Health Consultation

Evaluation of Exposure of Mine Contaminants through the Surface Soil and Groundwater Pathways

CAPTAIN JACK MILL

WARD, BOULDER COUNTY, COLORADO

EPA FACILITY ID: COD981551427

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

Health Consultation: A Note of Explanation

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

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

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Prepared By:

Colorado Department of Public Health and Environment
Under a Cooperative Agreement with the
U.S. Department of Health and Human Services
Agency for Toxic Substances and Disease Registry

Table of Contents

Foreword

The Colorado Department of Public Health and Environment's (CDPHE) Environmental Epidemiology Section has prepared this health consultation in cooperation with the Agency for Toxic Substances and Disease Registry (ATSDR). ATSDR is part of the US Department of Health and Human Services and is the principal federal public health agency responsible for the health issues related to hazardous waste. This health consultation was prepared in accordance with the methodologies and guidelines developed by ATSDR.

The purpose of this health consultation is to identify and prevent harmful health effects resulting from exposure to hazardous substances in the environment. Health consultations focus on health issues associated with specific exposures so that the state or local department of public health can respond quickly to requests from concerned citizens or agencies regarding health information on hazardous substances. The Environmental Epidemiology Section (EES) evaluates sampling data collected from a hazardous waste site, determines whether exposures have occurred or could occur in the future, reports any potential harmful effects, and then recommends actions to protect public health. The findings in this report are relevant to conditions at the site during the time this health consultation was conducted and should not necessarily be relied upon if site conditions or land use changes in the future.

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Summary and Statement of Issues

The purpose of this health consultation is to examine potential public health hazards from the surface soil and groundwater pathways at the Captain Jack Mill Superfund site (CJM). This document is a follow-up activity to the Public Health Assessment conducted in 2005 due to a limited amount of environmental data available at that time. The information within is based on the environmental data that was collected during the Remedial Investigation and Feasibility Study conducted by the Colorado Department of Public Health and Environment (CDPHE) and the Environmental Protection Agency (EPA).

The Captain Jack Mill site is an abandoned mining area that was listed on the National Priorities List (NPL) on September 29, 2003. In 2005, a Public Health Assessment was conducted on this site under a cooperative agreement between the CDPHE and the federal Agency for Toxic Substances and Disease Registry (ATSDR). The 2005 Health Assessment document concluded the Captain Jack Mill site (CJM) was a public health hazard due to a number of physical hazards found on site that were dangerous for residents and recreational users. In regards to environmental contamination, the site was classified as an indeterminate public health hazard because there was not a sufficient amount of environmental data to accurately determine public health conclusions. Recommendations were made to review the additional environmental data that was to be collected during the Remedial Investigation and Feasibility Study (RI/FS) phase of Superfund remediation. This document is one of two health consultations planned for the site based on the additional information currently available.

It is important to note that this health consultation is not intended as a complete assessment of total health hazards and theoretical cancer risks from all contaminants of concern and complete exposure pathways at the site. Rather, this health consultation evaluates two media of concern (surface soils and ground water) using an indicator chemical approach. The focus of the document is on primary chemicals of concern (lead, arsenic, copper) and two critical exposure pathways (ingestion of surface soils and ground water). Health hazards from multiple chemical interactions are not evaluated quantitatively, but are evaluated qualitatively using an indicator chemical approach.

Four out of five areas of investigation are considered to constitute a public health hazard due to the potential noncancer health hazards and theoretical cancer risk to human health which result from exposure primarily to lead, arsenic, or copper in surface soils, and manganese and zinc in groundwater. Public health hazards include: (1) acute, subchronic, and chronic exposures to surface soils through the ingestion pathway for residential and recreational children, (2) chronic exposure to surface soils through ingestion pathway for residential adults and outdoor adult workers; and (3) ingestion of groundwater by residential children.

Background

The site background material has been described in documents: ATSDR 2005, URS 1994, UOS 1998, and Walsh 2006. The background information presented here is a synopsis of the available background material that is relevant for this health consultation. For more detailed background information, please refer to the aforementioned documents.

Site Description

The CJM Superfund site is located approximately 1.5 miles south of the small community of Ward, Colorado in the eastern foothills of the Rocky Mountains. The site is positioned in a narrow valley, known locally as the California Gulch, at a mean elevation of approximately 8,800 feet above sea level (USGS 1978a). The area surrounding the site is relatively rugged with an approximate gradient of 11% to the southeast (USGS 1978a). The mines and mill that compose the CJM site are positioned along the banks of Lefthand Creek, a perennial stream that serves as a source of drinking water and agricultural irrigation for the downstream population. Vegetation surrounding the site is somewhat sparse and consists of Lodgepole and Ponderosa Pines, Aspen, various wildflowers, and other native plants and grasses. The climate zone is semi-arid with a mean annual precipitation of 15 inches (URS 1994).

The CJM site is a former mining and milling operation, which operated intermittently from the late 1800s through 1995. The site contains numerous source/waste areas, which contain high levels of heavy metals from prior operations. One of the major contributors of environmental contamination at the site is the Big Five adit drainage. The drainage is acidic in nature, which is formed by a chemical reaction between water, oxygen, and sulphite ores. Metals in rock and waste rock are more soluble in acidic solutions. This, in turn, increases the metals concentration in the water, and metals are more readily transported through the environment. An abundance of waste rock and mine tailings found at the site is the other major contributor to environmental contamination. Metal-contaminated mine workings are present on the surface and can contribute to the contamination of groundwater, surface water, and other surface soils. This document will focus on human exposures via the surface soil, which includes mine workings, and groundwater pathways.

The land encompassing the CJM site has been divided into five areas of investigation for the RI/FS. The same areas of investigation were adopted for this health consultation. The major components of each Area of Investigation (AI) are listed below. For a more detailed description of the AIs, please refer to the RI/FS document (Walsh 2006).

Big Five (BFV) AI

- Big Five Adit (Tunnel),
- Big Five Mine Dump,
- Big Five Settling Pond,
- Big Five Mill, and
- Cornucopia Mine and Dump

Big Five to Captain Jack (BFC) AI

- Wetland area below the Big Five Settling Pond
- Segment of Lefthand Creek that receives AMD from the Big Five Adit

Captain Jack Mill (CJM) AI

- Captain Jack Mill,
- A filled in, unlined settling pond,
- A filled in, lined settling pond,
- A residence,
- The Black Jack Mine Adit,
- The Philadelphia Mine/dump, and
- At least two other mine/dumps on the hillsides

White Raven (WHR) AI

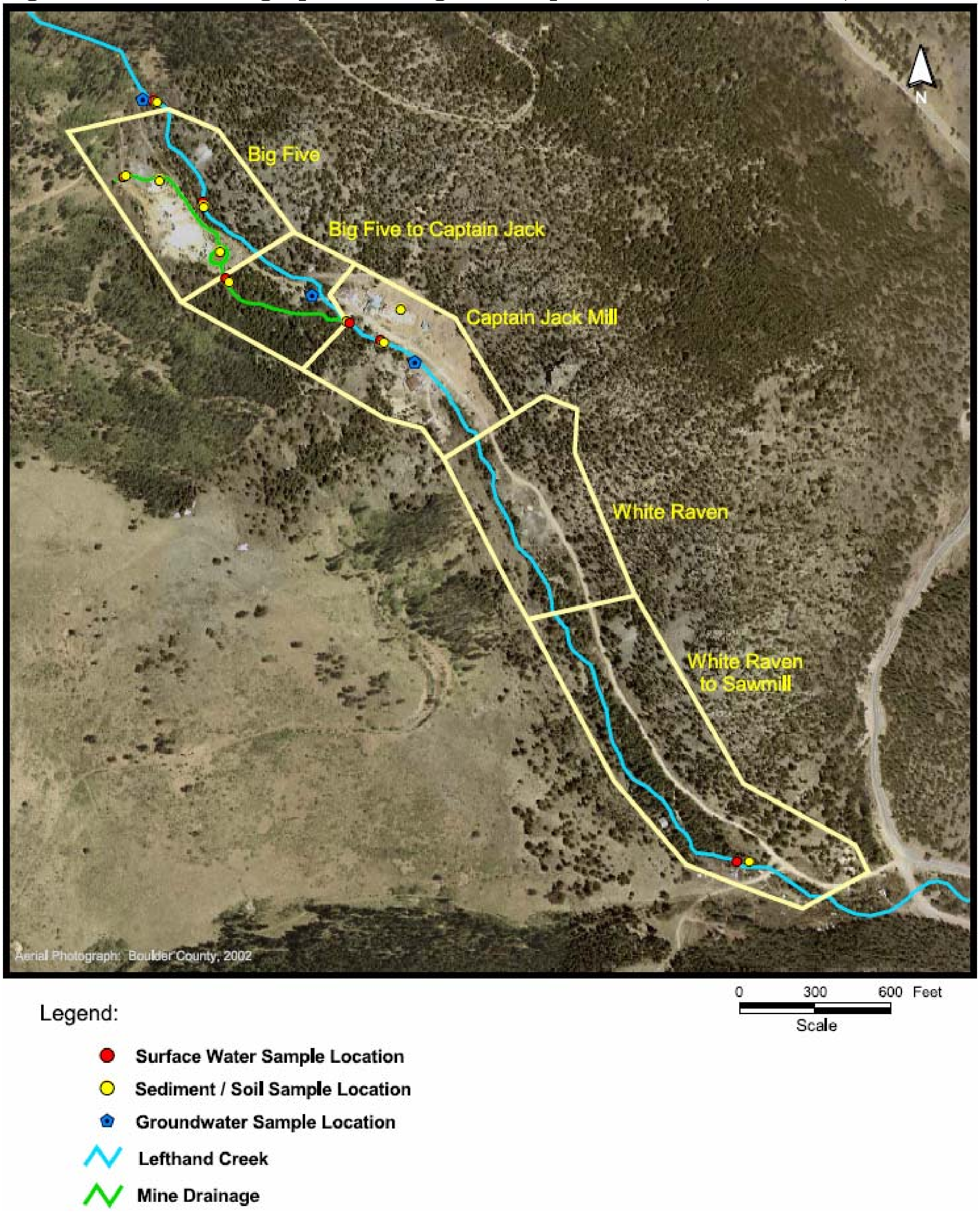
- White Raven Mine Adit,
- White Raven Shaft, and
- A mine/mill dump

White Raven to Sawmill (WRS) AI

- Residential dwellings,
- Riparian wetland adjacent to Lefthand Creek,
- Two mine dumps, and
- The Conqueror Mill

Each AI listed above will be discussed independently throughout this assessment. A limited amount of groundwater data is available and will only be considered collectively as a site-wide exposure scenario. Figure 1 is an aerial photograph of the CJM site depicting the location of each AI.

Figure 1. Aerial Photograph Outlining CJM Superfund Site (Walsh 2006)



Demographics

Three distinct communities have been identified in the area surrounding the CJM site. The residents of California Gulch Road, Ward, and Jamestown/Rowena are most likely to come into contact with site-related contaminants by either living on the property or visiting the site for recreational purposes. Individuals living on California Gulch Rd. have the highest probability of exposure. People living in Ward and Jamestown/Rowena may visit the site on a regular basis for recreational purposes.

Approximately 12-24 people are living in close proximity to the site in the California Gulch. According to Census 2000 data, there are 169 and 205 individuals living in Ward and Jamestown/Rowena, respectively. More detailed demographic information on these communities is available in Appendix B.

Community Health Concerns

In preparation for the Public Health Assessment completed in 2005, community concerns were solicited from four distinct community groups: residents of California Gulch Road; residents of the Town of Ward; residents of the communities of Rowena and Jamestown; and residents of the City of Boulder. These concerns are discussed in detail in Appendix B. Overall residents had many issues and concerns and general concerns are briefly summarized below.

- Residents wanted clean up to occur quickly in an environmentally sound and cost effective manner with minimal disruptions to their lifestyle, and with community input in the cleanup decisions made by the state and EPA.
- Boulder residents fear that the cleanup could release contaminants that could move downstream. They hope to see other mines in the watershed addressed as well, and they desire all factors and perimeters outside the targeted site be carefully considered.
- The EPA and CDPHE have "created confusion about the immediate health risks". They have created the public perception for many that there *is* an immediate health risk. However, when asked directly, they say that there is not an immediate health risk and there is no data that indicates there is a risk.

Discussion

Evaluation Process

The process used to reach the conclusions and recommendations contained within this document is summarized here. For more information on the public health consultation process, please refer to the Public Health Assessment Guidance Manual (ATSDR 2005). The initial steps of the assessment process involve screening the available environmental data for contaminants and then comparing this information to conservative, health-based environmental guidelines. Exposures to contaminated sources below the environmental guidelines are not expected to result in adverse or harmful health effects. If the concentration of a particular contaminant is above the chosen environmental guideline, the contaminant is normally retained for further analysis. However, exceeding the screening value does not necessarily mean that the contaminant poses a public health hazard only that further evaluation may be necessary. ATSDR and CDPHE's Environmental Epidemiology Section also consider sampling location, data quality, exposure probability, frequency and duration; and community health concerns in determining which contaminants to evaluate further.

If the contaminant is selected for extended evaluation, the next step is to identify pathways of probable exposure that could pose a hazard. Simply having the substance present in the environment does not necessarily mean that people will come into contact with it and subsequently experience adverse health effects. An exposure pathway consists of five elements: a source, a contaminated environmental medium and transport mechanism, a point of exposure, a route of exposure, and a receptor population. Exposure pathways are classified as either complete, potential, or eliminated. Only complete exposure pathways can be fully evaluated and characterized to determine the public health implications. Site-specific contaminants of concern and completed exposure pathways are discussed further in the exposure assessment section below.

Data Used

The Surface Soil and Groundwater data that was utilized for this health consultation was collected during the RI/FS phase of Superfund remediation (Walsh 2006). This data was collected from one of the AIs described above. A large amount of surface soil data was collected on-site. Surface soil data was organized and will be discussed by the AI that the sample was collected from. On the other hand, only a limited amount of groundwater data was collected during the RI/FS. This data was not divided into the respective AI location. Rather, the data was combined and reviewed in terms of a site-wide exposure to groundwater.

<u>Surface Soil</u>
Soil data collection for the RI/FS focused on characterizing the soil in terms of potential surface exposure, leaching potential, confirmatory sampling for previously identified contaminants, and also to define the lateral and vertical extent of contamination present. An X-Ray Fluorescence (XRF) field device was used to screen the soil prior to collecting samples for laboratory analysis. Laboratory analysis of surface soil samples included the Target Analyte List (TAL) of metals as well as a random sampling of various organic compounds. Surface soil data at 126 locations was collected at a depth of 0-2 inches, and is likely to represent the level of contamination to which most receptors are exposed.

<u>Subsurface Soil</u>
Twenty-five soil bore samples were also collected to determine the vertical extent of contamination in sub-surface soils (up to 10 feet). This data was reviewed and was found to contain lower concentrations of each metal than was found in the surface soils. Therefore, surface soil samples are likely to overestimate risk to some types of workers, such as a construction worker, when evaluating a subsurface pathway. Any risk from exposure to subsurface soils is considered accounted for by examining only surface soils. Thus, subsurface soils were not considered further in this consultation.

<u>Groundwater</u>
Groundwater under the CJM site is characterized as a shallow, alluvial aquifer, which is thought to flow sub parallel to Lefthand Creek. Unconfined water levels varied from approximately 4 feet below ground surface (bgs) to 24 feet bgs during the RI/FS (WALSH 2006). Lefthand Creek and the alluvial aquifer are in direct communication with a losing reach of the creek between the Big Five and Captain Jack AIs. Eight monitoring wells were constructed for the groundwater characterization and one round of sampling was conducted in the fall of 2005 (during low-flow

conditions). Two domestic wells and one background well were also sampled. Groundwater samples at 10 locations were analyzed for dissolved TAL metals and cyanide. The background sample was collected up gradient of any known site influence.

Exposure Assessment

The groundwater and surface soil data described above were validated and inserted into a database for the exposure assessment. Summary statistics for both sets of data that were used in this health consultation are presented in Tables C1 and C2 of Appendix C. The location of these samples is presented in Figures C1 to C6 of Appendix C.

Selection of Contaminants of Potential Concern (COPCs)

The major step in the exposure assessment is to determine which contaminants (maximum detected concentrations) exceed the comparison value (CV). Those contaminants that do not exceed the respective CV are dropped from further analysis since they are unlikely to result in adverse health effects.

The screening or comparisons values (CVs) used in this assessment are the Environmental Protection Agency's (EPA) Region 9 Preliminary Remediation Goals (PRG) for surface soil and groundwater (EPA 2004). PRGs are conservative, health-based environmental guidelines which consider carcinogenic and non-cancer health effects from exposure to contaminants through a variety of exposure pathways from each specific type of media. Adverse health effects are not expected to occur below the PRG values. PRGs are the standard comparison value used at the CDPHE and in EPA Region 8 risk assessment. In accordance with the CDPHE and EPA Region 8 process for selection of COPCs (EPA, 1994), when multiple contaminants exist on-site, the PRG values are multiplied by 0.1 (10% of original value). For noncarcinogenic contaminants, the comparison value of 0.1 PRG ensures that any additive adverse effects will still result in a cumulative hazard of less than one.

<u>Groundwater</u>
Groundwater data from monitoring and residential wells exceeded the CV for 9 contaminants: antimony, arsenic, boron, cadmium, copper, manganese, nickel, thallium, and zinc (Table C3 of Appendix C). However, only 1 out of 10 samples exceeded the CV for Nickel. The average site-wide nickel concentration is 17.5 parts per billion, which is well below the CV of 73 ppb. The sample that did exceed the CV had a concentration of 79 ppb. This exceedance is considered relatively minor and is not likely to result in adverse health effects. Therefore, nickel was not retained for further evaluation.

Antimony, arsenic, and thallium also exceeded the CVs. However, all of these contaminants were reported as "not detected" in laboratory analysis. In this health consultation, all samples that were reported as "not detected" were inserted into the database with a concentration of ½ the reporting limit of the analytical method. In this scenario, ½ the reporting limit exceeds the CV for these contaminants. Historical data, collected during the SSI and the ESI, were also reviewed on antimony, arsenic, and thallium (URS 1994, UOS 1998). All groundwater samples that were collected during these site inspections contained non-detectable concentrations of each contaminant. These contaminants are not likely to be present in groundwater at the CJM site and are not expected to be significant in terms of adverse health effects from exposure to groundwater. Thus, antimony, arsenic, and thallium were dropped from further evaluation.

Boron, cadmium, copper, manganese, and zinc were selected as COPCs and were retained for more detailed analyses.

<u>Surface Soil</u>
Surface soil data was organized by Area of Investigation (AIs) to characterize exposures by location within the CJM site. Surface soil data is summarized and presented in Table C4 of Appendix C with the respective comparison value (CV) for each contaminant. Overall, the contaminants that exceeded the CV included aluminum, antimony, arsenic, barium, cadmium, copper, iron, lead, manganese, mercury, silver, thallium, vanadium, and zinc. These contaminants are listed by the AI in which they occur in Table C5 of Appendix C.

The next step of the evaluation process is to determine how individuals may come into contact with site-related contaminants. This is accomplished through the development of a Conceptual Site Model (CSM), which identifies each of the five components of an exposure pathway.

Conceptual Site Model

The overall conceptual site model for ground water and surface soil pathways at the CJM site is presented below in Table 1. The conceptual site model lists the possible routes of exposure and receptor populations for these two pathways. Each pathway considered in this health consultation is briefly discussed below.

Table 1: Conceptual Site Model

Source	Transport Mechanism	Point of Exposure	Affected Environmental Medium	Timeframe of Exposure	Potentially Exposed Population	Route of Exposure[a]
Mine Workings	Anthropogenic Big Five Adit, Runoff	All Exposure Areas of Investigation	Surface Soil	Past, Current, Future	Residents, Construction Workers, and Recreationalists	Ingestion, Dermal, Particulate Inhalation
Mine Workings	Leachate, Runoff, Surface Water, Mine Water	Domestic Wells located in Big Five, Captain Jack, and White Raven Exposure Areas	Groundwater	Past, Current, Future	Residents, Construction Workers (Potential)	Ingestion, Dermal via Showering, Bathing, Washing

[a] Only ingestion of surface soil is quantitatively evaluated in this assessment. Other complete exposure pathways (e.g., dermal contact with soil and groundwater, use of groundwater for irrigating domestic gardens, and inhalation of particulates) are not evaluated quantitatively and discussed qualitatively.

