Health Consultation

Evaluation of Onsite Human Exposures to Mining Related
Contaminants in Sediment and Surface Water

CAPTAIN JACK MILL

WARD, 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:

The Colorado Department of Public Health and Environment
under cooperative agreement with the
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 Colorado Cooperative Program for Environmental Health Assessments (CCPEHA) of 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.

For additional information or questions regarding the contents of this health consultation or the Environmental Epidemiology Section, please contact the authors of this document:

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Summary and Statement of Issues

The purpose of this health consultation is to examine the potential human health risks associated with exposure to contaminants found in surface water and sediments at the Captain Jack Mill Superfund Site. The Captain Jack Mill site (CJM) is located in unincorporated Boulder County, Colorado near Ward, Colorado. The site is an abandoned mining and milling area that was added to the National Priorities List on September 29, 2003. The Colorado Department of Public Health and Environment (CDPHE) conducted a public health assessment (PHA) in 2005 under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). The PHA concluded that the site was a public health hazard to residents, workers, and recreational users based on physical hazards such as open mine shafts, sink holes, and pits. The environmental data collected at that time was not sufficient to determine the potential public health implications. It was recommended that the additional environmental data, to be collected during the Remedial Investigation and Feasibility Study (RI/FS), be reviewed in order to fill this data gap. This document is part of the follow-up activities that were recommended in the initial public health assessment on this site.

To determine the potential threats to human health from environmental media located at the CJM site, two public health consultations were planned. The first health consultation, published in 2006, examined the surface soil and ground water pathways. It was concluded that exposure to these media represents a significant public health hazard to residents and recreational users from arsenic, copper, lead, manganese, and zinc. The second health consultation (the current document) examines exposure to site-related contaminants in surface water and sediment.

After a thorough review and evaluation of the available RI/FS data at the CJM site, it is concluded that all current and future chronic exposures to iron in sediments present a public health hazard to residential and recreational children in the Big Five (BFV) and the Big Five to Captain Jack (BFC) Areas of Investigation. Incidental ingestion of iron containing sediments at the CJM site could result in minor adverse health effects such as gastrointestinal illness if the exposure assumptions used in this consultation are consistent with on-site exposures. It should also be noted that iron is an essential element, required by the human body for normal physiologic functioning and that iron deficiency is one of the most common forms of nutritional deficiency. Arsenic in sediments is the only carcinogen evaluated in this document. Exposure to arsenic in sediments is considered to constitute no apparent public health hazard, based on the maximum theoretical cancer risk estimates of about 3 excess cancer cases in 100,000 exposed people.

Intentional ingestion of surface water at the CJM site is considered a potential exposure pathway for permanent and temporary residents because the drinking water source for all residents is not known. If residents were using surface water for potable purposes, the concentrations of copper, iron, and manganese would present a public health hazard. However, some uncertainty exists with these conclusions since the drinking water source for all residents has not been determined. Furthermore, it is concluded that all current and future acute exposures of 1-day duration to copper in surface water and sediments in the Big Five Area of Investigation (AIs) constitute a public health hazard to residents, recreational visitors, and outdoor workers. These conclusions are based on the estimated exposure doses exceeding less serious gastrointestinal health effect levels in humans (e.g., nausea, vomiting, and /or abdominal pain). However, these conclusions are associated with some uncertainty. The exposure point concentrations are biased high by sampling from mine drainage and the settling pond, areas not expected to be used as a drinking water source. In addition, the default exposure assumption for acute soil ingestion was used to evaluate sediments in lieu of an alternative default value for sediments. It is unlikely, but possible, that children would ingest 400 mg of sediment in a day. Another area of uncertainty is if the form of copper that was used in the critical study is the same as the form of copper that exists on the CJM site.

Past exposures (before the collection of RI/FS data) to all residents, recreational visitors, and outdoor workers are considered to constitute an indeterminate public health hazard due to an insufficient amount of environmental data to evaluate health risks (See ATSDR 2005).

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 and History

The Captain Jack Mill site is a former mining and milling operation, which operated intermittently from the late 1800s through 1995. The former mines and mill that compose the CJM site are positioned along the banks of Left Hand Creek, a perennial stream that serves as a source of drinking water and agricultural irrigation for the downstream population. The site consists of numerous source/waste areas from prior operations, which contain high levels of heavy metals. One of the major contributors of environmental contamination is the Big Five adit drainage. The other major source of environmental contamination at the CJM site is numerous waste rock and tailings piles scattered throughout the site. The CJM site was added to the National Priorities List on September 29, 2003, primarily due to the potential effect of the contamination on the local environment and ecology.

Acid mine drainage flows from the portal of the Big Five Adit, across the Big Five tailings pile and into a settling pond at the base of the tailings pile. The settling pond overflow traverses a wetland area and joins Left Hand Creek near the mill site (Figure 1). The drainage is acidic in nature, which is formed by a chemical reaction between water, oxygen, and sulphite ores. Metals found in rock and waste rock will readily dissolve into acidic solution where they can then be transported through the environment. The adit drainage is highly oxidized, brightly colored, and contains heavy metal contamination. At the confluence with Left Hand Creek, the drainage appears clear, which indicates the drainage has deposited a large amount of sediment up gradient of this point. A collapse was discovered in the Big Five adit during the Remedial Investigation. Behind the collapse, a pool of mine drainage nearly eight feet deep existed. The pool was drained in the spring of 2007 by the EPA Emergency Response Branch and no longer remains a threat to blow out.

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 focuses on human exposures via the surface water and sediment pathways. Surface soil and ground water exposures were addressed in a previous health consultation.

As mentioned above, Left Hand Creek is used as a drinking water source for the downstream population of approximately 18,000 individuals. This evaluation focuses only on the surface water exposures at the CJM site since a number of off-site metal loading sources exist in the Lefthand Watershed. The Lefthand Watershed Oversight Group (LWOG) was established to study the Lefthand Watershed and establish future directions for remediation as a whole. LWOG has documented many of the metal loaders located throughout the watershed (visit lwog.org for more information). The Loder Smelter, located only a couple hundred yards from the distal extent of the site is a documented metal loader to Left Hand Creek. Thus, delineating the impact of the CJM site from the rest of the metal sources is outside the scope of this evaluation.

In addition, Left Hand Creek is listed on the state's 303(d) list of impaired water bodies for not supporting aquatic life. Three fish samples were collected after numerous attempts during the RI. Fish are not evaluated in this assessment due to the very low sample number and the limited possibility that individuals can catch and consume edible size fish at the CJM site.

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 evaluation. Figure 1 is an aerial photograph of the CJM site depicting the location of each AI.

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.

Approximately 12-24 people are living in close proximity to the CJM site in the California Gulch. There are approximately 5 permanent dwellings located in the gulch that are occupied year round. In addition, a seasonal population of approximately 10 individuals also exists. This population utilizes temporary housing such as buses, campers, tents, and other makeshift dwellings for shelter. Individuals living on California Gulch Rd. likely have the highest probability of exposure.

According to Census 2000 data, there are 169 and 205 individuals living in Ward and Jamestown/Rowena, respectively. People living in Ward and Jamestown/Rowena may visit the site on a regular basis for recreational purposes, such as hiking or camping. More detailed demographic information on these communities is available in Appendix A.

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 more detail in

Appendix A. 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.
- Residents think that the EPA and CDPHE have "created confusion about the immediate health risks", and 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

Data Used

The data used in this health consultation was collected in 2004 and 2005 for the RI phase of Superfund remediation by Walsh Environmental Engineers. Surface water and sediment samples were gathered from each of the 5 previously described Areas of Investigation. Mine water was also collected from the Big Five adit (tunnel), the Black Jack adit, and the White Raven mine tunnel. The mine water encountered in the Black Jack adit and the White Raven tunnel showed no evidence of acid mine drainage and was not discharging to the outdoor environment during mining reconnaissance conducted for the RI. It is unlikely that water contained within the mine shafts would be encountered on a regular basis by residents and recreational users. Therefore, the mine water data collected from the Black Jack adit and White Raven mine tunnel is not considered to represent a significant exposure pathway in this evaluation and efforts were focused on mine water in Big Five adit, which is known to discharge beyond the portal of the adit. Each data set used in this consultation is discussed in greater detail below.

Surface Water

Surface Water samples were collected on 5 occasions between 2004 and 2005. Samples were collected during high and low flow seasons to determine seasonal variance of contaminant levels. The samples were analyzed for TAL metals, alkalinity, hardness, and sulfates (Walsh 2006). In addition, Wet Chemistry data, including nitrates/nitrites, fecal coliform, total suspended solids and total dissolved solids, were also collected for surface water samples. Surface water samples were collected from Left Hand Creek, the Big Five Adit Drainage, the settling pond, located in the Big Five AI; and the wetland area below the settling pond. Grab samples were collected from each sampling location and the GPS coordinates were recorded at the time of sampling. Results were reported for total and dissolved metals. However, only total metal results were used in this evaluation. Evaluating total metals is a conservative approach because total metal concentrations are generally higher than the dissolved fraction metals. A total of 49 surface water samples were collected from 11 sampling locations throughout the site for the RI. Summary statistics on the surface water results for total metals are listed in Appendix Table B1.

Sediment

Sediment sampling initially began in September 2004 and was then conducted at the same time that surface water samples were being collected thereafter. However, not all locations were sampled on each sampling event. Sediment samples were collected as grab samples and were analyzed for TAL metals. Two sediment samples were also analyzed for organic compounds such as polychlorinated biphenyls, pesticides, and polycyclic aromatic hydrocarbons. These contaminants were not found to be of potential concern and are not further evaluated in this document. Effort was made to collect sediment samples from deposition pools that contained a large amount of sediment. A total of 127 samples were analyzed for TAL metals from 31 sampling locations. Sediment samples roughly coincided with surface water locations and were primarily collected from Left Hand Creek, the Big Five drainage, the settling pond, and the wetland area below the settling pond. Summary statistics on the sediment sampling results are listed in Appendix Table B2.

Exposure Evaluation

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 the Colorado Cooperative Program for Environmental Health Assessments (CCPEHA) of CDPHE 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 potential concern and completed exposure pathways are discussed further in the section below.

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). The screening or comparisons values (CVs) used in this assessment are the Environmental Protection Agency's (EPA) Region 9 Preliminary Remediation Goals (PRG) for water and soil ingestion (EPA 2004). Soil PRG values were used to evaluate sediment samples because no approved sediment screening values exist. This is a conservative assumption since it is unlikely that individuals will ingest as much sediment as soil, based on the relative volume and transferability of soils compared to sediment.

PRGs are conservative, health-based environmental guidelines that consider carcinogenic and non-cancer health effects from exposure to contaminants through a variety of exposure pathways from each specific type of media. PRGs are the standard comparison value used at the CDPHE and in EPA Region 8 risk assessment. Adverse health effects are not expected to occur below the PRG values. In accordance with the CDPHE and EPA Region 8 protocol for the selection of COPCs, if multiple contaminants exist on-site, the PRG values are multiplied by 0.1 (EPA, 1994). For non-carcinogenic contaminants, multiplying the PRG by 0.1 is thought to account for any additive adverse effects from multiple chemicals. Contaminants that do not exceed the respective CV are dropped from further analysis since they are unlikely to result in adverse health effects. Surface water and sediment COPCs are discussed in greater detail below. For a detailed account of the derivation of PRGs, see http://www.epa.gov/region09/waste/sfund/prg/index.html.

Surface Water

COPCs were found in each area of investigation at the CJM site including background samples not thought to be associated with site-related contamination. Some contaminants were not detected in the sample, but are identified as COPCs based on the surrogate value for non-detects of ½ the reporting limit exceeding the CV. If the contaminant was detected in less than 5% of the samples, it is not retained for further examination as a contaminant of potential concern. Under these stipulations, no COPCs were detected in background samples. However, ½ the reporting limits for arsenic, antimony, cadmium, and thallium exceeded the respective CV. These chemicals were not considered further in this evaluation as COPCs. Based on the maximum detected concentration of contaminants, site-wide surface water COPCs include antimony, cadmium, cobalt, copper, manganese, thallium, vanadium, and zinc. These are listed in Table 1 by area of investigation. A few of the COPCs listed in Table 1 were not retained further due to a low detection frequency and/or the selection of the COPCs based on ½ the reporting limit of the analytical method (See Table 1 Notes).

