Health Consultation

Evaluation of Recreational Exposures to Surface Water, Sediment, and Fish Consumption

STANDARD MINE
GUNNISION COUNTY, COLORADO

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

Health Consultation: A Note of Explanation

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

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

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HEALTH CONSULTATION

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STANDARD MINE
GUNNISION COUNTY, COLORADO

Prepared By:

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

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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 Standard Mine is an abandoned gold and silver mine located in the Ruby Mining District in Southwestern Colorado. The site was listed on the National Priorities List (NPL) in September 2005 due to the potential impact of metal contaminants on human and ecological health. The primary contaminants that have been identified at the site include arsenic, barium, cadmium, chromium, copper, lead and zinc. This document is the third health consultation that has been performed on the Standard Mine site, which examines the human health risks associated with recreational exposure to site-related contaminants in surface water, sediments, and fish tissue. The other health consultations have examined the human health implications of recreational exposure to onsite surface soil and the impact of mining related contaminants on the town of Crested Butte's municipal water supply, which is located approximately 5 miles east of the mining site.

After a thorough review of the environmental data, it was concluded that exposure to onsite lead contaminated surface water and sediment poses a public health hazard to children who visit the site for recreational purposes. In addition, lead in onsite surface soil also poses a potential future health hazard for pregnant women who frequently visit the site for recreational purposes. These conclusions are based on the results of lead uptake modeling. The non-cancer health hazards and theoretical cancer risks associated with exposure to all other contaminants found in surface water and sediment are not likely to result in adverse health effects in recreational children or adults. Consumption of contaminated fish from surface waters impacted by the Standard Mine site was also evaluated in this consultation and is considered to be no apparent public health hazard. Overall, it is recommended that the concentration of lead in onsite surface and sediment is reduced to protect the health of recreational users and that health education activities are conducted to inform recreational users of the potential hazards associated with recreational use of the Standard Mine site.

Background

Site Description and History

The Standard Mine is located in the Ruby Mining District of the Gunnison National Forest, approximately 5 miles west of Crested Butte, Colorado. It is thought that heavy metal mining began in the southern Ruby Mining District in 1874 and continued until 1974. The Standard Mine was one of the three largest producing silver mines in the area along with the Forest Queen and Keystone Mine. The Standard Mine was called the most environmentally degraded mine site in the entire Ruby Mining District by a report from the Colorado Geological Survey (cited in EPA 2008). The contaminants of concern are primarily heavy metals with samples showing elevated levels of arsenic, barium, lead, zinc, cadmium, copper and chromium. On September 14, 2005, the Standard Mine site was listed on the National Priorities List due to the potential impact of mining related contaminants on the Town of Crested Butte's water supply, as well as, the surrounding environment.

The Standard Mine site is approximately 11,000 feet above sea level in a remote and isolated location on the south side of Mt. Emmons. It is only accessible in the summer by off-road vehicles, mountain bikes, and hiking. The site consists of 6 operating levels and the Level 1 adit (mine tunnel) releases 100-200 gallons per minute (gpm) of groundwater during high flow season and 1-10 gpm during low flow season to Elk Creek (EPA 2008). Historically, Elk Creek flowed through the mine site and along a surface impoundment depositing heavy metals into Coal Creek. Coal Creek runs through the town of Crested Butte until it meets the Slate River. Crested Butte's municipal drinking water intake is located on Coal Creek approximately 100 yards downstream of the confluence with Elk Creek. Thus, there was a potential threat to Crested Butte's water supply from heavy metals stemming from the Standard Mine.

In 2006, the Agency for Toxic Substances and Disease Registry (ATSDR) conducted a health consultation to evaluate the potential threat of site-related contamination on Crested Butte's municipal water supply. It was found that the Standard Mine site does not impact Crested Butte's drinking water supply (Coal Creek) to a degree that would pose a public health hazard to residents. However, it was noted that a major release from the onsite surface water impoundment could potentially impact Crested Butte's water supply for a short period. In the summer of 2007, the EPA Emergency Response and Removal Unit began remediating critical areas of the site including the removal of the surface water impoundment and the construction of a nearby repository to consolidate site-related wastes. These improvements are likely to decrease the impact to downstream receptors from mine drainage, particularly the potential threat to Crested Butte's water supply. However, it is too early to determine the effect of these actions at this time. This health consultation is based on pre-remedial data.

The Standard Mine site also consists of waste piles along with open and unmarked adits (horizontal) and shafts (vertical) with the following characteristics (UOS 2006):

- access to 8400 feet of drifts on six levels
- 61,700 cubic yards of waste rock
- 29,000 cubic yards of mill tailings

It should be noted that some of this data may be inaccurate due to the 2007 remedial actions undertaken by the EPA.

In 2008, the Colorado Department of Public Health and Environment (CDPHE), under cooperative agreement with ATSDR, conducted an additional health consultation on recreational exposures to onsite surface soil. This health consultation concluded that high lead concentrations in onsite surface soil poses a public health hazard for children and adults (e.g. pregnant women) that visit the site for recreational purposes. The current document evaluates the remaining recreational exposure pathways to surface water, sediment, and fish.

Demographics

Figure 1 shows the demographic information for individuals living in the vicinity of the Standard Mine. The vast majority of people live in Crested Butte, a town of just over 1,500 residents (Census 2000). No residents have been identified in the immediate vicinity of the site. This figure is adopted from the initial ATSDR health consultation (ATSDR 2006).

Community Health Concerns

In February 2006, ATSDR participated in an EPA-sponsored public meeting in Crested Butte, CO. Approximately 20 residents, as well as several officials from city, state, and federal organizations attended the meeting. During this meeting, community members conveyed their health concerns regarding the site. These health concerns included: the potential accumulation of cadmium in human tissue from low dose exposures, fishing advisories on Coal Creek, the possibility of multiple sclerosis and other autoimmune diseases from exposure to site-related contaminants, and elevated risks of breast and skin cancers. Community members were also concerned about potential exposures from additional pathways to recreational users (including camping), which are evaluated in this health consultation and in the previous health consultation. The health concerns are presented in detail with responses from ATSDR in the initial health consultation on the Standard Mine site (ATSDR 2006).

Discussion

Environmental Data

The data used in this evaluation consists of surface water, sediment, and fish tissue samples collected onsite (Elk Creek), in Elk Creek, and Coal Creek. Spatially, the data spans approximately 10 linear miles from above the mine site to the eastern edge of Crested Butte where Coal Creek meets the Snake River (Figures 2 and 3). Contaminant levels in surface water and sediment vary greatly over this area with high metal concentrations onsite, which generally decrease with increasing distance from the site. Therefore, exposure to contaminants also varies by location. To account for this variability, the data was divided into 3 exposure units: onsite (Elk Creek), Elk Creek down stream of the site, and Coal Creek.

Surface Water

The surface water samples used in this assessment were collected during the years of 1998-2006 by the EPA (or their contractors), the Coal Creek Watershed Coalition, and the University of Colorado. Approximately 90 total metal surface water samples were collected and analyzed by EPA method 200.7/200.8 for the Contract Laboratory Program's Target Analyte List (TAL) metals. Total metal results were used because they contain both suspended and dissolved metals. The complete surface water data results are shown in Tables 1-3 by exposure unit. The sampling location of surface water samples is shown in Figure 2. Highlights of the surface water data are discussed below.