Groundwater
Individuals living on the CJM site are likely to use groundwater as their major source of drinking water due to a limited number of other sources available on-site. Residents living at the CJM site were the only receptors evaluated in the groundwater pathway. Three possible routes of exposure to contaminants in groundwater can occur: consumption, dermal (skin) contact, and inhalation via showering, dishwashing, etc. The Contaminants of Potential Concern (COPC) identified above are all metals. Typically, dermal exposure and inhalation of water vapors containing metals are considered relatively minor contributors to health risk. These exposure pathways will not be evaluated quantitatively. Ingestion, or consumption, of groundwater is the major health risk driver in this situation, and exposure dose calculations will be performed for this pathway.

Surface Soil
Individuals may be exposed to surface soil via three potential pathways: incidental ingestion, inhalation of particulates, and dermal exposure to contaminants. Incidental ingestion is the primary pathway that is likely to result in health risks. Dermal exposure and inhalation of particulates are not likely to be substantial health risk drivers when considering metal contaminants. Therefore, dermal exposure and inhalation of particulates will only be qualitatively assessed in this consultation. The primary receptors of these types of interactions with surface soil at the CJM site are residents, construction workers, and recreational users.

Exposure Dose Estimation

As noted above in the Evaluation Process section, if a contaminant exceeds the CV and a complete exposure pathway exists, exposure doses are estimated and compared to health-based guidelines. To calculate exposure doses, the exposure point concentration must first be estimated.

The Exposure Point Concentration (EPC) is a high-end, yet reasonable concentration of contaminants in groundwater that people could be exposed to based on the available environmental data. The standard procedure for calculating EPCs is to use the 95% Upper Confidence Interval on the mean of the data for each COPC. To calculate the EPC, the data was inserted into the EPA's statistical software package, ProUCL Version 3.02. The groundwater EPC results are presented in Table C6 of Appendix C. If the data is not normally distributed, ProUCL recommends an alternative value to use in lieu of the 95% UCL depending on the type of data distribution. When less than ten samples exist for a particular contaminant the EPC becomes the maximum value of the data. EPCs for surface soil contaminants were calculated with the same procedure described above for ground water. The EPCs for surface soil COPCs are listed in Table C7 of Appendix C.

Exposure doses are estimates of the concentration of contaminants that people may come into contact with or be exposed to under specified exposure conditions. These exposure doses are estimated using: (1) Exposure point concentration estimated above and (2) the length of time and frequency of exposure to site contaminants. Generally, the default exposure parameters established by EPA and ATSDR are used. When necessary, site-specific information about the frequency and duration of exposure was used. Please refer to Tables C8 and C9 of Appendix C for details on the various exposure parameters and methods of calculating exposure doses for different receptor populations.

Toxicological Evaluation

The basic objective of a toxicological evaluation is to identify what adverse health effects a chemical causes, and how the appearance of these adverse effects depends on dose. The toxicity assessment process is usually divided into two parts: the cancer effects and the non-cancer effects of the chemical. This two-part approach is employed because there are typically major differences in the time-course of action and the shape of the dose-response curve for cancer and non-cancer effects. Please see Appendix D for details on toxicological evaluation.

Public Health Implications: Noncarcinogenic Health Hazards and Theoretical Cancer Risks

The purpose of reviewing public health implications is to determine whether exposures to chemicals that exceed the CVs for the groundwater and surface soil exposure pathways might be associated with adverse health effects. If the contaminant is a carcinogen, the cancer risk is also estimated. This process is conducted in a step-wise manner below:

Step-1: Compare the estimated exposure doses to health guidelines. Health guideline values are considered acceptable or "safe" doses; that is, health effects are not likely below this level. If the exposure dose for a contaminant is greater than the health guideline, then Step-2 is performed. More detailed information on the health-based guidelines used in this consultation can be found in Appendix E.

Step-2: In-depth analysis to compare the estimated exposure doses to known adverse health effect levels such as the No Observed Adverse Effect Level (NOAEL) and the Lowest Observed Adverse Effect Level (LOAEL). NOAEL is defined as the highest observed dose that has not resulted in adverse health effects in experimental and/or human data. The LOAEL value refers to the lowest dose of that contaminant in which adverse health effects have been observed in experimental and/or animal data. When the estimated exposure dose exceeds known adverse health effect levels for that contaminant, the scientific literature is reviewed in detail and likely health effects from this exposure are predicted.

It is important to note that the likelihood of adverse health effects occurring from exposure to contaminated soil at the Captain Jack Mill site is dependent upon the frequency, duration, and amount of soil ingested by the individual child and/or adult. Thus, the estimated exposure doses may overestimate or underestimate the risk to some individuals. The uncertainties associated with the dose calculations and exposure assumptions made in this consultation are discussed in more detail in Appendix J.

Groundwater

Exposure doses were estimated for boron, cadmium, copper, manganese, and zinc. The results are presented in Table 2 with their respective health-based guidelines. Contaminants of Concern

(COC) are contaminants that are greater than or equal to the health-based value for that contaminant. Groundwater COCs include cadmium, copper, manganese, and zinc. Boron was dropped from further evaluation due to the fact that estimated exposure dose for groundwater ingestion does not exceed health-based guideline for this contaminant. Therefore, adverse health effects are unlikely to result from boron exposure from consuming ground water at the CJM site. The remaining COCs are discussed in detail below.

Table 2. CJM Health Guideline Comparison of Groundwater Exposure Dose

Contaminant	Exposure Point Concentration (mg/L)	Child Consumption Results (mg/kg-day)	Adult Consumption Results (mg/kg-day)	Health-Based Guideline (mg/kg-day)	Child HQ	Adult HQ
Boron	1350.3	0.09	0.039	0.2[2]	0.45	0.19
Cadmium	27.82	0.0019	0.00079	0.0002[3]	9.5	3.9
Copper	394.48	0.026	0.011	0.01[1]	2.6	1.1
Manganese	3980.05	0.27	0.11	0.05[4]	5.4	2.2
Zinc	18307.34	1.2	0.52	0.3[3]	4	1.7

[1]ATSDR Acute Oral MRL
[2]ATSDR Intermediate Oral MRL
[3]ATSDR Chronic Oral MRL
[4]EPA Oral RfD
*Doses in red indicate that the health-based guideline was exceeded

Cadmium

A large amount of human and laboratory animal data exists on exposure to cadmium. The NOAEL for oral exposure is 0.0021 mg/kg-day. This value is derived from a study of a female human who was chronically exposed to cadmium over the course of a lifetime. The highest estimated exposure dose to cadmium at the CJM site was 0.0019 mg/kg-day (Child Dose Result). The adult exposure dose result is 0.00079 mg/kg-day. No adverse health effects are known to occur at this dose level following oral exposure to cadmium.

The dose calculations are based on the ingestion of 1 Liter (L) of CJM well water per day from birth to the age of 6 for children and 2L per day over 30 years for adults. An EPC of 27.82 parts per billion (ppb) was used for the dose calculations. The EPC is a high-end average concentration of cadmium in well water at the CJM site. The maximum concentration of cadmium found in CJM groundwater is 39.9 ppb and the average concentration is 5.9 ppb. The values used in the dose calculations are conservative and are likely to overestimate the exposure to any one individual. Therefore, cadmium exposure via groundwater ingestion is considered no apparent public health hazard.

Copper

Oral exposure to copper from ingesting contaminated beverages and water has been very well documented in human beings. The intermediate and acute NOAEL values for oral copper exposure are 0.0272 mg/kg-day and 0.042 mg/kg-day, respectively. The acute NOAEL value for copper (Cu) is based on 2-week exposure study conducted by Pizarro et al (1999). In this study, gastrointestinal symptoms were observed in humans orally exposed to 0.0731 mg Cu/kg-day and 0.124 mg Cu/kg-day, but not at 0.0272 mg Cu/kg-day. The highest estimated exposure dose from groundwater ingestion at the CJM site is 0.026 mg/kg-day. The exposure dose assumptions for ingestion rate and exposure duration are the same as described above for cadmium. The EPC of copper is also a high-end estimate of the average concentration of copper found in CJM groundwater. At this dose level, no known adverse health effects are thought to exist. Therefore, copper exposure via groundwater ingestion is considered no apparent public health hazard.

Manganese

Manganese (Mn) is an essential trace element, which is required by the body for normal function in all animal species. Regular dietary intake of Mn ranges from 2-10 mg/day depending on the type of diet, with vegetarians ingesting the highest level of Mn per day. However, the health effects of deficient and toxic intake levels of Mn are still not well defined. Based on the available information, the EPA has determined a NOAEL for Mn of 0.14 mg/kg-day for food. A LOAEL value has not been established in the EPA's IRIS. One study, cited by the NAS (2000) in their evaluation of recommended dietary intakes of Mn, determined a LOAEL of 15 mg Mn/day in food (0.21 mg/kg-day for a 70kg individual). This study was conducted on 47 females receiving 15 mg Mn/day as an oral supplement over a 90-day period. Notable increases in Mn serum concentration and lymphocyte Mn-dependent superoxidase dismutase (MnSOD) were observed 25 days after supplementation. The highest estimated exposure dose of Mn from ingesting groundwater at the CJM site is 0.27 mg/kg-day (child). The estimated exposure dose for adults is below the NOAEL value.

A number of uncertainties exist in the health evaluation of Mn in groundwater at the CJM site. For instance, it has been suggested that Mn is more bioavailable in water than food, which leaves a question as to the applicability of applying the NOAEL and LOAEL values derived for food to water ingestion exposures. Another confounding variable in this assessment is the amount of Mn ingested through the individual diet, which appears to vary greatly amongst the general population. After considering these factors, it is concluded that groundwater ingestion of Mn at the CJM site is considered a public health hazard based on the estimated exposure dose for children exceeding the LOAEL value for food. However, some uncertainty in the public health hazard conclusion exists because of the limitations associated with applying the identified LOAEL for food.

Zinc

Zinc (Zn) is another essential trace element that is required by the body for normal physiologic function. The average dietary intake of Zn in the United States is 5.2 – 16.2 mg per day (0.074 – 0.23 mg/kg-day based on 70 kg body weight). Many daily vitamin supplements also contain Zn. The LOAEL value for Zn is 0.91 mg/kg-day. No NOAEL value has been accepted by ATSDR or the EPA IRIS for oral ingestion. Estimated exposure doses of Zn from groundwater ingestion are 1.2 mg/kg-day (child) and 0.52 mg/kg-day (adult) at the CJM site. At the estimated dose level for child, hematological effects were observed in female and male subjects ingesting Zn as a supplement over a 6-10 week period. Researchers in these studies noted marked decreases in erythrocyte superoxidase dismutase (47%), serum ferritin levels, and hematocrit values. The overall effect is a reduction in red blood cell production. Higher intakes of Zn have been associated with gastrointestinal distress including nausea, vomiting, cramping, and diarrhea.

Based on the groundwater data that is currently available, it is concluded that exposure to Zn in drinking water wells on the CJM site pose a public health hazard to child residents.

Surface Soil

Surface soil COCs for which estimated exposure doses exceeded the health guideline (i.e., HQs greater than or equal to 1 are summarized below in Table 3 by the AI. Table E1 in Appendix E contains more information on the COCs including the receptor, exposure dose, the applicable health-based guideline, and the corresponding HQ. In addition, exposure doses for iron exceeded the health-based guideline. However, no reliable data exists to quantitatively evaluate oral exposure to iron. The ATSDR and EPA have not accepted a NOAEL or LOAEL value for iron exposures. Thus, iron exposures from incidental ingestion of surface soil cannot readily be evaluated and are not considered to be significant in terms of public health when compared to other COCs found in surface soil. Therefore, iron was dropped from further consideration in this assessment.

Lead is also a primary COC of the surface soil pathway. However, adverse health effects related to lead exposure are not generally quantified by dose. Rather, a predictive model of blood lead concentrations in children and women of childbearing age is used to indicate the potential of adverse health effects. The lead IEUBK model and evaluation process of this COC is summarized in this section and presented in greater detail in Appendix F.

Table 3. Surface Soil Contaminants of Concern

Big Five (BFV)	Big Five to Captain Jack (BFC)	Captain Jack (CJM)	White Raven (WHR)	White Raven to Sawmill Rd. (WRS)
Arsenic	Antimony	Antimony	Arsenic	Arsenic
Iron	Arsenic	Arsenic	Iron	Iron
	Copper	Cadmium	Lead	
	Iron	Copper	Manganese	
	Silver	Iron	Thallium	
		Thallium		
		Zinc		

Table 4 contains the COCs (arsenic, copper, and lead) for which an in-depth analysis was conducted, and is briefly discussed below. All other COCs identified above do not exceed known adverse health effect levels and are not likely to constitute a public health hazard individually. Therefore, this section focuses on the major COCs that are likely to result in adverse health effects. For more information on the minor surface soil COCs please refer to Appendix C.

Table 4. Primary Surface Soil COCs

COC	Area of Investigation	Receptor	Exposure Dose Result (mg/kg-day)	NOAEL HQ (mg/kg-day)	LOALEL HQ (mg/kg-day)
Arsenic	Big Five to Captain Jack (BFC)	• C_{res}	0.013	16.25	0.93
		• C_{rec}	0.0036	4.50	0.26
		• A_{res}	0.0014	1.75	0.10
		• A_{rec}	0.0004	0.49	0.03
		• CW	0.0032	4.00	0.23
Arsenic	Captain Jack (CJM)	• C_{res}	0.06	75.0	4.29
		• C_{rec}	0.016	20.0	1.14
		• A_{res}	0.0064	8.0	0.46
		• A_{rec}	0.0017	2.13	0.12
		• CW	0.014	17.5	1.0
Arsenic	White Raven to Sawmill (WRS)	C_{res}	0.0011	1.4	0.08
Copper	Captain Jack Mill (CJM)	• C_{res}	0.15	5.51	2.05
		• C_{rec}	0.042	1.54	0.57
		• CW	0.037	1.36	0.51
Lead	BFC, CJM, WRS, and White Raven (WHR)	C_{res}, Outdoor adult/CW	EPA Predictive modeling (IEUBK and ALM)	Exceeds EPA's goal of 5% for children and fetuses	See Appendix F for details of lead health assessment

C_{rec} = Child Recreational User, C_{res} = Child Resident, A_{rec} = Adult Recreation User, A_{res} = Adult Resident, CW = Construction Worker

Note:
Arsenic NOAEL = 0.0008 mg/kg/day; LOAEL = 0.014 mg/kg/day
Copper NOAEL = 0.0272 mg/kg/day; LOAEL = 0.0731 mg/kg/day

Arsenic

Arsenic exists in both inorganic and organic forms. Speciation, to determine which form of arsenic is present at the CJM site, was not performed during the RI/FS investigation. Organic arsenates are primarily found in pesticides, and it was therefore assumed that arsenic at the CJM site is in an inorganic form. Noncarcinogenic health effects of arsenic exposure have been very well studied in humans. Most cases of arsenic toxicity in humans have resulted from accidental, suicidal, homicidal, or medicinal ingestion of arsenic containing substances or by the consumption of contaminated foodstuffs or water. The chronic duration NOAEL for arsenic is 0.0008 mg As/kg-day and the LOAEL is 0.014 mg/kg-day based on the critical health effects of hyperpigmentation, keratosis and possible vascular complications. As shown in Table 3, chronic, non cancer estimated doses exceed NOAEL and/or LOAEL for all receptors, or child residents at 3 out of 5 AIs. Estimated exposure doses did not exceed the NOAEL or LOAEL values at the Big Five (BFV) or White Raven (WHR) AIs.

The only known carcinogen in the surface soil pathway is arsenic. Carcinogenic risks were evaluated by using an age-adjusted equation, which accounts for exposure to arsenic from childhood until the age of 30. Factors such as body weight and the rate of soil ingestion vary over this timeframe of exposure and the age-adjusted equation provides a more realistic approach to estimating cancer risk. The theoretical cancer risks for arsenic are above the CDPHE's target risk level of one in a million excess cancer risk for all receptors at all AIs. The highest cancer risk observed on-site was 2 in 100 (Table E2 of Appendix E). Therefore, arsenic constitutes a public health hazard based on noncancer health hazards and/or theoretical cancer risk in some areas of the site; for example, exposure to arsenic for the residents constitutes a public health hazard in 4 out of 5 AIs, except the Big Five AI (Table 4 and Appendix Table E2).

It is, however, important to note that there is some uncertainty associated with the conclusions because of the reduced relative bioavailability of arsenic from soils, cancer slope factor for arsenic, and background levels of arsenic in soil. Please refer to Appendix J for the relative bioavailability and cancer slope factor uncertainty discussion, and Table I1 of Appendix I for background risk comparisons. Background risks for arsenic based on the maximum detected concentration of arsenic in soil and the residential exposure scenario are: theoretical cancer risk = 1E-05 (one in 100,000); and noncancer HQ = 0.2.

Copper

Oral exposure to copper-containing compounds has been well documented. Adverse health effects, ranging from death to gastrointestinal distress have been reported following oral exposure to copper-containing compounds. The chronic duration NOAEL and LOAEL are not available from EPA and ATSDR. The ATSDR (2004) intermediate and acute NOAEL values for oral copper exposure are 0.0272 mg/kg-day and 0.042 mg/kg-day, respectively. The acute NOAEL value for copper (Cu) is based on 2-week exposure study conducted by Pizarro et al (1999). In this study, gastrointestinal symptoms were observed in humans orally exposed to 0.0731 mg Cu/kg-day and 0.124 mg Cu/kg-day, but not at 0.0272 mg Cu/kg-day. For this study the acute LOAEL value was determined as 0.0731 mg Cu/kg-day. The intermediate NOAEL value was derived from a 2-month study with daily exposures to copper sulfate in drinking water. Significant increases of gastrointestinal symptoms were observed in the 0.091 mg Cu/kg-day group when compared to other study groups.

The Captain Jack AI was the only area under investigation, which exceeded the NOAEL value for copper ingestion. All other AIs are considered no apparent public health hazard in regards to ingestion of copper from contaminated soils. The estimated exposure dose for child residents in the Captain Jack AI is 0.15 mg Cu/kg-day. This dose exceeds the acute and intermediate duration LOAELs of 0.0731 mg/kg-day and 0.091 mg/kg-day, respectively. Adverse health effects, such as nausea and vomiting, are likely to occur under the assumptions made for this consultation.

Lead

Health effects of lead are well known from studies of children. Lead affects virtually every organ and system in the body and exhibits a broad range of health effects. The most sensitive among these are the central nervous system, hematological, and cardiovascular systems, and the kidney. Blood lead levels as low as 10 ug/dL that do not cause distinct symptoms are associated with decreased intelligence and impaired neurobehavioral development (CDC, 1991). Blood lead levels of 10 ug/dL or greater are considered elevated, but there is no demonstrated safe level of lead in blood.

Please see Appendix F for details on lead exposure, health effects, and health assessment using the EPA recommended predictive modeling, in accordance with the ATSDR and CDPHE guidelines. Overall, exposures to lead for residential young children and outdoor adults (e.g., pregnant workers) constitutes a public health hazard for 4 out of 5 AIs, under the EPA default assumptions used in the model. Lead poses no apparent public health hazard in the Big Five AI. The Integrated Exposure Uptake Biokinetic (IEUBK) model predicts elevated blood lead levels (above 10 ug/dL) in 88 to 99 % of young children. The Adult Lead Model (ALM) predicts the probability that fetal blood lead will exceed target blood lead level of 10 ug/dL ranges from 15 to 83%. The uncertainties associated with the predictive lead modeling and the relative bioavailability of lead are discussed in Appendix F.

Evaluation of acute and subchronic exposure/health hazard to surface soil for young children (0-6 years)

As discussed in Appendix G, the levels (maximum and/or the 95^{th} percentile UCL) of aluminum, arsenic, copper, vanadium, or zinc are significantly above the acute and intermediate comparison value for pica children. Therefore, more realistic acute and subchronic exposures/hazards based on the soil ingestion rate of 400 mg/day were estimated.

Estimated acute and subchronic noncancer health hazards from exposure of residential and recreational children to arsenic and copper in surface soils are shown in Tables G2 and G3 of Appendix G. These data demonstrate that the maximum acute and subchronic health hazards are possible in the Captain Jack Mill (CJM) area of investigation because the estimated exposure dose exceeds LOAELs for both arsenic and copper.