Sediment
Contaminants of potential concern were also found in sediment samples collected from each AI, including background samples. Overall, antimony, arsenic, chromium, copper, iron, lead, manganese, thallium, and vanadium were selected as COPCs based on the maximum detected concentration. Antimony, arsenic, iron, manganese, and vanadium were also detected in background samples, which could indicate that some of the contamination found in on-site sediments might be due to natural release from rock and soils. However, a comparative analysis of site-related contamination and background samples is not possible due to the limited number of background samples currently available. Site-specific COPCs found in sediment samples per AI are listed in Table 2.

Conceptual Site Model

A conceptual site model identifies the 5 components of an exposure pathway. Surface water and sediment are the primary environmental media of concern in this health consultation. Other media such as surface soil and groundwater have been evaluated in a separate health consultation, published in 2006. The conceptual site model for surface water and sediment is presented below.

Four primary routes of exposure to contaminants in sediment and surface water at the CJM site are possible: intentional ingestion of surface water, incidental ingestion of surface water during swimming/wading, dermal contact with contaminants in sediment and surface water; and incidental ingestion of sediment. Dermal contact with metals is considered a relatively insignificant exposure pathway in comparison to the ingestion pathway due to the limited ability of metal contaminants to cross the skin barrier and enter the bloodstream. Therefore, dermal contact with metals in surface water and sediment is not quantitatively addressed in this evaluation.

Four primary receptor populations of concern were identified in this evaluation: permanent residents, temporary residents, recreational users, and outdoor workers. Each receptor population is described in more detail below.

Permanent Residents

As mentioned earlier in this document, approximately 15 individuals live in the California Gulch near the CJM site. It is not likely that permanent residents use surface water at the site for potable use. However, the water supply for each resident has not been determined and it is possible that permanent residents use portions of Left Hand Creek for potable use at times. This pathway is considered potential since the actual drinking water source of each permanent resident is unknown and the ingestion of surface water by permanent residents is highly uncertain. Permanent residents are likely to come into contact with contaminated surface water and sediments during domestic and/or recreational activities at the CJM site. Contaminated surface water is found throughout the site near the residential properties. Incidental ingestion of surface water and sediments are considered complete exposure pathways.

Temporary Residents

A small group of individuals have traditionally used the CJM site as a temporary residence during the warmer months of the year (April-September). This group utilizes campers, buses, sheds, tents, and old mine buildings for shelter. No plumbing for potable use water exists for this population. The water source of temporary residents is unknown. Due to the limited number of alternate drinking water supplies in the area, it is possible that surface water is being used at the site for drinking water and other potable uses. This is of particular concern for incoming temporary residents that may not be aware of the contamination at the site. Intentional ingestion of surface water by temporary residents is considered a potential pathway since the water source has not been defined and it is unknown if this population actually uses surface water at the CJM site for potable use.

Similar to permanent residents, temporary residents will also come into contact with contaminated surface water and sediments during domestic and/or recreational activities while living at the CJM site. Incidental ingestion of surface water and sediments by temporary residents are considered complete exposure pathways.

Recreational Users

Recreational use at the site includes hiking, biking, and camping. Campers and other recreational users may use surface water at the CJM site for potable use during these activities. Although some uncertainty exists with the actual use of surface water by recreational users, this pathway is considered complete based on the increased likelihood that it actually occurs.

Individuals may also be exposed to site contaminants from the incidental ingestion of sediments and surface water during hiking, camping, wading, and other recreational activities. Incidental ingestion of sediments and surface water are considered complete exposure pathways.

Outdoor Worker

Future outdoor workers were also identified as a receptor population of potential concern. Outdoor workers could be carpenters, road builders, landscapers, and other types of construction workers that are on site for only short periods of time (<2 yrs.), but are of concern due to the soil intrusive nature of their work. To date, no construction activities have been observed at the CJM site. However, construction activities could occur in the future. Intentional and incidental ingestion of surface water and incidental ingestion of sediments by future outdoor workers are considered potential exposure pathways.

The table below summarizes the conceptual site model for the surface water and sediment exposures at CJM site.

Conceptual Site Model

Source	Transport Mechanism	Point of Exposure	Affected Environmental Medium	Timeframe of Exposure	Potentially Exposed Population	Route of Exposure	Pathway Status
Mine Workings	Anthropogenic, Big Five Adit, Runoff, and Left Hand Creek	All Exposure Areas of Investigation (Mine drainage areas, Tailings Pond, and Left Hand Creek)	Surface Water and Sediment	Past, Current, Future	Permanent and Temporary Residents	Intentional Ingestion of Surface Water	Potential
						Dermal Contact with Surface Water and Sediment	Complete
						Incidental Ingestion of Sediment and Surface Water	Complete
					Recreational User	Intentional Ingestion of Surface Water	Complete
						Dermal Contact with Surface Water and Sediments	Complete
						Incidental Ingestion of Sediment and Surface Water	Complete
					Future Outdoor Workers	Intentional Ingestion of Surface Water	Potential
						Dermal Contact with Surface Water and Sediments	Potential
						Incidental Ingestion of Sediment and Surface Water	Potential

Public Health Implications

In order to determine the public health implications of exposure to COPCs that exceed the CVs for the surface water and sediment exposure pathways, exposure doses are calculated for the recreational, residential, and outdoor worker exposure scenarios. The resulting doses are compared to the appropriate cancer and noncancer health-based guidelines. The exposure dose for each COPC is divided by the appropriate health-based guidelines to produce a Hazard Quotient (HQ). HQs greater than 1.0 warrant further investigation while HQs less than 1 are not considered to represent a public health hazard. Additional information on exposure dose calculations is presented in Appendix C. A toxicological evaluation, which describes the health-based guidelines and other values used in this evaluation, is provided in Appendix D. The results of the health risk calculations for surface water and sediment are presented in Tables 3 to 7 for chronic (long-term) exposures and in Tables 8 and 9 for acute (1-day) exposures.

Permanent Residents

Chronic incidental ingestion of surface water and sediment was evaluated as a complete exposure pathway for both children and adults. The exposure doses were calculated assuming that residents inadvertently ingest a small amount of surface water (50 ml) for 104 days per year over 30 years. Under these assumptions, no adverse health effects are likely to occur since all of health guideline based HQs for COPCs are well below 1.0 (Table C7). The complete exposure assumptions made in this evaluation can be found in Tables C1-C4.

Chronic intentional ingestion of surface water is considered a potential exposure pathway for permanent residents. COCs for permanent adult residents include antimony, copper, manganese, and vanadium (Table 4). For permanent child residents, iron was also identified as a COC in addition to the adult COCs. The estimated exposure doses were compared to known adverse health effect levels such as the No-Observed-Adverse-Effect-Level (NOAEL) and Lowest-Adverse-Effect-Level (LOAEL), identified by ATSDR and/or EPA IRIS. The NOAEL values of 0.0272 mg/kg/day for copper (Pizarro et al., 1999 cited in ATSDR 2004) and 0.14 mg/kg/day for manganese (EPA IRIS) are exceeded for the adult resident, but the LOAEL values were not exceeded for these contaminants (Table 5). The estimated exposures for intentional ingestion of surface water by permanent residential children exceed the LOAEL values for copper, iron, and manganese (Table 5). Therefore, if permanent residents were using surface water for drinking water purposes, they would likely experience less serious adverse health effects such as gastrointestinal distress from copper and iron. It is, however, important to note that iron is an essential nutrient, required by the human body for normal function. Iron deficiency is one of the most common forms of nutritional deficiency known to occur in the human population.

A number of uncertainties exist in the health hazard evaluation of manganese in surface water at the CJM site. For instance, it is suggested that Mn is more bioavailable in water than food. Another confounding factor is the amount of manganese ingested through the individual diet, which appears to vary amongst the general population. Furthermore, a LOAEL value has not been established in the EPA's IRIS. One study, cited by the National Academy of Science (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 calculation for chronic incidental ingestion of sediments during the daily activities of residents assumes adults and children ingest 100 mg and 200 mg, respectively. Under these assumptions, based on the exceedance of health guidelines, copper, iron, and thallium were identified as non-cancer contaminants of concern (COCs) for permanent child residents in the BFV and BFC Areas of Investigation (AIs) (Table C6). The estimated exposure dose for incidental ingestion of sediments by permanent residential children exceeds the LOAEL value for iron in both the BFV and BFC AIs (Table 7). At this dose, less serious adverse health effects such as gastrointestinal distress could occur.

Arsenic is the only carcinogen that exceeded the health based guideline at the CJM site and it was only found in sediment. An age-adjusted equation, which accounts for 30 yrs of exposure to arsenic in sediments from the time of birth to the age of 30, was used to evaluate carcinogenic health risks. The resulting theoretical carcinogenic risks range from $1.6 * 10^{-5}$ in the BFV AI to $3.1 * 10^{-5}$ in the WHR AI, which literally means that 1.6-3.1 excess cancer cases out of 100,000 people could be expected from exposure to arsenic at the site (Table 3 and C6). The theoretical cancer risk estimates at the CJM site exceed CDPHE’s target risk level of $1 * 10^{-6}$ or 1 excess cancer case per 1,000,000 people. The EPA considers the acceptable cancer risk range of $1*10^{-4} – 1*10^{-6}$. Therefore, theoretical cancer risk estimates from exposure to arsenic in sediments are not likely to pose a significant health risk. However, to achieve CDPHE’s target risk level, either continued monitoring of arsenic in sediments or remediation should be conducted. Arsenic concentrations in sediment are below non-cancer health-based guidelines. Thus, non-cancer adverse health effects are not likely to occur from exposure to sediments at the CJM site.

Temporary Residents

Incidental ingestion of surface water and sediments are complete exposure pathways for temporary residents. Since incidental ingestion of surface water is not a concern for permanent residents, it is not likely to be a concern for temporary residents who are exposed for a shorter period of time. Thus, incidental ingestion of surface water was not evaluated further for these individuals.

Chronic intentional consumption of surface water by temporary residents was quantitatively evaluated as a potentially complete exposure pathway since no evidence exists that temporary residents actually use on-site surface water. Drinking water consumption of 1L/day (child) and 2L/day (adult) for 175 days/year over 5 years was used to estimate exposure doses. Antimony, copper, manganese, and thallium were identified as COCs for temporary adult residents (Table 4). Iron in surface water also exceeded the health-based guideline for temporary residential children in addition to the adult COCs. The estimated exposure doses for temporary adult residents exceed the NOAEL value for copper in BFV AI, but do not exceed the LOAEL value (Table 6). The estimated exposure doses for temporary residential children exceed the NOAEL values for copper, iron, and manganese in the BFV AI and copper in the BFC AI. In addition, these doses also exceed the LOAEL values for copper and manganese in the BFV AI (Table 6). If temporary residential children are using surface water for potable use at the

CJM site, less serious adverse health effects such as gastrointestinal distress from copper and iron could occur. The uncertainty associated with manganese effects is already discussed above.

Exposure doses for incidental ingestion of sediments by temporary residents were calculated assuming that the exposure occurs less frequently and for a shorter duration than permanent residents. Generally speaking, non-cancer risks to temporary residents are approximately one-half that of permanent residents. The assumptions for temporary adult residents are 100 mg of sediment/day, 175-days/ year, for a 5-year period. Temporary residential children were evaluated with the same assumption with the exception of 200 mg of sediment ingested per day. Under these assumptions, iron and thallium exceeded the health-based guidelines for children in the BFV and BFC AIs (Table C6). Iron was the only contaminant to exceed known health effect levels including the NOAEL and LOAEL values in the BFV and BFC AIs (Table 7). At this exposure level, less serious adverse health effects such as gastrointestinal distress are likely to occur from exposure to iron in sediments. Theoretical cancer risks from exposure to arsenic in sediments were not estimated for temporary residents since the theoretical cancer risk estimates for permanent residents are not likely to pose significant concern for cancer.