Surface water contaminant levels varied by exposure unit and typically followed the general rule noted above, that contaminant levels decrease with increasing distance from the site. High levels of arsenic, cadmium, lead, manganese, and thallium were identified in onsite surface waters with maximum detected concentrations of 1.7 parts per billion (ppb), 61.1 ppb, 563 ppb, 2,600 ppb, and 1.4 ppb respectively. Notable exceptions to the general rule were observed for arsenic, fluoride, and manganese. The arsenic levels in Coal Creek (10.3 ppb) and Elk Creek (10 ppb) were much higher than arsenic in onsite surface water (1.7 ppb). Fluoride was only found at high concentrations in Coal Creek (2800 ppb). The manganese concentration in onsite surface water was high (2600 ppb), decreased in Elk Creek (772 ppb), and then increased again in Coal Creek (1200 ppb). These results are summarized below in Table 4.

Table 4. Summary of Major Surface Water Contaminants

Contaminant	Maximum Onsite Levels (in ppb)	Maximum Elk Creek Levels (in ppb)	Maximum Coal Creek Levels (in ppb)
Arsenic	1.7	10	10.3
Cadmium	61.1	17.7	1.6
Lead	563	37.9	5.5
Manganese	2600	772	1200
Thallium	1.4	1.0	0.6
Increasing Distance From Site →			

Sediment

Sediment samples were collected on 11 different occasions in 1999, 2005, and 2006. A total of approximately 50 sediment samples were collected and analyzed for TAL metals. The sediment samples were collocated with surface water samples. The complete sediment data results are shown in Tables 5-7 by exposure unit. The sampling location of the sediment data is shown in Figure 2. Sediment data highlights are discussed below.

High levels of arsenic, iron, lead, and manganese were identified in onsite sediment with maximum concentrations of 157 parts per million (ppm), 82,300 ppm, 7,800 ppm, and 10,400 ppm, respectively. As expected, the contaminant levels found in sediment generally decreased with increasing distance from the site. However, some exceptions to this rule occurred for arsenic, iron, and cadmium. Arsenic levels were higher in Coal Creek sediment (178 ppm) than in both onsite (157 ppm) and Elk Creek (90.7 ppm) sediments. Iron levels in sediment were highest onsite, but Coal Creek sediment samples were higher in iron than in Elk Creek sediment. The maximum detected concentration of cadmium in Elk Creek sediment (68.2 ppm) was approximately two times greater than the cadmium levels found onsite (34.2 ppm) and in Coal Creek (32.1 ppm) sediments. The major sediment contaminants from each exposure unit are summarized below in Table 8.

Table 8. Summary of Major Sediment Contaminants

Contaminant	Maximum Onsite Levels (in ppm)	Maximum Elk Creek Levels (in ppm)	Maximum Coal Creek Levels (in ppm)
Arsenic	157	90.7	178
Cadmium	34.2	68.2	32.1
Iron	82300	28800	45400
Lead	7880	1670	411
Manganese	10400	9510	7150
Mercury	0.1	0.04	0.16

Fish Tissue

Fish samples were collected in July 2006 from Elk Creek and Coal Creek. A total of 16 fillet samples were analyzed by EPA Method 200.2/200.8 for TAL metals. Fish tissue results are shown in Table 9 and the sampling locations are depicted in Figure 3. Due to the small sample size and comparable metal concentrations found, the fish tissue results were analyzed as a whole as opposed to separating into exposure units. Moreover, no fish were observed onsite or in Elk Creek, except near the confluence with Coal Creek during fish sampling. The only notable contaminant observed in fish tissue was arsenic with a maximum detected concentration of 3.2 ppm. The highest levels of arsenic were found in fish caught in Coal Creek.

Exposure Evaluation

Selection of Contaminants of Potential Concern

The first step in the exposure evaluation is to determine if the maximum detected concentration of each contaminant exceeds the respective screening value. The screening values used in this evaluation are ATSDR CVs, which are conservative values based on health guidelines and high-end exposures for each contaminant. CVs are media-specific and multiple exposure routes to that medium are generally used in the derivation of a CV. If a particular contaminant exceeds the respective CV, it does not necessarily indicate a health risk, only that additional evaluation is necessary. If the maximum detected concentration of a particular contaminant is below the CV, it was dropped from further evaluation since it is unlikely to result in non-cancer or cancer adverse health effects. The selection of COPCs (i.e. contaminants above the CV) is discussed below by environmental medium.

Surface Water

The screening level assessment of the surface water data used in this evaluation identified several COPCs, which are listed in Table 10 and summarized below in Table 11. Overall, the surface water COPCs are arsenic, cadmium, fluoride, lead, manganese, thallium, and zinc. Fluoride and thallium were only selected as COPCs in Coal Creek.

Sediment

The screening level assessment of the sediment data identified several COPCs that are shown in Table 12 and summarized below in Table 11. Overall, the sediment COPCs are aluminum, arsenic, cadmium, chromium, copper, iron, lead, manganese, mercury, thallium, vanadium, and zinc. Mercury was identified as a COPC only in Coal Creek.

Fish Tissue

The EPA Region 3 Risk Based Concentration (RBC) was used as the CV for screening fish tissue since no CVs are available from ATSDR for fish tissue. The RBCs for fish consumption are developed with the assumption of a fish consumption rate equal to 54g per day, 350 days per year over a 30-year period. For detailed information on RBCs, please see http://www.epa.gov/reg3hwmd/risk/human/index.htm.

Very little information exists on the consumption of fish from Elk Creek and Coal Creek. However, it is highly unlikely that any individual consumes fish from these creeks at the same rate as the RBC assumptions. Thus, the RBC value for fish consumption is considered conservative and appropriate for use as a screening value in this evaluation. The only contaminant that exceeded the screening value in fish tissue was arsenic. As mentioned previously, fish tissue was not analyzed by each exposure unit considered in this evaluation, but was instead combined due to a limited number of fish tissue samples. It was found that the concentration of arsenic in fish was higher in Coal Creek than Elk Creek (no onsite samples were available).

Table 11. Summary of Surface Water and Sediment COPCs

Exposure Unit	Surface Water COPCs	Sediment COPC
Onsite	Arsenic, Cadmium, Lead, Manganese, and Zinc	Aluminum, Arsenic, Cadmium, Copper, Iron, Lead, Manganese, and Zinc
Elk Creek (Below mine site)	Arsenic, Cadmium, Manganese, and Zinc	Aluminum, Arsenic, Cadmium, Chromium, Copper, Iron, Manganese, Thallium, Vanadium, and Zinc
Coal Creek	Arsenic, Fluoride, Manganese, and Thallium	Aluminum, Arsenic, Cadmium, Chromium, Iron, Manganese, Mercury, Thallium, Vanadium, and Zinc

Conceptual Site Model

A conceptual site model identifies the 5 components of an exposure pathway. Exposure pathways can be classified as complete, potential or incomplete based on the available information and the likelihood of a particular pathway actually occurring. As discussed elsewhere in this document, the environmental media of concern in this health consultation are surface water, sediment, and fish tissue. Individuals who use the site for recreational purposes are the receptor population of concern since no residents have been identified in the vicinity of the site. Recreational exposures to contaminated surface soil and the impact of mining related contaminants on the Town of Crested Butte's water supply have been evaluated previously in health consultations published in 2006 and early 2008. This consultation focuses on the remaining potential exposures to recreational users from contaminated surface water, sediment, and fish tissue.

