manganese.

***<u>Sediment Ingestion and Dermal Absorption Pathway</u>***

Diving for clams and deploying a steel pipe into the Selawik River are two methods to harvest clams. Sediment ingestion and the absorption of contaminants from sediments are not likely when harvesting clams when diving for two reasons. During diving people would not open their mouths and water would likely wash away any sediment on the body. However, in the steel pipe method, people may have sediment stick to their skin when picking clams out of the sediment collected from the pipe. The stuck skin sediment may be absorbed or accidently ingested if people smoke or eat during clamming activities or before washing.

**Metals in Selawik sediments eliminated as contaminants of concern**

Antimony, cadmium, molybdenum, selenium, silver, sodium, and thallium concentrations were below detection limits (Table 2) and therefore not assessed for the potential to cause health effects from ingestion or dermal contact of Selawik sediments. However, ill effects are not likely when detection limits are so low.

Aluminum, barium, beryllium, chromium, cobalt, copper, lead, manganese, nickel, uranium, and zinc levels were not above soil CV (Table 2) so these are not likely to have harmful cancer nor non-cancer effects either through ingestion or dermal absorption of the sediment.

**Metals in Selawik sediments that were above or had no soil CVs**

***Arsenic***

Arsenic exceeded the soil CV of 0.5 mg/kg (Table 2). Occasional exposure to arsenic is not likely to cause non-carcinogenic health effects (such as vomiting or diarrhea). Arsenic exposure may be associated with lung and skin cancers and increasing evidence suggests bladder cancer may also result (21).

Adults and children had very low estimated lifetime arsenic doses for sediment ingestion and dermal absorption, respectively (Table 6). The carcinogenic doses are a minimum of 10,000 times lower than the lowest inorganic arsenic level that produced cancer (1,100 ng/kg-day). Selawik sediment samples do not provide enough arsenic to be at a level of health concern. The theoretical excess lifetime cancer risks, ELCRs, for arsenic exposure from sediments were between 5 per 100 million to 8 additional persons per 10 million individuals (Table 6). These ELCRs would be considered acceptable risk by EPA standards.

***Calcium, magnesium, potassium, and sodium***
Calcium, magnesium, potassium, and sodium have no soil CVs (Table 2). These substances are analytes necessary for human bodies to function and are not carcinogens. Rates (Table 6) obtained by incidental ingestion or dermal absorption of these elements in Selawik sediments are extremely low (0.0005 to 0.004 mg/day) in comparison to the Dietary CVs (30 to 5,100 mg/day). The concentrations of these essential elements are not expected to cause adverse health effects for adults or children exposed to Selawik sediments.

***Iron***
The maximum level of iron was above the soil CV (Table 2). Total iron intake (0.93 and 1.34 mg/day) from sediments was estimated to be 10 to 100 times less than the health CV (Table 6, representative calculations). Exposure to iron in Selawik sediments would not be expected to cause ill effects. Please refer to the previous discussion on iron in clams for more information.

***Thorium***
Thorium is a naturally occurring radioactive metal and as such has the ability to decay and produce radioactive substances. Thorium does not have a soil CV (Table 2). Exposures to thorium are extremely small (0.006 to 4.3 ng/kg-day; Table 6). The smallest Lowest Observable Adverse Effect Level (LOAEL) of 132,500,000 ng/kg-day occurred from dermal absorption and had a systemic effect in rats exposed to thorium for 15 days (28). The doses observed from thorium in Selawik sediments are extremely low in comparison to the LOAEL. No adverse non-carcinogenic health effects are expected from exposure to thorium in Selawik sediments.

As thorium is radioactive there is a the potential for cancers to result from thorium exposure. However, the potential carcinogenic doses of thorium are a minimum of 1,000 times lower than an inhaled dose that observed a cancer rate increase (Table 6). Further, these exposures occur by different pathways. No adverse carcinogenic health effects are expected in adults exposed to thorium in Selawik sediments. No data is available to calculate ELCRs for thorium (Table 6).

**Community Concerns**

***Are metals concentrations from nature or made by people or people's activities (anthropogenic)?***

> ADHSS is unable to determine if the current levels of metals in Selawik clams and sediments are from nature (a result of natural processes) or human activities (such as land disturbance) because of the limited number of samples that were obtained at each site. Sample concentration can vary greatly due to the methods of sample collection, preparation, and analysis so a minimum of three samples were needed per site (accident and control) to be able to determine if sites are statistically significant from each other. Laboratory results did not provide ADHSS with three or more samples per site. However, it should be noted that all detected elements are normally found in nature and it is likely that the concentrations in the clams and sediments are from natural or other factors.

***Can any of the contaminants of concern in Selawik clam samples cause adverse health effects?***

> Yes, manganese levels, if from the clam and not from the knife used in sampling, may cause adverse health effects for people eating these clams, but this is only likely after a certain number of meals (see Metals ingested in

Selawik clams that exceed health CVs, manganese). However, these estimates do not consider possible changes in manganese levels caused by different cooking methods. Manganese health effects (neurological) may be permanent if it enters the brain, but symptoms might not be apparent for 6 to 18 months. Cardio-vascular changes may also occur when exposed to too much manganese. However, cancer is unlikely from any of the contaminants obtained by eating Selawik clams.

***Are arsenic and cadmium levels in Selawik clams out of the ordinary?***

No, based on the limited number of samples between the control and accident sites, the levels of arsenic in Selawik clams are not out of the ordinary and are probably from naturally occurring arsenic deposits. Unpolluted U.S. sites may have arsenic concentrations in invertebrates (shellfish, crabs, shrimp, etc) between 2.1 and 2.4 ppm (21). Selawik clams were 1.42 ppm or less. Cadmium was not elevated out of the ordinary between the control and accident sample sites in Selawik clams. Clams average 0.5 to 1 ppm of cadmium (22). The cadmium levels (up to 0.82 ppm) observed in Selawik clams were within the reported range.