Recreational Users

Chronic recreational exposures include incidental ingestion of surface water and sediment and intentional ingestion of surface water as complete pathways. The exposure assumptions used in the recreational calculations account for 52 days/year of exposure or, on average, 1 day per week over a period of 30-years. The sediment and surface water ingestion rates used for the recreational population are the same as the residential users. Incidental ingestion of surface water during swimming/wading was not quantitatively evaluated for recreational users because it was not a concern for permanent residents that are exposed more frequently over longer periods of time than recreational users.

A number of COCs were identified for child recreational users that intentionally drink surface water at the CJM site including copper, manganese, and thallium (Table C5). Copper was the only COC that was identified for adult recreational users. The estimated exposure doses were compared to known adverse health effect levels for these contaminants and all estimated doses for surface water consumption are below the health effect levels, except for copper the NOAEL HQ is 0.9 for recreational children. Thus, less serious gastrointestinal health effects could occur.

The estimated exposure doses for the incidental ingestion of sediments during recreational use exceed the health-based guidelines for iron and thallium in the BFV AI for children (Table C6). All adult exposure doses had HQs less than 1 and are not likely to result in adverse health effects. The estimated exposure doses for recreational children exceed the NOAEL value for iron in the BFV AI, but not the LOAEL value (Table 7). Theoretical cancer risks from exposure to arsenic in sediments range from $2.3 * 10^{-6} – 4.6 * 10^{-6}$ using the age-adjusted equation (Table 3). These risks are above CDPHE's target risk level, but are within the EPA acceptable cancer risk range. Thus, continued monitoring and/or remediation may be necessary to achieve the target cancer risk level of $1 * 10^{-6}$.

Outdoor Workers

Intentional ingestion of surface water and incidental ingestion of sediments are considered potentially complete exposure pathways for future outdoor workers. It is assumed that outdoor workers may be on-site for only short periods of time (250 days/year for 2 years). COCs for the intentional consumption of surface water include antimony, copper, manganese, and thallium (Table 4). The estimated exposure doses for all COCs are below known adverse health effect levels with the exception of copper. The copper dose for outdoor workers exceeds the NOAEL, but is below the LOAEL value for this contaminant and could result in mild adverse effects such as gastrointestinal distress, as already discussed above for other receptors.

For incidental ingestion of sediment, it is assumed that outdoor workers will ingest larger quantities of sediment (330 mg/day) due to the soil intrusive groundwork typical of an outdoor worker. Under these assumptions, iron and thallium were the only COCs identified from exposure to sediments at the CJM site (Table 3). However, the estimated exposure doses for incidental ingestion of sediments by outdoor workers do not exceed known health effect levels for iron or thallium. Theoretical cancer risk estimates to outdoor workers ranged from $9.4 * 10^{-7} – 1.8 *10^{-6}$ (Table C6). These risks are only slightly above CDPHE's target cancer risk level and are not considered significant.

Acute Health Hazards for All Receptor Populations

Acute health hazards exposures are evaluated over a short period of time (1-day) and could apply to all of the previously described receptors (e.g., Permanent/temporary residents, recreational users, and outdoor workers). Acute exposures to copper were evaluated for adults and children for surface water exposures and for children for sediment exposures.

Acute intentional ingestion of surface water exceeds the NOAEL and LOAEL values for both adults and children. The highest NOAEL and LOAEL HQs were estimated in the BFV AI, followed by the BFC AI (Table 8). The acute NOAEL value for copper (Cu) is based on a 2-week exposure study conducted by Pizarro et al (1999). In this study, gastrointestinal symptoms (e.g., nausea, vomiting, and/or abdominal pain) were observed in humans orally exposed to 0.0731 mg Cu/kg-day and 0.124 mg Cu/kg-day of copper sulfate in drinking water, but not at 0.0272 mg Cu/kg-day. The highest estimated exposure dose from surface water ingestion at the CJM site is 0.17 mg/kg-day (child residents, BFV AI). As such, copper exposures to residents, recreational visitors, and construction workers from surface water consumption at the CJM site are considered a public health hazard, especially, in the Big Five AI for acute exposure duration of 1-day. These findings are based on the conservative exposure assumptions of 1L/day (child) and 2 L/day (adult) intentional consumption of surface water for drinking purposes and the use of the maximum detected concentration of copper as the exposure point concentration (as a result of small sample size). It is important to note that the surface water data is somewhat skewed in the BFV and BFC AIs due to the inclusion of adit drainage and the settling pond in the data set. Therefore, it is more realistic to assume the mean concentration of copper in the surface water as the point of contact for drinking purposes, which is not likely to result in significant non-cancer adverse health effects. Moreover, the actual use of surface water for drinking purposes by recreational visitors or residents has not been determined.

The exposure dose for acute exposure to sediments assumes children could ingest 400 mg of sediment in a single day. Based on these assumptions, acute exposures to copper in sediment exceed the NOAEL value in the BFV AI, but not the LOAEL values (Table 9). Adverse health effects such as gastrointestinal distress for copper and iron (as described above for surface water) are likely to occur under the conservative exposure assumptions (400 mg of soil ingestion in one day) used for residents and recreational visitors in this evaluation. Furthermore, short-term non-cancer health hazards for copper in sediments may be of potential concern for residential and recreational children based on the exceedance of ATSDR pica comparison value. However, it should be noted that pica behavior (ingestion of 5,000 mg/day) and/or acute exposures (400mg in one day) for sediments is possible, but not likely to occur.

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.

Child receptors were included in this evaluation and were found to be most likely to experience adverse health effects. Both non-cancer and cancer endpoints were examined with exposure assumptions appropriate for children. Children should not drink water from surface waters found at the CJM site including Left Hand Creek and the mine drainage areas. In addition, frequent exposure to sediments in the creek and deposition pools is likely to result in adverse health effects for children due to the increased hand-to-mouth activity typical of children's behavior.

Conclusions

Based on a thorough review and evaluation of the available RI/FS data for sediments and surface water at the CJM site, it is concluded that all current and future chronic exposures to iron in sediments present a public health hazard to residential, and recreational children at the Big Five (BFV) and the Big Five to Captain Jack (BFC) Areas of Investigation. Minor health effects such as gastrointestinal illness are likely to occur to these receptors under the exposure assumptions used for this evaluation. Arsenic in sediments is the only carcinogen evaluated in this document Exposure to arsenic in sediments is considered to constitute a no apparent public health hazard, based on the theoretical cancer risk estimates of about 3 excess cancer cases in 100,000 exposed people.

Intentional ingestion of surface water at the CJM site is considered a potential exposure pathway for permanent and temporary residents because the drinking water source for all residents is not known. If residents are using surface water for potable purposes, the concentrations of copper, iron, and manganese pose a public health hazard. However, some uncertainty exists with these conclusions since the drinking water source for all residents has not been determined.

Furthermore, it is concluded that all current and future acute exposures of 1-day duration to copper in surface water and sediments in the Big Five Area of Investigation (AIs) constitute a public health hazard to residents, recreational visitors, and construction workers. These conclusions are based on the exceedance of less serious gastrointestinal effect (e.g., nausea, vomiting, and /or abdominal pain) levels in humans from exposure to copper sulfate containing drinking water. However, these conclusions are associated with some uncertainty. The exposure point concentrations are biased high by sampling from mine drainage and the settling pond areas, which are not likely to be used as a drinking water source. It is also unknown if the form of copper that was used in the critical study is the same as the form of copper that exists on the CJM site. Another area of uncertainty is that incidental ingestion of 400 mg of sediment per day (for acute exposures) is possible, but not likely to occur.

The past exposures (before the collection of RI/FS data) to all residents, recreational visitors, and construction workers are considered to constitute an indeterminate public health hazard due to a lack of data (See PHA).

Recommendations

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

- CDPHE and EPA should progress with the proposed remedial actions for reducing or eliminating exposures.

- In the interim, reduce or eliminate exposure of children and adults to contaminated surface water and sediments by using appropriate reduction methods: restricting access to highly contaminated areas and installing signs to warn visitors and residents of potential public health hazards in highly contaminated areas.

- In addition, CCPEHA should try to identify the drinking water source for all area residents to ensure that individuals are not drinking water from Left Hand Creek in areas adjacent to the CJM site.

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. The CCPEHA of 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:

- The CCPEHA conducted a public health assessment on this site in 2005. It was determined at that time that the site posed a public health hazard to residents and recreational users due to physical hazards such as mine openings and pits. Environmental data could not be characterized.

- Additional environmental data was collected during the Remedial Investigation and Feasibility Study. The CCPEHA reviewed this data to determine the public health implications of environmental exposures to surface soils and groundwater at the CJM site (published 2006).

- The CCPEHA has installed signs to warn visitors and residents of potential public health hazards in areas of highly contaminated surface soils.

Future Activities:

- 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.

- CDPHE and EPA will modify the current sign that has been placed at the CJM site to include public health hazards associated with surface water and sediments.

- The CCPEHA will conduct the appropriate health education activities including the presentation of the findings of this health consultation in a public meeting, distributing the document to the information repositories, and the production of fact sheets to relay this information to the public.

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Tables and Figures

Table 1. Summary of Site-Specific Surface Water Contaminants of Potential Concern

Area of Investigation	Contaminant of Potential Concern	Notes
BFV	Aluminum, Antimony, Arsenic, Cadmium, Cobalt, Copper, Iron, Manganese, Nickel, Thallium, Vanadium, Zinc	Antimony, arsenic, thallium, and vanadium were identified as COPCs based on ½ the reporting limit of the analytical method exceeding the CV. Antimony and Arsenic were not detected and will be dropped from further analysis.
BFC	Aluminum, Antimony, Arsenic, Cadmium, Copper, Manganese, Thallium, Vanadium	Antimony, arsenic, thallium, and vanadium were identified as COPCs based on ½ the reporting limit of the analytical method exceeding the CV. Arsenic was not detected in this AI and will be dropped from further evaluation.
CJM	Antimony, Arsenic, Cadmium, Copper, Manganese, Thallium, and Vanadium	Antimony, arsenic and thallium, and vanadium were identified as COPCs based on ½ the reporting limit of the analytical method exceeding the CV. Arsenic was not detected and will be dropped from further analysis.
WHR	Antimony, Arsenic, Cadmium, Manganese, and Thallium	Antimony, arsenic and thallium were not detected in WHR, but were identified as COPCs based on ½ the reporting limit of the analytical method exceeding the CV. All will be dropped from further evaluation.
WRS	Antimony, Arsenic, Cadmium, Manganese, Thallium, and Vanadium	Antimony, arsenic and vanadium were identified as COPCs based on ½ the reporting limit of the analytical method exceeding the CV. Arsenic was not detected and will be dropped from further evaluation.

Table 2. Summary of Site-Specific Sediment Contaminants of Potential Concern

Area of Investigation	Contaminant of Potential Concern	Notes
BFV	Aluminum, Antimony, Arsenic, Cadmium, Chromium, Copper, Iron, Lead, Manganese, Thallium, and Vanadium	All COPCs were detected above the CV.
BFC	Aluminum, Antimony, Arsenic, Chromium, Copper, Iron, Lead, Manganese, Thallium, and Vanadium	All COPCs were detected above the CV.
CJM	Antimony, Arsenic, Cadmium, Chromium, Copper, Iron, Lead, Manganese, Thallium, and Vanadium	All COPCs were detected above the CV.
WHR	Antimony, Arsenic, Cadmium, Chromium, Copper, Iron, Lead, Manganese, Thallium, and Vanadium	All COPCs were detected above the CV.
WRS	Aluminum, Antimony, Arsenic, Cadmium, Chromium, Copper, Iron, Lead, Manganese, Thallium, Vanadium, and Zinc	All COPCs were detected above the CV.