The area surrounding the Standard Mine Site is primarily controlled by the U.S. Forest Service and is only accessible by off-road vehicles, hiking, and mountain biking. The surrounding slopes are steep and heavily forested, which discourages visits to the site to some degree. Land use information at the Standard Mine site is limited. However, a community survey was conducted by the EPA Region 8 in the summer of 2006 to determine potential land use at the site (Appendix D). A total of 29 adults responded to the survey and identified recreational use as the primary land use. The percentage of survey respondents constitutes only a small fraction of the total surrounding population (1.8%) and may not be representative of the "site population" as a whole. However, this is the only land-use data that was made available for this evaluation. The recreational uses identified in the survey, from most popular response to least popular response, include hiking and mountain biking (28), skiing and snowmobiling (17), ATV and motorcycle riding (14), and camping (6). No one indicated they thought fishing, mining, or other activities were occurring on-site. With this information, a conceptual site model, which describes the components of the exposure pathways, was developed.

Surface Water

Three primary routes of exposure to surface water exist. They are incidental ingestion of surface water during swimming/wading, intentional ingestion of surface water during camping or hiking, and dermal (skin) exposure to contaminants while swimming/wading. Incidental ingestion of surface water while swimming or wading is considered the most significant exposure pathway for this evaluation since this pathway is the most likely to actually occur. Intentional ingestion of surface water could possibly occur onsite and along the drainage areas during camping or hiking. However, consumption of surface water at the mine site and drainage areas is not likely to occur on a regular basis and there is no available information to suggest that this pathway actually occurs. Therefore, this pathway is considered a potential exposure pathway. Dermal exposure to metal-contaminated surface water is considered a relatively insignificant exposure pathway since metals do not generally penetrate the skin barrier and enter the body. Thus, incidental ingestion of surface water, while swimming/wading, and intentional ingestion of surface water, during camping or hiking, are the two surface water exposure pathways analyzed in this evaluation with the latter considered a potential pathway.

Sediment

The primary routes of exposure to sediment include incidental ingestion of sediment and dermal contact with sediment. Dermal contact is not considered a relevant exposure pathway for metal-contaminated sediment for the same reasons mentioned above for surface water. Incidental ingestion of sediment occurs along the shoreline and while swimming/wading.

Consumption of Contaminated Fish Tissue

Very little information is available on fish consumption in the areas examined in this evaluation. No one responded that fishing occurred in the land-use survey. However, anecdotal information does exist to indicate that fishing occurs along Coal Creek based on observations from the CDPHE site manager during site visits. How often fishing occurs in the areas investigated is unknown. Therefore, fish consumption is considered a potential exposure pathway.

Conceptual Site Model

Source	Transport Mechanism	Point of Exposure	Affected Environmental Medium	Timeframe of Exposure	Potentially Exposed Population	Route of Exposure
Acid Mine drainage and other mining related sources	Surface Water	Onsite, Elk Creek, and Coal Creek	Surface Water, Sediment and Fish Tissue	Past, current, and Future	Recreational Users Including: Hikers, Campers, and Anglers	Incidental Ingestion of Surface Water
						Incidental Ingestion of Sediment
						Fish Consumption
						Intentional Ingestion of Surface Water

Notes: 1) Dermal exposure to metals in surface water and sediment is considered an insignificant exposure pathway and is not quantitatively evaluated in this consultation.
2) Intentional Ingestion of Surface Water is considered a potential exposure pathway.
3) Heavy site use scenario of >20 days is considered a potential exposure pathways based on the site-specific land use survey and site conditions.

Exposure Scenarios based on Land-Use Survey

To determine the potential health hazards to recreational users from exposure to the pathways identified above, exposure doses must be calculated. To the extent possible, information from the Land-Use Survey described above was used to estimate exposure doses. Default exposure assumptions and professional judgment were used in cases where the Land-Use Survey data was inadequate.

Exposures to campers, hikers, and ATV riders are not expected to significantly differ for the complete recreational pathways analyzed in this evaluation. Thus, it was assumed that all of these users could be exposed to contaminants from each complete exposure pathway at a similar rate. A general exposure scenario for complete pathways, which accounts for average (5 days/year) and high-end (52 days/yr.) recreational use of the site, was deemed appropriate and protective of all recreational users. Only 1 person out of 29 survey respondents claimed to visit the site for more than 20 days (Appendix D) and other information from site managers indicates that individuals do not frequent the site that often for recreation. Based on that information, the high frequency scenario is considered a potential exposure pathway due to the low probability of people visiting the site that often. The exposure assumptions used in this evaluation are consistent with the values used to assess recreational exposures to surface soils at the Standard Mine site (ATSDR 2008).

The other potential pathways identified above, intentional ingestion of surface water and fishing, are only likely to occur for some recreational users. For instance, it is reasonable to assume that only campers and backcountry hikers would use the surface waters under consideration in this evaluation as a source of drinking water. Fishing would only seem to apply to recreational anglers and, perhaps, campers. The same exposure frequencies that were used for the complete exposure pathways were selected for the potential exposure pathways. However, it is unlikely that individuals would use these particular surface water bodies for drinking water purposes more than 5 days per year.

Some amendments to the exposure frequencies discussed above had to be made to meet the requirements for the lead model, which is described in more detail below. All of the exposure assumptions made in this evaluation are discussed in detail in Appendices A and B (Lead).

Public Health Implications

Lead Exposures

Lead was the primary contaminant of concern identified in this evaluation. The concentration of lead in onsite sediment at the Standard Mine site ranges from 838-7880 parts per million (ppm) with an average concentration of 3159 ppm. Both the maximum and average concentrations of lead in sediment exceed the comparison value (CV) of 400 ppm, requiring further evaluation. The concentration of lead in onsite surface water at the Standard Mine site ranges from 3.1 to 563 ppb with an average concentration of 86.2 ppb. Both the maximum and average concentrations of lead in onsite surface water exceed the EPA action level of 15.0 ppb for lead, requiring further evaluation. In addition, the State acute (14-280 ppb) and chronic (0.5-11 ppb) ambient water quality criteria for lead in surface water are also exceeded. Lead was not evaluated in Elk Creek or Coal Creek because the lead concentration in these areas was below the CV and dropped from further evaluation.

The method of evaluating risks from exposure to lead differs from the assessment method mentioned previously where exposure doses are calculated and compared to health-based guidelines. To assess the health risks associated with lead exposure, modeling is used to predict the blood lead concentration of those exposed because individuals are exposed to lead from a variety of environmental sources and lead exposures, and the subsequent health effects, have traditionally been described in terms of blood lead concentrations in the scientific literature. Young children (0-7 years) and the developing fetus are the most sensitive receptor population to the toxic effects of lead. Analysis of these susceptible subpopulations is also considered protective of the general population. Therefore, the overall objective is to determine the probable blood lead concentration of young children and the fetus of pregnant women that use the mine site for recreational purposes.