The ATSDR (2005) and EPA-NCEA (2000) acute duration and subchronic duration LOAELs for arsenic are 0.05 mg/kg-day. When this dose is exceeded, gastrointestinal effects such as nausea, vomiting, diarrhea, and blood in stool, are likely. It should be noted that serious neurological and cardiovascular effects also occurred at the same dose (ATSDR, 2005). The ATSDR (2004) intermediate NOAELs and LOAELs for copper and the associated adverse health effects have already been discussed under surface soil COCs because no chronic NOAELs and LOAELs are available for copper.

No potential acute and subchronic health hazards are expected at the Big Five (BFV) area of investigation. It is, however, important to note that acute and subchronic health hazards enter a range of concern with HQs ranging from 1.0 to 31.0 at the other three areas of investigation, Big Five Captain Jack (BFC), White Raven (WHR), and White Raven to Sawmill (WRS). Finally, as discussed earlier for chronic arsenic risks, there is uncertainty associated with acute and sub-chronic health hazards for arsenic and copper due to the reduced relative bioavailability of metals from soils.

Cumulative Exposures and Health Hazards

A qualitative assessment and discussion of combined exposures to multiple contaminants in surface soils is given in Appendix H. Overall, there is insufficient information to consider all the possible interactions that may occur from multiple chemical exposures at this site. Therefore, health hazards from hypothetical multiple chemical interactions are not evaluated quantitatively and evaluated qualitatively using the ATSDR indicator chemical approach. In this approach, the most toxic known chemical from the mixture (i.e., lead) is selected as an indicator (or marker) chemical for the mixture, assuming that the indicator chemical lead is driving the exposure and hazard at this site and further assessment of the mixture is not necessary.

Comparison with Background Exposures to Surface Soils

Since many of the contaminants of concern are also normally found in the environment, it is important to compare the hazards and theoretical cancer risk from site-specific data with background. The screening level evaluation is briefly discussed in Appendix I. Overall, the estimated site-specific potential health hazards and theoretical cancer risk are attributed to site-specific sources, based on the residential exposure scenario evaluation.

Child Health Considerations

In communities faced with air, water, or food contamination, the many physical differences between children and adults demand special emphasis. Children could be at greater risk than are adults from certain kinds of exposure to hazardous substances. Children play outdoors and sometimes engage in hand-to-mouth behaviors that increase their exposure potential. Children are shorter than are adults; this means they breathe dust, soil, and vapors close to the ground. A child’s lower body weight and higher intake rate results in a greater dose of hazardous substance per unit of body weight. If toxic exposure levels are high enough during critical growth stages, the developing body systems of children can sustain permanent damage. Finally, children are dependent on adults for access to housing, for access to medical care, and for risk identification. Thus adults need as much information as possible to make informed decisions regarding their children’s health.

Young children and fetuses are the most sensitive population considered in this health consultation. The results of this assessment demonstrate that some of the site contaminants (e.g., lead, arsenic, and copper) in certain AIs (especially the CJM) pose a public health hazard to young children and fetuses (through exposure of pregnant women). Fetal and child exposure to lead can cause permanent damage during critical growth stages.

Conclusions

Overall, based on the evaluation of ingestion of surface soils and groundwater by residential children and adults, recreational children and adults, and construction workers, it is concluded that some contaminants, especially, lead, arsenic, or copper, constitute a *public health hazard* at 4 out of 5 AIs because exposure doses exceed the identified NOAELs and/or LOAEL, and/or the acceptable level of theoretical cancer risks for arsenic in surface soils. Specific conclusions are briefly noted below:

- There is *no apparent public health hazard* at the Big Five AI (BFV) from exposure to surface soils through the ingestion pathway.
- Exposure to lead in surface soils constitutes a *public health hazard* at the BFC, CJM, WHR, and WHS AIs based on the EPA predictive modeling for young children and pregnant outdoor workers.
- Acute, subchronic, and chronic exposures through ingestion of arsenic and copper in surface soils by residential children at the Captain Jack Mill AI (CJM) poses a *public health hazard*. These conclusions are, however, associated with some uncertainty because of the likelihood of reduced bioavailability of metals from soils.
- Chronic exposure through ingestion of arsenic in surface soils by all adult receptors at the Captain Jack Mill AI (CJM) poses a *public health hazard*. These conclusions are, however, associated with some uncertainty due to the reduced relative bioavailability of metals from soils.
- Ingestion of groundwater by area child and adult residents poses a *public health hazard* for manganese and zinc. However, these conclusions are associated with some uncertainty due to the availability of limited groundwater data and the lack of an identified LOAEL for manganese.

Recommendations

Based upon the data and information reviewed, CDPHE has made the following recommendations:

- CDPHE and EPA should progress with the proposed remedial actions.
- In the interim, reduce or eliminate children's exposure to contaminated surface soils by using appropriate reduction methods: restricting access to highly contaminated areas by fencing; reducing or eliminating soil intrusive activities; washing hands and face prior to eating or drinking; and cleaning shoes to reduce the amount of soil being tracked into the house.
- Appropriate measures for worker protection activities and worker safety procedures should be implemented to prevent workers from exposures to site-related contaminants in

surface soil, especially during any on-site activities that involve disturbing soil at the CJM.

- To reduce the magnitude of uncertainty associated with the estimated exposure doses and health hazards, perform additional groundwater sampling, and better characterize the relative bioavailability of arsenic and lead from the site-specific surface soils.

Public Health Action Plan

The Public Health Action Plan describes the actions that are necessary to reduce exposure to site-related contaminants and how these actions can be executed. Overall, the health consultation supports the remedial actions proposed by the CDPHE and EPA risk managers to reduce or eliminate the contaminants in surface/subsurface soils and groundwater. EES will work in conjunction with CPDHE and EPA risk managers to carry out the Public Health Action Plan as described below.

Past and Ongoing Activities:

- CDPHE and the EPA should continue working to secure mine openings, sink holes, and pits to reduce access to physical hazards found on-site.
- The EES will continue the review of environmental data that was collected during the Remedial Investigation to determine additional pathways of potential concern. This includes an examination of the surface water and biotic consumption pathways.

Future Activities:

- CDPHE and EPA environmental risk managers should execute institutional controls to reduce exposure to contaminants in groundwater as discussed in the feasibility study (Walsh 2006). This includes continued groundwater monitoring and providing an alternative water source as deemed necessary and appropriate.
- The EES will work to define the actual exposure conditions of the groundwater ingestion pathway and will review the additional groundwater monitoring data as it becomes available to determine the appropriate actions to protect public health.
- The EES will install signs to warn visitors and residents of potential public health hazards in areas of highly contaminated surface soils.
- The EES will conduct the appropriate health education activities including the presentation of the findings of this document in a public meeting, distributing the document to the information repositories, and the production of fact sheets and verbal communication to relay this information to the public.
- The CDPHE and EPA will continue to investigate the appropriate methods of remedial action at the CJM site and, once established, will implement activities to reduce exposure to site population, visitors, and construction workers.

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APPENDICES

Appendix A. ATSDR Plain Language Glossary of Environmental Health Terms

Absorption: How a chemical enters a person's blood after the chemical has been swallowed, has come into contact with the skin, or has been breathed in.

Acute Exposure: Contact with a chemical that happens once or only for a limited period of time. ATSDR defines acute exposures as those that might last up to 14 days.

Additive Effect: A response to a chemical mixture, or combination of substances, that might be expected if the known effects of individual chemicals, seen at specific doses, were added together.

Adverse Health Effect: A change in body function or the structures of cells that can lead to disease or health problems.

Antagonistic Effect: A response to a mixture of chemicals or combination of substances that is **less** than might be expected if the known effects of individual chemicals, seen at specific doses, were added together.

ATSDR: The **A**gency for **T**oxic **S**ubstances and **D**isease **R**egistry. ATSDR is a federal health agency in Atlanta, Georgia that deals with hazardous substance and waste site issues. ATSDR gives people information about harmful chemicals in their environment and tells people how to protect themselves from coming into contact with chemicals.

Background Level: An average or expected amount of a chemical in a specific environment. Or, amounts of chemicals that occur naturally in a specific environment.

Bioavailability: See **Relative Bioavailability.**

Biota: Used in public health, things that humans would eat - including animals, fish and plants.

Cancer: A group of diseases, which occur when cells in the body become abnormal and grow, or multiply, out of control

Carcinogen: Any substance shown to cause tumors or cancer in experimental studies.

CERCLA: See **C**omprehensive **E**nvironmental **R**esponse, **C**ompensation, and **L**iability **A**ct.

Chronic Exposure: A contact with a substance or chemical that happens over a long period of time. ATSDR considers exposures of more than one year to be *chronic*.

Completed Exposure Pathway: See **Exposure Pathway**.

Comparison Value (CVs): Concentrations or the amount of substances in air, water, food, and soil that are unlikely, upon exposure, to cause adverse health effects. Comparison values are used by health assessors to select which substances and environmental media (air, water, food and soil) need additional evaluation while health concerns or effects are investigated.

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA): **CERCLA** was put into place in 1980. It is also known as **Superfund**. This act concerns releases of hazardous substances into the environment, and the cleanup of these substances and hazardous waste sites. ATSDR was created by this act and is responsible for looking into the health issues related to hazardous waste sites.

Concern: A belief or worry that chemicals in the environment might cause harm to people.

Concentration: How much or the amount of a substance present in a certain amount of soil, water, air, or food.

Contaminant: See **Environmental Contaminant**.

Delayed Health Effect: A disease or injury that happens as a result of exposures that may have occurred far in the past.

Dermal Contact: A chemical getting onto your skin. (see **Route of Exposure**).

Dose: The amount of a substance to which a person may be exposed, usually on a daily basis. Dose is often explained as "amount of substance(s) per body weight per day".

Dose / Response: The relationship between the amount of exposure (dose) and the change in body function or health that result.

Duration: The amount of time (days, months, years) that a person is exposed to a chemical.

Environmental Contaminant: A substance (chemical) that gets into a system (person, animal, or the environment) in amounts higher than that found in **Background Level**, or what would be expected.

Environmental Media: Usually refers to the air, water, and soil in which chemical of interest are found. Sometimes refers to the plants and animals that are eaten by humans. **Environmental Media** is the second part of an **Exposure Pathway**.

U.S. Environmental Protection Agency (EPA): The federal agency that develops and enforces environmental laws to protect the environment and the public's health.

Exposure: Coming into contact with a chemical substance.(For the three ways people can come in contact with substances, see **Route of Exposure**.)

Exposure Assessment: The process of finding the ways people come in contact with chemicals, how often and how long they come in contact with chemicals, and the amounts of chemicals with which they come in contact.

Exposure Pathway: A description of the way that a chemical moves from its source (where it began) to where and how people can come into contact with (or get exposed to) the chemical.

ATSDR defines an exposure pathway as having 5 parts:

- Source of Contamination,
- Environmental Media and Transport Mechanism,
- Point of Exposure,
- Route of Exposure; and,
- Receptor Population.

When all 5 parts of an exposure pathway are present, it is called a **Completed Exposure Pathway**. Each of these 5 terms is defined in this Glossary.

Frequency: How often a person is exposed to a chemical over time; for example, every day, once a week, and twice a month.

Hazardous Waste: Substances that have been released or thrown away into the environment and, under certain conditions, could be harmful to people who come into contact with them.

Health Effect: ATSDR deals only with **Adverse Health Effects** (see definition in this Glossary).

Indeterminate Public Health Hazard: The category is used in Public Health Assessment documents for sites where important information is lacking (missing or has not yet been gathered) about site-related chemical exposures.

Ingestion: Swallowing something, as in eating or drinking. It is a way a chemical can enter your body (See **Route of Exposure**).

Inhalation: Breathing. It is a way a chemical can enter your body (See **Route of Exposure**).

LOAEL: **L**owest **O**bserved **A**dverse **E**ffect **L**evel. The lowest dose of a chemical in a study, or group of studies, that has caused harmful health effects in people or animals.

MRL: **M**inimal **R**isk **L**evel. An estimate of daily human exposure - by a specified route and length of time -- to a dose of chemical that is likely to be without a measurable risk of adverse, noncancerous effects. An MRL should not be used as a predictor of adverse health effects.

NPL: The **N**ational **P**riorities **L**ist. (Which is part of **Superfund**.) A list kept by the U.S. Environmental Protection Agency (EPA) of the most serious, uncontrolled or abandoned hazardous waste sites in the country. An NPL site needs to be cleaned up or is being looked at to see if people can be exposed to chemicals from the site.

NOAEL: **N**o **O**bserved **A**dverse **E**ffect **L**evel. The highest dose of a chemical in a study, or group of studies, that did not cause harmful health effects in people or animals.

No Apparent Public Health Hazard: The category is used in ATSDR's Public Health Assessment documents for sites where exposure to site-related chemicals may have occurred in the past or is still occurring but the exposures are not at levels expected to cause adverse health effects.

No Public Health Hazard: The category is used in ATSDR's Public Health Assessment documents for sites where there is evidence of an absence of exposure to site-related chemicals.

PHA: **P**ublic **H**ealth **A**ssessment. A report or document that looks at chemicals at a hazardous waste site and tells if people could be harmed from coming into contact with those chemicals. The PHA also tells if possible further public health actions are needed.

Point of Exposure: The place where someone can come into contact with a contaminated environmental medium (air, water, food or soil). Some examples include: the area of a playground that has contaminated dirt, a contaminated spring used for drinking water, the location where fruits or vegetables are grown in contaminated soil, or the backyard area where someone might breathe contaminated air.

Population: A group of people living in a certain area; or the number of people in a certain area.

Public Health Assessment(s): See **PHA**.

Public Health Hazard: The category is used in PHAs for sites that have certain physical features or evidence of chronic, site-related chemical exposure that could result in adverse health effects.

Public Health Hazard Criteria: PHA categories given to a site which tell whether people could be harmed by conditions present at the site. Each is defined in the Glossary. The categories are:

- Urgent Public Health Hazard
- Public Health Hazard
- Indeterminate Public Health Hazard
- No Apparent Public Health Hazard
- No Public Health Hazard

Receptor Population: People who live or work in the path of one or more chemicals, and who could come into contact with them (See **Exposure Pathway**).

Reference Dose (RfD): An estimate, with safety factors (see **safety factor**) built in, of the daily, life-time exposure of human populations to a possible hazard that is <u>not</u> likely to cause harm to the person.

Relative Bioavailability: The amount of a compound that can be absorbed from a particular medium (such as soil) compared to the amount absorbed from a reference material (such as water). Expressed in percentage form.

Route of Exposure: The way a chemical can get into a person's body. There are three exposure routes:

- breathing (also called inhalation),
- eating or drinking (also called ingestion), and/or
- getting something on the skin (also called dermal contact).

Safety Factor: Also called **Uncertainty Factor**. When scientists don't have enough information to decide if an exposure will cause harm to people, they use "safety factors" and formulas in place of the information that is not known. These factors and formulas can help determine the amount of a chemical that is not likely to cause harm to people.

SARA: The **S**uperfund **A**mendments and **R**eauthorization **A**ct in 1986 amended CERCLA and expanded the health-related responsibilities of ATSDR. CERCLA and SARA direct ATSDR to look into the health effects from chemical exposures at hazardous waste sites.

Sample: A small number of people chosen from a larger population (See **Population**).

Source (of Contamination): The place where a chemical comes from, such as a landfill, pond, creek, incinerator, tank, or drum. Contaminant source is the first part of an **Exposure Pathway**.

Special Populations: People who may be more sensitive to chemical exposures because of certain factors such as age, a disease they already have, occupation, sex, or certain behaviors (like cigarette smoking). Children, pregnant women, and older people are often considered special populations.

Statistics: A branch of the math process of collecting, looking at, and summarizing data or information.

Superfund Site: See **NPL**.

Survey: A way to collect information or data from a group of people (**population**). Surveys can be done by phone, mail, or in person. ATSDR cannot do surveys of more than nine people without approval from the U.S. Department of Health and Human Services.

Synergistic effect: A health effect from an exposure to more than one chemical, where one of the chemicals worsens the effect of another chemical. The combined effect of the chemicals acting together is greater than the effects of the chemicals acting by themselves.

Toxic: Harmful. Any substance or chemical can be toxic at a certain dose (amount). The dose is what determines the potential harm of a chemical and whether it would cause someone to get sick.

Toxicology: The study of the harmful effects of chemicals on humans or animals.

Tumor: Abnormal growth of tissue or cells that have formed a lump or mass.

Uncertainty Factor: See **Safety Factor**.

Urgent Public Health Hazard: This category is used in ATSDR's Public Health Assessment documents for sites that have certain physical features or evidence of short-term (less than 1 year), site-related chemical exposure that could result in adverse health effects and require quick intervention to stop people from being exposed.

Appendix B. Additional Information on Demographics and Community Health Concerns

Demographics

The population surrounding the CJM Superfund site can be divided into three distinct communities of California Gulch Road, Ward, and Rowena/Jamestown. In relation to these communities, the site is located on California Gulch Road with the town of Ward to the north (~1.5 mi.). Rowena and Jamestown are separate communities, which both share a Jamestown mailing address. They are located roughly 7.5 miles (straight line distance) from the CJM site. Rowena is located downstream and east of the site on Lefthand Creek. Jamestown is located east-northeast of the CJM site near the confluence of the James and Little James Creeks (See Figure 2). The largest proximal city, Boulder, Colorado, lies approximately 14 miles to the east-southeast of the site. A demographic overview of the communities located near the CJM site is provided below.

1. California Gulch Road

A small community lives on the CJM Superfund site. No specific demographic information is available from the U.S Census Bureau on the site population. Therefore, all of the demographic information described in this section is derived from the background documents and site visits conducted in 2003 and 2005. It appears there are approximately 24 people living on the three branches of California Gulch. This number fluctuates seasonally, with a slight increase in population during the warmer months of the year. No specific information on the average age of residents or the number of children living on-site is available. The majority of the population living in the California Gulch area resides in temporary structures such as buses, campers, and abandoned mine/mill buildings. It appears that these residents typically reside on-site for only a few years. Two permanent housing units are also located on-site. One of the houses has been unoccupied for the past few years, but there have been reports that it was recently purchased. The new owners of this property are unknown at this time.

2. Town of Ward

The CJM site is located 1 ½ miles south of the town of Ward, Colorado. Due to the close proximity of the site to the town of Ward, residents frequently visit the area for recreation. The town of Ward's water supply does not appear to be affected by contamination from the site, as their source of water is collected from 3 springs located approximately 5 miles west of the town and up gradient of the Captain Jack site. However, the proximity of the town to the site and the fact that residents commonly frequent the area makes Ward significant in terms of the public health implications from the CJM site. The recreational pathway appears to be the most significant pathway for Ward residents.

Ward has a population of 169 individuals according to Census 2000 statistics. There are approximately equal numbers of males (50.9%) and females (49.1%) with a median age of 34.7 years. Approximately 12% of the total population is under the age of 10 years with only 4 individuals over the age of 60. The population is largely white (98.8%) and English speaking (US Census 2000).

3. Rowena/Jamestown

Rowena and Jamestown Colorado are small mountain communities that are located approximately 7.5 miles to the east-northeast of the CJM site. The two communities have a combined population of approximately 205 individuals and almost equal numbers of males and females. The median age is 38.8 years with 18 children under the age of 10 years and 12 people over the age of 65 years. The population is largely white (97.6%) and English speaking (US Census 2000). Rowena and Jamestown residents are likely to visit the CJM site for recreational purposes. It is also possible that Rowena and Jamestown residents could be affected by surface water contamination of Lefthand Creek stemming from the CJM site and other historic mining operations within Lefthand watershed. This possibility will be discussed in a future health consultation.

Community Health Concerns

1. California Gulch Road

Individuals and families living along one of three branches of California Gulch Road will be impacted the greatest by remediation activities including dust, noise, and traffic. Residents here expressed a great deal of concern, primarily dealing with the direct impact associated with the clean-up process. Some residents were concerned that they may be moved out of the Gulch. Questions concerning contaminated dust, truck traffic, and noise also arose. They wanted the clean up to occur quickly with minimal disruption to their lifestyle. Additionally, due to a lack of interaction with government officials, these residents may be somewhat distrustful of the Superfund process and those involved.