Table 3. Summary of Chronic, Health Guideline-based Hazard Quotients (HQ) and Theoretical Cancer Risks from Incidental Ingestion of Sediment by all Receptors

Area of Investigation	COC	Receptor	HQ Health Guideline	Cancer Risk
BFV	Copper	Permanent Child Resident	1.8	NA
BFV	Iron	Permanent Child Resident	7.7	NA
		Temporary Child Resident	3.9	NA
		Child Recreation	1.2	NA
		Construction Worker	2.0	NA
BFV	Thallium	Permanent Child Resident	8.3	NA
		Temporary Child Resident	4.2	NA
		Child Recreation	1.2	NA
		Construction Worker	2.1	NA
BFV	Arsenic (cancer)	Age-Adjusted Resident	NA	$1.6 * 10^{-5}$
		Age-Adjusted Recreation	NA	$2.4 * 10^{-6}$
		Construction Worker	NA	$9.4 * 10^{-7}$
BFC	Copper	Child Resident	1.2	NA
BFC	Iron	Permanent Child Resident	3.4	NA
		Temporary Child Resident	1.7	NA
BFC	Thallium	Permanent Child Resident	3.1	NA
		Temporary Child Resident	1.5	NA
BFC	Arsenic (cancer)	Age-Adjusted Resident	NA	$2.4 * 10^{-5}$
		Age-Adjusted Recreation	NA	$3.6 * 10^{-6}$
		Construction Worker	NA	$1.4 * 10^{-6}$
CJM	Arsenic (cancer)	Age-Adjusted Resident	NA	$2.4 * 10^{-5}$
		Age-Adjusted Recreation	NA	$3.6 * 10^{-6}$
		Construction Worker	NA	$1.4 * 10^{-6}$
WHR	Arsenic (cancer)	Age-Adjusted Resident	NA	$3.1 * 10^{-5}$
		Age-Adjusted Recreation	NA	$4.6 * 10^{-6}$
		Construction Worker	NA	$1.8 * 10^{-6}$
WRS	Copper	Permanent Child Resident	1.0	NA
WRS	Arsenic (cancer)	Age-Adjusted Resident	NA	$2.3 * 10^{-5}$
		Age-Adjusted Recreation	NA	$3.4 * 10^{-6}$
		Construction Worker	NA	$1.4 * 10^{-6}$

Table 4. Summary of Chronic Non-cancer, Health Guideline-based, Hazard Quotients (HQ) from Intentional Ingestion of Surface Water by all Receptors

AI	COC	Receptor	HQ Health Guideline
BFV	Copper	Permanent Child Resident	15.98
		Permanent Adult Resident	6.85
		Temporary Child Resident	8.00
		Temporary Adult Resident	3.43
		Child Recreation	2.37
		Adult Recreation	1.02
		Construction Worker	4.89
BFV	Iron	Permanent Child Resident	2.27
		Temporary Child Resident	1.14
BFV	Manganese	Permanent Child Resident	8.55
		Permanent Adult Resident	3.67
		Temporary Child Resident	4.28
		Temporary Adult Resident	1.83
		Child Recreation	1.27
		Construction Worker	2.62
BFV	Thallium	Permanent Child Resident	12.11
		Permanent Adult Resident	5.19
		Temporary Child Resident	6.06
		Temporary Adult Resident	2.60
		Child Recreation	1.80
		Construction Worker	3.71
BFV	Vanadium	Child Resident	1.60
BFC	Antimony	Permanent Child Resident	4.79
		Permanent Adult Resident	2.05
		Temporary Child Resident	2.40
		Temporary Adult Resident	1.03
		Construction Worker	1.47
BFC	Copper	Permanent Child Resident	7.86
		Permanent Adult Resident	3.37
		Temporary Child Resident	3.94
		Temporary Adult Resident	1.69
		Child Recreation	1.17
		Construction Worker	2.41
BFC	Manganese	Permanent Child Resident	3.91
		Permanent Adult Resident	1.68
		Temporary Child Resident	1.96
		Construction Worker	1.20
BFC	Thallium	Permanent Child Resident	12.11
		Permanent Adult Resident	5.19
		Temporary Child Resident	6.06
		Temporary Adult Resident	2.60
		Child Recreation	1.80
		Construction Worker	3.71
BFC	Vanadium	Child Resident	1.60

Table 4 (cont.). Summary of Chronic Non-cancer, Health Guideline-based, Hazard Quotients (HQ) from Intentional Ingestion of Surface Water by all Receptors

AI	COC	Receptor	HQ Health Guideline
CJM	Antimony	Permanent Child Resident	4.79
		Permanent Adult Resident	2.05
		Temporary Child Resident	2.40
		Temporary Adult Resident	1.03
		Construction Worker	1.47
CJM	Copper	Child Resident	1.43
CJM	Thallium	Permanent Child Resident	12.11
		Permanent Adult Resident	5.19
		Temporary Child Resident	6.06
		Temporary Adult Resident	2.60
		Child Recreation	1.80
		Construction Worker	3.71
CJM	Vanadium	Child Resident	1.60
WRS	Antimony	Permanent Child Resident	4.79
		Permanent Adult Resident	2.05
		Temporary Child Resident	2.40
		Temporary Adult Resident	1.03
		Construction Worker	1.47
WRS	Thallium	Permanent Child Resident	12.11
		Permanent Adult Resident	5.19
		Temporary Child Resident	6.06
		Temporary Adult Resident	2.60
		Child Recreation	1.80
		Construction Worker	3.71
WRS	Vanadium	Child Resident	1.60

Table 5. Summary of Chronic Non-cancer, Health Effects-based, Hazard Quotients (HQs) for Intentional Ingestion of Surface Water by Permanent Residents

AI	Contaminant	Estimated Dose (mg/kg-day)		NOAEL (mg/kg-day)	NOAEL based HQ		LOAEL (mg/kg-day)	LOAEL based HQ	
		Child	Adult		Child	Adult		Child	Adult
BFV	Copper [a]	0.16	0.068	0.0272	***5.9***	***2.5***	0.0731	***2.2***	***0.94***
BFV	Iron	1.6	0.68	0.7	***2.3***	***0.97***	1	***1.6***	***0.68***
BFV	Manganese	0.43	0.18	0.14	***3.0***	***1.3***	0.21	***2.0***	***0.9***
BFC	Copper [a]	0.08	0.03	0.0272	***2.9***	***1.2***	0.0731	***1.1***	***0.5***
BFC	Manganese	0.2	0.08	0.14	***1.4***	***0.6***	0.21	***0.9***	***0.4***

[a] Copper was evaluated using acute NOAEL and LOAEL values used in ATSDR's MRL derivation because no chronic health guidelines are available. The ATSDR MRL (ATSDR, 2004) is based on the acute NOAEL value for copper (Cu) in a 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.

[b] For iron, the NOAEL and LOAEL values are based on the EPA provisional toxicity value since no iron toxicity values have been established in the EPA IRIS or by the ATSDR. The chronic LOAEL value of 1 mg/kg-day was derived from a study of Swedish men and women under daily treatment with 60 mg/day ferrous fumarate for one month. The study group reported a statistically significant increase in gastrointestinal effects when compared with the placebo group. The reported gastrointestinal effects were described as minor and this LOAEL value is considered a minimal LOAEL.

[c] The EPA has determined a NOAEL of manganese exposure at 0.14 mg/kg-day for food. A LOAEL value has not been established in the EPA's IRIS. One study, cited by the National Academy of Science (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.

Table 6. Summary of Chronic Non-cancer, Health Effects-based, Hazard Quotients (HQs) for Intentional Ingestion of Surface Water by Temporary Residents

AI	Contaminant	Estimated Dose (mg/kg-day)		NOAEL (mg/kg-day)	NOAEL based HQ		LOAEL (mg/kg-day)	LOAEL based HQ	
		Child	Adult		Child	Adult		Child	Adult
BFV	Copper [a]	0.08	0.034	0.0272	***2.9***	***1.25***	0.0731	***1.1***	***0.47***
BFV	Iron	0.8	0.34	0.7	***1.1***	***0.49***	1	***0.8***	***0.34***
BFV	Manganese	0.215	0.09	0.14	***1.5***	***0.64***	0.21	***1.0***	***0.45***
BFC	Copper [a]	0.04	0.015	0.0272	***1.47***	***0.55***	0.0731	***0.55***	***0.25***
BFC	Manganese	0.1	0.04	0.14	***0.71***	***0.29***	0.21	***0.45***	***0.2***

Table 7. Summary of Chronic Non-cancer, Health Effects-based Hazard Quotients from Incidental Ingestion of Sediments by Residential and Recreational Children

COC	AI	Receptor	Dose (mg/kg-day)	NOAEL (mg/kg-day)	HQ_{NOAEL}	LOAEL (mg/kg-day)	HQ_{LOAEL}
Iron	BFV	Permanent Child Resident	5.42	0.7	***7.7***	1.0	***5.4***
		Temporary Child Resident	2.71	0.7	***3.9***	1.0	***2.7***
		Recreational Child	0.81	0.7	***1.1***	1.0	***0.8***
Iron	BFC	Permanent Child Resident	2.4	0.7	***3.4***	1.0	***2.1***
		Temporary Child Resident	1.2	0.7	***1.7***	1.0	***1.2***

Table 8. Evaluation of acute exposure to copper in surface water for young children (0-6 years) and adults.

Area of Investigation (AI)	EPC Ug/L	Exposure dose[a] (mg/kg/day)	Health Guideline [b] based HQ	NOAEL[c] based HQ	LOAEL[d] based HQ
BFV					
	Max. 2500.0	Child = 0.166 Adult = 0.071	Child = 16.7 Adult = 7.1	Child = 6.1 Adult = 2.6	Child = 2.3 Adult = 1.0
	Mean 948.0	Child =0.063 Adult =0.027	Child = 6.3 Adult = 2.7	Child = 2.3 Adult = 1.0	Child = 0.9 Adult = 0.4
BFC					
	Max. 1230.0	Child = 0.082 Adult = 0.035	Child = 8.0 Adult = 3.5	Child = 3.0 Adult = 1.3	Child = 1.1 Adult = 0.5
	Mean 426.7	Child = 0.03 Adult = 0.01	Child = 2.8 Adult = 1.2	Child = 1.0 Adult = 0.4	Child = 0.4 Adult = 0.2
CJM					
	Max. 224.0	Child = 0.015 Adult = 0.006	Child = 1.5 Adult = 0.6	Child = 0.6 Adult = 0.2	Child = 0.2 Adult = 0.08
	Mean 108.6	NA	NA	NA	NA
WRV					
	Max. 111.0	NA	NA	NA	NA
	Mean 73.1	NA	NA	NA	NA
WRS					
	Max. 127.0	NA	NA	NA	NA
	Mean 69.4	NA	NA	NA	NA

[a] Exposure dose = Conc. in Surface water (mg/L) x Ingestion rate for water (L/day) x EF/ AT x Body weight: Child and adult Ingestion rates for water are 1 L/day and 2 L/day, respectively; EF = 1 day; Body weight = 15 kg (child) and 70 kg (adult); AT = 1 day
[b] Copper acute health guideline (MRL) for ATSDR = 0.01 mg/kg/day
[c] Copper acute NOAEL for ATSDR MRL = 0.0272 mg/kg/day
[d] Copper acute LOAEL for ATSDR MRL = 0.0731 mg/kg/day