To accomplish this goal in accordance with the ATSDR and CDPHE guidelines, EPA recommended predictive modeling was performed. The Integrated Exposure Uptake Biokinetic (IEUBK) model is used to predict blood lead levels in children and the Adult Lead Model (ALM) is used to predict blood lead levels in the fetus of pregnant women. Blood lead levels as low as 10 μg/dL, which do not cause distinct symptoms, are associated with decreased intelligence and impaired neurobehavioral development (CDC, 1991). Blood lead levels of 10 μg/dL or greater is considered elevated, but there is no demonstrated safe level of lead in blood. A growing body of research has shown that there are measurable adverse neurological effects in children at blood lead concentrations as low as 1 μg/dL (EPA, 2003a).

It should be noted that 12 days is the minimum exposure frequency that is recommended for use in lead models. Thus, slightly different exposure frequencies had to be used to evaluate lead. Again, the high-frequency scenario is considered a potential exposure pathway since there is some uncertainty regarding how often young children and pregnant women actually frequent the site. An extended discussion of the methods used to evaluate lead risks is contained in Appendix B.

The IEUBK model predicted elevated blood levels (> 5% probability that blood lead is over 10 μg/dL) from incidental ingestion of surface water and sediments for each input frequency evaluated in this assessment. The model predicted that 18.8 to 85.0 % of young children will have elevated blood lead levels (above 10 μg/dL) depending on how often they visit the site for recreation (Appendix Table B1). This indicates that incidental ingestion of contaminated onsite surface water and sediment at the Standard Mine site by recreational children would likely result in adverse health effects. This conclusion is based on the IEUBK model results using the default soil ingestion and surface water ingestion rates. Since there is some uncertainty regarding the application of soil ingestion rates for sediment ingestion, the model was also performed using ½ the default soil ingestion rate and the conclusion remains the same. For example, by using half the IEUBK model default soil ingestion rate (Appendix Table B2) elevated blood lead levels remain for all exposure frequencies evaluated.

According to the Adult Lead Model (ALM), elevated fetal blood levels are predicted only under the high-frequency scenario that is classified as a potential exposure. As shown in Appendix Table B3, the probability that fetal blood lead will exceed the target blood lead level of 10 μg/dL is 19.7%, under the high-frequency recreational scenario.

Overall, exposure to lead in onsite sediment and surface water at the Standard Mine by recreational children (age 0-6 years) constitutes a public health hazard under the EPA default assumptions used in the model. In addition, exposure to lead in onsite sediment constitutes a public health hazard to pregnant women for the potential high frequency recreational scenario. Lead is not likely to result in significant health hazards for pregnant women that occasionally visit the site for recreational purposes. It is important to note that the child and adult lead models rely on many input parameters to estimate blood lead levels as discussed in Appendix B. EPA developed default values for all parameters to allow the model to be used without performing costly and time-consuming site-specific studies. Several of these parameters can be measured more accurately on a site-specific basis. In the absence of site-specific data, this evaluation uses default values. These default values could lead the model to over predict or under predict actual blood lead levels.

Exposure to Non-Lead COPCs

The estimated exposure doses for fish ingestion, surface water and sediment ingestion were calculated using standard dose equations provided by the ATSDR and EPA. The dose results are presented in full in Appendix A and are summarized below by exposure pathway.

Incidental Ingestion of Surface Water for Non-Lead COPCs

Ingestion of surface water that is inadvertently ingested during activities such as swimming and/or wading is considered incidental ingestion in this evaluation. The EPA standard default exposure assumptions for freshwater swimming pools were used to evaluate incidental ingestion of surface water by recreational adults. In this evaluation, it was assumed that children will incidentally ingest twice as much surface water as the average adult. It should be noted that the actual incidental ingestion rate for children and adults could be higher or lower than the values used in this evaluation.

Under these assumptions, the estimated non-cancer exposure doses for both children and adults were well below the health-based guidelines for all contaminants. The highest estimated non-cancer hazards were observed from incidental exposure to cadmium (onsite, Elk Creek), zinc (onsite), thallium (onsite), and fluoride (Coal Creek). The highest dose observed (relative to the health-based guideline) for incidental ingestion of surface water was for the potential heavy use recreational child exposed to cadmium in onsite surface water. The dose estimated for cadmium for a recreational child visiting the site 52 days per year was nearly an order of magnitude lower than the health-based guideline, or "safe" dose. This indicates that non-cancer health effects are not likely to occur for all receptors from this exposure pathway alone. The complete list of exposure dose results for incidental surface water ingestion and the comparison to the health-based guidelines is shown in Table 15 and Appendix Table A2.

Arsenic was the only oral carcinogen evaluated for surface water ingestion. Theoretical cancer risks were estimated for incidental ingestion of surface water using an age-adjusted equation that includes children and adults. The highest theoretical cancer risk for high frequency recreational users was $6.1 * 10^{-7}$, which means at a maximum only 0.6 excess cancer cases per 1,000,000 exposed individuals would be expected to occur from incidentally ingesting surface water from the areas evaluated in this assessment (Table 18). This theoretical level of risk is below the acceptable risk range of $1 * 10^{-4}$ - $1* 10^{-6}$ and does not constitute a significant cancer risk.

Incidental Ingestion of Sediment for Non-Lead COPCs

Incidental ingestion of sediment can occur while playing on the shoreline of a water body or while swimming and wading. As previously mentioned, no formally established intake guidelines exist for incidental sediment ingestion. The sediment ingestion rates used in this evaluation are one-half the default values for soil ingestion. It should be noted that the actual sediment ingestion rates could be higher or lower than the value used in this evaluation.

All estimated non-cancer exposure doses for incidental ingestion of sediment were below the respective health-based guideline for each contaminant. The highest non-cancer hazards were estimated for recreational children incidentally ingesting arsenic-containing sediments onsite for 52 days per year (Tables 16 and A3). This non-cancer dose was approximately ½ the health-based guideline, which indicates that non-cancer hazards are not likely from this exposure pathway. Theoretical cancer risks were also calculated for this pathway using an age-adjusted equation that accounts for exposure during childhood through adulthood. Arsenic was the only oral carcinogen evaluated for sediment. The highest theoretical cancer risk of $2.74 * 10^{-5}$ (27 excess cancer cases per 1,000,000 exposed individuals) was estimated based on the potential heavy use scenario for recreational child exposures to onsite sediment. The theoretical cancer risks for sediment ingestion were higher in Coal Creek than in Elk Creek. However, all theoretical cancer risk estimates are fairly similar in each exposure unit as shown in Table 19.

The EPA has established an acceptable risk range of $1* 10^{-4}$ – $1 * 10^{-6}$. CDPHE strives to achieve a target theoretical cancer risk value of $1 * 10^{-6}$ or 1 excess cancer case in 1,000,000 exposed individuals. The arsenic levels in Coal Creek are higher than the levels found in Elk Creek downstream of the Standard Mine site, which indicates that some of the arsenic may not be site-related. Arsenic is a naturally occurring element in soils and rock. Background concentrations of arsenic are higher in the west than in most other areas of the U.S. due to the geologic conditions and constituents of soil/rock. The risks are within the acceptable cancer risk range and do not warrant immediate action to reduce exposure.

Incidental ingestion of sediment and surface could also occur simultaneously while swimming and/or wading. To assess the cumulative impact of both pathways on public health, the non-cancer hazards and theoretical cancer risks were combined. It was found that combined exposure to contaminants in surface water and sediment while swimming/wading onsite and in the drainage areas evaluated in this assessment is not likely to result in non-cancer or cancer adverse health effects. The combined exposure doses were well below the non-cancer health-based guidelines and the combined theoretical cancer risk was $2.76 * 10^{-5}$, which is also within the acceptable range (Table 20).