***Can any contaminants of concern in Selawik sediment samples cause adverse health effects?***

No, metals in Selawik sediments are not expected to cause adverse health effects. Cancer is unlikely from occasional contact with Selawik sediments.

***Is arsenic, cadmium, or iron levels in Selawik sediments out of the ordinary?***

No, based on the limited samples of the control and accident site sediment samples, arsenic, cadmium and iron levels were not out of the ordinary for naturally occurring levels. Natural concentrations (worldwide) of arsenic in sediments are less than 10 ppm (21), with averages from non-contaminated U.S. sites having arsenic levels in the 5 to 6 ppm range (21). Cadmium levels were below the detection limit in both the accident and control sediment sites. Cadmium in sediments may range from 0.01 to 4.5 mg/kg (22).

## Child Health Considerations

Children differ in the routes that contaminants are taken up and eliminated from the body than what is observed in adults. For instance, children often engage in hand-to-mouth behaviors, thereby increasing the possibility of ingesting a contaminant in greater amounts than an adult. If exposure levels are high enough during critical growth stages, the developing body systems of children can sustain permanent damage. Adults should encourage healthy behaviors and inform their children of potential dangers. Childhood exposures were evaluated in this health consultation to aid parents in identifying risk.

## Conclusions

The validity of the analyses and conclusions drawn for this health consultation are determined by the availability and reliability of the referenced information. The residents of Selawik had specifically raised concerns about pesticides, PCBs, and PAHs in their subsistence foods, but unfortunately, these contaminants could not be evaluated in this report.

- At the exposure frequency and ingestion rates utilized in this health consultation, the data suggest a potential health effect from the amount of manganese ingested in Selawik clams.

However, due to questionable sampling practices and a lack of consistency in the findings for humans orally exposed to manganese, the subsistence food pathway of eating Selawik clams would be considered an indeterminate public health hazard. The rest of the contaminants present no apparent public health hazard.

- The sediment ingestion and dermal absorption pathways present no apparent public health hazard.
- Based on the information evaluated, it is not clear whether contaminants from the plane are impacting the shellfish/sediment or not.

**Recommendations**

- If there are ongoing concerns about the presence of pesticides, PCBs, and PAHs in Selawik sediments and clams, it is recommended that a laboratory with more rigorous quality assurance and quality control plans be utilized for analyses of these contaminants.
- It is unknown if clams have elevated manganese because of the lack of information on how sampling occurred and whether contamination was an issue. However, based on the data obtained for Selawik clams harmful health effects may occur if too many clams are eaten. Should clam consumers have further concerns about the amount of manganese present in local clams then it is suggested that clams be collected under a more stringent sampling plan and then analyzed. If manganese levels are determined to be near the levels reported then it is recommended that Selawik clam consumers reduce their consumption from 30 days per month. Adults and children would be able to eat 6 (8 ounce) or 12 (4 ounce) clam meals a month without worry of ill effects.

**Public Health Action Plan**

- This health consultation will be shared with the requestor (Maniilaq Association) who is planning to communicate the results to the community.
- After the report is distributed, within one month the Alaska Department of Health and Social Services will conduct an informal needs assessment with the community to ensure that the results of the report have been disseminated broadly, and to identify any potential health education needs or ongoing concerns.
- Based on the needs assessment findings, educational materials (e.g. fact sheets) and other information will be developed and distributed in a timely manner.
- No other public health actions are planned at this time.
- ADHSS will review any additional data based on the recommendations of this health consult.

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## Certification

This Health Consultation (Metals in clams and sediment samples from Selawik, Alaska) was prepared by the Alaska Department of Health and Social Services under a cooperative agreement with the federal 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 were 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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## References


1. Shestakovich, N. 2008. From Maniilaq Tribal Environmental program. Email to Lori Verbrugge, State of Alaska, Environmental Public Health Program Manager. July 10, 2008.

2. State of Alaska. 2008. Alaska Community Database Community Information Series (CIS), Selawik. http://www.dced.state.ak.us/dca/commdb/CF_CIS.htm Accessed July 31, 2008.

3. Brown, R.J. 2007. Freshwater mollusks survive fish gut passage. Arctic, 66(2); 124-128.

4. Wikipedia. 2009. Carbon steel webpage. http://en.wikipedia.org/wiki/Carbon_steel and Manganese. http://en.wikipedia.org/wiki/Manganese Accessed January 14, 2009.

5. ATSDR, Agency for Toxic Substances and Disease Registry. 2006. Aluminum toxicological profile, Draft. http://www.atsdr.cdc.gov/toxprofiles/tp22.html Accessed September 24, 2008.

6. NAS, National Academies of Science. 2004. Dietary Reference Intakes. Accessed at the USDA website, http://fnic.nal.usda.gov/nal_display/index.php?info center =4&tax_level=3&tax_subject=256&topic_id=1342&level3_id=5140 Accessed August 4, 2008.

7. ATSDR, Agency for Toxic Substances and Disease Registry. 1994. Chromium toxicological profile http://www.atsdr.cdc.gov/toxprofiles/tp7.html Accessed September 24, 2008.

8. ATSDR, Agency for Toxic Substances and Disease Registry. 2004. Cobalt toxicological profile. http://www.atsdr.cdc.gov/toxprofiles/tp33.html Accessed September 24, 2008.