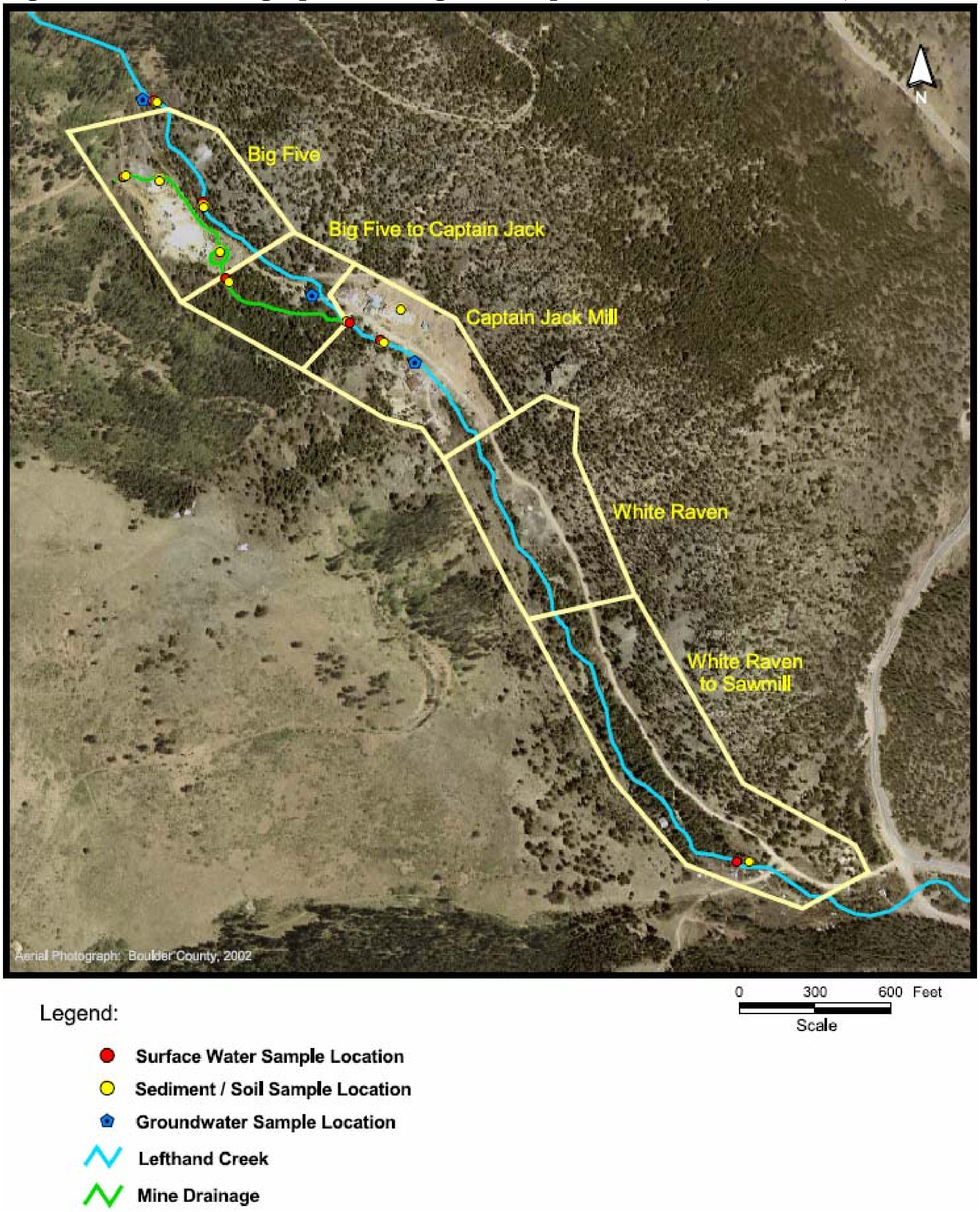
NA- not applicable because not a COPC or health guideline based HQ <1.0

Table 9. Evaluation of acute exposure to copper in sediments for young children (age 0-6 years)

Area of Investigation (AI)	EPC 95% UCL (mg/kg)	Exposure dose[a] (mg/kg/day)	Health Guideline[b] based HQ	NOAEL[c] based HQ	LOAEL[d] based HQ
BFV					
	1399.5	0.0373	3.7	1.4	0.5
BFC					
	928.6	0.0247	2.5	0.9	0.3
CJM					
	382.2	0.01	1.0	0.4	0.1
WRV					
	398.1	0.01	1.0	0.4	0.1
WRS					
	763.4	0.02	2.0	0.7	0.3

[a] Exposure dose = Soil Concentration (mg/kg) x Sediment intake rate (mg/day) x EF x CF/ Child Body wt.(kg) x AT : Sediment intake rate = 400 mg/day; EF= 1 day; AT = 1 day; Body weight = 15 kg; CF = 0.000001 kg/mg
[b] Copper acute health guideline (MRL) for ATSDR = 0.01 mg/kg/day
[c] Copper acute NOAEL for ATSDR MRL = 0.0272 mg/kg/day
[d] Copper acute LOAEL for ATSDR MRL = 0.0731 mg/kg/day
NA- not applicable because health guideline based HQ <1.0

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



Appendices

Appendix A. 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. 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 B. Data Summary and Selection of Contaminants of Potential Concern

Table B1. Surface Water Summary Statistics

Contaminant	Area of Investigation														
	Big Five (µg/kg)			Big Five to Captain Jack (µg/kg)			Captain Jack (µg/kg)			White Raven (µg/kg)			White Raven to Sawmill Rd. (µg/kg)		
	Mean	Max.	Min.	Mean	Max.	Min.	Mean	Max.	Min.	Mean	Max.	Min.	Mean	Max.	Min.
Aluminum	1851.4	5560	ND	1601	4530	76.7	621.6	1370	174	408.4	762	238	394	820	157
Antimony	19.3	30*	ND	18.0	30*	ND	14.4	30*	ND	19.5*	30*	ND	16.88	30*	ND
Arsenic	3.5	5*	ND	3.64	5*	ND	3.5*	5*	ND	3.5*	5*	ND	3.50*	5*	ND
Barium	21.2	33.8	6.59	18.2	25.8	8.9	13.63	22.2	7.43	15.56	24.7	8.6	16.92	26.6	8.24
Beryllium	2.18	2.8	ND	2.0	2.5*	ND	2.04	2.5*	ND	1.56	2.5*	ND	1.58	2.5	ND
Boron	50*	50*	ND	50.0*	50*	ND	47.3	47.3	47.3	47.3	47.3	47.3	45.65	46.5	44.8
Cadmium	4.03	8.1	ND	2.52	5.35	ND	1.77	2.5	ND	15.8	2.5*	ND	1.62	2.5*	ND
Calcium	48148.6	111000	6990	20590	52500	3770	8600.0	12400	4800	8775.0	12800	4750	8995	13200	4790
Chromium	3.8	5*	0.84	3.96	5*	ND	4.26	5*	ND	4.24	5*	ND	4.26	5*	ND
Cobalt	36.6	75.3	0.91	13.24	27.8	ND	14.05	25	3.1	13.8	25*	ND	13.80	25*	ND
Copper	948.1	2500	2.2	426.7	1230	ND	108.64	224	21.7	73.10	111	23.4	69.42	127	24
Iron	6715	26700	51.1	213.3	380	ND	222.76	413	ND	254.80	512	ND	224.20	366	ND
Lead	6.1	14.8	0.41	4.5	10.1	ND	4.01	6.09	ND	2.86	5*	ND	3.26	5*	ND
Magnesium	23017.1	56800	1060	8616	24200	1080	3030	4500	1560	3115	4690	1540	3217.5	4850	1570
Manganese	2242.1	6690	5.6	1033.8	3060	16.8	248	446	77.8	214.78	365	65.3	198	349	62.3
Mercury	0.11	0.15*	0.03	0.1*	0.15*	ND	0.11*	0.15*	ND	0.11	0.15*	ND	0.11	0.15*	ND
Nickel	32.4	77.8	ND	20.8	46.2	ND	9.66	20*	ND	9.37	20*	ND	7.27	20*	ND
Potassium	1096.3	1380	575	1033	1390	475	809	1070	548	822	1080	564	854.25	1140	576
Selenium	13.2	17.5*	1.28	14.8	17.5*	ND	14.5*	17.5*	ND	8.22	17.5*	ND	16.0*	17.5*	ND
Silver	2.0	5*	ND	1.9	5*	ND	2.3*	5*	ND	2.30	5*	ND	2.30*	5*	ND
Sodium	6502.9	9720	2060	4472	6780	1460	3950	5770	2130	3980	5660	2300	3877.5	5620	2020
Thallium	5.1	12.5*	0.14	5.5	12.5*	ND	5.18*	12.5*	ND	5.2*	12.5*	ND	5.23	12.5	ND
Vanadium	14.8	25*	1.1	6.0	25*	ND	13.2*	25*	ND	0.75	0.76	0.74	7.11	25*	ND
Zinc	682.1	1730	4.6	396	1060	6.9	515.12	900	88.6	477.92	823	83.6	453.16	810	83.1

Table B2. Sediment Summary Statistics

Contaminant	Area of Investigation														
	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	2840.65	8380	540	4188.06	16900	811	3065.5	7220	1210	2997.7	6630	1000	4101.1	16700	1760
Antimony	3.72	7.7	ND	4.66	9.3	ND	2.31	7.0	0.47	1.8	6*	0.54	1.52	3.8	0.64
Arsenic	2.16	9.5	ND	7.40	54.6	ND	7.14	30.5	1.0	6.4	36.8	2.3	7.03	28.1	2.0
Barium	68.84	298	19.40	102.06	225	23.60	53.41	116	15.30	71.5	283	12.9	72.3	204	25.9
Beryllium	0.19	0.51	0.07	0.29	0.7	ND	0.53	1.7	0.18	0.5	1.2	0.2	0.9	4.7	0.26
Cadmium	1.18	9.1	0.14	0.79	2.5	ND	1.60	5.9	0.44	1.7	5.5	0.4	2.8	11	0.82
Calcium	1489.48	6870	188.0	870.86	2130	245	1411.8	3990	762	1178.4	2560	394.0	1211.7	4880	465.0
Chromium	5.50	13.2	ND	10.94	32.2	1.50	3.45	7.9	1.3	3.7	7.6	0.85	4.6	14.7	1.9
Cobalt	3.11	6.8	ND	2.79	7.1	ND	9.44	29.7	4.1	12.1	29.9	4.5	16.9	54.6	5.2
Copper	424.20	1700	13.10	700.70	1930	25.30	286.2	1150	78.8	314.8	896	42.8	539.04	2960	85.7
Iron	131625.61	495000	4100	136459.31	435000	3850	8826	15900	4350	9240.4	16100	2950	9728.9	27600	4970
Lead	94.63	885	3.20	132.52	428	18.60	210.2	542	14.9	213.5	566	70.8	258.11	574	128.0
Magnesium	1002.77	3150	219	812.78	1940	319	908.5	1530	452	892.6	1890	287.0	1036.7	2960	528.0
Manganese	187.28	478	29.7	187.58	1000	34.80	1344.5	3470	396	1816.4	8100	415.0	2113.6	6430	874.0
Mercury	0.13	1.1	ND	0.30	0.72	ND	0.05	0.15	0.01	0.05	0.18	0.01	0.05	0.12	0.01
Nickel	4.56	27.4	ND	3.2	18.8	ND	7.08	24.7	3.5	8.0	29.1	2.6	12.3	46.5	5.5
Potassium	1159.06	4490	333	1363.44	4040	458	738.3	1330	332.0	756.7	1560	335.0	858.4	2230	459.0
Selenium	6.34	23.5	ND	6.79	22.3	ND	1.96	3.5*	0.32	2.1	3.5*	0.44	2.33**	3.5*	ND
Silver	1.02	8.3	ND	4.54	20.2	ND	1.28	5.8	0.11	2.3	22.8	0.1	2.15	12	0.21
Sodium	252.36	758	ND	254.15	1250	ND	506.7	2320	45.70	545.1	2240	44.8	663.9	2270	44.5
Thallium	9.13	75.9	ND	4.90	25.5	ND	2.0	7.5	0.27	1.8	3.4	0.45	2.6	12.8	0.36
Vanadium	14.38	47.1	ND	9.79	31.5	ND	10.4	20.8	4.0	11.4	23.5	2.4	12.3	41.7	4.6
Zinc	64.92	231	ND	107.88	592	ND	311.4	889	72.5	356.1	809	118	587.9	2330	187.0