Recreational Fish Consumption

Arsenic was the only contaminant that exceeded the EPA Region 3 RBC for fish tissue. Based on a limited amount of fish tissue data, the data was not separated in exposure units. Fish consumption risk estimates were conducted in a slightly different manner than the other routes of exposure. In this case, the exposure point concentration was directly compared with the Risk-Based Concentration (RBC) to determine the theoretical cancer risks estimates. As previously mentioned, the RBC assumes the average adult individual ingests 54 grams of fish per day, 350 days per year, over a 30-year period. To derive the theoretical cancer risk, the exposure point concentration was divided by the RBC and the result was multiplied by $1 * 10^{-6}$.

The estimated theoretical cancer risk was $6.90 * 10^{-4}$ or 690 excess cancer cases per 1 million exposed individuals. The theoretical cancer risk estimate for fish consumption is above the acceptable risk range established by the EPA. However, the cancer risk estimate does not represent a public health hazard for three primary reasons: 1) the majority of arsenic in fish is in the relatively non-toxic organic arsenic form, 2) no one in the land-use survey indicated that fishing occurs now or will likely occur in the future, and 3) the RBC likely overestimates the actual amount of fish that are caught and consumed in the areas investigated in this evaluation. The general consensus in the scientific literature is that the majority (85->90%) of arsenic in the edible parts of freshwater and marine fish tissue is in some nontoxic form of organic arsenic (ATSDR, 2007). Very little information is available on fish consumption in the areas examined in this evaluation. However, no one responded that fishing occurred in the land-use survey. Therefore, the RBC, which is based on 54g of fish per day, 150 days per year for 30 years, likely overestimates the actual fish consumption from the areas evaluated in this assessment. Together, these factors indicate no apparent public health hazard as a result of the consumption of fish from Elk Creek and Coal Creek down stream of the Standard Mine site. No fish were observed onsite.

Intentional Ingestion of Surface Water
As mentioned previously in this document, intentional ingestion of surface water could occur during camping or backcountry hiking when other sources of water are not readily available. This exposure pathway is considered potential since there is no specific evidence of individuals actually using surface water in Elk Creek or Coal Creek for drinking water. However, it is also unreasonable to completely exclude this pathway from a public health perspective. It was assumed that areas of Elk Creek and Coal Creek downstream of the mining site would be the likely place for this activity to occur since the aesthetics of the mine drainage would likely prevent most individuals from consuming water onsite. All estimated exposure doses for intentional ingestion of surface water were below the health-based guidelines with the exception of the onsite cadmium concentration. For the high frequency recreational child, the estimated exposure dose for cadmium was slightly above the health guideline as shown in Table 17. Again, it is not expected that individuals would consume surface water onsite for drinking water purposes, especially not that often. Thus, it is not likely that intentional ingestion of surface water would result in non-cancer adverse health effects. Theoretical cancer risks were not evaluated for this pathway.

Child Health Considerations

In communities faced with air, water, or food contamination, the many physical and behavioral 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.

Health effects for children were considered in this evaluation and were found to be a concern for young campers from exposure to lead at the Standard Mine site. Children and women of childbearing age should limit contact with surface water and sediment at the Standard Mine site. Fetal and child exposure to lead can cause permanent damage to the central nervous system during critical growth stages.

Conclusions

The major conclusions of this evaluation are summarized below:

- Exposure to lead in sediment and surface water presents a public health hazard for young children who visit the Standard Mine site for recreational use. In addition, the future potential non-cancer health hazards from exposure to lead are of concern to adult recreational users (e.g. pregnant women) such as campers that may frequently visit the site. Occasional recreational use of the site by pregnant women is not likely to result in elevated fetal blood levels.

- The non-cancer health hazards and theoretical cancer risks associated with exposure to all other contaminants found in surface water and sediment represent no apparent public health hazard to recreational children and adults.

- Consumption of contaminated fish was also evaluated in this assessment as a potential exposure pathway and is considered no apparent public health hazard.

Recommendations

- Frequent campers and their children should not use onsite surface water bodies for recreational activities and drinking water purposes due to lead contamination.

- EPA should remediate the site to reduce contaminant levels. In particular, onsite lead concentrations should be decreased to alleviate the public health concern to recreational children.

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 project managers to carry out the Public Health Action Plan as described below.

- CCPEHA will review any additional surface water and sediment data upon request and/or necessity.

- Signs will be installed by CDPHE to warn recreational users of the potential hazards associated with exposure to surface water and sediments. The sign will specifically address the lead risks to small children.

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

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References

Agency for Toxic Substances and Disease Registry (ATSDR 2005). *Public Health Assessment Guidance Manual,* Revised January 2005. Available on the Internet at: http://www.atsdr.cdc.gov/HAC/PHAManual/toc.html, accessed November 2007.

Agency for Toxic Substances and Disease Registry (ATSDR 2006). *Evaluation of Potential Public Health Impact of Surface Water Contamination*, November 13, 2006. Available on the Internet at: http://www.atsdr.cdc.gov/HAC/pha/StandardMineNPLSite/StandardMineHC111306.pdf, accessed November 2007.

Agency for Toxic Substances and Disease Registry (ATSDR 2007). *Toxicological Profile for Lead,* August 2007. Available on the Internet at: http://www.atsdr.cdc.gov/toxprofiles/tp13.html, Accessed November 2007.

Agency for Toxic Substances and Disease Registry (ATSDR 2007). *Toxicological Profile for Arsenic,* August 2007. Available on the Internet at: http://www.atsdr.cdc.gov/toxprofiles/tp13.html, Accessed November 2007

Syracuse Research Corporation (SRC 2007). *Baseline Human Health Risk Assessment for the Standard Mine Site (External Review Draft),* April 16, 2007. Prepared for and with oversight by the USEPA.

URS Operating Services, (UOS 2006). *Sampling Activities Report on the Standard Mine Site*, March 20, 2006.

U.S. Environmental Protection Agency, (EPA 1993). *Superfund's Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure (Draft),* November 1993.

U.S. Environmental Protection Agency, Region 9 (EPA 2004). *Preliminary Remediation Goals*, last update October 2004. Available on the Internet at: http://www.epa.gov/reg3hwmd/risk/human/rbc/RBCoct07.pdf, Accessed September 2007.

U. S. Environmental Protection Agency, Region 3 (EPA 2007a). *Human Health Risk Assessment, Risk-Based Concentration Table,* last update October 11, 2007. Available on the Internet at: http://www.epa.gov/reg3hwmd/risk/human/index.htm, Accessed November 2007.

U.S. Environmental Protection Agency, National Center for Environmental Assessment (EPA 1997). *Exposure Factors Handbook*, last update August 1997. Available on the Internet at: http://www.epa.gov/ncea/efh/, Accessed November 2007.

U.S Environmental Protection Agency (EPA 2008). Standard Mine Superfund Webpage, last update February 5, 2008. Available on the Internet at: http://www.epa.gov/Region8/sf/co/standard/, Accessed February 2008.