One property owner said that the mine negatively impacted her property. The acid mine drainage from the tunnel is of great concern to her and her family. They have frequently shoveled soil in an attempt to prevent the orange-colored water from flowing into Lefthand Creek. No other residents felt they had experienced any problems on the property in which they are living. Everyone stated they want to be kept informed. The kinds of information they desire include: progress reports and timelines; what chemicals were used in the mining process, what raw minerals are leaching from the adit, and how the watershed as a whole will be addressed.

2. The Town of Ward

Ward is a small, independent mountain community, located just a mile and a half north of the site. Although it is close to the site, to date it has not been significantly impacted. If the Superfund boundaries do not extend into the town limits, the impact to Ward will be primarily from the construction and traffic affiliated with a remedial action effort, and possibly, from any stigma attached to being located near a Superfund site.

Residents in the town of Ward, have many issues and concerns. They would like to see the cleanup done in an environmentally sound manner, completely finished and funded. They want to know the cleanup processes and timelines. The residents are concerned about the dust, noise and traffic that may be associated with the cleanup. They hope the historic aspects of the area, including the mill, will be valued. Ward residents also worry that there may be a lack of true community input in the decisions EPA and the state make concerning the cleanup.

3. Rowena/Jamestown

A third sub-community, also located within the Lefthand Watershed, includes Rowena, located in unincorporated Boulder County (shares Jamestown mailing address) and the town of Jamestown. This community is highly interested in the Superfund process and greatly influenced by its outcome. Many of the homes, including all homes along the Lefthand Creek corridor (Rowena) have private drinking water wells. The town of Jamestown, however, is served by a municipal surface water treatment and distribution system that derives its water from James Creek.

The residents of Rowena and Jamestown are concerned that the cleanup be completed cost effectively and in a timely manner. They worry that Superfund dollars may dry up before the cleanup is complete, or that additional contaminants could be released downstream during the cleanup process. Residents are concerned about the watershed as a whole and want all agencies and funding sources to work together to address the problem. They want knowledgeable, experienced contractors to do the work. Finally, they are concerned about the people living in the Gulch and the equipment and truck traffic traveling to and from the site.

4. The City of Boulder

Boulder residents are concerned for the people living in the gulch. They would like the bureaucracy to be aware of community concerns and issues and work strongly and closely with all components of the various communities.

Boulder residents fear that the cleanup could release contaminants that could move downstream. They hope to see other mines in the watershed addressed as well, and they desire all factors and perimeters outside the targeted site be carefully considered.

5. Lefthand Watershed Task Force and the Community Advisory Group for the Environment (CAGE), currently Lefthand Watershed Oversight Group (LWOG)

Additionally, a review of comments from the Lefthand Watershed Task Force and the Community Advisory Group for the Environment (CAGE) were reviewed. Although they created a list of both “positive experiences” and “negative experiences”, only the negative experiences are summarized here in order to better address communication concerns (LWTF 2002).

Comments

- Residents were frustrated by the tendency of EPA and CDPHE personnel to be "vague and imprecise" when it did not appear to be necessary.
- "Contradictory" messages were sent to the community. EPA and CDPHE personnel have contradicted each other.
- The EPA and CDPHE have "created confusion about the immediate health risks". They have created the public perception for many that there *is* an immediate health risk. However, when asked directly, they say that there is not an immediate health risk and there is no data that indicates there is a risk.

Appendix C. Additional Information on Exposure Assessment

Figure C1. Groundwater Sampling Locations

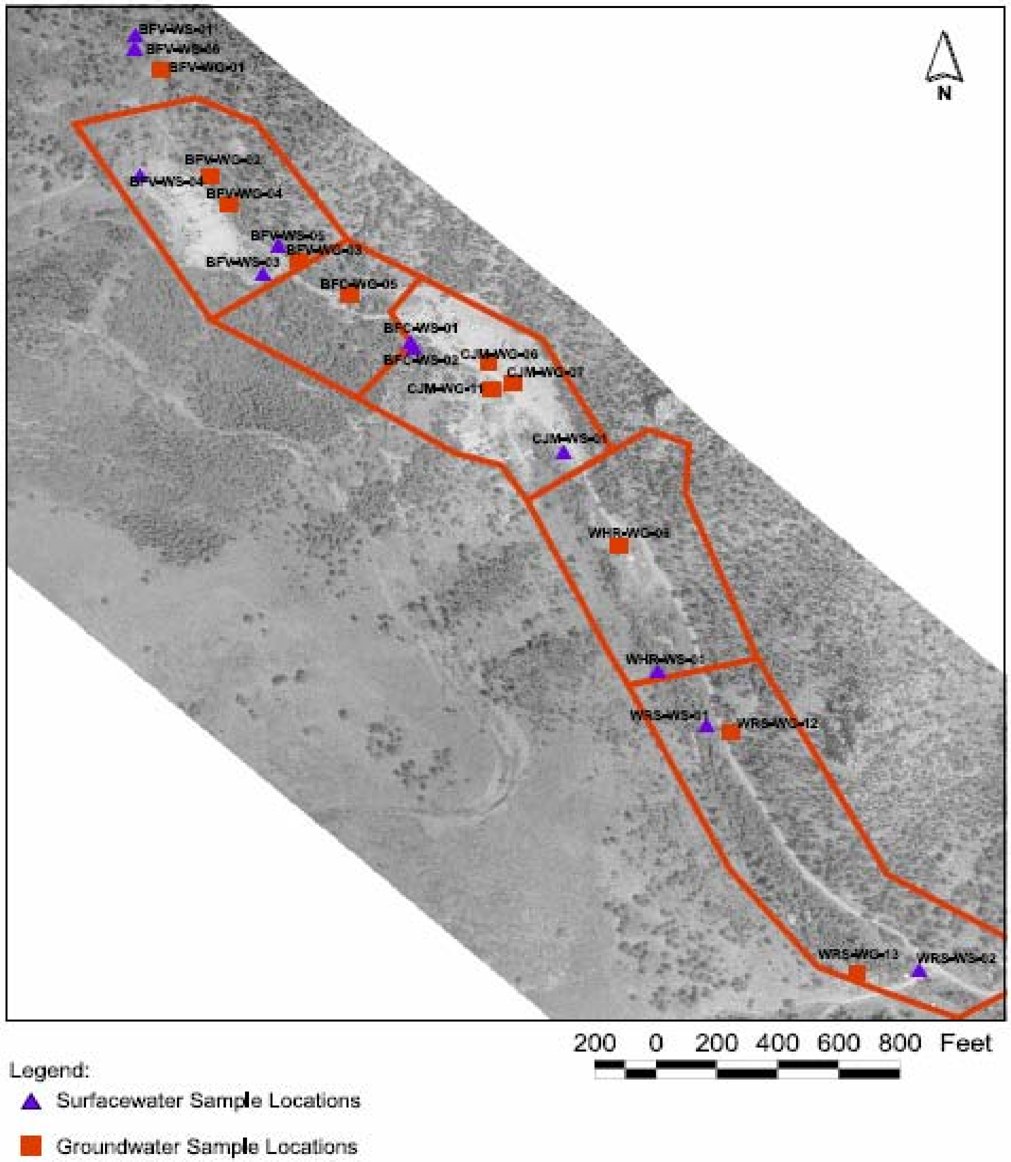

Figure 4-11
Surfacewater and Groundwater Sample Locations
Captain Jack Mill Superfund Site

Walsh

Figure C2. Surface Soil Sampling Locations (Big Five AI)

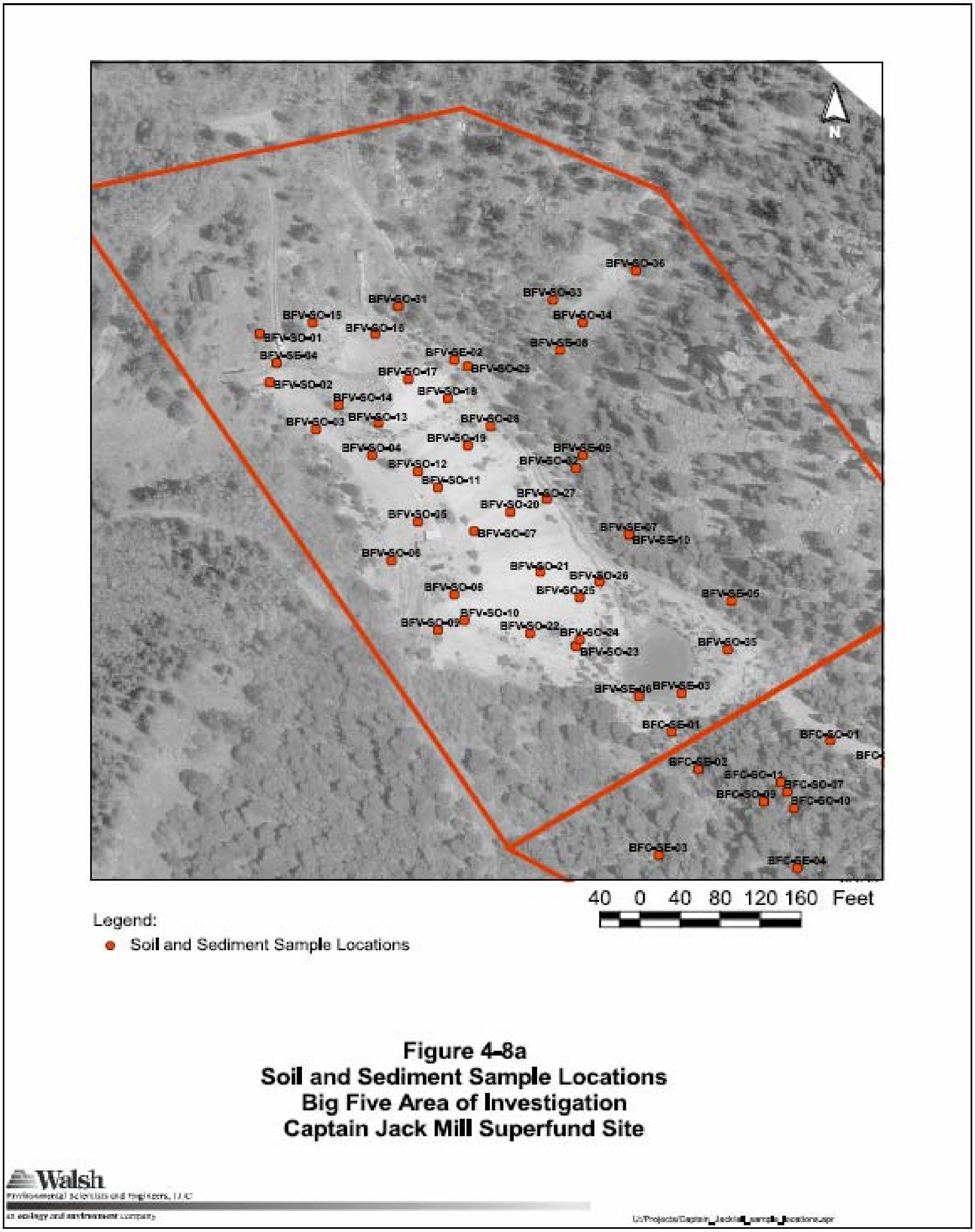

Figure C3. Soil Sampling Locations (Big Five to Capt. Jack AI)

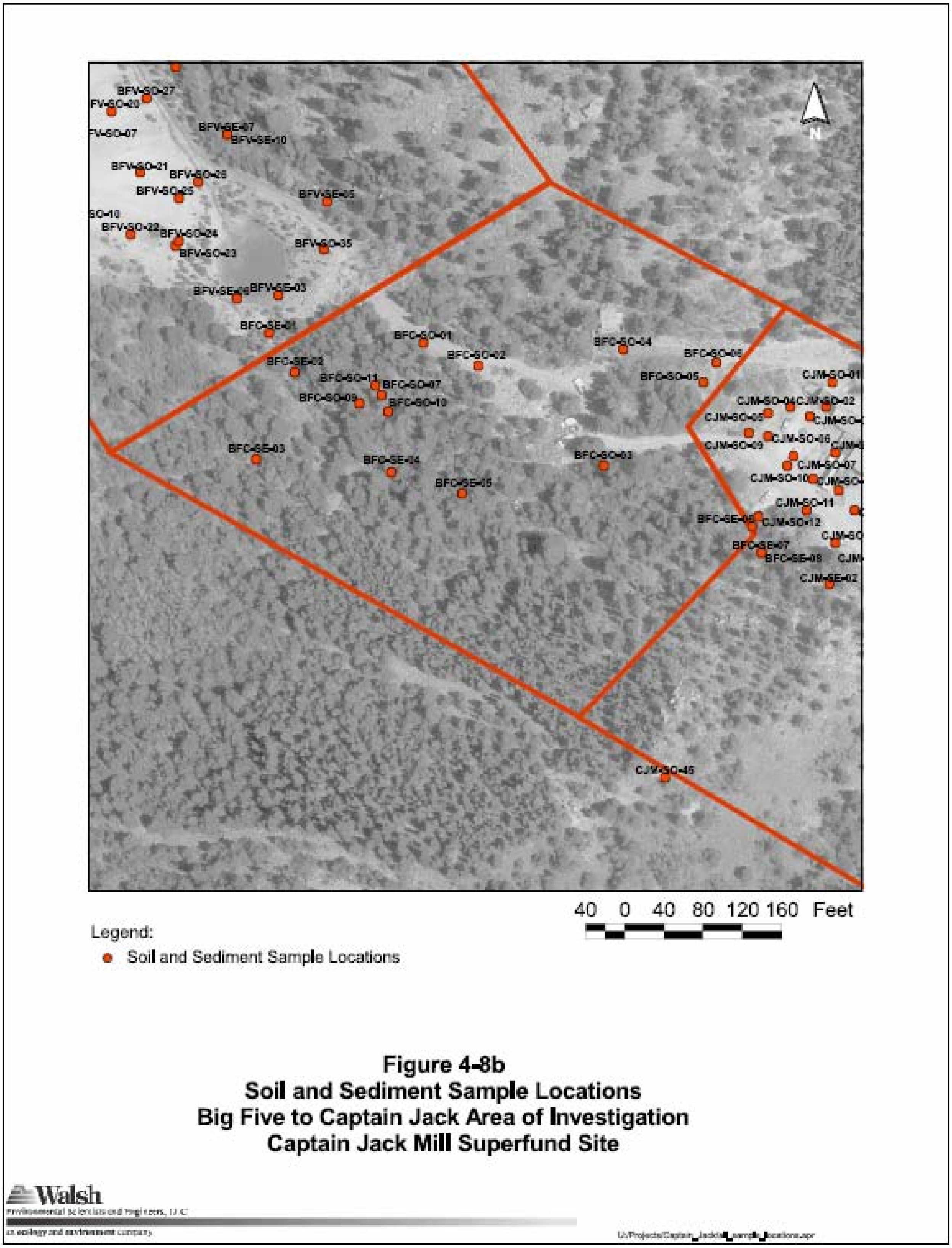

Figure C4. Soil Sampling Locations (Capt. Jack AI)

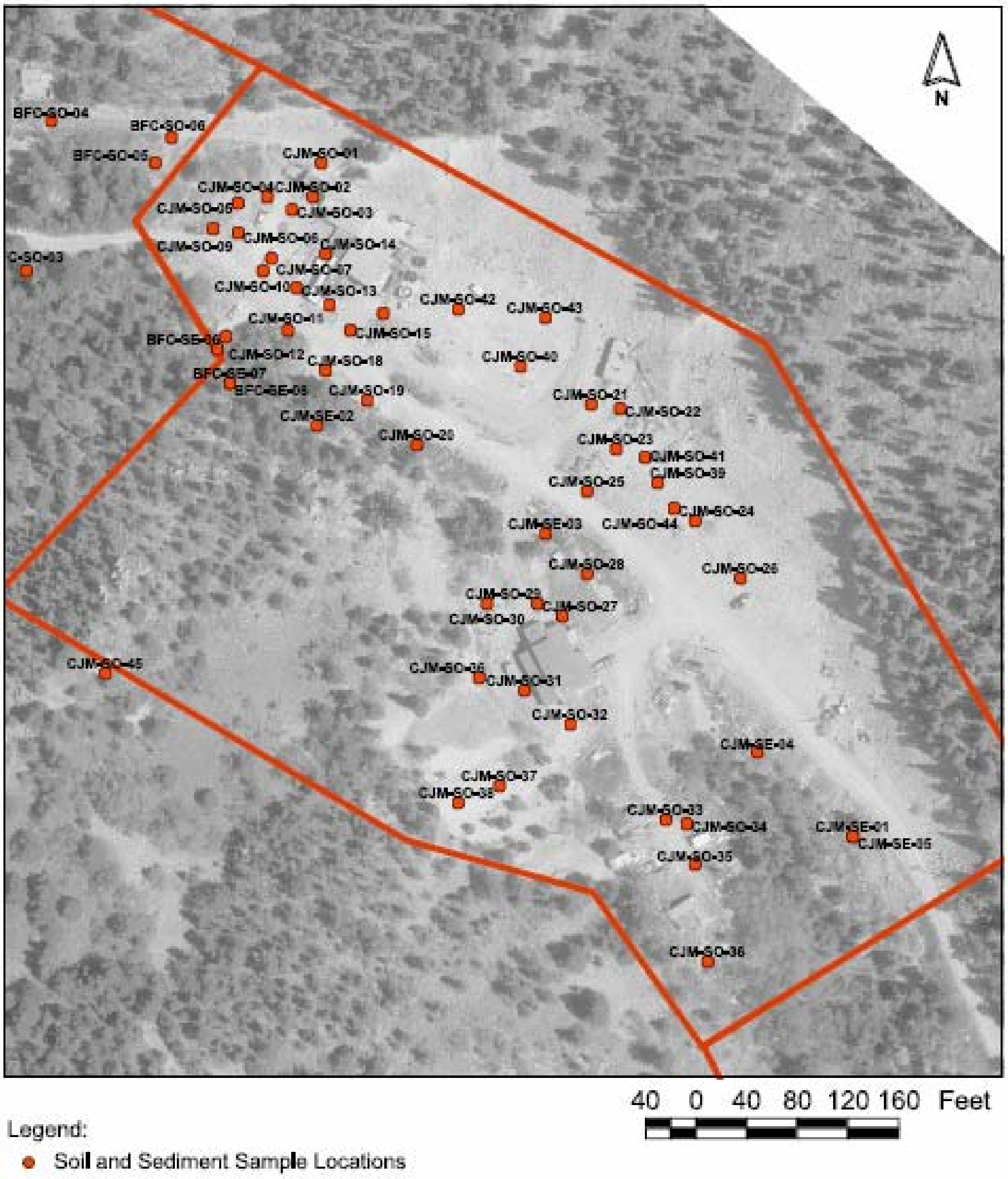

Figure 4-8c
Soil and Sediment Sample Locations
Captain Jack Mill Area of Investigation
Captain Jack Mill Superfund Site

Walsh
Environmental Scientists and Engineers, LLC
an ecology and environment company

Figure C5. Soil Sampling Locations (White Raven AI)