Table B3. Surface Water COPC Selection

Contaminant	Area of Investigation														
	Big Five (µg/kg)			Big Five to Captain Jack (µg/kg)			Captain Jack (µg/kg)			White Raven (µg/kg)			White Raven to Sawmill Rd. (µg/kg)		
	Max.	CV*	COPC	Max.	CV*	COPC	Max.	CV*	COPC	Max.	CV*	COPC.	Max.	CV*	COPC
Aluminum	5560	3600	X	4530	3600	X	1370	3600			3600		820	3600	
Antimony	30*	1.5	X	30*	1.5	X	30*	1.5	X	30*	1.5	X	30*	1.5	X
Arsenic	5*	0.0045	X	5*	0.0045	X	5*	0.0045	X 762	5*	0.0045	X	5*	0.0045	X
Barium	33.8	260		25.8	260		22.2	260		24.7	260		26.6	260	
Beryllium	2.8	7.3		2.5*	7.3		2.5*	7.3		2.5*	7.3		2.5	7.3	
Boron	50*	730		50*	730		47.3	730		47.3	730		46.5	730	
Cadmium	8.1	1.5	X	5.35	1.5	X	2.5	1.5	X	2.5*	1.5	X	2.5*	1.5	X
Calcium	111000			52500			12400			12800			13200		
Chromium	5*	11			11		5*	11			11		5*	11	
Cobalt	75.3	73	X	27.8	73		25	73		25*	73		25*	73	
Copper	2500	150	X	1230	150	X	224	150	X	111	150		127	150	
Iron	26700	1100	X 5*	380	1100		413	1100	5*		1100		366	1100	
Lead	14.8	15[1]			15[1]			15[1]			15[1]			15[1]	
Magnesium	56800			24200			4500			4690			4850		
Manganese	6690	88	X 10.1	3060	88	X 6.09	446	88	512 X	365	88	X	349	88	X
Mercury	0.15*	1.1		0.15*	1.1		0.15*	1.1	5*	0.15*	1.1	5*	0.15*	1.1	
Nickel	77.8	73	X	46.2	73		20*	73		20*	73		20*	73	
Potassium	1380			1390			1070			1080			1140		
Selenium	17.5*	18		17.5*	18		17.5*	18		17.5*	18		17.5*	18	
Silver	5*	18			18		5*	18			18		5*	18	
Sodium	9720			6780			5770			5660			5620		
Thallium	12.5*	0.24	X	12.5*	0.24	X	12.5*	0.24	X	12.5*	0.24	X	12.5	0.24	X
Vanadium	25*	3.6	X 5*	25*	3.6	X	25*	3.6	X 5*	0.76	3.6		25*	3.6	X
Zinc	1730	1100	X	1060	1100		900	1100			1100		810	1100	

Items in red were not selected as COPCs in this evaluation. Please see Table 1 "Notes" for more details.

*The comparison values used in this evaluation are equal to 1/10th the EPA Region Preliminary Remediation Goal (PRG) except where otherwise noted.

[1] The lead CV for surface water is derived from the EPA's Drinking Water Quality Standards, Action Level for Lead 823

Table B4. Sediment COPC Selection

Contaminant	Area of Investigation														
	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*	COPC	Max.	CV*	COPC	Max.	CV*	COPC	Max.	CV*	COPC	Max.	CV*	COPC
Aluminum	8380	7600	X	16900	7600	X	7220	7600		6630	7600		16700	7600	X
Antimony	7.7	3.1	X	9.3	3.1	X	7.0	3.1	X	6*	3.1	X	3.8	3.1	X
Arsenic	9.5	0.039	X	54.6	0.039	X	30.5	0.039	X	36.8	0.039	X	28.1	0.039	X
Barium	298	540		225	540		116	540			540		204	540	
Beryllium	0.51	15		0.7	15		1.7	15		1.2	15		4.7	15	
Cadmium	9.1	3.7	X	2.5	3.7		5.9	3.7	X 283	5.5	3.7	X	11	3.7	X
Calcium	6870			2130			3990			2560			4880		
Chromium	13.2	3	X	32.2	3	X	7.9	3	X	7.6	3	X	14.7	3	X
Cobalt	6.8	90		7.1	90		29.7	90		29.9	90		54.6	90	
Copper	1700	310	X	1930	310	X	1150	310	X	896	310	X	2960	310	X
Iron	495000	2300	X	435000	2300	X	15900	2300	X	16100	2300	X	27600	2300	X
Lead	885	40	X	428	40	X	542	40	X	566	40	X	574	40	X
Magnesium	3150			1940			1530			1890			2960		
Manganese	478	180	X	1000	180	X	3470	180	X	8100	180	X	6430	180	X
Mercury	1.1	2.3		0.72	2.3		0.15	2.3		0.18	2.3		0.12	2.3	
Nickel	27.4	160		18.8	160		24.7	160		29.1	160		46.5	160	
Potassium	4490			4040			1330			1560			2230		
Selenium	23.5	39		22.3	39		3.5*	39			39		3.5*	39	
Silver	8.3	39		20.2	39		5.8	39		22.8	39		12	39	
Sodium	758			1250			2320		3.5*	2240			2270		
Thallium	75.9	0.52	X	25.5	0.52	X	7.5	0.52	X	3.4	0.52	X	12.8	0.52	X
Vanadium	47.1	7.8	X	31.5	7.8	X	20.8	7.8	X	23.5	7.8	X	41.7	7.8	X
Zinc	231	2300		592	2300		889	2300		809	2300		2330	2300	X

* The comparison values (CVs) used in this evaluation are equal to 1/10th the EPA Region 9 PRG value for residential soils

Exposure Point Concentration

The Exposure Point Concentration (EPC) is a high-end, yet reasonable concentration of contaminants 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 Limit 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 surface water and sediment EPC results are presented in Table B3 and Table B4, respectively. 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 detected value or ½ the detection limit, whichever value is larger.

Table B5. Surface Water Exposure Point Concentrations and Detection Frequencies

Area of Investigation	COPC	*n*	Maximum	EPC (µg/L)	Detection Frequency
BFV	Aluminum	18	5560.00	3458.83	94.00%
	Antimony	18	ND	30.00	0.00%
	Arsenic	18	ND	5.00	0.00%
	Cadmium	18	8.10	5.37	61.00%
	Cobalt	7	75.30	75.30	86.00%
	Copper	18	2500.00	2500.00	78.00%
	Iron	18	26700.00	24866.95	89.00%
	Manganese	18	6690.00	6690.00	83.00%
	Nickel	18	77.80	77.80	56.00%
	Thallium	18	0.14	12.50	6.00%
	Vanadium	7	1.30	25.00	20.00%
	Zinc	18	1730.00	1730.00	100.00%
BFC	Aluminum	11	4530.00	3700.20	100.00%
	Antimony	11	3.30	30.00	9.00%
	Arsenic	11	ND	5.00	0.00%
	Cadmium	11	5.35	3.45	63.60%
	Copper	11	1230.00	1230.00	81.80%
	Manganese	11	3060.00	3060.00	100.00%
	Thallium	11	9.00	12.50	27.30%
	Vanadium	5	1.70	25.00	80.00%
CJM	Antimony	5	4.50	30.00	20.00%
	Arsenic	5	ND	5.00	0.00%
	Cadmium	5	2.50	2.50	80.00%
	Copper	5	224.00	224.00	100.00%
	Manganese	5	446.00	446.00	100.00%
	Thallium	5	0.14	12.50	20.00%
	Vanadium	2	1.40	25.00	50.00%
WHR	Antimony	5	ND	30.00	0.00%
WHR	Arsenic	5	ND	5.00	0.00%
WHR (Cont.)	Cadmium	5	1.90	2.50	80.00%

WHR	Manganese	5	365.00	365.00	100.00%
WRS	Antimony	10	3.80	30.00	10.00%
	Arsenic	10	ND	5.00	0.00%
	Cadmium	10	2.20	2.50	80.00%
	Manganese	10	349.00	261.59	100.00%
	Thallium	10	0.42	12.50	20.00%
	Vanadium	4	1.40	25.00	75.00%
Sitewide	Aluminum	49	5560.00	n/a	97.96%
	Arsenic	49	ND	n/a	0.00%
	Antimony	49	4.50	n/a	6.12%
	Cadmium	49	8.10	n/a	69.39%
	Cobalt	20	75.30	n/a	75.00%
	Copper	49	2500.00	n/a	87.76%
	Iron	49	26700.00	n/a	75.51%
	Manganese	49	6690.00	n/a	93.88%
	Nickel	49	77.80	n/a	61.22%
	Thallium	49	9.00	n/a	14.28%
	Vanadium	20	1.70	n/a	50.00%
	Zinc	49	1730.00	n/a	100.00%

Values in red indicate that the EPC is based on ½ the reporting limit

Table B6. Sediment Exposure Point Concentrations and Detection Frequencies

Area of Investigation	COPC	*n*	Maximum	EPC (mg/kg)	Detection Frequency
BFV	Aluminum	31	8380.0	3526.5	100.00%
	Antimony	31	7.7	5.3	45.16%
	Arsenic	31	9.5	6.8	64.52%
	Cadmium	31	9.1	5.2	77.42%
	Chromium	31	13.2	6.7	96.77%
	Copper	31	1700.0	1399.5	100.00%
	Iron	31	495000.0	423820.6	100.00%
	Lead*	31	885.0	n/a	100.00%
	Manganese	31	478.0	238.8	100.00%
	Thallium	31	75.9	42.9	51.61%
	Vanadium	31	47.1	20.2	93.55%
BFC	Aluminum	36	16900.0	5057.3	100.00%
	Antimony	36	9.3	6.5	66.67%
	Arsenic	36	54.6	10.3	91.67%
	Chromium	36	32.2	17.0	100.00%
	Copper	36	1930.0	928.6	100.00%
	Iron	36	435000.0	188378.5	100.00%
	Lead*	36	428.0	n/a	100.00%
	Manganese	36	1000.0	257.4	100.00%
	Thallium	36	25.5	15.8	55.56%
	Vanadium	36	31.5	15.5	97.22%
CJM	Antimony	20	7.0	4.2	75.00%

	Arsenic	20	30.5	10.2	100.00%
	Cadmium	20	5.9	2.1	100.00%
	Chromium	20	7.9	4.2	100.00%
	Copper	20	1150.0	382.2	100.00%
	Iron	20	15900.0	9975.2	100.00%
	Lead*	20	542	n/a	100.00%
	Manganese	20	3470.0	1720.9	100.00%
	Thallium	20	7.5	3.0	40.00%
	Vanadium	20	20.8	12.2	100.00%
WHR	Antimony	22	6.0	2.5	81.82%
	Arsenic	22	36.8	13.3	100.00%
	Cadmium	22	5.5	2.1	100.00%
	Copper	22	896.0	398.1	100.00%
	Iron	22	16100.0	10734.0	100.00%
	Lead*	22	566.0	n/a	100.00%
	Manganese	22	8100.0	2384.1	100.00%
	Thallium	22	3.4	2.6	40.91%
	Vanadium	22	23.5	14.2	100.00%
WRS	Aluminum	18	16700.0	5401.8	100.00%
	Antimony	18	3.8	2.6	83.33%
	Arsenic	18	28.1	9.7	100.00%
	Cadmium	18	11.0	3.7	100.00%
	Chromium	18	14.7	5.8	100.00%
	Copper	18	2960.0	763.4	100.00%
	Iron	18	27600.0	11769.1	100.00%
	Lead*	18	574.0	n/a	100.00%
	Manganese	18	6430.0	2580.26	100.00%
	Thallium	18	12.8	3.8	66.67%
	Vanadium	18	41.7	15.9	100.00%
	Zinc	18	2330.0	774.7	100.00%
Sitewide	Aluminum	127	16900.0	n/a	100.00%
	Antimony	127	9.3	n/a	67.72%
	Arsenic	127	54.6	n/a	88.98%
	Cadmium	127	11.0	n/a	87.40%
	Chromium	127	32.2	n/a	99.21%
	Copper	127	2960.0	n/a	100.00%
	Iron	127	495000.0	n/a	100.00%
	Lead	127	885.0	n/a	100.00%
	Manganese	127	6430.0	n/a	100.00%
	Thallium	127	75.9	n/a	51.18%
Sitewide (Cont.)	Vanadium	127	47.1	n/a	97.64%
	Zinc	127	2330	n/a	97.64%

* Lead was not evaluated further using the EPA lead uptake biokinetic models because the mean lead concentration (EPC used for lead models) was significantly below the screening value of 400 mg/kg for all Areas of Investigation.