9. ATSDR, Agency for Toxic Substances and Disease Registry. 2004. Copper toxicological profile. http://www.atsdr.cdc.gov/toxprofiles/tp132.html Accessed September 24, 2008.

10. ATSDR, Agency for Toxic Substances and Disease Registry. 2005. Nickel toxicological profile. http://www.atsdr.cdc.gov/toxprofiles/tp15.html Accessed August 8, 2008.

11. ATSDR, Agency for Toxic Substances and Disease Registry. 2005. Zinc toxicological profile. http://www.atsdr.cdc.gov/toxprofiles/tp60.html Accessed September 24, 2008.

12. ATSDR, Agency for Toxic Substances and Disease Registry. 2003. Selenium toxicological profile. http://www.atsdr.cdc.gov/toxprofiles/tp92.html Accessed September 24, 2008.

13. ATSDR, Agency for Toxic Substances and Disease Registry. 1992. Vanadium toxicological profile. http://www.atsdr.cdc.gov/toxprofiles/tp58.html Accessed September 24, 2008.

14. NAS, National Academies Press. 2000. Dietary reference intakes for vitamin A, vitamin K, arsenic, boron, chromium, copper, iodine, iron, manganese, molybdenum, nickel, silicon, vanadium, and zinc. Food and Nutrition Board of the Institute of Medicine. http://books.nap.edu/openbook.php?record_id=10026&page=409 Accessed September 30, 2008.

15. ATSDR, Agency for Toxic Substances and Disease Registry. 2007. Barium toxicological profile. http://www.atsdr.cdc.gov/toxprofiles/tp24.html Accessed September 24, 2008.

16. Kids grow.com. Iron, helping your child get enough. http://www.kidsgrowth.com/resources/articledetail.cfm?id=1097 Accessed September 25, 2008.

17. Parkinson, A.J., Gold, B.D., Bulkow, L., Wainwright, R.B., Swaminathan, B., Khanna, B., Petersen, K.M., Fitzgerald, M.A. 2000. High prevalence of *Helicobacter pylori* in the Alaska native population and association with low serum ferritin levels in young adults. Clinical and Diagnostic Laboratory Immunology, 7; 885-888.

18. WebMD. 2007. Toxicity, iron. http://www.emedicine.com/EMERG/topic285.htm January 8, 2007. Accessed September 30, 2008.

19. EmedicineHealth. 2008. Iron poisoning. http://www.emedicinehealth.com/iron_poisoning/article_em.htm Accessed September 30, 2008.

20. ATSDR, Agency for Toxic Substances and Disease Registry. 2008. Manganese toxicological profile, Draft. http://www.atsdr.cdc.gov/toxprofiles/tp151.html Accessed September 24, 2008.

21. ATSDR, Agency for Toxic Substances and Disease Registry. 2007. Arsenic toxicological profile. http://www.atsdr.cdc.gov/toxprofiles/tp2.html Accessed April 14, 2008.

22. ATSDR, Agency for Toxic Substances and Disease Registry. 1999. Cadmium toxicological profile. http://www.atsdr.cdc.gov/toxprofiles/tp5.html Accessed September 24, 2008.

23. ATSDR, Agency for Toxic Substance and Disease Registry. 2007. Lead toxicological profile. http://www.atsdr.cdc.gov/toxprofiles/tp13.html Accessed September 25, 2008.

24. CA OEHHA, California Office of Environmental Health Hazard Assessment. 2008. California EPA, Proposition 65 safe harbor levels: no significant risk levels for carcinogens and maximum allowable dose levels for chemicals causing reproductive toxicity. January 2008. http://www.oehha.ca.gov/prop65/pdf/feb2008 statusreport.pdf Accessed September 2, 2008.

25. NSF, National Science Foundation. 2006. American National Standards #173 for dietary supplements. Ann Arbor, MI. NSF International, 2006.

26. WHO, World Health Organization. Adequate Daily Intake based on weekly intake. *Codex General Standard for Contaminants and Toxins in Foods*. http://www.codexalimentarius.net/download/standards/17/CXS_193e.pdf Accessed March 14, 2008.

27. USEPA, United States Environmental Protection Agency. 2004. Preliminary Remediation Goals (PRGs) 2004 Table. http://epa.gov/region09/waste/sfund/prg/files/04prgtable.pdf Accessed August 5, 2008.

28. ATSDR, Agency for Toxic Substances and Disease Registry. 1990. Thorium toxicological profile. http://www.atsdr.cdc.gov/toxprofiles/tp147.html Accessed August 8, 2008.

29. ATSDR, Agency for Toxic Substance and Disease Registry. 2005. Public Health Assessment Guidance Manual. US Dept of Health and Human Services, January 2005. http://www.atsdr.cdc.gov/HAC/PHAManual/ Accessed September 2008.

30. USEPA, United States Environmental Protection Agency. 2002. Child-specific exposure factors handbook. National Center for Environmental Assessment, Washington, DC; EPA/600/P-00/002B. Available from: National Information Service, Springfield, VA; PB2003-101678 and http://www.epa.gov/ncea .