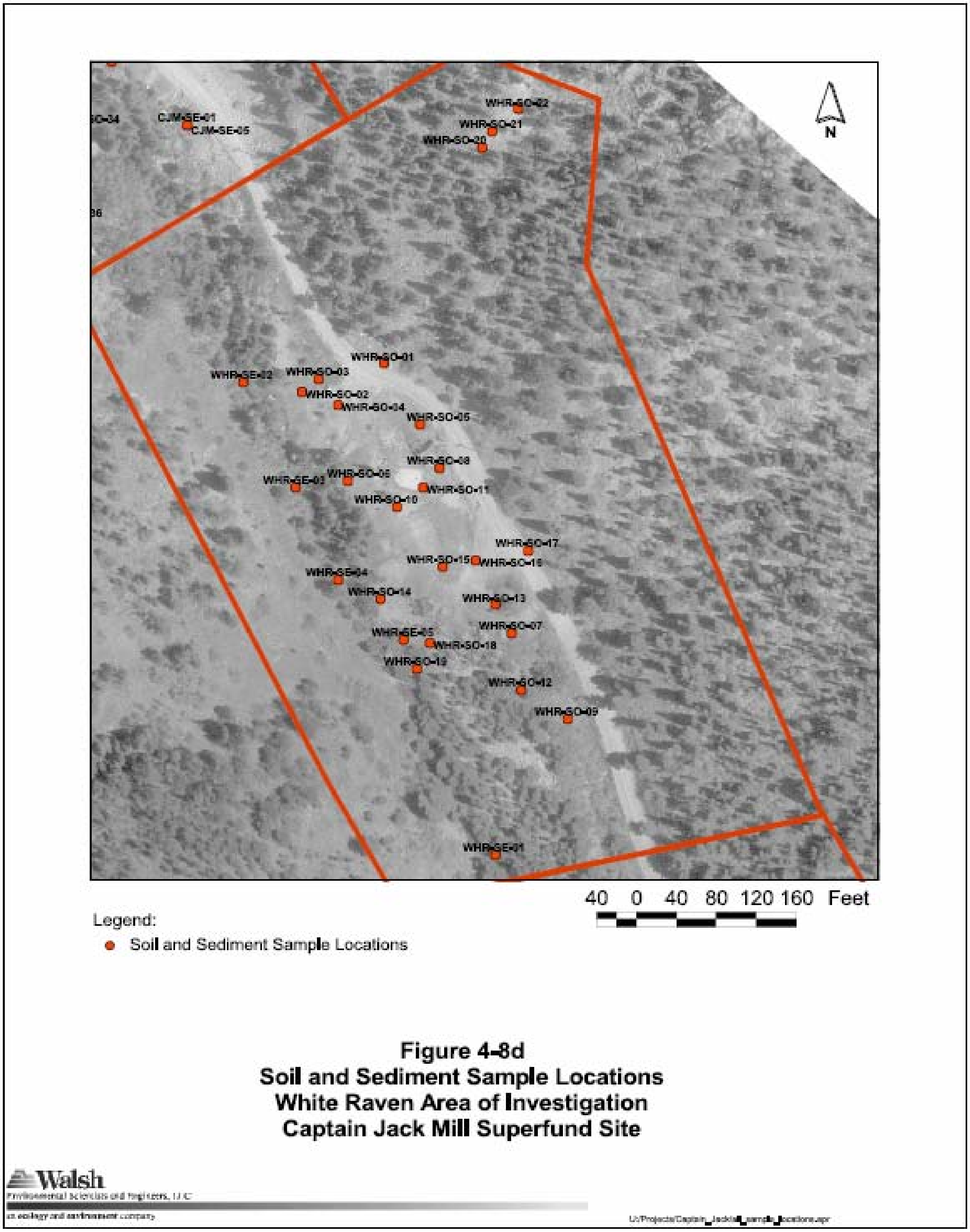

Figure 4-8d
Soil and Sediment Sample Locations
White Raven Area of Investigation
Captain Jack Mill Superfund Site

Figure C6. Soil Sampling Locations (White Raven to Sawmill Rd. AI)

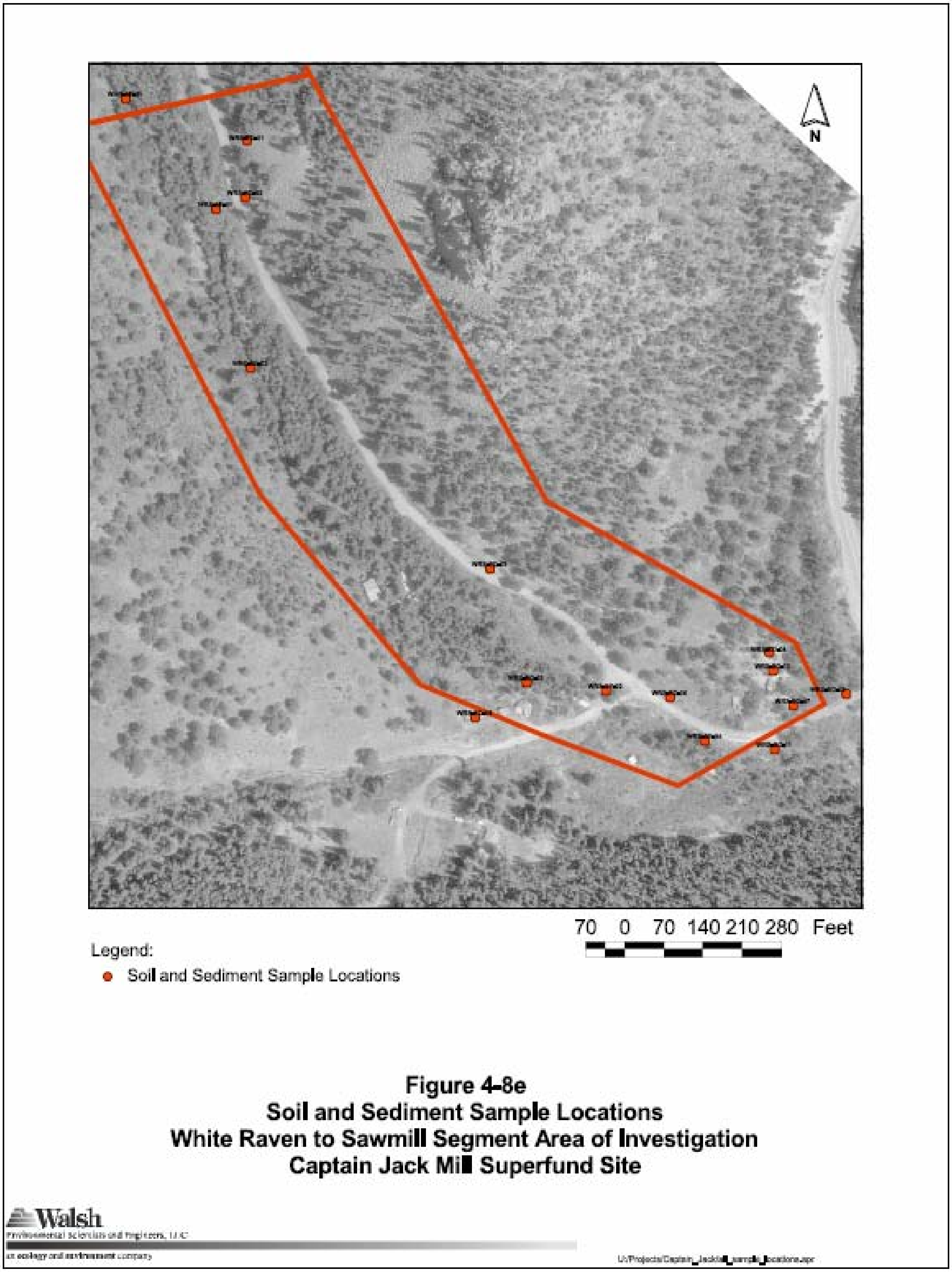

Table C1. Groundwater Summary Statistics

Contaminant	Minimum (μg/L)	Maximum (μg/L)	Mean (μg/L)
Aluminum	14.2	1,590	269.9
Antimony	12.5*	12.5*	12.5**
Arsenic	2.5*	2.5*	2.5**
Barium	15.2	94.1	39.6
Beryllium	1.4	2.5*	2.4**
Boron	21.4	1,480	290.6
Cadmium	0.28	39.9	5.9
Calcium	7,410	38,300	17,681
Chromium	5*	5*	5**
Copper	4.7	518	74.6
Cyanide	2.3	5*	4.73**
Iron	50.9	125	109.3
Lead	0.4	8.3	1.5
Magnesium	2,250	17,100	7,318
Manganese	7.0	4,110	1,063.9
Mercury	0.15*	0.15*	0.15**
Nickel	4.3	79	17.5
Potassium	701	1,480	1,039
Selenium	1.1	2.5*	2.2**
Silver	0.5*	0.5*	0.5**
Sodium	3,450	8,790	5,111
Thallium	0.25*	0.25*	0.25**
Zinc	17	23,400	3,810

* Value is equivalent to ½ the reporting limit of the analytical method
** Value is driven by ½ the reporting limit of the analytical method

Table C2. Surface Soil Summary Statistics

Contaminant	Big Five (mg/kg)			Big Five to Captain Jack (mg/kg)			Captain Jack (mg/kg)			White Raven (mg/kg)			White Raven to Sawmill Rd. (mg/kg)		
	Mean	Max.	Min.	Mean	Max.	Min.	Mean	Max.	Min.	Mean	Max.	Min.	Mean	Max.	Min.
Aluminum	2,898	10,900	1,240	5,714	13,100	1,580	4279	12,100	461	3,656	8,820	676	5,300	9,310	2,790
Antimony	3.9	11.2	0.86	22.5	109	1.8	181.4	5,570	0.88	5.3	19.8	0.88	4.6*	6*	0.91
Arsenic	16.1	98.4	0.46	202	1130	4.4	563	10,800	3.4	26.0	91.4	2.9	14.4	84.5	2.5
Barium	153	586	22.4	419	1200	101	205	567	32.6	786	2,360	76.1	293	686	72.7
Beryllium	0.28	1.1	0.07	0.42	0.8	0.22	0.35	0.86	0.09	0.55	1.2	0.1	0.61	1.3	0.35
Cadmium	0.64	2.9	0.03	8.94	65.6	0.27	20.1	241	0.25	5.2	17.5	0.13	0.79	4.1	0.04
Calcium	1,867	17,700	49	1,302	2,870	505	2,372	66,800	51.3	5,807	62,600	46.8	5,797	25,300	608
Chromium	4	28.6	0.42	20.9	148	1.8	9.4	25.9	0.1	8.2	16.8	0.26	8.1	15	1.9
Cobalt	3.4	23.2	0.11	6.2	31	0.75	5.3	24.3	0.35	6.3	19.5	0.4	6.6	10.7	2.3
Copper	188	1,310	1.4	592	2,720	17.7	1,525	24,500	29.4	395	2,610	23	217	643	14.3
Iron	32,993	94,300	6,360	33,373	92,500	11,900	32,758	174,000	9,210	28,756	45,600	6,970	22,187	34,100	12,300
Lead	299	1,380	18.1	1,909	9,840	45.3	7,825	177,000	83.5	4848	14,000	338	479	2,530	14
Magnesium	1,406	13,400	115	1,381	3,820	267	1385	5,160	35	1521	3,170	105	2061	3,960	757
Manganese	311	2,850	11	567	1,780	51.4	734	3,720	13.1	4,763	14,500	34.8	493	820	129
Mercury	0.37	1.1	0.05	0.3	1.2	0.05	2.0	30.2	0.07	0.91	5.4	0.05	1.4	9.5	0.03
Nickel	4.3	25.3	0.26	8.5	33	1.8	9.5	53.4	0.3	8.1	17.8	0.32	8.9	19.6	4
Potassium	1,911	3,400	1,110	2,078	3,890	1,310	2,165	6520	876	1,908	3,300	686	2,123	2,550	1,410
Selenium		5.8	0.55	3.3	5.1	1.3	3.7	19.9	0.88		3.5	1.4	3.2*	3.5*	1.4
Silver	5.1	63.7	0.26	11.1	52.9	0.5	47.1	699	0.84	92.3	544	3.8	6.0	20.6	0.59
Sodium		500	22.4	442	1,820	77.1	10,668	180,000	17.3		500	17.6	95.3	158	47.5
Thallium	1.7	6.3	0.64	2.4	5.6	0.66	3.2	9.2	0.6	10.2	27.2	0.6	1.6	2.4	0.49
Vanadium	7.5	30.5	1	15.6	35.9	2.6	12.5	23.8	0.74	11.0	43.4	1.2	15.7	33.4	7.1
Zinc	154.3	683	12	1,937	15,000	14.8	4,260	56,800	96.6	958	3,010	102	178	720	44.4

Area of Investigation

Table C3. Groundwater COPC Selection

Contaminant	Maximum Value (µg/L)	CV (µg/L)	Notes
Aluminum	1590	3600	
Antimony	12.5*	1.5	
Arsenic	2.5*	0.045	
Barium	94.1	260	
Beryllium	2.5*	7.3	
Boron	1480	730	
Cadmium	39.9	1.8	
Calcium	38300	N/A	
Chromium	5*	11	
Copper	518	150	
Cyanide	5*	73	
Iron	125	1100	
Lead	8.34	N/A	
Magnesium	17100	N/A	
Manganese	4110	88	
Mercury	0.15*	1.1	
Nickel	79	73	One Sample Exceeded CV
Potassium	1480	N/A	
Selenium	2.5	18	
Silver	0.5*	18	
Sodium	8790	N/A	
Thallium	0.25	0.24	All Samples ND
Zinc	23400	1100	

Values in red indicate the CV was exceeded
* Value is equivalent to ½ the reporting limit of the analytical method

Table C4. Surface Soil COPC Selection

Contaminant	Area of Investigation for surface soil									
	Big Five (mg/kg)		Big Five to Captain Jack (mg/kg)		Captain Jack (mg/kg)		White Raven (mg/kg)		White Raven to Sawmill Rd. (mg/kg)	
	Max.	CV	Max.	CV	Max.	CV	Max.	CV	Max.	CV
Aluminum	10,900	7,600	13,100	7,600	12,100	7,600	8,820	7,600	9,310	7,600
Antimony	11.2	3.1	109	3.1	5,570	3.1	19.8	3.1	6*	3.1
Arsenic	98.4	0.39	1130	0.39	10,800	0.39	91.4	0.39	84.5	0.39
Barium	586	540	1200	540	567	540	2,360	540	686	540
Beryllium	1.1	15	0.8	15	0.86	15	1.2	15	1.3	15
Cadmium	2.9	3.7	65.6	3.7	241	3.7	17.5	3.7	4.1	3.7
Calcium	17,700	N/A	2,870	N/A	66,800	N/A	62,600	N/A	25,300	N/A
Chromium	28.6	210	148	210	25.9	210	16.8	210	15	210
Cobalt	23.2	900	31	900	24.3	900	19.5	900	10.7	900
Copper	1,310	310	2,720	310	24,500	310	2,610	310	643	310
Iron	94,300	2,300	92,500	2,300	174,000	2,300	45,600	2,300	34,100	2,300
Lead	1,380	40	9,840	40	177,000	40	14,000	40	2,530	40
Magnesium	13,400	N/A	3,820	N/A	5,160	N/A	3,170	N/A	3,960	N/A
Manganese	2,850	180	1,780	180	3,720	180	14,500	180	820	180
Mercury	1.1	2.3	1.2	2.3	30.2	2.3	5.4	2.3	9.5	2.3
Nickel	25.3	160	33	160	53.4	160	17.8	160	19.6	160
Potassium	3,400	N/A	3,890	N/A	6520	N/A	3,300	N/A	2,550	N/A
Selenium	5.8	2.3	5.1	2.3	19.9	2.3	3.5	2.3	3.5*	2.3
Silver	63.7	2.3	52.9	2.3	699	2.3	544	2.3	20.6	2.3
Sodium	500	N/A	1,820	N/A	180,000	N/A	500	N/A	158	N/A
Thallium	6.3	0.52	5.6	0.52	9.2	0.52	27.2	0.52	2.4	0.52
Vanadium	30.5	7.8	35.9	7.8	23.8	7.8	43.4	7.8	33.4	7.8
Zinc	683	2,300	15,000	2,300	56,800	2,300	3,010	2,300	720	2,300

Values in red indicate CV was exceeded

* Value is equivalent to ½ the reporting limit of the analytical method

Table C5. Summary of Surface Soil COPCs by AI

Big Five (BFV)	Big Five to Captain Jack (BFC)	Captain Jack (CJM)	White Raven (WHR)	White Raven to Sawmill Rd. (WRS)
Aluminum	Aluminum	Aluminum	Aluminum	Aluminum
Antimony	Antimony	Antimony	Antimony	Antimony
Arsenic	Arsenic	Arsenic	Arsenic	Arsenic
Barium	Barium	Barium	Barium	Barium
Copper	Cadmium	Cadmium	Cadmium	Cadmium
Iron	Copper	Copper	Copper	Copper
Lead	Iron	Iron	Iron	Iron
Manganese	Lead	Lead	Lead	Lead
Selenium	Manganese	Manganese	Manganese	Manganese
Silver	Selenium	Mercury	Mercury	Mercury
Thallium	Silver	Selenium	Selenium	Selenium
Vanadium	Thallium	Silver	Silver	Silver
	Vanadium	Thallium	Thallium	Thallium
	Zinc	Vanadium	Vanadium	Vanadium
		Zinc	Zinc	

Table C6. Groundwater Exposure Point Concentrations

Groundwater	EPC (μg/L)	Test	Notes
Boron**	1350.3	97.5% Chebyshev	Non-parametric Data Distribution
Cadmium	27.82	99% Chebyshev (MVUE)	Assuming Lognormal Distribution
Copper**	394.48	97.5% Chebyshev	Non-parametric Data Distribution
Manganese**	3980.05	97.5% Chebyshev	Non-parametric Data Distribution
Zinc**	18307.34	97.5% Chebyshev	Non-parametric Data Distribution

*****Indicates ProUCL recommended value exceeded Max Value of data set***

Table C7. Surface Soil Exposure Point Concentrations

Big Five Area of Investigation (AI)	EPC (mg/kg)	Test	Notes
Aluminum*	3500.56	Modified t-test	Modification due to skewness
Antimony	4.87	Approx. Gamma	Assuming Gamma Distribution
Arsenic	29.1	H-UCL	Lognormal Data Distribution
Barium*	186.69	Approx. Gamma	Assuming Gamma Distribution
Copper	260.29	Approx. Gamma	Assuming Gamma Distribution
Iron	38719.75	Approx. Gamma	Assuming Gamma Distribution
Lead	383.3	Approx. Gamma	Assuming Gamma Distribution
Manganese	1404.66	99% Chebyshev	Non-parametric Data Distribution
Silver*	7.34	95% Chebyshev	Non-parametric Data Distribution
Thallium	2.68	Approx. Gamma	Assuming Gamma Distribution
Vanadium	9.16	95% H-UCL	Lognormal Data Distribution

Indicates only one PRG exceedance in Data Set

Big Five to Captain Jack AI	EPC (mg/kg)	Test	Notes
Aluminum	7667.79	Students t-test	Normal Distribution
Antimony**	99.59	97.5% Chebyshev	Non-parametric Data Distribution
Arsenic**	1011.71	97.5% Chebyshev	Non-parametric Data Distribution
Barium	597.77	Students t-test	Normal Distribution
Cadmium**	47.43	97.5% Chebyshev	Non-parametric Data Distribution
Copper	1437.13	Approx. Gamma	Assuming Gamma Distribution
Iron	71762.87	95% Chebyshev	Non-parametric Data Distribution
Lead**	9233.77	97.5 % Chebyshev	Non-parametric Data Distribution
Manganese	1158.85	Approx. Gamma	Assuming Gamma Distribution
Silver**	50.07	97.5% Chebyshev	Non-parametric Data Distribution
Thallium	3.1	Students t-test	Normal Distribution
Vanadium	22.53	Students t-test	Normal Distribution
Zinc	9839.27	99% Chebyshe (MVUE)	Assuming Lognormal Distribution

*****Indicates ProUCL recommended value exceeded Max Value of data set***

Captain Jack Mill AI	EPC (mg/kg)	Test	Notes
Aluminum	5044.65	Students t-test	Normal Distribution
Antimony	1948.49	99% Chebyshev	Non-parametric Data Distribution
Arsenic	4504.65	99% Chebyshev	Non-parametric Data Distribution
Barium	259.04	Approx. Gamma	Assuming Gamma Distribution
Cadmium	130.84	99% Chebyshev	Non-parametric Data Distribution
Copper	11545.6	99% Chebyshev	Non-parametric Data Distribution
Iron	55711.27	95% Chebyshev	Non-parametric Data Distribution
Lead	14467.83	95% Chebyshev (MVUE)	Assuming Lognormal Distribution
Manganese	1280.14	Approx. Gamma	Assuming Gamma Distribution
Mercury	2.67	95% H-UCL	Assuming Lognormal Distribution
Silver	121.5	95% Chebyshev (MVUE)	Assuming Lognormal Distribution
Thallium	5.51	95% Chebyshev	Non-parametric Data Distribution
Vanadium	14.26	Students t-test	Normal Distribution
Zinc	28066.26	99% Chebyshev	Non-parametric Data Distribution

White Raven AI	EPC (mg/kg)	Test	Notes
Aluminum	4396.38	Students t-test	Normal Distribution
Antimony	6.88	Approx. Gamma	Assuming Gamma Distribution
Arsenic	36.56	Approx. Gamma	Assuming Gamma Distribution
Barium	1157.12	Approx. Gamma	Assuming Gamma Distribution
Cadmium	8.26	Approx. Gamma	Assuming Gamma Distribution
Copper	600.36	Approx. Gamma	Assuming Gamma Distribution
Iron	32618.94	Students t-test	Normal Distribution
Lead	6373.03	Students t-test	Normal Distribution
Manganese	7943.82	Approx. Gamma	Assuming Gamma Distribution