Appendix C. Exposure Parameters, Estimation of Exposure Dose, and Risk Calculations

Exposure Dose Estimation

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 concentrations 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. The detailed exposure parameters and dose equations are presented below. It should be noted that in the absence of site–specific data, the default exposure assumptions are used to evaluate potential risks for residents and are likely to result in overestimations of actual risks to the site population.

Table C1. Permanent Resident Exposure Parameters

Exposure Pathway	Exposure Parameter	Units	Receptor	
			Child	Adult
General	Body Weight (BW)	kg	15	70
	Exposure Frequency (EF)	days/yr	350	350
	Exposure Duration$_{Non\text{-}cancer}$ (ED$_{Non\text{-}cancer}$)	years	6	30
	Exposure Duration$_{Cancer}$ (ED$_{Cancer}$)	years	30*	30*
	Averaging Time$_{Non\text{-}cancer}$ (AT$_{Non\text{-}cancer}$)	days	2190	10950
	Averaging Time$_{Cancer}$ (AT$_{Cancer}$)	days	na	25550
Incidental Ingestion of Sediment	Ingestion Rate$_{Non\text{-}cancer}$ (IR$_{Non\text{-}cancer}$)	mg/day	200	100
	Ingestion Rate$_{Cancer}$ (IR$_{Cancer}$)	(mg-yr)/(kg-day)	114.3*	114.3*
Incidental Ingestion of Surface Water	Ingestion Rate	mL/day	50	50
	Exposure Frequency	days/yr	104	104
Intentional Ingestion of Surface Water	Ingestion Rate	L/day	1	2

* Age-adjusted equation was used to assess carcinogenic risk (6 yrs. as child, 24 yrs. as adult)

Table C2. Temporary Resident Exposure Parameters

Exposure Pathway	Exposure Parameter	Units	Receptor	
			Child	Adult
General	Body Weight (BW)	kg	15	70
	Exposure Frequency (EF)	days/yr	350	350
	Exposure Duration$_{Non\text{-}cancer}$ ($ED_{Non\text{-}cancer}$)	years	5	5
	Averaging Time$_{Non\text{-}cancer}$ ($AT_{Non\text{-}cancer}$)	days	1825	1825
Incidental Ingestion of Sediment	Ingestion Rate$_{Non\text{-}cancer}$ ($IR_{Non\text{-}cancer}$)	mg/day	200	100
Incidental Ingestion of Surface Water	Ingestion Rate	mL/day	50	50
	Exposure Frequency	days/yr	104	104
Intentional Ingestion of Surface Water	Ingestion Rate	L/day	1	2

Table C3. Recreational User Exposure Parameters

Exposure Pathway	Exposure Parameter	Units	Receptor	
			Child	Adult
General	Body Weight (BW)	kg	15	70
	Exposure Frequency (EF)	days/yr	52	52
	Exposure Duration$_{Non\text{-}cancer}$ ($ED_{Non\text{-}cancer}$)	years	6	30
	Exposure Duration$_{Cancer}$ (ED_{Cancer})	years	30*	30*
	Averaging Time$_{Non\text{-}cancer}$ ($AT_{Non\text{-}cancer}$)	days	2190	10950
	Averaging Time$_{Cancer}$ (AT_{Cancer})	days	25550*	25550*
Incidental Ingestion of Sediment	Ingestion Rate$_{Non\text{-}cancer}$ ($IR_{Non\text{-}cancer}$)	mg/day	200	100
	Ingestion Rate$_{Cancer}$ (IR_{Cancer})	(mg-yr)/(kg-day)	114.3*	114.3*
Incidental Ingestion of Surface Water	Ingestion Rate	mL/day	50	50
	Exposure Frequency	days/yr	52	52
Intentional Ingestion of Surface Water	Ingestion Rate	L/day	1	2

* Age-adjusted exposure parameters used to assess carcinogenic risk (6 yr. Child, 24 yr. Adult)

Table C4. Outdoor Worker Exposure Parameters

Exposure Pathway	Exposure Parameter	Units	Value
General	Body Weight (BW)	kg	70
	Exposure Frequency (EF)	days/yr	250
	Exposure Duration$_{Non\text{-}cancer}$ (ED$_{Non\text{-}cancer}$)	years	2
	Exposure Duration$_{Cancer}$ (ED$_{Cancer}$)	years	2
	Averaging Time$_{Non\text{-}cancer}$ (AT$_{Non\text{-}cancer}$)	days	730
	Averaging Time$_{Cancer}$ (AT$_{Cancer}$)	days	25550
Incidental Ingestion of Sediment	Ingestion Rate$_{Non\text{-}cancer}$ (IR$_{Non\text{-}cancer}$)	mg/day	330
Intentional Ingestion of Surface Water	Ingestion Rate	L/day	2

* Age-adjusted equation was used to assess carcinogenic risk (6 yrs. as child, 24 yrs. as adult)

Sediment Ingestion:

Non-cancer Dose = $(C * IR * EF * CF) / BW$

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

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

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

Surface Water Ingestion:

Dose = $(C * IR * EF) / BW$

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

Table C5. Intentional Ingestion of Surface Water Non-cancer Health Guideline Based Hazard Quotients by AI

AI	COPC	Permanent Adult Resident HQ	Permanent Child Resident HQ	Temporary Adult Resident HQ	Temporary Child Resident HQ	Recreational Adult HQ	Recreational Child HQ	Construction Worker HQ
BFV	Aluminum	0.09	0.22	0.05	0.11	0.01	0.03	0.07
BFV	Cadmium	0.15	0.34	0.15	0.34	0.02	0.05	0.21
BFV	Cobalt	0.10	0.24	0.05	0.12	0.02	0.04	0.07
BFV	Copper	6.85	15.98	3.43	8.00	1.02	2.37	4.89
BFV	Iron	0.97	2.27	0.49	1.14	0.14	0.34	0.70
BFV	Manganese	3.67	8.55	1.83	4.28	0.54	1.27	2.62
BFV	Nickel	0.11	0.25	0.05	0.12	0.02	0.04	0.08
BFV	Thallium	5.19	12.11	2.60	6.06	0.77	1.80	3.71
BFV	Vanadium	0.68	1.60	0.34	0.80	0.10	0.24	0.49
BFV	Zinc	0.16	0.37	0.08	0.18	0.02	0.05	0.11
BFV Total		**17.97**	**41.93**	**9.07**	**21.15**	**2.67**	**6.23**	**12.94**

AI	COPC	Permanent Residential Adult HQ	Permanent Child Resident Child HQ	Temporary Adult Resident HQ	Temporary Child Resident HQ	Recreational Adult HQ	Recreational Child HQ	Construction Worker HQ
BFC	Aluminum	0.10	0.24	0.05	0.12	0.02	0.04	0.07
BFC	Antimony	2.05	4.79	1.03	2.40	0.31	0.71	1.47
BFC	Cadmium	0.09	0.22	0.09	0.22	0.01	0.03	0.14
BFC	Copper	3.37	7.86	1.69	3.94	0.50	1.17	2.41
BFC	Manganese	1.68	3.91	0.84	1.96	0.25	0.58	1.20
BFC	Thallium	5.19	12.11	2.60	6.06	0.77	1.80	3.71
BFC	Vanadium	0.68	1.60	0.34	0.80	0.10	0.24	0.49
BFC Total		**13.17**	**30.73**	**6.64**	**15.50**	**1.96**	**4.57**	**9.48**

AI	COPC	Permanent Adult Resident HQ	Permanent Child Resident HQ	Temporary Adult Resident HQ	Temporary Child Resident HQ	Recreational Adult HQ	Recreational Child HQ	Construction Worker HQ
CJM	Antimony	2.05	4.79	1.03	2.40	0.31	0.71	1.47
CJM	Cadmium	0.07	0.16	0.07	0.16	0.01	0.02	0.10
CJM	Copper	0.61	1.43	0.31	0.72	0.09	0.21	0.44
CJM	Manganese	0.24	0.57	0.12	0.29	0.04	0.08	0.17
CJM	Thallium	5.19	12.11	2.60	6.06	0.77	1.80	3.71
CJM	Vanadium	0.68	1.60	0.34	0.80	0.10	0.24	0.49
CJM Total		**8.86**	**20.66**	**4.47**	**10.43**	**1.32**	**3.07**	**6.37**

AI	COPC	Permanent Adult Resident HQ	Permanent Child Resident HQ	Temporary Adult Resident HQ	Temporary Child Resident HQ	Recreational Adult HQ	Recreational Child HQ	Construction Worker HQ
WHR	Cadmium	0.07	0.16	0.07	0.16	0.01	0.02	0.10
WHR	Manganese	0.20	0.47	0.10	0.23	0.03	0.07	0.14
WHR Total		**0.27**	**0.63**	**0.17**	**0.39**	**0.04**	**0.09**	**0.24**

AI	COPC	Permanent Adult Resident HQ	Permanent Child Resident HQ	Temporary Adult Resident HQ	Temporary Child Resident HQ	Recreational Adult HQ	Recreational Child HQ	Construction Worker HQ
WRS	Antimony	2.05	4.79	1.03	2.40	0.31	0.71	1.47
WRS	Cadmium	0.07	0.16	0.07	0.16	0.01	0.02	0.10
WRS	Manganese	0.14	0.33	0.07	0.17	0.02	0.05	0.10
WRS	Thallium	5.19	12.11	2.60	6.06	0.77	1.80	3.71
WRS	Vanadium	0.68	1.60	0.34	0.80	0.10	0.24	0.49
WRS Total		**8.14**	**18.99**	**4.11**	**9.59**	**1.21**	**2.82**	**5.86**

Values in red indicate an HQ greater than 1

Table C6. Incidental Ingestion of Sediments Non-cancer Health Guideline Based Hazard Quotients and Theoretical Cancer Risks by AI

AI	COPC	Permanent Adult Resident HQ	Permanent Child Resident HQ	Temporary Adult Resident HQ	Temporary Child Resident HQ	Recreational Adult HQ	Recreational Child HQ	Construction HQ
BFV	Aluminum	0.00	0.05	0.00	0.02	0.00	0.01	0.01
BFV	Antimony	0.02	0.17	0.01	0.08	0.00	0.03	0.04
BFV	Cadmium	0.01	0.07	0.00	0.03	0.00	0.01	0.02
BFV	Chromium	0.00	0.03	0.00	0.01	0.00	0.00	0.01
BFV	Copper	0.19	1.79	0.10	0.89	0.03	0.27	0.45
BFV	Iron	0.83	7.74	0.41	3.87	0.12	1.15	1.96
BFV	Manganese	0.01	0.06	0.00	0.03	0.00	0.01	0.02
BFV	Thallium	0.89	8.32	0.45	4.16	0.13	1.24	2.10
BFV	Vanadium	0.03	0.26	0.01	0.13	0.00	0.04	0.07
BFV Total		**1.98**	**18.48**	**0.98**	**9.22**	**0.29**	**2.75**	**0.31**
BFV	**Arsenic cancer risk**	1.59E-05				2.37E-06		9.40E-07

AI	COPC	Permanent Adult Resident HQ	Permanent Child Resident HQ	Temporary Adult Resident HQ	Temporary Child Resident HQ	Recreational Adult HQ	Recreational Child HQ	Construction HQ
BFC	Aluminum	0.01	0.06	0.00	0.03	0.00	0.01	0.02
BFC	Antimony	0.02	0.21	0.01	0.10	0.00	0.03	0.05
BFC	Chromium	0.01	0.07	0.00	0.04	0.00	0.01	0.02
BFC	Copper	0.13	1.19	0.06	0.59	0.02	0.18	0.30
BFC	Iron	0.37	3.44	0.18	1.72	0.05	0.51	0.87
BFC	Manganese	0.01	0.07	0.00	0.03	0.00	0.01	0.02
BFC	Thallium	0.33	3.06	0.16	1.53	0.05	0.45	0.77
BFC	Vanadium	0.02	0.20	0.01	0.10	0.00	0.03	0.05
BFC Total		**0.89**	**8.30**	**0.42**	**4.14**	**0.13**	**1.23**	**0.14**
BFC	**Arsenic cancer risk**	2.42E-05				3.59E-06		1.43E-06