**Table 1.** Metal concentration in Selawik clam samples

| Metal | Clam Concentration (ppm) ww | | |
|---|---|---|---|
| | *Accident Site Sample 1* | *Accident Site Sample 2* | *Control Site Sample 1* |
| **Aluminum** | **56** | 33 | 50 |
| Antimony | <0.07 | <0.15 | <0.04 |
| **Arsenic*** | 1.27 | 1.14 | **1.42** |
| **Barium** | **372** | 351 | 230 |
| Beryllium | <0.02 | <0.01 | <0.01 |
| **Cadmium** | **0.82** | 0.35 | 0.61 |
| **Calcium** | **17,569** | 11,603 | 12,463 |
| **Chromium** | **0.98** | 0.52 | 0.50 |
| **Cobalt** | 0.70 | 0.67 | **0.82** |
| **Copper** | 0.97 | **2.47** | 1.94 |
| **Iron** | **1,966** | 1,420 | 1,418 |
| **Lead*** | **0.12** | 0.04 | 0.09 |
| **Magnesium** | 271 | **324** | 257 |
| **Manganese** | **4,817** | 4,280 | 3,474 |
| **Molybdenum** | 0.11 | 0.06 | **0.11** |
| **Nickel** | **6.53** | 4.70 | 5.04 |
| **Potassium** | 220 | 296 | **311** |
| **Selenium** | 0.27 | **0.35** | 0.34 |
| Silver | <0.05 | <0.61 | <0.02 |
| **Sodium** | 382 | **590** | 542 |
| Thallium | <0.06 | <0.02 | <0.03 |
| Thorium* | <0.26 | <0.54 | <0.13 |
| Uranium | <0.08 | <0.03 | <0.04 |
| **Vanadium** | 0.23 | 0.10 | **0.24** |
| **Zinc** | 97 | **97** | 76 |

ppm = parts per million = mg/kg; ww = wet weight; < = less than—indicates the sample is below the number which is the limit of detection for analyte based on sample weight; * Known, probable, or possible human carcinogen from oral exposure (EPA, IARC, NTP); **Bold indicates contaminant requiring further evaluation and sample concentration used in calculations.**

**Table 2.** Metal concentrations (ppm) and comparison values (CVs) in Selawik sediment samples

| Metal | Sediment Concentration (ppm) dw | | Soil CV | |
|---|---|---|---|---|
| | *Accident Site Sample 1* | *Control Site Sample 1* | **Concentration (ppm)** | **Type of CV** |
| Aluminum | 11,090 | 11,972 | 50,000 | Child chronic EMEG |
| | | | 700,000 | Adult chronic EMEG |
| Antimony | <0.80 | <0.80 | 20 | Child intermediate RMEG |
| | | | 300 | Adult intermediate RMEG |
| **Arsenic*** | **4.52** | 4.38 | 20 | Child chronic EMEG |
| | | | 200 | Adult chronic EMEG |
| | | | **0.5** | **CREG** |
| Barium | 103 | 111 | 30,000 | Child chronic EMEG |
| | | | 400,000 | Adult chronic EMEG |
| Beryllium | <0.25 | 0.32 | 100 | Child chronic EMEG |
| | | | 1,000 | Adult chronic EMEG |
| Cadmium | <1.44 | <1.44 | 10 | Child chronic EMEG |
| | | | 100 | Adult chronic EMEG |
| **Calcium** | 3,882 | **4,183** | - | - |
| Total Chromium ($Cr^{3+}$, $Cr^{6+}$) | 22 | 23 | 200† | Child intermediate RMEG |
| | | | 2,000† | Adult intermediate RMEG |
| Cobalt | 12 | 13 | 500 | Child intermediate EMEG |
| | | | 20 | Pica child intermediate EMEG |
| | | | 7,000 | Adult intermediate EMEG |
| Copper | 20 | 23 | 500 | Child intermediate EMEG |
| | | | 7,000 | Adult intermediate EMEG |
| **Iron** | 23,217 | **24,628** | **23,500** | **EPA region IX PRG residential soil cleanup** |
| Lead* | 9.6 | 11.02 | 400 | EPA region IX PRG residential soil cleanup |
| **Magnesium** | 5,451 | **5,951** | - | - |
| Manganese | 328 | 353 | 3,000 | Child intermediate RMEG |
| | | | 40,000 | Adult intermediate RMEG |
| Molybdenum | <0.90 | <0.90 | 300 | Child intermediate RMEG |
| | | | 4,000 | Adult intermediate RMEG |
| Nickel | 27 | 30 | 1,000 | Child intermediate RMEG |
| | | | 10,000 | Adult intermediate RMEG |
| **Potassium** | **385** | 355 | - | - |
| Selenium | <1.26 | <1.26 | 300 | Child chronic EMEG |
| | | | 4,000 | Adult chronic EMEG |

**Table 2 (Cont'd).** Analyte concentrations (ppm) and comparison values (CVs) in Selawik sediment samples

| Metal | Sediment Concentration (ppm) dw | | Soil CV | |
|---|---|---|---|---|
| | ***Accident Site Sample 1*** | ***Control Site Sample 1*** | **Concentration (mg/kg)** | **Type of CV** |
| Silver | <0.52 | <0.52 | 300 | Child intermediate RMEG |
| | | | 4,000 | Adult intermediate RMEG |
| **Sodium** | <278 | <278 | - | - |
| Thallium | <2.82 | <2.82 | 4đ | Child intermediate RMEG |
| | | | 60đ | Adult intermediate RMEG |
| **Thorium*** | 4.31 | **4.9** | - | - |
| Uranium | <0.81 | 0.89 | 100‡ | Child intermediate EMEG |
| | | | 1,000‡ | Adult intermediate EMEG |
| Vanadium | 31 | 35 | 200 | Child intermediate EMEG |
| | | | 2,000 | Adult intermediate EMEG |
| Zinc | 75 | 81 | 20,000 | Child chronic EMEG |
| | | | 600 | Pica child intermediate EMEG |
| | | | 200,000 | Adult chronic EMEG |

ppm = parts per million = mg/kg; dw = dry weight; < = less than—indicates the sample is below the number which is the limit of detection for analyte; † as hexavalent chromium; ‡ as soluble salts; đ as thallium carbonate or thallium sulfate; * Known, probable, or possible human carcinogen from oral exposure (EPA, IARC, NTP); EMEG- Environmental Media Evaluation Guide; Chronic exposure is longer than 1 year (ATSDR); RMEG- Reference Dose Media Evaluation Guide (ATSDR); PRG- Preliminary Remediation Goals[27]; Superscript number is a reference number; **Bold indicates a contaminant that exceeded or had no CV.**