Mercury	1.39	Approx. Gamma	Assuming Gamma Distribution
Silver	148.83	Approx. Gamma	Assuming Gamma Distribution
Thallium	15.6	Approx. Gamma	Assuming Gamma Distribution
Vanadium	18.09	95% H-UCL	Assuming Lognormal Distribution
Zinc	1410.7	Approx. Gamma	Assuming Gamma Distribution

Maximum Contaminant Values were used as the EPC for the White Raven to Sawmill Area of Investigation Calculations (<10 samples)

Table C8. Exposure Parameters

C	Concentration of Contaminant (Soil in mg/kg, Water in µg/L)
IR	Ingestion Rate
ED	Exposure Duration
F	Frequency of Exposure
AT	Averaging Time
EF	Exposure Factor
BW	Body Weight

Soil Ingestion:

Residential Exposures

ED child resident cancer = 30 years [age-adjusted = child (6 y)+ adult (24 y)]
ED child resident noncancer = 6 years
ED adult resident cancer = 30 years (Age-Adjusted)
ED adult resident noncancer = 30 years
F resident = 350 days/year
$AT_{non\text{-}cancer}$ child resident = 6 years
$AT_{non\text{-}cancer}$ adult resident = 30 years
AT_{cancer} (Age-Adusted) = 70 years
IR child resident = 200 mg/day
IR adult resident = 100 mg/day
IR_{adj} (Age-Adjusted) = 114.3 (mg-yr) / (kg-day)
BW child = 15 kg
BW adult = 70 kg

Recreational Exposures

ED child recreation cancer = 30 years (age-adjusted)
ED child recreation noncancer = 6 years
ED adult recreation cancer = 30 years (age-adjusted)
ED adult recreation noncancer = 30 years
F recreation = 52 days/year
$AT_{non\text{-}cancer}$ child recreation = 6 years
$AT_{non\text{-}cancer}$ adult recreation = 30 years
AT_{cancer} (Age-Adusted) = 70 years
IR child recreation = 200 mg/day
IR adult recreation = 100 mg/day
IR_{adj} (Age-Adjusted) = 114.3 (mg-yr) / (kg-day)
BW child = 15 kg
BW adult = 70 kg

Construction Exposures

F construction worker = 250 days/year
IR_w construction worker = 330 mg/day
BW_a = 70 kg
AT_{cancer} construction worker = 70 years
$AT_{noncancer}$ construction worker = 2 years
ED construction worker = 2 years

Groundwater Ingestion:

Residential Exposures

ED_c resident noncancer = 6 years
ED_a resident noncancer = 30 years
F resident = 350 days/year
IR_c resident = 1 Liter/day
IR_a resident = 2 Liters/day
BW_c = 15 kg
BW_a = 70 kg

Table C9. Exposure Dose Equations

Groundwater Ingestion:

$$\text{Dose} = (C * IR * EF) / BW$$

$$EF = (F * ED) / AT$$

Soil Ingestion:

$$\text{Non-cancer Dose} = (C * IR * EF * CF) / BW$$

$$\text{Age-Adjusted Cancer Dose} = (C * IR_{adj} * CF * EF) / 25{,}550 \text{ Days}$$

$$IR_{adj} = [(ED_c * IR_c) / BW_c] + [(ED_a * IR_a) / BW_a]$$

Appendix D: Toxicological Evaluation

The basic objective of a toxicological evaluation is to identify what adverse health effects a chemical causes, and how the appearance of these adverse effects depends on dose. In addition, the toxic effects of a chemical frequently depend on the route of exposure (oral, inhalation, dermal) and the duration of exposure (acute, subchronic, chronic or lifetime). In general, acute and chronic neurological and hematological changes, gastrointestinal and cardiovascular effects, and kidney toxicity, have been observed in humans and animals exposed to chemicals of potential concern found at the captain Jack Mill site. Please see Appendix L for health effect fact sheet (ToxFaQs) on major risk contributing chemicals. It is important to note that estimates of human health risks may be based on evidence of health effects in humans and/or animals depending upon the availability of data.

The toxicity assessment process is usually divided into two parts: the cancer effects and the non-cancer effects of the chemical. This two-part approach is employed because there are typically major differences in the time-course of action and the shape of the dose-response curve for cancer and non-cancer effects.

The USEPA has also established an acute and subchronic oral reference dose (RfD) for non-cancer effects of arsenic. An RfD is the daily dose in humans (with uncertainty spanning perhaps an order of magnitude), including sensitive subpopulations, that is likely to be without an appreciable risk of noncancer adverse health effects during a lifetime exposure. The ATSDR has also established acute MRL for arsenic and copper and intermediate MRL for copper which are identified as primary contaminants of concern at this site.

The USEPA has also established in the EPA IRIS an oral cancer slope factor based on a “known human carcinogen” classification (Class A) for lifetime exposures to arsenic. Additionally, estimating the cancer slope factor is often complicated by the fact that observable increases in cancer incidence usually occur only at relatively high doses. Therefore, it is necessary to use mathematical models to extrapolate from the observed high dose data to the desired slope at low dose. In order to account for the uncertainty in this extrapolation process, EPA typically chooses to employ the upper 95th confidence limit of the slope as the Slope Factor. That is, there is a 95% probability that the true cancer potency is lower than the value chosen for the Slope Factor.

ATSDR has also derived acute, intermediate, and chronic duration oral minimal risk levels (MRLs) for several chemicals of potential concern. An MRL is the dose of a compound that is an estimate of daily human exposure that is likely to be without an appreciable risk of adverse noncancerous effects of a specified duration of exposure. The acute intermediate, and chronic MRLs address exposures of 14 days or less, 14 days to 365 days, and 1-year to lifetime, respectively.

Appendix E: Health Assessment of Primary COCs (except lead)

Chronic health hazards for residential exposure to Groundwater and Surface Soils

As part of an in-depth health assessment process, CDPHE and ATSDR compare exposure doses to standard health guidelines including EPA IRIS oral RfDs and/or ATSDR MRLs when RfDs are not available. The RfDs and MRLs are protective estimates of daily human exposure to a chemical that are unlikely to result in noncancer health effects over a specified duration of exposure. To maximize human health protection, RfDs and MRLs have built-in uncertainty or safety factors. Therefore, if an exposure dose is higher than the MRL or RfD, it does not necessarily imply that adverse health effects will occur. The exposure doses for various contaminants of concern (COCs) are divided by the appropriate health-based guidelines to produce a Hazard Quotient (HQ). HQ's greater than or equal to 1 are considered indicative of a potential health hazard and are carried forward into the next step of the evaluation process. However, if RfDs or MRLs are exceeded (i.e., HQ>1.0), CDPHE considers estimated exposures to be of potential health concern. In this case, chronic health guidelines are exceeded for antimony, arsenic, copper, lead, manganese, iron, silver, or zinc in surface soils (Appendix E). It is important to note that generally health guidelines are significantly exceeded for arsenic, copper, and antimony for all receptors at the Captain Jack Mill AI (CJM) and for arsenic alone at the Big Five to Captain Jack AI (BFC). In other cases, slight exceedances are generally for the residential children. For groundwater, chronic health guidelines are exceeded for cadmium, copper, manganese and zinc for ingestion of 2 L/day and 1 L/day ingestion of groundwater by residential children and adults, respectively. Appendix C contains more information on exposure assumptions and dose calculation methods.

However, in accordance with the ATSDR guidelines for public health assessment, if standard health guidelines are exceeded, the health effects observed in the literature are examined to more fully review the exposure potential to help predict the likelihood of adverse health effects. ATSDR examines at human studies, when available, as well as experimental animal studies. This process offers perspective on the plausibility of adverse health effects under site-specific conditions. Therefore, the exposure dose calculation results for COCs are compared to known adverse health effect levels such as the NOAEL and LOAEL that are derived from human data, when possible, or from laboratory animal data. If the estimated dose results for a particular contaminant are below the NOAEL, then the COC is dropped from further evaluation, provided the source of the NOAEL is reliable. COCs that did not exceed the NOAEL are considered no apparent public health hazard. If the dose results are greater than or equal to the LOAEL, a potential public health hazard exists and common health effects from this level of exposure will be presented.

Surface soils

Surface soil COCs for which the estimated exposure doses exceeded the standard health guideline are presented below in Table E1

Table E1. Surface Soil COCs based on health guideline comparison

Area of Investigation	Contaminant of Concern	Receptor	Exposure Dose Result (mg/kg-day)	Health-Based Guideline (mg/kg-day)	Hazard Quotient	Health-Based Guideline Source
Big Five	Arsenic	C_{res}	0.00039	0.0003	1.3	ATSDR Chronic Oral MRL
Big Five	Iron	C_{res}	0.52	0.3	1.7	NCEA
Big Five to Captain Jack	Antimony	C_{res}	0.0013	0.0004	3.25	EPA Oral RfD
Big Five to Captain Jack	Arsenic	All	0.013-0.00039	0.0003	1.3 – 43.3	ATSDR Chronic Oral MRL
Big Five to Captain Jack	Copper	C_{res}	0.019	0.01	1.9	ATSDR Int. Oral MRL
Big Five to Captain Jack	Iron	C_{res}	0.96	0.3	3.2	NCEA
Big Five to Captain Jack	Silver	C_{res}	0.00067	0.0005	1.34	EPA Oral RfD
Captain Jack	Antimony	All	0.00075 – 0.026	0.0004	1.9 - 65	EPA Oral RfD
Captain Jack	Arsenic	All	0.0017 – 0.016	0.0003	5.7 – 200	ATSDR Chronic Oral MRL
Captain Jack	Cadmium	C_{res}	0.0017	0.001	1.7	ATSDR Chronic Oral MRL
Captain Jack	Copper	C_{rec}, C_{res}, CW, A_{res}	0.15 – 0.016	0.01	1.6 – 15	ATSDR Int. Oral MRL

Captain Jack	Iron	C_{rec}	0.74	0.3	2.5	NCEA
Area of Investigation	**Contaminant of Concern**	**Receptor**	**Exposure Dose Result (mg/kg-day)**	**Health-Based Guideline (mg/kg-day)**	**Hazard Quotient**	**Health-Based Guideline Source**
Captain Jack	Zinc	C_{res}	0.37	0.3	1.2	
White Raven	Arsenic	C_{res}	0.00049	0.0003	1.6	ATSDR Chronic Oral MRL
White Raven	Iron	C_{res}	0.43	0.3	1.4	NCEA
White Raven	Manganese	C_{res}	0.11	0.05	2.2	EPA Oral RfD
White Raven	Thallium	C_{res}	0.00021	0.000066	3.2	EPA Region 9 Adj. Oral RfD
White Raven to Sawmill	Arsenic	C_{res}, C_{rec}	0.0011-0.0003	0.0003	1 - 3.7	ATSDR Chronic Oral MRL
White Raven to Sawmill	Iron	C_{res}	0.45	0.3	1.5	NCEA

Table E2. Summary of CJM Cancer Risks by Area of Investigation

Area of Investigation	Receptor	Estimated Carcinogenic Dose Result (mg/kg-day)	Theoretical Cancer Risk
Big Five	Age-Adjusted Resident	0.0000475	7.1 e-05
Big Five	Age-Adjusted Recreationalist	0.000013	1.9 e-05
Big Five	Construction Worker	0.0000027	4.1 e-06
Big Five to Captain Jack	Age-Adjusted Resident	0.0017	2.5 e-03
Big Five to Captain Jack	Age-Adjusted Recreationalist	0.00045	6.7 e-04
Big Five to Captain Jack	Construction Worker	0.000093	1.4 e-04
Captain Jack	Age-Adjusted Resident	0.0073	1.1 e-02
Captain Jack	Age-Adjusted Recreationalist	0.0020	3.0 e-03
Captain Jack	Construction Worker	0.00021	3.1 e-04
White Raven	Age-Adjusted Resident	0.00006	9.0 e-05
White Raven	Age-Adjusted Recreationalist	0.000016	2.4 e-05
White Raven	Construction Worker	0.0000017	2.5 e-06
White Raven to Sawmill Rd.	Age-Adjusted Resident	0.00014	2.1 e-04
White Raven to Sawmill Rd.	Age-Adjusted Recreationalist	0.000038	5.7 e-05
White Raven to Sawmill Rd.	Construction Worker	0.0000039	5.9 e-06

Appendix F: Lead Exposure and Health Assessment

Lead is naturally occurring element found at low levels in soils. Background lead levels in surface soils range between 28 ppm and 130 ppm in the Captain Jack Mill area. However, lead is ubiquitous in the environment as a result of industrial operations which have resulted in substantially higher levels in many areas of the state. For example, lead levels in surface soils in the Captain Jack Mill area ranges between 14 ppm and 177,000 ppm. These lead levels are significantly higher than the EPA and CDPHE lead screening level of 400 ppm in 4 out of 5 exposure units/areas at the Captain Jack Mill.

Exposure Assessment

Lead exposure can occur via multiple pathways (air inhalation and ingestion of water, food, and soil). Therefore, exposure to lead is assessed based on total exposure through all pathways rather than site-specific exposures. However, a primary human exposure pathway to lead is through ingestion of soil and dust. A primary difference between lead and other chemicals exposure/health risk assessment is that lead exposure is monitored by measuring blood lead levels (BLL) because the existing epidemiological evidence for various health effects of lead exposure is linked to BLLs rather than to dose rates. Therefore, EPA has adopted a method that entails modeling lead exposure (uptake/biokinetic) rather than biomonitoring as first line of defense. Lead has significant effects in young children (0-6 years) who also have the most exposure to environmental sources. Pregnant women and women of child bearing age should also be aware of lead in their environment because lead ingested by a mother can affect the fetus. Thus, the population of most concern is young children for residential use, and pregnant women for nonresidential use.

Health Effects/Lead Levels of Concern

It is important to note that risks of lead exposure are not based on theoretical calculations and are not extrapolated from data on lab animals or high-dose occupational exposures. Health effects of lead are well known from studies of children. Lead affects virtually every organ and system in the body and exhibits a broad range of health effects. The most sensitive among these are the central nervous system, hematological, and cardiovascular systems, and the kidney. However, it is particularly harmful to the developing brain and nervous system of fetuses and young children (CDC, 1991, ATSDR, 2006). It should be noted that many health effects of lead may occur without overt signs of toxicity: most poisoned children have no symptoms. Extremely high levels of lead in children (BLL of 380 ug/dL) can cause coma, convulsions, and even death. Lower levels of blood lead cause effects on the central nervous system, kidney, and hematopoietic system. Blood lead levels as low as 10 ug/dL, which do not cause distinct symptoms, are associated with decrease intelligence and impaired neurobehavioral development (CDC, 1991). Blood lead levels of 10 ug/dL or greater is considered elevated but there is no demonstrated safe level of lead in blood. A growing body of research has shown that there are measurable adverse neurological effects in children at blood lead concentrations as low as 1 ug/dL (EPA, 2003a). EPA believes that effects may occur at blood levels so low that there is essentially no threshold or "safe" level of lead (EPA IRIS, 2004). Although the concentration lead in blood is an important indicator of risk, it reflects only current exposures. Lead also accumulated in bone. Recent research suggests that lead concentrations in bone may be related to adverse health effects in children.

Lead is classified as a probable human carcinogen by the EPA based on sufficient evidence of carcinogenicity in animals and inadequate evidence in humans. However, no toxicity value has been derived for cancer effects and EPA has determined that noncancer effects discussed above provide a more sensitive endpoint than cancer effects to assess health risks from exposure to lead.

Health Risk Assessment

Health risks of exposure to lead are determined using predictive modeling. EPA uses two predictive lead models for risk assessment purposes: the Integrated Exposure Uptake Biokinetic (IEUBK) model for children up to the age of 7 years (EPA, 2002), and the adult lead model; ALM (EPA, 2003b) for adolescents and adults for assessing nonresidential exposures. The ALM model is designed to be protective of a fetus of a worker as a result of nonresidential exposure to lead. EPA considers protection of the fetus as the most sensitive health endpoint for adults. Whether lead risk is deemed acceptable or unacceptable is determined by comparing the predicted BLLs with target BLLs of 10 ug/dL (for fetuses and young children), established by the CDC (1991). The EPA has set a goal that there should be no more than a 5% chance that a typical (or hypothetical) child or group of similarly exposed children will exceed a blood lead value of 10 ug/dL. This approach focuses on the risk to a child at the upper bound of the distribution (i.e., 95^{th} percentile).

The IEUBK Model for Residential Children

The IEUBK model is designed to estimate the percentage of children that could have elevated blood lead levels as a result of exposure to lead in soil and dust. The model calculates the expected distribution of blood lead and estimates the probability that any random child might have a blood lead value over10 ug/dL. Under the residential exposure scenario (past, current, or future) and using the calculated 95% upper confidence limit on the mean for surface soil lead concentrations, the IEUBK model predicts elevated blood lead levels (above 10 ug/dL) in 88 to 99 % of young children at 4 out of 5 Areas of Investigation (Table F1). Therefore, exposure to lead is considered a public health hazard for young children in this assessment under the EPA default assumptions used in the model. Table F3 summarizes the IEUBK model default assumptions.

The ALM Model for Outdoor Adults

The ALM model is designed to express the probability that fetal lead will be greater than the target blood lead value of 10 ug/dL assuming a lognormal distribution. Table F2 shows results of the ALM using the default input parameters and site-specific surface soil lead concentrations. The probability that fetal blood lead will exceed target blood lead level of 10 ug/dL ranges from 15 to 83% in 4 out of 5 Areas of Investigation. Therefore, exposure to lead is considered a "*public health hazard*" for outdoor adults (pregnant women) in this assessment under the EPA default assumptions used in the model. Soil lead concentrations only in 1 out of 5 Areas of

Investigation (Big Five Area) result in less than a 5% probability of fetal blood lead exceeding 10 ug/dL target level and is considered a "*no apparent public health hazard*". Table F4 summarizes the ALM model default assumptions for exposure during pregnancy.

Table F1. The IEUBK Model Estimated Risk to Residential Children (0-84 months) from exposure to site-specific surface soil and dust: Percentage of Children that Exceed the Target Average Blood Lead Level of 10 ug/dL in Various Exposure Unit/Areas, Based on the Default Assumptions.

Areas of Investigation	Exposure Point Concentration (PPM)	Geometric Mean Blood Lead Level (ug/dL)	% Children >10 ug/dL
Big Five Area (BFV)	383.3	4.47	4.35
Big Five to Captain Jack (BFC)	9233.77	38.20	99.78*
Captain Jack Mill (CJM)	14467.8	49.27	99.96*
White Raven (WHR)	6373.0	38.87	99.17*
White Raven to Saw Mill (WRS)	2530.0 [a]	17.42	88.12*

Note: Please see Table F3 for details of exposure/input parameters for the IEUBK model
* Indicates blood lead levels exceed EPA's goal of 5% (i.e., having no more than 5% of the community with blood lead levels > 10ug/dL
[a] Represents maximum soil concentration because of small sample size.

Table F2. The ALM Model Results for Outdoor Adults: Probability of Fetal Blood Lead (PbB) >10 ug/dL and the 95th Percentile PbB among Fetuses of Adult workers

Areas of Investigation	Exposure Point Concentration (PPM)	95th percentile fetal PbB (ug/dL)	Probability of fetal PbB >10 ug/dL
Big Five Area (BFV)	383.3	6.30	1.10
Big Five to Captain Jack (BFC)	9233.77	45.10	65.00*
Captain Jack Mill (CJM)	14467.8	68.10	82.70*
White Raven (WHR)	6373.0	32.60	47.90*
White Raven to Saw Mill (WRS)	2530.0 [a]	15.70	15.00*

Note: Please see Table F4 for details of exposure/input parameters for the ALM model

* Indicates fetal blood lead levels exceed EPA's goal of 5% (i.e., having no more than 5% of the community with blood lead levels >10ug/dL
[a] Represents maximum soil concentration because of small sample size.