Additional Tables and Figures

Table 1. Standard Mine Onsite Surface Water

Contaminant	Maximum (μg/L)	Minimum (μg/L)	Mean (μg/L)	Detection Frequency	Number of Samples	Comparison Values (μg/L)		COPC
						PRG*	ATSDR	
Aluminum	413	21.2	182.2	56%	18	3600	10000	
Antimony	0.16	0.16	0.16	6%	17	1.5	4.0	
Arsenic	**1.68**	0.1	0.77	21%	19	0.0045	0.02	X
Barium	12	7.35	9.08	50%	8	260	2000	
Beryllium	0.75	0.75	0.75	7%	15	7.3	20	
Cadmium	**61.1**	0.738	22.29	67%	18	1.8	2	X
Calcium	47000	3550	15706	100%	11	NA	NA	
Chromium	0.06	0.06	0.06	6%	18	11	30	
Cobalt	7.36	0.032	3.70	33%	6	73	100	
Copper	**335**	1.24	63.93	71%	17	150	100	X
Fluoride	100	100	100	11%	9	220	600	
Iron	936	171	348.1	47%	17	1100	NA	
Lead	**563**	3.11	86.11	94%	17	1.5	15	X
Magnesium	5100	317	1710	69%	13	NA	NA	
Manganese	**2600**	1.93	730.6	83%	18	88	2000	X
Mercury	N/a	N/a	N/a	0%	7	0.36	NA	
Molybdenum	0.11	0.11	0.11	12%	8	18	200	
Nickel	7.6	0.35	3.44	47%	17	73	700	
Potassium	880	473	668.8	36%	11	NA	NA	
Selenium	2	0.1	1.23	17%	18	18	200	
Silver	0.5	0.02	0.26	11%	18	18	200	
Sodium	2200	674	1314	67%	9	NA	NA	
Strontium	188	37.3	90.9	100%	9	2200	20000	
Thallium	**1.37**	0.08	0.72	12%	16	0.24	NA	X
Vanadium	0.1	0.06	0.08	25%	8	3.6	100	
Zinc	**11000**	127	2737	100%	16	1100	10000	X

* Value is equal to 1/10th of the EPA Region 9 Preliminary Remediation Goal (PRG) due to potential chemical interactions of multiple contaminants.
μg/L: micrograms contaminant per liter of water (parts per billion)

Table 2. Standard Mine Elk Creek Surface Water Data Summary

Contaminant	Maximum (μg/L)	Minimum (μg/L)	Mean (μg/L)	Detection Frequency	Number of Samples	Comparison Value (μg/L)		COPC
						PRG*	ATSDR	
Aluminum	175	20	80.3	40.0%	25	3600	10000	
Antimony	**5**	0.037	2.1	8.3%	24	1.5	4.0	X
Arsenic	**10**	0.057	3.1	54.2%	24	0.0045	0.02	X
Barium	100	8	34.0	62.5%	8	260	2000	
Beryllium	1	0.036	1.0	4.6%	22	7.3	20	
Cadmium	**17.7**	1.9	6.1	92.0%	25	1.8	2	X
Calcium	30300	12500	21011.1	100.0%	18	NA	NA	
Chromium	10	1	2.3	4.0%	25	11	30	
Cobalt	25	0.283	9.2	33.3%	6	73	100	
Copper	29	1	9.5	68.0%	25	150	100	
Fluoride	100	50	88.0	6.2%	16	220	600	
Iron	186	50	84.5	50.0%	24	1100	NA	
Lead	**37.9**	0.3	10.3	79.2%	24	1.5	15	X
Magnesium	2740	913	1718.4	89.5%	19	NA	NA	
Manganese	**772**	3.7	173.0	91.7%	24	88	2000	X
Mercury	0.2	0.1	0.2	0.0%	4	0.36	NA	
Molybdenum	0.081	0.081	0.081	14.3%	7	18	200	
Nickel	20	0.8	3.5	50.0%	24	73	700	
Potassium	2500	376	872	72.7%	11	NA	NA	
Selenium	15	0.2	3.0	12.0%	25	18	200	
Silver	5	0.022	1.0	4.0%	25	18	200	
Sodium	2500	1360	2008.2	81.8%	11	NA	NA	
Strontium	212	88.9	148.9	100.0%	18	2200	20000	
Thallium	**1**	0.011	0.7	4.8%	21	0.24	NA	X
Vanadium	**25**	0.03	9.0	12.5%	8	3.6	100	X
Zinc	**3450**	230	1095.4	100%	24	1100	10000	X

* Value is equal to 1/10th of the EPA Region 9 Preliminary Remediation Goal (PRG) due to potential chemical interactions of multiple contaminants.
μg/L: micrograms contaminant per liter of water (parts per billion)

Table 3. Standard Mine Coal Creek Surface Water Data Summary

Contaminant	Maximum (μg/L)	Minimum (μg/L)	Mean (μg/L)	Detection Frequency	Number of Samples	Comparison Value (μg/L)		COPC
						PRG*	ATSDR	
Aluminum	478.0	1.0	124.6	80.0%	50	3600	10000	
Antimony	0.9	0.7	0.8	6.8%	44	1.5	4.0	
Arsenic	**10.3**	0.5	3.5	64.0%	50	0.0045	0.02	X
Barium	42.2	11.9	21.5	100.0%	18	260	2000	
Beryllium	N/A	N/A	N/A	0.0%	39	7.3	20	
Cadmium	1.6	0.2	0.8	44.0%	50	1.8	2	
Calcium	140000.0	7210.0	28010.3	100.0%	38	NA	NA	
Chromium	2.1	1.7	1.9	8.2%	49	11	30	
Cobalt	1.1	1.0	1.1	15.4%	13	73	100	
Copper	13.1	1.0	3.2	40.0%	50	150	100	
Fluoride	**2800.0**	100.0	833.2	57.1%	28	220	600	X
Iron	248.0	1.0	123.8	95.9%	49	1100	NA	
Lead	**5.5**	0.3	1.5	38.8%	49	1.5	15	X
Magnesium	4250.0	861.0	2318.4	100.0%	38	NA	NA	
Manganese	**1200.0**	5.2	79.8	100.0%	50	88	2000	X
Molybdenum	N/A	N/A	N/A	0.0%	15	18	NA	
Nickel	4.2	0.5	1.7	36.4%	44	73	200	
Potassium	2300.0	1.0	678.2	100.0%	25	NA	700	
Selenium	1.9	1.9	1.9	2.3%	44	18	NA	
Silver	0.2	0.2	0.2	2.0%	49	18	200	
Sodium	11000.0	1.0	3930.8	100.0%	25	NA	200	
Strontium	309.0	69.7	163.8	100.0%	34	2200	NA	
Thallium	**0.6**	0.2	0.3	8.3%	36	0.24	20000	X
Vanadium	N/A	N/A	N/A	0.0%	18	3.6	NA	
Zinc	398.0	1.0	137.9	100.0%	48	1100	100	

* Value is equal to 1/10th of the EPA Region 9 Preliminary Remediation Goal (PRG) due to potential chemical interactions of multiple contaminants
μg/L: micrograms contaminant per liter of water (parts per billion)