**Table 3. Completed exposure pathways for measured metals**

| Pathway Name | Source | Media (Way) | Point | Route | Time Frame of Exposure | Estimated Number of People Exposed | Contaminant |
|---|---|---|---|---|---|---|---|
| **Subsistence Foods** | Contaminants from nature and or from human activities | Soils, sediments in the earth's crust | Accident site and 0.5 miles upriver from the accident site | Ingestion of contaminated clams | Past Present Future | $\leq$ 828 | See Table 1 |
| **Incidental Ingestion & Dermal Contact** | Contaminants from nature and or from human activities | Soils, sediments in the earth's crust | Accident site and 0.5 miles upriver from the accident site | Absorption through skin; Ingestion during clamming activities | Past Present Future | < 828 | See Table 2 |

**Table 4. Acute exposure doses and health comparison values (CVs) from Selawik clam ingestion**

| Metal | Individual | Dose (mg/kg-day) | Health CV | Type of CV |
|---|---|---|---|---|
| Aluminum | Adult | 0.001 | 1 mg/kg-day | Intermediate and chronic oral Minimal Risk Level (MRL)[6] |
| | Child (1-6 yrs) | 0.0009 | | |
| | Child (7-19 yrs) | 0.002 | | |
| **Arsenic*** | Adult | 0.004 | **0.005 mg/kg-day** | **Acute oral MRL**[21] |
| | Child (1-6 yrs) | 0.003 | | |
| | **Child (7-19 yrs)** | **0.005** | | |
| **Barium** | **Adult** | **0.72** | **0.7 mg/kg-day** | **Intermediate oral MRL**[15] |
| | Child (1-6 yrs) | 0.48 | | |
| | **Child (7-19 yrs)** | **0.95** | | |
| Cadmium | Adult | 0.001 | 0.001 mg/kg-day | Reference Dose (RfD)[22] |
| | Child (1-6 yrs) | 0.0004 | | |
| | Child (7-19 yrs) | 0.0009 | | |
| Calcium | Adult | 57 | 2,500 mg/day | Dietary Reference Intake, Upper Limit, 1+ yrs old (DRI-UL)[6] |
| | Child (1-6 yrs) | 37 | | |
| | Child (7-19 yrs) | 75 | | |
| Chromium | Adult | 0.0006 | 0.003 mg/kg-day | RfD for hexavalent chromium[7] |
| | Child (1-6 yrs) | 0.0004 | 0.011-0.015 mg/day<br>0.021-0.035 mg/day | Adequate Intake (AI), 1-8 yrs old[6]<br>AI, 9-50 yrs old |
| | Child (7-19 yrs) | 0.0008 | | |
| Cobalt | Adult | 0.003 | 0.01 mg/kg-day | Intermediate oral MRL[8] |
| | Child (1-6 yrs) | 0.002 | | |
| | Child (7-19 yrs) | 0.004 | | |
| Copper | Adult | 0.005 | 0.02 mg/kg-day | Acute and intermediate oral MRL[9] |
| | Child (1-6 yrs) | 0.003 | 10 mg/day<br>1-8 mg/day | DRI-UL, 19-70 yrs old[6]<br>DRI-UL, 1-18 yrs old[6] |
| | Child (7-19 yrs) | 0.006 | | |

**Table 4 (Cont'd). Acute exposure doses and health comparison values (CVs) from Selawik clam ingestion**

| Metal | Individual | Dose (mg/kg-day) | Health CV | Type of CV |
|---|---|---|---|---|
| **Iron** | **Adult** | **0.96** | **45 mg/day**<br>**40 mg/day** | **DRI-UL, 14+ yrs old**[6]<br>**DRI-UL, 1-13 yrs old**[6] |
| | Child (1-6 yrs) | 0.63 | | |
| | **Child (7-19 yrs)** | **1.26** | | |
| **Lead*** | **Adult** | **0.0003** | **0.0005**-0.25 mg/day | **California Office of Environmental Health Hazard Assessment**[24], World Health Organization[25], American National Standards Institute[26] |
| | **Child (1-6 yrs)** | **0.0002** | | |
| | **Child (7-19 yrs)** | **0.0003** | | |
| Magnesium | Adult | 1.05 | 240-420 mg/day<br>80-130 mg/day | AI, 9-13 yrs old[6]<br>AI, 1-8 yrs old[6] |
| | Child (1-6 yrs) | 0.69 | | |
| | Child (7-19 yrs) | 1.38 | | |
| **Manganese** | **Adult** | **0.78** | **0.16 mg/kg-day** | **Interim health guidance value**[20] |
| | **Child (1-6 yrs)** | **0.51** | **11 mg/day** | **DRI-UL, 19+ yrs old**[6] |
| | **Child (7-19 yrs)** | **1.03** | **2-9 mg/day** | **DRI-UL, 1-18 yrs old**[6] |
| Molybdenum | Adult | 0.0004 | 2 mg/day | DRI-UL, 19+ yrs[6] |
| | Child (1-6 yrs) | 0.0002 | 0.3-1.7 mg/day | DRI-UL, 1-13 yr olds[6] |
| | Child (7-19 yrs) | 0.0005 | | |
| Nickel | Adult | 0.009 | 0.02 mg/kg-day | RfD for nickel salts[10] |
| | Child (1-6 yrs) | 0.006 | 0.2-0.6 mg/day<br>1 mg/day | DRI-UL 1-13 yrs old[6]<br>DRI-UL, 14+ yrs old[6] |
| | Child (7-19 yrs) | 0.011 | | |
| Potassium | Adult | 1.01 | 4,700 mg/day<br>400-4,500 mg/day | AI, 14-70+ yrs old[6]<br>AI, 1-13 yrs old[6] |
| | Child (1-6 yrs) | 0.66 | | |
| | Child (7-19 yrs) | 1.32 | | |