Uncertainty in Risks Predicted by the IEUBK and ALM Lead Models

Reliable estimates of exposure and risk using the IEUBK and ALM models depend on site-specific information for a number of key parameter, including lead concentration in outdoor soil (fine fraction) and indoor dust, soil ingestion rate, interindividual variability in child blood lead concentrations (GSD) and the rate and extent of lead absorption from soil. Therefore, uncertainties are discussed qualitatively here. In this case, for example, lead risks are over- or underestimated based on the availability of insufficient site-specific data for the relative bioavailability of lead from soil. In assessing risks from lead exposure, the EPA assumes 60% relative bioavailability of lead in soil which is a measure of the difference in absorption between different forms of chemical or between different dosing vehicles (e.g., lead in water, or soil). The site-specific relative bioavailability was evaluated in only one sample per exposure unit/area using an *in vitro* extraction method to measure the fraction of lead that could become available for absorption in the human gastrointestinal tract (i.e., the bioaccessible fraction). This study provided the relative bioavailability of 0, 1, 3, 58, and 69% for Big Five Captain Jack (BFC), Big Five Area (BFV), White Raven to Sawmill (WRS), White Raven (WHR), and Captain Jack Mill (CJM) Areas of Investigationa, respectively. Based on these limited site-specific values, risks from exposure to lead are likely to be significantly overestimated for the exposure unite/areas with lead bioavailability range of 0 to 3% (vs. 60% EPA default) and slightly underestimated for the exposure unite/areas with lead bioavailability range of 58 to 69 % (vs. 60% EPA default). However, in the absence of adequate site-specific data, it is prudent to use the default bioavailability assumption in order to ensure the public health protection. In summary, without adequate site-specific data, there will be uncertainty about how well the risk estimates predicted by computer modeling based on the default parameters reflect the true conditions at a site.

In addition, it is important to keep in mind that evidence is growing that there are measurable adverse neurological effects in children at blood lead concentrations as low as 1 ug/dL (EPA, 2003a). This suggests that the target blood lead level of 10 ug/dL in fetuses and young children for the IEUBK model and ALM model may result in underestimation of lead hazards at the Captain Jack Mill site

Table F3. Default Input Parameters for the IEUBK Model for exposure to Residential Children

Exposure variable	EPA Default Value
Groundwater concentration (Cgw)	4.0 mg/L
Dust Fraction	70% (0.70)
Geometric standard deviation (GSD) or interindividual variability	1.6
Soil Concentration (ppm)	Exposure area specific
FDA dietary parameters	Downloaded from the EPA TRW website
Relative bioavailability	60%

Table F4. Default Input Parameters for the ALM Model for Outdoor Adults

Exposure Variable	Equation [1]		Description of Exposure Variable	Units	Using Equation 1
	1*	2**			GSDi = Hom
PbS	X	X	Soil lead concentration	ug/g or ppm	Site-specific
$R_{fetal/maternal}$	X	X	Fetal/maternal PbB ratio	--	0.9
BKSF	X	X	Biokinetic Slope Factor	ug/dL per ug/day	0.4
GSD_i	X	X	Geometric standard deviation PbB	--	2.1
PbB_0	X	X	Baseline PbB	ug/dL	1.5
IR_S	X		Soil ingestion rate (including soil-derived indoor dust)	g/day	0.050
IR_{S+D}		X	Total ingestion rate of outdoor soil and indoor dust	g/day	--
W_S		X	Weighting factor; fraction of IR_{S+D} ingested as outdoor soil	--	--
K_{SD}		X	Mass fraction of soil in dust	--	--
$AF_{S,D}$	X	X	Absorption fraction (same for soil and dust)	--	0.12
$EF_{S,D}$	X	X	Exposure frequency (same for soil and dust)	days/yr	219
$AT_{S,D}$	X	X	Averaging time (same for soil and dust)	days/yr	365

[1] Equation 1 does not apportion exposure between soil and dust ingestion (excludes W_S, K_{SD}).
When $IR_S = IR_{S+D}$ and $W_S = 1.0$, the equations yield the same $PbB_{fetal,0.95}$.

***Equation 1, based on Eq. 1, 2 in USEPA (1996).**

PbB_{adult} =	$(PbS*BKSF*IR_{S+D}*AF_{S,D}*EF_S/AT_{S.D}) + PbB_0$
$PbB_{fetal,0.95}$ =	$PbB_{adult} * (GSD_i^{1.645} * R)$

Appendix G: Evaluation of Acute and subchronic (intermediate) exposure/health hazards to surface soils for Young Children

Pica Children

Several ATSDR acute and intermediate EMEGs (comparison values) for soils are available. The levels (maximum and/or the 95th percentile UCL) of aluminum, arsenic, copper, vanadium, or zinc are significantly above the acute and intermediate EMEGs (Table G1). The screening level evaluation, using the ATSDR comparison values for pica children, suggest that acute intake (pica) of surface soil (5000 mg) by recreational or residential children might be of potential health concern at all five areas of investigation. However, there is uncertainty associated with this finding because of the lack of reliable information on the magnitude of pica soil ingestion. Therefore, more realistic acute and subchronic exposures and hazards for young children are quantitatively evaluated for two major health hazard driving chemicals of concern, arsenic and copper.

Table G1. Acute and Subchronic (intermediate) exposure to surface soils for Pica Children

Area of Investigation (AI)	EPC in surface soil (ppm)	Acute Pica EMEG (ppm)	Intermediate Pica EMEG (ppm)	Exceedance of EMEG*
Big Five Area (BFV)				
Aluminum	3500.6		4000.0	**Yes**
Arsenic	29.1	10.0		**Yes**
Barium	186.7		1000	No
Copper	260.3	20.0	20.0	**Yes**
Vanadium	9.2		6.0	**Yes**
Big Five to Captain Jack (BFC)				
Aluminum	7667.8		4000.0	**Yes**
Arsenic	1011.7	10.0		**Yes**
Barium	597.8		1000	No
Copper	1437.1	20.0	20.0	**Yes**
Vanadium	22.5		6.0	**Yes**
Zinc	9839.3		600.0	**Yes**
Captain Jack Mill (CJM)				
Aluminum	5044.7		4000.0	**Yes**
Arsenic	4504.7	10.0		**Yes**
Barium	259.0		1000	No
Copper	11545.6	20.0	20.0	**Yes**
Vanadium	14.26		6.0	**Yes**
Mercury	2.7	10.0	4.0	No
Zinc	28066.3		600	**Yes**
White Raven (WHR)				
Aluminum	4396.4		4000.0	**Yes**
Arsenic	36.6	10.0		**Yes**
Barium	1157.1		1000	**Yes**
Copper	600.4	20.0	20.0	**Yes**
Vanadium	18.1		6.0	**Yes**
Mercury	1.4	10.0	4.0	No
Zinc	1410.7		600.0	**Yes**
White Raven Sawmill (WRS)				
Aluminum	9310.0		4000.0	**Yes**
Arsenic	84.5	10.0		**Yes**
Barium	686.0		1000	No
Copper	643.0	20.0	20.0	**Yes**
Vanadium	33.4		6.0	**Yes**
Mercury	9.5	10.0	4.0	**Yes**
Zinc	720.0		600.0	**Yes**

* indicates potential health concern

Table G2. Evaluation of arsenic and copper (indicator chemicals) acute exposure to surface soil for young children (0-6 years)

Area of Investigation (AI)	EPC 95% UCL (ppm)	Exposure dose[a] (mg/kg/day)	Health Guideline (mg/kg/day)	Health Guideline based HQ	NOAEL[b] based HQ	LOAEL[c] based HQ
BFV						
Arsenic	29.1	0.0008	0.005	0.15	NA	NA
Copper	260.3	0.0069	0.01	0.7	NA	NA
BFC						
Arsenic	1011.7	0.027	0.005	**5.4**	NA	0.5
Copper	1437.1	0.0383	0.01	**3.8**	**1.4**	0.5
CJM						
Arsenic	4504.7	0.12	0.005	**24.0**	NA	**2.4**
Copper	11545.6	0.3079	0.01	**30.8**	**11.3**	**4.2**
WRV						
Arsenic	36.6	0.001	0.005	0.54	NA	NA
Copper	600.6	0.016	0.01	**1.6**	0.6	0.2
WRS						
Arsenic	84.5	0.0022	0.005	0.45	NA	NA
Copper	643.0	0.017	0.01	**1.7**	0.6	0.2

[a] Exposure dose = Soil intake rate (mg/day) x EF x CF/ Child Body wt.(kg) x AT (see Table G4 for details)
[b] Arsenic acute NOAEL was not identified. Copper acute NOAEL for ATSDR MRL = 0.0272 mg/kg/day
[c] Arsenic Acute LOAEL for ATSDR MRL = 0.05 mg/kg/day based on serious neurological, gastrointestinal and cardiovascular effects. Copper acute LOAEL for ATSDR MRL = 0.0731 mg/kg/day
NA- not applicable because NOAEL is not available or health guideline based HQ <1.0

Table G3. Evaluation of arsenic and copper (indicator chemicals) subchronic exposure to surface soil for young children (0-6 years)

Areas of Investigation	EPC 95% UCL (ppm)	Exposure dose[a] (mg/kg/day)	Health guideline (mg/kg/day)	Health Guideline based HQ	NOAEL[b] based HQ	LOAEL[c] based HQ
BFV						
Arsenic	29.1	0.0006	0.005	0.13	NA	NA
Copper	260.3	0.006	0.01	0.6	NA	NA
BFC						
Arsenic	1011.7	0.0224	0.005	**4.5**	NA	0.45
Copper	1437.1	0.0319	0.01	**3.2**	NA	0.35
CJM						
Arsenic	4504.7	0.01	0.005	**20.0**	NA	**2.0**
Copper	11545.6	0.2566	0.01	**25.6**	**6.1**	**2.8**
WRV						
Arsenic	36.6	0.0008	0.005	0.2	NA	NA
Copper	600.6	0.0133	0.01	**1.3**	NA	NA
WRS						
Arsenic	84.5	0.0019	0.005	0.4	NA	NA
Copper	643.0	0.0143	0.01	**1.4**	NA	NA

[a] Exposure Dose = Soil intake rate (mg/day) x EF x CF/ Body wt.(kg)xAT (see Table G4 for details)
[b] Arsenic subchronic NOAEL was not identified. Copper subchronic NOAEL for ATSDR MRL = 0.042 mg/kg/day
[c]Arsenic subchronic LOAEL for EPA RfD = 0.05 mg/kg/day. Copper subchronic LOAEL for ATSDR MRL = 0.091 mg/kg/day
NA- not applicable because NOAEL is not available or health guideline based HQ <1.0

Table G4. Exposure parameters for acute and subchronic exposure evaluation for young children (0-6 years).

Exposure parameter	Acute input value	Subchronic input value
EPC (ppm)	95 % UCL on the mean	95 % UCL on the mean
Soil Intake rate (mg/day)	400	400
Body Weight (kg)	15	15
Exposure Frequency (EF)	1 day	25 days/month
Averaging Time (AT)	1 day	30 days
Conversion Factor (CF)	0.000001 kg/mg	0.000001 kg/mg

Appendix H: Evaluation of Cumulative Exposures and Hazards

Exposures due to multiple pathways and media of potential concern

In this assessment there is potential exposure to multiple contaminants through multiple exposure pathways (e.g., soil ingestion, dermal contact, and inhalation of dust particulates). However, only soil ingestion pathway is evaluated quantitatively as a risk driving exposure pathway. Therefore, cumulative risks from multiple exposure pathways are not evaluated quantitatively here. The cumulative exposures and hazards from multiple exposure media (e.g., soil and groundwater) are not calculated quantitatively for residents because each individual medium poses an increased hazard based on an HQ and/or HI >1.0 (using health guidelines). According to the CDPHE, HQs or HIs >1.0 are likely to pose an increased health hazard. However, the ATSDR hazard categories are concluded using an indicator chemical approach discussed below.

Multiple Chemical Exposures

The potential health impact of multiple contaminants can be of particular concern in many cases because of the combined action of chemicals (e.g., additive, antagonistic, and synergistic effects). The initial step in estimating cumulative exposures/hazards is made by calculating the HI based on the assumption of additive toxic effects. As shown in Table E1 of Appendix E, HIs for all receptor populations at 4 out of 5 AIs (except Big Five Area) significantly exceed the acceptable level of 1.0. Traditionally, HQs for groups of chemicals that have similar toxic effects or mechanisms of action can be added (e.g., chemicals causing kidney toxicity); however, this step is not considered necessary because hazards for the most toxic chemicals are driving this assessment. According to the CDPHE, an exceedance of an HI of 1.0 is likely to pose an increased health hazard. However, the assumption of additivity of exposures/hazards is likely to over-or under-estimate hazards due to possible synergistic and antagonistic interactions. Therefore, the ATSDR hazard categories are concluded using an indicator chemical approach discussed below.

For many chemicals found at this site, however, information is limited in order to quantitatively evaluate toxic interaction by using a weight-of-evidence approach to evaluate influence of interactions in the overall toxicity of the mixture. For this assessment, therefore, exposures are generally evaluated on a chemical-by-chemical basis and combined action of multiple chemicals is addressed qualitatively using an indicator chemical approach, in accordance with ATSDR's *Guidance Manual for the Assessment of Joint Action of Chemical Mixtures* (ATSDR, 2004). In this approach, the most toxic known chemical from the mixture (i.e., lead) is selected as an indicator (or marker) chemical for the mixture, assuming that the indicator chemical lead is driving the exposure and hazard at this site and further assessment of the mixture is not necessary. Based on lead hazards, 4 out of 5 AIs for all receptors (young children and outdoor adults) are categorized as public health hazards (Tables F1 and F2 of Appendix F). Therefore, evaluation of additivity or interactions among the mixture components is not necessary. It is, however, important to note that at the Big Five AI, where lead is unlikely to pose a hazard to public health, HQs for the other mixture components are <0.1, based on NOAELs. Thus, additivity or interactions among the mixture components are unlikely to pose a hazard, in accordance with ATSDR's *Public Health Assessment Guidance Manual* (ATSDR, 2005)

Appendix I: Comparison with Background Exposures and Risks

The presence of metals in ambient environment that are contaminants of potential concern at this site has been well established. Background is defined here as the concentration of metals in surface soils that are not known to be affected by a site-specific source. Based on general observation, it is clear that site-specific concentrations of several metals in surface soils are consistently higher than those found in background soils. Therefore, it is important to consider the background exposures and risks. Screening level evaluation, based on the residential exposure scenario, using ATSDR or EPA Region 9 comparison values, suggests that background hazards for all metals (except aluminum) and theoretical cancer risk for arsenic are significantly lower than the site-specific noncancer hazards and theoretical cancer risks (Table E2 of Appendix E). Thus, the estimated site-specific potential health hazards and theoretical cancer risk are attributed to site-specific sources.

Table I1. Evaluation of background noncancer hazards and theoretical cancer risk for the residential exposure scenario

Contaminant of Concern	Maximum Detected level (ppm)	Comparison Value (ppm)	Hazard Quotient or Cancer Risk
Aluminum	18700.0	76000.0	0.20
Antimony	6.0	30.1	0.20
Arsenic	3.7	0.39 (c) 22.0 (nc)	HQ= 0.2 Cancer risk=**9.5×10^{-6}**
Barium	373.0	5400.0	0.07
Cadmium	0.75	37.0	0.02
Copper	44.1	3100.0	0.01
Iron	27300.0	23000.0	**1.20**
Lead	130.0	400	3-fold below screening level
Manganese	514.0	1800.0	0.30
Silver	1.9	390.0	0.00
Thallium	3.6	5.2	0.70
Vanadium	64.2	70.8	0.90
Zinc	111.0	23000.0	0.00

Appendix J. Uncertainty Analysis

This section addresses the uncertainty and limitations of this health consultation. It is not intended to be an all-encompassing rendition of all uncertainties when performing this type of health evaluation. Rather, the focus is to highlight the major assumptions and limitations made within the document that are unique to this evaluation. Overall, the uncertainties discussed below are likely to either over- or under-estimate risk. The magnitude of this uncertainty is unknown.

Sampling procedures, Quality control, and laboratory analysis of samples will not be discussed in more detail. For more information of these topics, please refer to the RI/FS work/sampling plan, and the RI/FS document.

EPCs for groundwater

A limited amount of groundwater data exists, one sampling event (during low-flow conditions) was all that was collected, and groundwater EPCs may over/under estimate the actual dose received by any one individual because of the unnormal distribution of the data (97.5% Chebyshev was used in most cases). This means that the sample set varied greatly throughout the site. Risk to some receptors may be higher or lower depending on the concentration in a particular well. Antimony, Arsenic, Nickel, and Thallium were not evaluated to a great extent even though the CVs were exceeded by the maximum detected concentration or half the detection limit value.

EPCs for Surface Soils

A large amount of surface soil data was collected during the RI/FS. Most of this data was collected from source areas, namely tailings piles. This is likely to overestimate chronic exposures and hazards. No organics were evaluated based on a limited amount of evidence indicating that they exist.

EPCs for past, current, and future exposures

The same data set was used to evaluate past, current, and future exposures to various receptor populations. This may underestimate risk for past exposures and overestimate risk for future exposures.

Essential Nutrients

Some essential nutrients such as calcium, iron, potassium, and sodium were also not evaluated in great detail. All substances can be toxic at some dose. However, most nutrients are rapidly eliminated when the body has more than it needs for normal function.

<u>Subsurface soil exposures</u>

Exposures to subsurface soil were not evaluated quantitatively because the concentrations are significantly lower than those in the surface soil and residents are not frequently exposed to subsurface soils.

<u>Exposure Parameters</u>

Although EPA default exposure parameters were mainly used, the various exposure assumptions could lead to over or underestimation of risk.

<u>Cumulative Exposures</u>

The cumulative exposures due to multiple media of concern, exposure pathways, and multiple contaminants are not quantitatively evaluated and discussed qualitatively using an indicator approach. For example, an indicator chemical approach to address multiple chemical interactions could lead to underestimation or overestimation of noncancer health hazards as a result of potential additive, synergistic, and antagonistic interactions.

<u>Uncertainty in arsenic health hazard and theoretical cancer risk evaluation</u>

Relative bioavailability of arsenic

It is important to stress that noncancer health hazard quotients and theoretical excess cancer risks calculated based on the relative bioavailability of 100% are likely to overestimate risk because forms of arsenic in site soils are likely to be less absorbed than readily absorbable forms used in studies used to derive the oral health guidelines (e.g., RfD, MRL, and cancer slope factor). However, the available information is not yet adequate to derive reliable conclusions regarding the default assumption of relative bioavailability of arsenic from site soils. This uncertainty is because of a number of factors; for example, more information is needed on the appropriate animal model for measuring the relative bioavailability and variations in the relative bioavailability based on different types of soil. Additionally, it is important to note that *in vitro* extraction method as describe for lead relative bioavailability studies (Appendix F) are not yet quantitatively reliable for arsenic because of the uncertainty in correlations between *in vitro* and *in vivo* measurements. Therefore, the limited available data on the site-specific *in vitro* relative bioavailability for arsenic that indicates significantly reduced relative bioavailability (3-7%), based on one sample per exposure unit/area, cannot be applied qualitatively or quantitatively and are not discussed further here.

Cancer slope factor for arsenic

Consideration should also be given to the uncertainty associated with the cancer slope factor for arsenic. According to NRC (2001), more recent data indicate that oral exposure to arsenic can also increase the risk of internal cancers (e.g., lung and bladder cancer). The current EPA IRIS oral cancer slope factor is under evaluation and the various cancer slope factors derived by the NRC (2001), CAL EPA (OEHHA, 2004), and the EPA IRIS SAB Review Draft (July, 2005) are more conservative than the current EPA IRIS cancer slope factor of 1.5 per mg/kg/day (or Unit Risk Factor of $5x10^{-5}$ per ug/L) which is based on the incidence of skin cancer in the Taiwanese population and may not be appropriate for estimation of risks from other types of cancer (e.g., lung and bladder cancer). For example, CAL EPA calculated the oral cancer slope factor of 9.5 per mg/kg/day (or Unit Risk Factor of $2.7x10^{-4}$ per ug/L); the NRC (2001) calculated cancer slope factors of up to 23.4 per mg/kg/day; and the EPA IRIS SAB Review Draft cancer calculated the slope factor of 5.5 per mg/kg/day (or Unit Risk Factor of $1.6x10^{-4}$ per ug/L).