AI	COPC	Permanent Adult Resident HQ	Permanent Child Resident HQ	Temporary Adult Resident HQ	Temporary Child Resident HQ	Recreational Adult HQ	Recreational Child HQ	Construction HQ
CJM	Antimony	0.01	0.14	0.01	0.07	0.00	0.02	0.03
CJM	Cadmium	0.00	0.03	0.00	0.01	0.00	0.00	0.01
CJM	Chromium	0.00	0.02	0.00	0.01	0.00	0.00	0.00
CJM	Copper	0.05	0.49	0.03	0.24	0.01	0.07	0.12
CJM	Iron	0.02	0.18	0.01	0.09	0.00	0.03	0.05
CJM	Manganese	0.05	0.44	0.02	0.22	0.01	0.07	0.11
CJM	Thallium	0.06	0.58	0.03	0.29	0.01	0.09	0.15
CJM	Vanadium	0.02	0.16	0.01	0.08	0.00	0.02	0.04
CJM Total		**0.22**	**2.03**	**0.11**	**1.01**	**0.03**	**0.30**	**0.03**
CJM	**Arsenic cancer risk**	2.39E-05				3.55E-06		1.41E-06

AI	COPC	Permanent Adult Resident HQ	Permanent Child Resident HQ	Temporary Adult Resident HQ	Temporary Child Resident HQ	Recreational Adult HQ/CR	Recreational Child HQ/ CR	Construction HQ/ CR
WHR	Antimony	0.01	0.08	0.00	0.04	0.00	0.01	0.02
WHR	Cadmium	0.00	0.03	0.00	0.01	0.00	0.00	0.01
WHR	Copper	0.05	0.51	0.03	0.25	0.01	0.08	0.13
WHR	Iron	0.02	0.20	0.01	0.10	0.00	0.03	0.05
WHR	Manganese	0.07	0.61	0.03	0.30	0.01	0.09	0.15
WHR	Thallium	0.05	0.51	0.03	0.26	0.01	0.08	0.13
WHR	Vanadium	0.02	0.18	0.01	0.09	0.00	0.03	0.05
WHR Total		**0.23**	**2.11**	**0.11**	**1.05**	**0.03**	**0.31**	**0.04**
WHR	**Arsenic cancer risk**	3.13E-05				4.65E-06		1.84E-06

AI	COPC	Permanent Adult Resident HQ	Permanent Child Resident HQ	Temporary Adult Resident HQ	Temporary Child Resident HQ	Recreational Adult HQ	Recreational Child HQ	Construction HQ
WRS	Aluminum	0.01	0.07	0.00	0.03	0.00	0.01	0.02
WRS	Antimony	0.01	0.08	0.00	0.04	0.00	0.01	0.02
WRS	Cadmium	0.01	0.05	0.00	0.02	0.00	0.01	0.01
WRS	Chromium	0.00	0.02	0.00	0.01	0.00	0.00	0.01
WRS	Copper	0.10	0.98	0.05	0.49	0.02	0.15	0.25
WRS	Iron	0.02	0.21	0.01	0.11	0.00	0.03	0.05
WRS	Manganese	0.07	0.66	0.04	0.33	0.01	0.10	0.17
WRS	Thallium	0.08	0.74	0.04	0.37	0.01	0.11	0.19
WRS	Vanadium	0.02	0.20	0.01	0.10	0.00	0.03	0.05
WRS	Zinc	0.00	0.03	0.00	0.02	0.00	0.00	0.01
WRS Total		**0.33**	**3.05**	**0.15**	**1.52**	**0.05**	**0.45**	**0.05**
WRS	**Arsenic cancer risk**	2.28E-05				3.39E-06		1.35E-06

Values in red indicate an HQ greater than or equal to 1

Table C7. Incidental Ingestion of Surface Water Non-cancer Health Guideline Based Hazard Quotients by AI

AI	COPC	Permanent Adult Resident HQ	Permanent Child Resident HQ
BFV	Aluminum	0.001	0.003
BFV	Cadmium	0.002	0.010
BFV	Cobalt	0.001	0.004
BFV	Copper	0.051	0.237
BFV	Iron	0.007	0.034
BFV	Manganese	0.027	0.127
BFV	Nickel	0.001	0.004
BFV	Thallium	0.039	0.180
BFV	Vanadium	0.005	0.024
BFV	Zinc	0.001	0.005
BFV Total		**0.135**	**0.628**

AI	COPC	Permanent Residential Adult HQ	Permanent Child Resident Child HQ
BFC	Aluminum	0.001	0.003
BFC	Antimony	0.015	0.071
BFC	Cadmium	0.001	0.007
BFC	Copper	0.025	0.117
BFC	Manganese	0.012	0.058
BFC	Thallium	0.039	0.180
BFC	Vanadium	0.005	0.024
BFC Total		**0.098**	**0.460**

AI	COPC	Permanent Adult Resident HQ	Permanent Child Resident HQ
CJM	Antimony	0.015	0.071
CJM	Cadmium	0.001	0.005
CJM	Copper	0.005	0.021
CJM	Manganese	0.002	0.008
CJM	Thallium	0.039	0.180
CJM	Vanadium	0.005	0.024
CJM Total		**0.069**	**0.309**

AI	COPC	Permanent Adult Resident HQ	Permanent Child Resident HQ
WHR	Cadmium	0.001	0.005
WHR	Manganese	0.001	0.007
WHR Total		**0.002**	**0.012**

AI	COPC	Permanent Adult Resident HQ	Permanent Child Resident HQ
WRS	Antimony	0.015	0.071
WRS	Cadmium	0.001	0.004
WRS	Manganese	0.001	0.005
WRS	Thallium	0.039	0.180
WRS	Vanadium	0.005	0.024
WRS Total		**0.061**	**0.284**

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.

The USEPA has also established oral reference dose (RfD) for non-cancer effects. 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 copper and intermediate MRL for copper, which is identified as the primary contaminants of concern at this site. 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 non-cancer 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.

The USEPA has also established in the EPA IRIS an oral cancer slope factor of 1.5 per mg/kg/day 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.

Oral RfDs (mg/kg/day) used in this evaluation:

Aluminum = 1.0 (Provisional EPA-NCEA)
Antimony = 0.0004 (EPA IRIS)
Cadmium = 0.001 (ATSDR Chronic MRL for food)
Cobalt = 0.02 (Provisional EPA-NCEA)
Copper = 0.01 (ATSDR intermediate MRL)
Iron = 0.7 (Provisional EPA-NCEA)
Manganese = 0.05 (EPA IRIS)

Nickel = 0.02 (EPA IRIS)
Thallium = 0.000066 (EPA Region 9 Adjusted value)
Vanadium = 0.001 (Provisional EPA NCEA)
Zinc = 0.3 (EPA IRIS)

COC	NOAEL	LOAEL
Copper	0.0272	0.0731
Iron	0.7	1
Manganese	0.14	0.21
Thallium	0.23	n/a
Vanadium	0.3	0.57
Antimony	n/a	0.35

Appendix E. 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 F. ATSDR Tox FAQs for Copper and Manganese

Appendix F1. Copper ToxFAQ

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/m3) 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.

Appendix F2. Manganese ToxFAQ

CAS#: 7439-96-5

This fact sheet answers the most frequently asked health questions about manganese. 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
Manganese is a trace element and eating a small amount from food or water is needed to stay healthy. Exposure to excess levels of manganese may occur from breathing air, particularly where manganese is used in manufacturing, and from drinking water and eating food. At high levels, it can cause damage to the brain, liver, kidneys, and the developing fetus. This chemical has been found in at least 603 of 1,467 National Priorities List sites identified by the Environmental Protection Agency (EPA).

What is manganese?
Manganese is a naturally occurring metal that is found in many types of rocks. Pure manganese is silver-colored, but does not occur naturally. It combines with other substances such as oxygen, sulfur, or chlorine. Manganese can also be combined with carbon to make organic manganese compounds. Common organic manganese compounds include pesticides, such as maneb or mancozeb, and methylcyclopentadienyl manganese tricarbonyl (MMT), a fuel additive in some gasolines. Manganese is an essential trace element and is necessary for good health. Manganese can be found in several food items, including grains and cereals, and is found in high amounts in other foods, such as tea.

What happens to manganese when it enters the environment?
Manganese can enter the air from iron, steel, and power plants, coke ovens, and from dust from mining operations. It can enter the water and soil from natural deposits, disposal of wastes, or deposits from airborne sources. Manganese exists naturally in rivers, lakes, and underground water. Plants in the water can take up some of the manganese from water and concentrate it.

How might I be exposed to manganese?
Everyone is exposed to small amounts of manganese in air, water, and food. Individuals who work in occupations that mine or use manganese are likely to be exposed to excess levels in their work environment. People who improperly use pesticides such as maneb and mancozeb, may be exposed to excess levels.

How can manganese affect my health?
Some individuals exposed to very high levels of manganese for long periods of time in their work developed mental and emotional disturbances and slow and clumsy body

movements. This combination of symptoms is a disease called "manganism." Workers usually do not develop symptoms of manganism unless they have been exposed to manganese for many months or years. Manganism occurs because too much manganese injures a part of the brain that helps control body movements. Exposure to high levels of airborne manganese, such as in a manganese foundry or battery plant, can affect motor skills such as holding one's hand steady, performing fast hand movements, and maintaining balance. Exposure to high levels of the metal may also cause respiratory problems and sexual dysfunction.

How likely is manganese to cause cancer?
There are no human cancer data available for manganese. Exposure to high levels of manganese in food resulted in a slightly increased incidence of pancreatic tumors in male rats and thyroid tumors in male and female mice. The EPA has determined that manganese is not classifiable as to human carcinogenicity.

How does manganese affect children?
Daily intake of small amounts of manganese is needed for growth and good health in children. Manganese is constantly present in the mother and is available to the developing fetus during pregnancy. Manganese is also transferred from a nursing mother to her infant in breast milk at levels that are appropriate for proper development. Children, as well as adults, who lose the ability to remove excess manganese from their bodies develop nervous system problems. Because at certain ages children take in more than adults, there is concern that children may be more susceptible to the toxic effects of excess manganese. Animal studies indicate that exposure to high levels of manganese can cause birth defects in the unborn. There is no information on whether mothers exposed to excess levels of manganese can transfer the excess to their developing fetus during pregnancy or to their nursing infant in breast milk.

How can families reduce the risk of exposure to manganese?
In most situations, there is no need to reduce one's exposure to manganese because it is an essential nutrient for good health. Excess levels of manganese may be present in soils, especially at or near hazardous waste sites. Therefore, it is important to discourage hand-to-mouth activity in young children, especially near hazardous waste sites or in areas that may have increased manganese levels in the soil. Manganese is also present in pesticides that may be used around the home. These pesticides should be used in a manner consistent with manufacturer's instructions.

Is there a medical test to show whether I've been exposed to manganese?
Tests are available that show levels of manganese in different body fluids. Measurements of manganese in blood, urine, feces, and scalp hair can be used to determine exposure to excess levels of manganese by testing whether levels of the metal in your body tissues are greater than normal. However, these tests cannot predict how the levels in your tissues will affect your health. Your doctor can take samples and send them to a testing laboratory.

Has the federal government made recommendations to protect human health?

The EPA has set a non-enforceable guideline for the level of manganese in drinking water at 0.05 milligrams per liter (0.05 mg/L). The Occupational Safety and Health Administration (OSHA) has set a limit of 5 milligrams manganese per cubic meter (5 mg/m^3) of workplace air for the average amount of manganese during an 8-hour workday, 40-hour workweek. The National Research Council has recommended safe and adequate daily intake levels for manganese that range from 0.3 to 1 mg/day for children up to 1 year, 1 to 2 mg/day for children up to age 10, and 2 to 5 mg/day for children 10 and older.

References

Agency for Toxic Substances and Disease Registry (ATSDR). 2000. Toxicological Profile for Manganese. 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.

CERTIFICATION

This 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 begun. Editorial review was completed by the Cooperative Agreement partner.

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

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