**Table 4 (Cont'd). Acute exposure doses and health comparison values (CVs) from Selawik clam ingestion**

| Metal | Individual | Dose (mg/kg-day) | Health CV | Type of CV |
|---|---|---|---|---|
| Selenium | Adult | 0.0011 | 0.005 mg/kg-day | Chronic oral MRL[12] |
| | Child (1-6 yrs) | 0.0007 | 0.09–0.28 mg/day | DRI-UL, 1-13 yrs old[6] |
| | Child (7-19 yrs) | 0.0014 | 0.4 mg/day | DRI-UL, 19+ yrs old[6] |
| Sodium | Adult | 1.91 | 2,300 mg/day<br>1,500-2,200 mg/day | DRI-UL, 14+ yrs old[6]<br>DRI-UL, 1-13 yrs old[6] |
| | Child (1-6 yrs) | 1.26 | | |
| | Child (7-19 yrs) | 2.51 | | |
| Vanadium | Adult | 0.00002 | 0.003 mg/kg-day | Intermediate oral MRL[13] |
| | Child (1-6 yrs) | 0.00001 | | |
| | Child (7-19 yrs) | 0.00003 | | |
| Zinc | Adult | 0.26 | 0.3 mg/kg-day | Intermediate and chronic oral MRL[11] |
| | Child (1-6 yrs) | 0.17 | 40 mg/day<br>7-34 mg/day | DRI-UL, 19+ yrs old[6]<br>DRI-UL, 1-18 yrs old[6] |
| | Child (7-19 yrs) | 0.34 | | |

D, dose = (C*IR*AF*EF*CF)/(BW); C, Concentration (maximum) from Table 2, ppm = mg/kg; IR, Intake Rate adults = 227,000 mg/d, children = 34,050 mg/d (1-6 yrs) or 204,300 mg/d (7-19 yrs); 8 ounces = 227,000 mg; AF, Absorption Factor for food ingestion aluminum (0.0076), arsenic (0.95), barium and copper (0.6), cadmium (0.25), calcium, cobalt, magnesium, molybdenum, potassium, sodium (1), chromium (0.18), iron (0.15), lead (0.63), manganese (0.05), nickel (0.4), selenium (0.97), vanadium (0.026), zinc (0.81); EF, Exposure Factor = 1; CF, Conversion Factor = 0.000001 mg/kg-day; BW, Body Weight, adults = 70 kg, children (1-6 yrs old) = 16 kg or 48 kg (7-19 yrs old)[29,30]; 8 ounces =227,000 mg; MRL = Minimal Risk Level (ATSDR); RfD = Reference Dose; (EPA); DRI-UL = Dietary Reference Intake, Upper Limit (IOM); AI = Adequate Intake (IOM); Superscript numbers are reference numbers; * Known, probable, or possible human carcinogens from oral exposures (EPA, IARC, NTP). **Bold indicates a contaminant that exceeded a health CV.**

Representative calculation:
DRI-UL for manganese and an adult (see bold text):
DRI-UL = D*BW
Manganese, adult DRI-UL = 0.78 mg/kg-day*70 kg = 54.6 mg/day of manganese for an adult.

**Table 5. Doses possible from long-term ingestion of Selawik clams and health comparison values (CVs)**

| Metal | Individual | Dose (mg/kg-day) | Health CV and Type of CV | Excess Lifetime Cancer Risk |
|---|---|---|---|---|
| Arsenic* | Adult | 0.00022 | 0.0011 mg/kg-day Cancer Effect Level[21] | 0.00033 |
| | Child (1-6 yrs) | 0.0001 | | 0.00022 |
| | Child (7-19 yrs) | 0.0003 | | 0.00043 |
| Cadmium | Adult | 0.00003 | 50 mg/kg-day-Non-cancerous tumors in rats[22] | NA |
| | Child (1-6 yrs) | 0.00002 | | |
| | Child (7-19 yrs) | 0.00004 | | |
| Lead* | Adult | 0.00001 | NA | NA |
| | Child (1-6 yrs) | 0.00001 | | |
| | Child (7-19 yrs) | 0.00001 | | |
| Nickel | Adult | 0.00042 | 0.6 mg/kg-day-No cancer in rats[10] | NA |
| | Child (1-6 yrs) | 0.00028 | | |
| | Child (7-19 yrs) | 0.00056 | | |

D, dose = (C*IR*AF*EF*CF)/(BW); C, Concentration (maximum) from Table 2, ppm = mg/kg; Intake Rate, IR, adults = 227,000 mg/d, children = 34,050 mg/d (1-6 yrs) or 204,300 mg/d (7-19 yrs); AF, Absorption Factor for ingestion, arsenic (0.95), cadmium (0.25), lead (0.63), nickel (0.4), EF, Exposure Factor = 0.05 (30 d/yr*45 yrs)/(70 yrs*365 d/yr); CF, Conversion Factor = 0.000001 mg/kg-day; BW, Body Weight, adults = 70 kg, children (1-6 yrs old) = 16 kg or 48 kg (7-19 yrs old)[29,30]; Superscript numbers are reference numbers; * Known, probable, or possible human carcinogen from oral exposure (EPA, IARC, NTP). NA = Not Applicable, either contaminant is not a carcinogen or no numerical data available to evaluate as a carcinogen; 8 ounces =227,000 mg.