Appendix K. ATSDR Public Health Hazard Categories

Category / Definition	Data Sufficiency	Criteria
A. Urgent Public Health Hazard This category is used for sites where short-term exposures (< 1 yr) to hazardous substances or conditions could result in adverse health effects that require rapid intervention.	This determination represents a professional judgment based on critical data which ATSDR has judged sufficient to support a decision. This does not necessarily imply that the available data are complete; in some cases additional data may be required to confirm or further support the decision made.	Evaluation of available relevant information* indicates that site-specific conditions or likely exposures have had, are having, or are likely to have in the future, an adverse impact on human health that requires immediate action or intervention. Such site-specific conditions or exposures may include the presence of serious physical or safety hazards.
B. Public Health Hazard This category is used for sites that pose a public health hazard due to the existence of long-term exposures (> 1 yr) to hazardous substance or conditions that could result in adverse health effects.	This determination represents a professional judgment based on critical data which ATSDR has judged sufficient to support a decision. This does not necessarily imply that the available data are complete; in some cases additional data may be required to confirm or further support the decision made.	**Evaluation of available relevant information* suggests that, under site-specific conditions of exposure, long-term exposures to site-specific contaminants (including radionuclides) have had, are having, or are likely to have in the future, an adverse impact on human health that requires one or more public health interventions. Such site-specific exposures may include the presence of serious physical or safety hazards.**
C. Indeterminate Public Health Hazard **This category is used for sites in which "*critical*" data are *insufficient* with regard to extent of exposure and/or toxicologic properties at estimated exposure levels.**	This determination represents a professional judgment that critical data are missing and ATSDR has judged the data are insufficient to support a decision. This does not necessarily imply all data are incomplete; but that some additional data are required to support a decision.	**The health assessor must determine, using professional judgment, the "criticality" of such data and the likelihood that the data can be obtained and will be obtained in a timely manner. Where some data are available, even limited data, the health assessor is encouraged to the extent possible to select other hazard categories and to support their decision with clear narrative that explains the limits of the data and the rationale for the decision.**
D. No Apparent Public Health Hazard This category is used for sites where human exposure to contaminated media may be occurring, may have occurred in the past, and/or may occur in the future, but the exposure is not expected to cause any adverse health effects.	This determination represents a professional judgment based on critical data which ATSDR considers sufficient to support a decision. This does not necessarily imply that the available data are complete; in some cases additional data may be required to confirm or further support the decision made.	Evaluation of available relevant information* indicates that, under site-specific conditions of exposure, exposures to site-specific contaminants in the past, present, or future are not likely to result in any adverse impact on human health.
E: No Public Health Hazard **This category is used for sites that, because of the absence of exposure, do NOT pose a public health hazard.**	**Sufficient evidence indicates that no human exposures to contaminated media have occurred, none are now occurring, and none are likely to occur in the future**	

Appendix L. Toxicological Information on Contaminants of Concern

Public Health Statement Links

Arsenic: http://www.atsdr.cdc.gov/toxprofiles/phs2.html
Copper: http://www.atsdr.cdc.gov/toxprofiles/phs132.html
Lead: http://www.atsdr.cdc.gov/toxprofiles/tp13.html
Manganese: http://www.atsdr.cdc.gov/toxprofiles/phs151.html
Zinc: http://www.atsdr.cdc.gov/toxprofiles/phs60.html

Tox FAQs for arsenic copper, lead, are provided below

September 2005

ToxFAQs™
for
Arsenic
(Arsénico)

CAS# 7440-38-2

This fact sheet answers the most frequently asked health questions about arsenic. For more information, you may call the ATSDR Information Center at 1-888-422-8737. This fact sheet is one in a series of summaries about hazardous substances and their health effects. This information is important because this substance may harm you. The effects of exposure to any hazardous substance depend on the dose, the duration, how you are exposed, personal traits and habits, and whether other chemicals are present.

HIGHLIGHTS: Exposure to higher than average levels of arsenic occur mostly in the workplace, near hazardous waste sites, or in areas with high natural levels. At high levels, inorganic arsenic can cause death. Exposure to lower levels for a long time can cause a discoloration of the skin and the appearance of small corns or warts. Arsenic has been found in at least 784 of the 1,662 National Priority List sites identified by the Environmental Protection Agency (EPA).

What is arsenic?
Arsenic is a naturally occurring element widely distributed in the earth's crust. In the environment, arsenic is combined with oxygen, chlorine, and sulfur to form inorganic arsenic compounds. Arsenic in animals and plants combines with carbon and hydrogen to form organic arsenic compounds.

Inorganic arsenic compounds are mainly used to preserve wood. Copper chromated arsenic (CCA) is used to make "pressure-treated" lumber. CCA is no longer used in the U.S. for residential uses; it is still used in industrial applications. Organic arsenic compounds are used as pesticides, primarily on cotton plants.

What happens to arsenic when it enters the environment?

- Arsenic occurs naturally in soil and minerals and it therefore may enter the air, water, and land from wind-blown dust and may get into water from runoff and leaching.
- Arsenic cannot be destroyed in the environment. It can only change its form.
- Rain and snow remove arsenic dust particles from the air.
- Many common arsenic compounds can dissolve in water. Most of the arsenic in water will ultimately end up in soil or sediment.
- Fish and shellfish can accumulate arsenic; most of this arsenic is in an organic form called arsenobetaine

that is much less harmful.

How might I be exposed to arsenic?

- Ingesting small amounts present in your food and water or breathing air containing arsenic.
- Breathing sawdust or burning smoke from wood treated with arsenic.
- Living in areas with unusually high natural levels of arsenic in rock.
- Working in a job that involves arsenic production or use, such as copper or lead smelting, wood treating, or pesticide application.

How can arsenic affect my health?

Breathing high levels of inorganic arsenic can give you a sore throat or irritated lungs.
Ingesting very high levels of arsenic can result in death. Exposure to lower levels can cause nausea and vomiting, decreased production of red and white blood cells, abnormal heart rhythm, damage to blood vessels, and a sensation of "pins and needles" in hands and feet.
Ingesting or breathing low levels of inorganic arsenic for a long time can cause a darkening of the skin and the appearance of small "corns" or "warts" on the palms, soles, and torso.
Skin contact with inorganic arsenic may cause redness and swelling.
Organic arsenic compounds are less toxic than inorganic arsenic compounds. Exposure to high levels of some organic arsenic compounds may cause similar effects as inorganic arsenic.

How likely is arsenic to cause cancer?

Several studies have shown that ingestion of inorganic arsenic can increase the risk of skin cancer and cancer in the lungs, bladder, liver, kidney and prostate. Inhalation of inorganic arsenic can cause increase risk of lung cancer. The Department of Health and Human Services (DHHS) has determined that inorganic arsenic is a known carcinogen. The International Agency for Research on Cancer (IARC), and the EPA have determined that inorganic arsenic is carcinogenic to humans.

How does arsenic affect children?

There is also some evidence that suggests that long-term exposure to arsenic in children may result in lower IQ scores. There is some information suggesting that children may be less efficient at converting inorganic arsenic to the less harmful organic forms. For this reason, children may be more susceptible to health effects from inorganic arsenic than adults.
There is some evidence that inhaled or ingested arsenic can injure pregnant women or their unborn babies, although the studies are not definitive. Studies in animals show that large doses of arsenic that cause illness in pregnant females can also cause low birth weight, fetal malformations, and even fetal death. Arsenic can cross the placenta and has been found in fetal tissues. Arsenic is found at low levels in breast milk.

How can families reduce their risk for exposure to arsenic?

- If you use arsenic-treated wood in home projects, you should wear dust masks, gloves, and protective clothing to decrease exposure to sawdust.
- If you live in an area with high levels of arsenic in water or soil, you should use cleaner sources of water and limit contact with soil.

Is there a medical test to show whether I've been exposed to arsenic?

There are tests available to measure arsenic in your blood, urine, hair, and fingernails. The urine test is the most reliable test for arsenic exposure within the last few days. Tests on hair and fingernails can measure exposure to high levels of arsenic over the past 6-12 months. These tests can determine if you have been exposed to above-average levels of arsenic. They cannot predict how the arsenic levels in your body will affect your health.

Has the federal government made recommendations to protect human health?

The EPA has set limits on the amount of arsenic that industrial sources can release to the environment and has

restricted or cancelled many of the uses of arsenic in pesticides. EPA has set a limit of 0.01 parts per million (ppm) for arsenic in drinking water.
The Occupational Safety and Health Administration (OSHA) has set a permissible exposure limit (PEL) of 10 micrograms of arsenic per cubic meter of workplace air (10 µg/m³) for 8 hour shifts and 40 hour work weeks.

References

Agency for Toxic Substances and Disease Registry (ATSDR). 2005. Toxicological Profile for arsenic. *(Draft for Public Comment.*) Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

Where can I get more information?
ATSDR can tell you where to find occupational and environmental health clinics. Their specialists can recognize, evaluate, and treat illnesses resulting from exposure to hazardous substances. You can also contact your community or state health or environmental quality department if you have any more questions or concerns.
For more information, contact:

September 2004

ToxFAQs™
for
Copper
(Cobre)

CAS# 7440-50-8

This fact sheet answers the most frequently asked health questions about copper. For more information, you may call the ATSDR Information Center at 1-888-422-8737. This fact sheet is one in a series of summaries about hazardous substances and their health effects. This information is important because this substance may harm you. The effects of exposure to any hazardous substance depend on the dose, the duration, how you are exposed, personal traits and habits, and whether other chemicals are present.

HIGHLIGHTS: Copper is a metal that occurs naturally in the environment, and also in plants and animals. Low levels of copper are essential for maintaining good health. High levels can cause harmful effects such as irritation of the nose, mouth and eyes, vomiting, diarrhea, stomach cramps, nausea, and even death. Copper has been found in at least 906 of the 1,647 National Priority Sites identified by the Environmental Protection Agency (EPA).

What is copper?
Copper is a metal that occurs naturally throughout the environment, in rocks, soil, water, and air. Copper is an essential element in plants and animals (including humans), which means it is necessary for us to live. Therefore, plants and animals must absorb some copper from eating, drinking, and breathing.

Copper is used to make many different kinds of products like wire, plumbing pipes, and sheet metal. U.S. pennies made before 1982 are made of copper, while those made after 1982 are only coated with copper. Copper is also combined with other metals to make brass and bronze pipes and faucets.

Copper compounds are commonly used in agriculture to treat plant diseases like mildew, for water treatment and, as preservatives for wood, leather, and fabrics.

What happens to copper when it enters the environment?

- Copper is released into the environment by mining, farming, and manufacturing operations and through waste water releases into rivers and lakes. Copper is also released from natural sources, like volcanoes, windblown dusts, decaying vegetation, and forest fires.
- Copper released into the environment usually attaches to particles made of organic matter, clay, soil, or sand.
- Copper does not break down in the environment. Copper compounds can break down and release free copper into the air, water, and foods.

How might I be exposed to copper?

- You may be exposed to copper from breathing air, drinking water, eating foods, or having skin contact with copper, particulates attached to copper, or copper-containing compounds.
- Drinking water may have high levels of copper if your house has copper pipes and acidic water.
- Lakes and rivers that have been treated with copper compounds to control algae, or that receive cooling water from power plants, can have high levels of copper. Soils can also contain high levels of copper, especially if they are near copper smelting plants.
- You may be exposed to copper by ingesting copper-containing fungicides, or if you live near a copper mine or where copper is processed into bronze or brass.

- You may be exposed to copper if you work in copper mines or if you grind metals containing copper.

How can copper affect my health?
Everyone must absorb small amounts of copper every day because copper is essential for good health. High levels of copper can be harmful. Breathing high levels of copper can cause irritation of your nose and throat. Ingesting high levels of copper can cause nausea, vomiting, and diarrhea. Very-high doses of copper can cause damage to your liver and kidneys, and can even cause death.

How likely is copper to cause cancer?
We do not know whether copper can cause cancer in humans. The EPA has determined that copper is not classifiable as to human carcinogenicity.

How can copper affect children?
Exposure to high levels of copper will result in the same type of effects in children and adults. We do not know if these effects would occur at the same dose level in children and adults. Studies in animals suggest that the young children may have more severe effects than adults, but we don't know if this would also be true in humans. There is a very small percentage of infants and children who are unusually sensitive to copper.
We do not know if copper can cause birth defects or other developmental effects in humans. Studies in animals suggest that high levels of copper may cause a decrease in fetal growth.

How can families reduce the risk of exposure to copper?
The most likely place to be exposed to copper is through drinking water, especially if your water is corrosive and you have copper pipes in your house. The best way to lower the level of copper in your drinking water is to let the water run for at least 15 seconds first thing in the morning before drinking or using it. This reduces the levels of copper in tap water dramatically.
If you work with copper, wear the necessary protective clothing and equipment, and always follow safety procedures. Shower and change your clothes before going home each day.

Is there a medical test to show whether I've been exposed to copper?
Copper is found throughout the body; in hair, nails, blood, urine, and other tissues. High levels of copper in these samples can show that you have been exposed to higher- than normal levels of copper. These tests cannot tell whether you will experience harmful effects. Tests to measure copper levels in the body are not usually available at a doctor's office because they require special equipment, but the doctor can send samples to a specialty laboratory.

Has the federal government made recommendations to protect human health?
The EPA requires that levels of copper in drinking water be less than 1.3 mg of copper per one liter of drinking water (1.3 mg/L).
The U.S. Department of Agriculture has set the recommended daily allowance for copper at 900 micrograms of copper per day (µg/day) for people older than eight years old.
The Occupational Safety and Health Administration (OSHA) requires that levels of copper in the air in workplaces not exceed 0.1 mg of copper fumes per cubic meter of air (0.1 mg/m^3) and 1.0 mg/m^3 for copper dusts.

References
Agency for Toxic Substances and Disease Registry (ATSDR). 2004. Toxicological Profile for Copper. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

Where can I get more information?
ATSDR can tell you where to find occupational and environmental health clinics. Their specialists can recognize, evaluate, and treat illnesses resulting from exposure to hazardous substances. You can also contact your community or state health or environmental quality department if you have any more questions or concerns.

ToxFAQs™
for
Lead

(Plomo)

CAS# 7439-92-1

This fact sheet answers the most frequently asked health questions about lead. For more information, you may call the ATSDR Information Center at 1-888-422-8737. This fact sheet is one in a series of summaries about hazardous substances and their health effects. This information is important because this substance may harm you. The effects of exposure to any hazardous substance depend on the dose, the duration, how you are exposed, personal traits and habits, and whether other chemicals are present.

HIGHLIGHTS: Exposure to lead can happen from breathing workplace air or dust, eating contaminated foods, or drinking contaminated water. Children can be exposed from eating lead-based paint chips or playing in contaminated soil. Lead can damage the nervous system, kidneys, and reproductive system. Lead has been found in at least 1,280 of the 1,662 National Priority List sites identified by the Environmental Protection Agency (EPA).

What is lead?
Lead is a naturally occurring bluish-gray metal found in small amounts in the earth's crust. Lead can be found in all parts of our environment. Much of it comes from human activities including burning fossil fuels, mining, and manufacturing.

Lead has many different uses. It is used in the production of batteries, ammunition, metal products (solder and pipes), and devices to shield X-rays. Because of health concerns, lead from gasoline, paints and ceramic products, caulking, and pipe solder has been dramatically reduced in recent years.

What happens to lead when it enters the environment?
- Lead itself does not break down, but lead compounds are changed by sunlight, air, and water.
- When lead is released to the air, it may travel long distances before settling to the ground.
- Once lead falls onto soil, it usually sticks to soil particles.
- Movement of lead from soil into groundwater will depend on the type of lead compound and the characteristics of the soil.

How might I be exposed to lead?
- Eating food or drinking water that contains lead. Water pipes in some older homes may contain lead solder. Lead can leach out into the water.
- Spending time in areas where lead-based paints have been used and are deteriorating. Deteriorating lead paint can contribute to lead dust.
- Working in a job where lead is used or engaging in certain hobbies in which lead is used, such stained glass.
- Using health-care products or folk remedies that contain lead.

How can lead affect my health?
The effects of lead are the same whether it enters the body through breathing or swallowing. Lead can affect almost every organ and system in your body. The main target for lead toxicity is the nervous system, both in adults and children. Long-term exposure of adults can result in decreased performance in some tests that measure functions of the nervous system. It may also cause weakness in fingers, wrists, or ankles. Lead exposure also causes small increases in blood pressure, particularly in middle-aged and older people and can cause anemia. Exposure to high lead levels can severely damage the brain and kidneys in adults or children and ultimately cause death. In pregnant women, high levels of exposure to lead may cause miscarriage. High-level exposure in men can damage the organs responsible for sperm production.

How likely is lead to cause cancer?

We have no conclusive proof that lead causes cancer in humans. Kidney tumors have developed in rats and mice that had been given large doses of some kind of lead compounds. The Department of Health and Human Services (DHHS) has determined that lead and lead compounds are reasonably anticipated to be human carcinogens and the EPA has determined that lead is a probable human carcinogen. The International Agency for Research on Cancer (IARC) has determined that inorganic lead is probably carcinogenic to humans and that there is insufficient information to determine whether organic lead compounds will cause cancer in humans.

How does lead affect children?
Small children can be exposed by eating lead-based paint chips, chewing on objects painted with lead-based paint, or swallowing house dust or soil that contains lead.
Children are more vulnerable to lead poisoning than adults. A child who swallows large amounts of lead may develop blood anemia, severe stomachache, muscle weakness, and brain damage. If a child swallows smaller amounts of lead, much less severe effects on blood and brain function may occur. Even at much lower levels of exposure, lead can affect a child's mental and physical growth.
Exposure to lead is more dangerous for young and unborn children. Unborn children can be exposed to lead through their mothers. Harmful effects include premature births, smaller babies, decreased mental ability in the infant, learning difficulties, and reduced growth in young children. These effects are more common if the mother or baby was exposed to high levels of lead. Some of these effects may persist beyond childhood.

How can families reduce the risk of exposure to lead?

- Avoid exposure to sources of lead.
- Do not allow children to chew or mouth painted surfaces that may have been painted with lead-based paint.
- If you have a water lead problem, run or flush water that has been standing overnight before drinking or cooking with it.
- Some types of paints and pigments that are used as make-up or hair coloring contain lead. Keep these kinds of products away from children
- If your home contains lead-based paint or you live in an area contaminated with lead, wash children's hands and faces often to remove lead dusts and soil, and regularly clean the house of dust and tracked in soil.

Is there a medical test to show whether I've been exposed to lead?
A blood test is available to measure the amount of lead in your blood and to estimate the amount of your recent exposure to lead. Blood tests are commonly used to screen children for lead poisoning. Lead in teeth or bones can be measured by X-ray techniques, but these methods are not widely available. Exposure to lead also can be evaluated by measuring erythrocyte protoporphyrin (EP) in blood samples. EP is a part of red blood cells known to increase when the amount of lead in the blood is high. However, the EP level is not sensitive enough to identify children with elevated blood lead levels below about 25 micrograms per deciliter (µg/dL). These tests usually require special analytical equipment that is not available in a doctor's office. However, your doctor can draw blood samples and send them to appropriate laboratories for analysis.

Has the federal government made recommendations to protect human health?
The Centers for Disease Control and Prevention (CDC) recommends that states test children at ages 1 and 2 years. Children should be tested at ages 3-6 years if they have never been tested for lead, if they receive services from public assistance programs for the poor such as Medicaid or the Supplemental Food Program for Women, Infants, and Children, if they live in a building or frequently visit a house built before 1950; if they visit a home (house or apartment) built before 1978 that has been recently remodeled; and/or if they have a brother, sister, or playmate who has had lead poisoning. CDC considers a lead level of 10 µg/dL to be a level of concern for children.
EPA limits lead in drinking water to 15 µg per liter.

References
Agency for Toxic Substances and Disease Registry (ATSDR). 2005. Toxicological Profile for lead. (*Draft for Public Comment*). Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

Where can I get more information?
ATSDR can tell you where to find occupational and environmental health clinics. Their specialists can recognize,

evaluate, and treat illnesses resulting from exposure to hazardous substances. You can also contact your community or state health or environmental quality department if you have any more questions or concerns.

For more information, contact:

CERTIFICATION

This Captain Jack Mill health consultation was prepared by the Colorado Department of Public Health and Environment under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with approved methodology and procedures existing at the time the health consultation was completed. Editorial review was completed by the Cooperative Agreement partner.

Jennifer Freed
Technical Project Officer
CAT, CAPEB, DHAC, ATSDR

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

Alan Yarbrough
Team Lead, CAT, CAPEB, DHAC, ATSDR