Table 5. Standard Mine Onsite Sediment Data Summary

Contaminant	Maximum (mg/kg)	Minimum (mg/kg)	Mean (mg/kg)	Detection Frequency	Number of Samples	Comparison Value (mg/kg)		COPC
						PRG*	ATSDR	
Aluminum	**33900**	2660	9423	100%	8	7600	50000	X
Antimony	1.03	0.17	0.5	62%	8	3.1	20	
Arsenic	**157**	9.2	43.82	100%	8	0.039	0.5	X
Barium	47.7	33	41.23	100%	3	540	10000	
Beryllium	11	0.6	2.64	100%	8	15	100	
Cadmium	**34.2**	3.8	16.94	100%	8	3.7	10	X
Calcium	4400	472	1691	100%	8	NA	NA	
Chromium	**7**	1.7	3.62	88%	8	3.0	200	X
Cobalt	12.1	5.3	8.66	100%	3	90	500	
Copper	**1720**	13.8	395.1	100%	8	310	500	X
Cyanide	0.12	0.1	0.11	100%	2	120	1000	
Iron	**82300**	7790	33415	100%	8	2300	NA	X
Lead	**7880**	838	3159	100%	8	40	NA	X
Magnesium	1830	467	1004	100%	8	NA	NA	
Manganese	**10400**	1370	4215	100%	8	180	3000	X
Mercury	0.10	0.0041	0.024	91%	11	2.3	NA	
Molybdenum	0.51	0.46	0.48	100%	2	39	300	
Nickel	9.03	2.8	5.97	100%	8	160	1000	
Potassium	624	550	576	100%	3	NA	NA	
Selenium	7.6	0.6	3.52	75%	8	39	300	
Silver	17.9	0.21	4.67	88%	8	39	300	
Sodium	40.4	40.4	40.4	33%	3	NA	NA	
Strontium	15.1	9.42	12.26	100%	2	4700	30000	
Thallium	0.4	0.16	0.24	62%	8	0.52	NA	
Vanadium	6.6	3.9	5.17	100%	3	7.8	200	
Zinc	**6890**	493	2407	100%	8	2300	20000	X

* Value is equal to 1/10th of the EPA Region 9 Preliminary Remediation Goal (PRG) due to potential chemical interactions of multiple contaminants.
mg/kg: milligrams contaminant per kilogram soil (parts per million)

Table 6. Standard Mine Elk Creek Sediment Data Summary

Contaminant	Maximum (mg/kg)	Minimum (mg/kg)	Mean (mg/kg)	Detection Frequency	Number of Samples	Comparison Value (mg/kg)		COPC
						PRG*	ATSDR	
Aluminum	**12400**	6390	9191	100%	14	7600	50000	X
Antimony	0.6	0.2	0.4	36%	14	3.1	20	
Arsenic	**90.7**	13.2	52.7	100%	14	0.039	0.5	X
Barium	98.7	64.6	83.2	100%	6	540	10000	
Beryllium	2	0.43	1.2	100%	14	15	100	
Cadmium	**68.2**	2.6	34.2	100%	14	3.7	10	X
Calcium	7110	1420	3486	100%	14	NA	NA	
Chromium	**5**	0.52	2.95	86%	14	3.0	200	X
Cobalt	24.2	8.2	18.23	100%	6	90	500	
Copper	**598**	18.6	264.7	100%	14	310	500	X
Cyanide	1.6	NA	NA	100%	1	120	1000	
Iron	**28800**	17900	22500	100%	14	2300	NA	X
Lead	**1670**	29	720	100%	14	40	NA	X
Magnesium	3970	2010	2936	100%	14	NA	NA	
Manganese	**9510**	560	5104	100%	14	180	3000	X
Mercury	0.04	0.001	0.021	66%	18	2.3	NA	
Molybdenum	0.67	NA	NA	100%	1	39	300	
Nickel	12.2	7	9.7	100%	14	160	1000	
Potassium	1130	736	901	100%	6	NA	NA	
Selenium	3.2	0.7	2.2	36%	14	39	300	
Silver	2.39	0.17	1.07	93%	14	39	300	
Sodium	84.9	31	53	100%	6	NA	NA	
Strontium	53.3	23.2	33.8	100%	4	4700	30000	
Thallium	**2.5**	0.2	0.9	71%	14	0.52	NA	X
Vanadium	**16.5**	4.8	9.0	100%	6	7.8	200	X
Zinc	**7180**	619	4556	100%	14	2300	20000	X

* Value is equal to 1/10th of the EPA Region 9 Preliminary Remediation Goal (PRG) due to potential chemical interactions of multiple contaminants.
mg/kg: milligrams contaminant per kilogram soil (parts per million)

Table 7. Standard Mine Coal Creek Sediment Data Summary

Contaminant	Maximum (mg/kg)	Minimum (mg/kg)	Mean (mg/kg)	Detection Frequency	Number of Samples	Comparison Value (mg/kg)		COPC
						PRG*	ATSDR	
Aluminum	**31600**	4540	9772	100%	27	7600	50000	X
Antimony	0.8	0.11	0.3	44%	27	3.1	20	
Arsenic	**178**	22.4	74.6	100%	27	0.039	0.5	X
Barium	117	27	72.4	100%	14	540	10000	
Beryllium	2	0.28	0.8	93%	27	15	100	
Cadmium	**32.1**	1.77	9.6	100%	27	3.7	10	X
Calcium	6950	1190	3330	100%	27	NA	NA	
Chromium	**11.2**	0.58	4.3	100%	27	3.0	200	X
Cobalt	14.9	5.6	9.6	100%	14	90	500	
Copper	278	9.8	58	100%	27	310	500	
Cyanide	1.5	1.3	1.4	33%	6	120	1000	
Iron	**45400**	10900	19456	100%	27	2300	NA	X
Lead	**411**	35.4	121.4	100%	27	40	NA	X
Magnesium	5520	1280	2731	100%	27	NA	NA	
Manganese	**7150**	761	2423	100%	27	180	3000	X
Mercury	0.156	0.01	0.044	73%	33	2.3	NA	
Molybdenum	2.8	0.6	1.2	100%	6	39	300	
Nickel	17.3	3	7	100%	27	160	1000	
Potassium	1040	470	697	100%	14	NA	NA	
Selenium	2.3	0.8	1.4	37%	27	39	300	
Silver	4.5	0.36	1.7	100%	27	39	300	
Sodium	97.2	38	62	100%	14	NA	NA	
Strontium	68.9	26.4	46.2	100%	7	4700	30000	
Thallium	**2.1**	0.12	0.6	59%	27	0.52	NA	X
Vanadium	**13.4**	7.9	10	100%	14	7.8	200	X
Zinc	**5240**	246	1582	100%	27	2300	20000	X

* Value is equal to 1/10th of the EPA Region 9 Preliminary Remediation Goal (PRG) due to potential chemical interactions of multiple contaminants.
mg/kg: milligrams contaminant per kilogram soil (parts per million)