**Table 6. Estimated doses and comparison values (CVs) from sediment ingestion and dermal absorption for adults and children**

| Metal | Pathway | Dose (mg/kg-day) | | Health CV and Type of CV | ELCRs | |
|---|---|---|---|---|---|---|
| | | Adults | Children (7-19 yrs old) | | Adults | Children (7-19 yrs old) |
| Arsenic* as a carcinogen | Sediment ingestion | 0.0000002 | **0.0000005** | 0.0011 mg/kg-day- Cancer Effect Level[21] | 0.0000003 | 0.0000008 |
| | Dermal absorption | 0.00000003 | **0.00000007** | | 0.00000005 | 0.0000001 |
| Calcium | Sediment ingestion | 0.0005 | 0.001 | 2,500 mg/day- Dietary Reference Intake-Upper Limit (DRI-UL) 1+ yrs old[6] | NA | |
| | Dermal absorption | 0.002 | 0.004 | | | |
| Iron | Sediment ingestion | 0.0028 | 0.008 | 45 mg/day- DRI-UL, 14+ yrs old[6]<br>40 mg/day- DRI-UL, 1-13 yrs old[6] | NA | |
| | Dermal absorption | 0.009 | 0.02 | | | |
| Lead* as a carcinogen | Sediment ingestion | 0.0000002 | 0.0000006 | NA | NA | |
| | Dermal absorption | 0.0000008 | 0.000002 | | | |
| Magnesium | Sediment ingestion | 0.0007 | 0.002 | 240-420 mg/day- Adequate Intake (AI), 9-13 yrs old[6]<br>80-130 mg/day- AI, 1-8 yrs old[6] | NA | |
| | Dermal absorption | 0.002 | 0.005 | | | |
| Potassium | Sediment ingestion | 0.00004 | 0.0001 | 4,700 mg/day- AI, 14-70+ yrs old[6]<br>400-4,500 mg/day- AI, 1-13 yrs old[6] | NA | |
| | Dermal absorption | 0.0001 | 0.0003 | | | |

**Table 6 (Cont'd) Estimated doses and comparison values (CVs) from sediment ingestion and dermal absorption for adults and children**

| Metal | Pathway | Dose (mg/kg-day) | | Health CV and Type of CV | ELCRs | |
|---|---|---|---|---|---|---|
| | | **Adults** | **Children (7-19 yrs old)** | | **Adults** | **Children (7-19 yrs old)** |
| Thorium | Sediment ingestion | 0.000000006 | 0.000000018 | 764 mg/kg-day- Acute NOAEL death rats[28] | NA | |
| | Dermal absorption | 0.000002 | 0.0000043 | 137 mg/kg-day- Intermediate LOAEL dermal rats[28] | NA | |
| Thorium* as a carcinogen | Sediment ingestion | 0.000000004 | 0.00000001 | 0.03 mg/kg-day- By inhalation; the dose increased cancer rates[28] | NA | |
| | Dermal absorption | 0.000001 | 0.000003 | | | |

Sediment ingestion dose = (C*IR*AF*EF*CF)/(BW); C, Concentration (maximum) from Table 2; IR, Intake Rate, adults = 100 mg/d, children = 200 mg/d[29]; AF, Absorption Factor sediment ingestion = 1 except for arsenic (0.5), cobalt (0.97), lead (1), nickel (0.4), thorium (0.01); Non-carcinogenic EF, Exposure Factor = 0.08; (30 d/yr * 45yr)/(45yr *365 d/yr); CF, Conversion Factor = 0.000001 mg/kg-day; BW, Body Weight, adults = 70 kg, children (7-19 yrs old) = 48 kg[29,30]; Dermal absorption dose = (C*A*AF*EF*CF)/(BW); A, total soil adhered (mg) adults = 326 mg, children (1-11 yrs old) = 525[29,30]; AF dermal absorption = 1 except for arsenic (0.03), cobalt (0.8), lead (0.30), nickel (0.77); To convert to mg/day, multiply by body weight; MRL = Minimal Risk Level; DRI-UL = Dietary Reference Intake, Upper Limit; AI = Adequate Intake; LOAEL = Lowest Observable Adverse Effect Level, NOAEL = No Observable Adverse Effect Level; Superscript numbers are reference numbers; * Known, probable, or possible human carcinogens from oral exposures (EPA, IARC, NTP) with EF = 0.05; (30 d/yr * 45yr)/(70yr *365 d/yr); NA = Not Applicable, either contaminant is not a carcinogen or no data available to evaluate as a carcinogen.

Representative calculations:

Sediment ingestion for arsenic and a 7-19 yr old child (see bold text):

$$D = \frac{4.52\ \text{mg/kg}*200\ \text{mg/d}*0.5*0.05*0.000001\ \text{kg/mg}}{48\ \text{kg}} = 0.0000004\ \text{mg/kg-day}$$

Dermal absorption for arsenic and a 7-19 yr old child (see bold text):

$$D = \frac{4.52\ \text{mg/kg}*525\ \text{mg}*0.03*0.05*0.000001\ \text{kg/mg}}{48\ \text{kg}} = 0.00000007\ \text{mg/kg-day}$$

Total intake of iron for an adult exposed to sediments: T, Total = (ingested dose+dermal dose)*bodyweight

T = (0.0028 mg/kg-day+0.009 mg/kg-day)*70 kg = 0.826 mg/day

**Table 7. Contribution to blood lead (PbB) levels**

| Adult | | | | | Child 1-18 yrs | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Media** | **Concentration (mg/kg)** | **Relative Time Spent (T)** | **Slope Factor (m)** | **PbB (µg/dL)** | **Media** | **Concentration (mg/kg)** | **Relative Time Spent (T)** | **Slope Factor (m)** | **PbB (µg/dL)** |
| Outdoor Air | 0.2 | 1 | 1.92 | 0.38 | Outdoor Air | 0.2 | 1 | 1.92 | 0.38 |
| | | | | | | | | | |
| Indoor Air | 0.06 | 1 | 1.92 | 0.12 | Indoor Air | 0.06 | 1 | 1.92 | 0.12 |
| | | | | | | | | | |
| Food | 0.12 | 1 | 0.034 | 0.004 | Food | 0.12 | 1 | 0.24 | 0.03 |
| Water | 4 | 1 | 0.06 | 0.24 | Water | 4 | 1 | 0.26 | 1.04 |
| Sediment | 11.02 | 1 | 0.003 | 0.03 | Soil | 11.02 | 1 | 0.0068 | 0.07 |
| | 1 | | | | | 1 | | | |
| Dust | 11.02 | 1 | 0.0096 | 0.11 | Dust | 11.02 | 1 | 0.00718 | 0.08 |
| **Total predicted PbB (µg/dL) levels** | | | | **0.88** | | | | | **1.72** |
| **CDC level of concern** | | | | **25** | | | | | **10** |

PbB, blood lead level = (ms*T*Pbs)+( md*T*Pbd)+( mw*T*Pbw)+( mao*T*Pbao)+ (mai*T*Pbai)+ (mf*T*Pbf); m = respective slope factor for specific media; T = relative time spent (1); Pbs = soil lead concentration; Pbw = water lead concentration; Pbai = inside air lead concentration; Pbd = dust lead concentration; Pbao = outside air lead concentration; Pbf = food lead concentration (23); site-specific numbers used for sediment, dust, (assumed equal to sediment), and food; all other concentrations are from Appendix D of lead toxicological profile; mg/kg = milligrams per kilogram; µg/dL = micrograms per DeciLiter.

## Glossary

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| **Acute Exposure** | Contact with a substance that occurs once or for only a short time (up to 14 days). |
| **Adequate Intake (AI)** | Observed intakes of a nutrient by a group of healthy persons as established by Institute of Medicine studies. |
| **Alaska Department of Health and Social Services (ADHSS)** | Alaska state government agency with the mission to promote and protect the health and well-being of all Alaskans. |
| **Agency for Toxic Substances and Disease Registry (ATSDR)** | The principal federal public health agency involved with hazardous waste issues, responsible for preventing or reducing the harmful effects of exposure to hazardous substances on human health and quality of life. ATSDR is part of the U.S. Department of Health and Human Services. |
| **Cancer Risk Evaluation Guide (CREG)** | The concentration of a chemical in air, soil, or water that is expected to cause no more than one excess cancer in a million persons exposed over a lifetime. The CREG is a CV used to select contaminants of potential health concern and is based on the cancer slope factor (CSF). |
| **Cancer Effect Level (CEL)** | The lowest dose level observed to produce a significant increase in the incidence of cancer or tumors (as shown in human epidemiologic or experimental animal studies). |
| **Carcinogen** | Any substance that causes cancer. |
| **Chronic Exposure** | Contact with a substance that occurs over a long time (more than 1 year). |
| **Comparison Value (CV)** | Concentration of a substance in air, water, food, or soil that is unlikely to cause harmful (adverse) health effects in exposed people. |
| **Composite** | Aggregate of more than one sampling effort. Combining many sampling efforts into one. |
| **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 the skin. |
| **Dietary Reference Intake (DRI) Upper Limit (UL)** | The highest daily intake of a nutrient that is likely to pose no risks of adverse health effects for almost all individuals as established by the Institute of Medicine. |
| **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. An “exposure dose” is how much of a substance is encountered in the environment but it is not necessarily the amount that is absorbed. |

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| **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 *CV* 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. The mission of the Environmental Protection Agency is to protect human health and the environment. |
| **Exposure** | Contact with a substance by swallowing, breathing, or touching the skin or eyes. Exposure may be acute (14 days or less), intermediate (15-364 days) or chronic (365 days or more). |
| **Exposure Duration (ED)** | The amount of time, in years, that a person is exposed to a contaminant. |
| **Frequency (F)** | The number of days per year that a person is exposed to a contaminant. |
| **Indeterminate public health hazard** | An ATSDR categorization where the professional judgment about the level of health hazard cannot be made because information critical to such a decision is lacking. |
| **Ingestion** | The act of swallowing something through eating, drinking, or mouthing objects. A hazardous substance can enter the body this way [see route of exposure]. |
| **Ingestion Rate (IR)** | The amount of an environmental medium that could be ingested usually on a daily basis. |
| **Intermediate Exposure** | Contact with a substance that occurs for more than 14 days and less than a year. |
| **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. |
| **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), non-cancerous effects. MRLs are calculated for a route of exposure (inhalation or oral) over a specified time period (acute, intermediate, or chronic). |
| **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. |

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| **No Observed Adverse Effect Level (NOAEL)** | The highest dose of a substance that has been reported to have no harmful (adverse) health effects on people or animals for the organ system studied. |
| **Reference Dose (RfD)** | An amount of chemical that can be ingested daily over the course of a lifetime and not cause serious adverse health effects. RfDs are calculated and published by EPA. |
| **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 *CV* used to select contaminants of potential health concern and is based on EPA's oral reference dose (RfD). |
| **Sediment** | Materials/soils found at the bottom of a liquid. |