Table 9. Standard Mine Fish Tissue Data

Contaminant	Maximum (mg/kg)	Minimum (mg/kg)	Mean (mg/kg)	Detection Frequency	Number of Samples	Comparison Value* (mg/kg)	COPC
Aluminum	1.853	0.248	1.216	100%	16	1400	
Antimony	NA	NA	NA	0%	16	0.54	
Arsenic	**3.2**	0.06	0.8	100%	16	0.0021	X
Beryllium	NA	NA	NA	0%	16	2.7	
Cadmium	0.119	0.0229	0.055	100%	16	1.4	
Calcium	2290	482.4	1059	100%	16	NA	
Chromium	0.797	0.63	0.71	100%	16	4.1	
Copper	1.967	0.563	0.996	100%	16	54	
Iron	8.485	0.06	5.18	93.75%	16	450	
Lead	0.069	0.0047	0.020	50%	16	NA	
Magnesium	365.7	0.05	315.8	100%	16	NA	
Manganese	2.507	0.389	0.801	100%	16	190	
Mercury	0.0806	0.019	0.037	100%	16	0.14	
Nickel	0.168	0.0458	0.095	100%	16	27	
Selenium	0.758	0.06	0.638	100%	16	6.8	
Silicon Dioxide	12.39	0.05	7.96	100%	16	NA	
Silver	NA	NA	NA	0%	16	6.8	
Strontium	4.644	0.06	2.28	100%	16	810	
Thallium	0.023	0.0047	0.012	19.75%	16	0.095	
Zinc	40.66	0.06	29.20	100%	16	410	

* Comparison Value is equal to the EPA Region 3 Risk Based Concentration
mg/kg: milligrams contaminant per kilogram soil (parts per million)

Table 13. Summary of Surface Water Contaminants of Potential Concern

Location	Contaminant of Potential Concern (COPC)	Exposure Point Concentration (µg/L)
Onsite Surface Water	Arsenic	1.3
	Cadmium	23.9
	Copper *	131.3
	Lead	223.7
	Manganese	1433
	Thallium*	1.3
	Zinc	10964
Elk Creek (Downstream of Std. Mine Site)	Antimony*	0.74
	Arsenic	2.7
	Cadmium	7.6
	Lead*	13.5
	Manganese	344.7
	Thallium*	1.0
	Vanadium*	25.0
	Zinc	1434
Coal Creek (Downstream of Confluence with Elk Creek)	Arsenic	3.5
	Fluoride	736.8
	Lead**	1.2
	Manganese	185
	Thallium	0.6

* Not carried forward for further evaluation based on comparison with EPA Region 9 PRGs, which are derived for residential use of 2L/day for drinking purposes.
** The exposure point concentration for Lead is below the EPA and State action level of 15 ppb and is dropped from further evaluation.

Table 14. Standard Mine Sediment COPCs and Exposure Point Concentrations

Location	COPC	Exposure Point Concentration (mg/kg)
Std. Mine Onsite	Aluminum	33900
	Arsenic	157
	Cadmium	34.2
	Chromium*	**7**
	Copper	1720
	Iron	82300
	Lead	7880
	Manganese	10400
	Zinc	6890
Elk Creek (Below Std. Mine)	Aluminum	10141
	Arsenic	64.08
	Cadmium	42.42
	Chromium*	3.62
	Copper	342.1
	Iron	24268
	Lead**	944.9
	Manganese	6296
	Thallium	1.12
	Vanadium	12.32
	Zinc	7049
Coal Creek	Aluminum	15232
	Arsenic	90.64
	Cadmium	12.15
	Chromium*	5.40
	Iron	22169
	Lead***	153.4
	Manganese	2957
	Mercury	16.15
	Thallium	0.62
	Vanadium	10.79
	Zinc	2038

mg/kg = milligram contaminant per kilogram soil

* The Exposure Point Concentration (EPC) is below the Region 9 Preliminary Remediation Goal (PRG) for Hexavalent Chromium (Cr VI) for residential soil exposures. Incidental ingestion of chromium in sediment was dropped from further analysis.

**The site-weighted lead concentration in Elk Creek sediment is estimated to be 311 mg/kg for recreational use, which is less than the CV of 400 mg/kg. Therefore, lead in Elk Creek sediment was not evaluated further.

*** The Lead EPC in Coal Creek is below the screening value and was dropped from further analysis.

Table 15. Incidental Ingestion of Surface Water Non-Cancer Hazard Quotients (HQs)

COPC	Exposure Unit	Health-Based Guideline (mg/kg-day)	CTE Recreational Child HQs	RME Recreational Child HQs	CTE Recreational Adult HQs	RME Recreational Adult HQs
Arsenic	Onsite	0.0003[a]	3.96E-04	4.12E-03	4.24E-05	4.41E-04
Cadmium	Onsite	0.0002[a]	1.09E-02	1.13E-01	1.17E-03	1.22E-02
Manganese	Onsite	0.14[b]	9.35E-04	9.72E-03	1.00E-04	1.04E-03
Thallium	Onsite	0.000066[b]	1.80E-03	1.87E-02	1.93E-04	2.00E-03
Zinc	Onsite	0.3[a]	3.34E-03	3.47E-02	3.58E-04	3.72E-03
Arsenic	Elk Creek	0.0003[a]	8.22E-04	8.55E-03	8.81E-05	9.16E-04
Cadmium	Elk Creek	0.0002[a]	3.47E-03	3.61E-02	3.72E-04	3.87E-03
Manganese	Elk Creek	0.14[b]	2.25E-04	2.34E-03	2.41E-05	2.51E-04
Zinc	Elk Creek	0.3[a]	4.37E-04	4.54E-03	4.68E-05	4.86E-04
Arsenic	Coal Creek	0.0003[a]	1.07E-03	1.11E-02	1.14E-04	1.19E-03
Fluoride	Coal Creek	0.05[a]	1.35E-03	1.40E-02	1.44E-04	1.50E-03
Manganese	Coal Creek	0.14[b]	1.21E-04	1.26E-03	1.29E-05	1.34E-04
Thallium	Coal Creek	0.000066[b]	8.30E-04	8.63E-03	8.90E-05	9.25E-04

[a] ATSDR Chronic Oral Minimal Risk Level (MRL), [b] EPA Integrated Risk Information System (IRIS) Oral Reference Dose (RfD)
Hazard Quotients (HQs) are derived by dividing the exposure dose in Appendix Table A2 by the health-based guideline for that contaminant. HQs>1 indicate potential risk.

Table 16. Incidental Ingestion of Sediment Non-Cancer Hazard Quotients

COPC	Exposure Unit	Health-Based Guideline (mg/kg-day)	CTE Recreational Child HQs	RME Recreational Child HQs	CTE Recreational Adult HQs	RME Recreational Adult HQs
Aluminum	Onsite	1[a]	3.10E-03	3.22E-02	3.32E-04	3.45E-03
Arsenic	Onsite	0.0003[a]	4.78E-02	4.97E-01	5.12E-03	5.33E-02
Cadmium	Onsite	0.0002[a]	1.56E-02	1.62E-01	1.67E-03	1.74E-02
Chromium	Onsite	0.003[b]	2.13E-04	2.22E-03	2.28E-05	2.37E-04
Copper	Onsite	0.04[e]	3.93E-03	4.08E-02	4.21E-04	4.38E-03
Iron	Onsite	0.7[c]	1.07E-02	1.12E-01	1.15E-03	1.20E-02
Manganese	Onsite	0.14[b]	6.78E-03	7.06E-02	7.27E-04	7.56E-03
Zinc	Onsite	0.3[a]	2.10E-03	2.18E-02	2.25E-04	2.34E-03
Aluminum	Elk Creek	1[a]	9.26E-04	9.63E-03	9.92E-05	1.03E-03
Arsenic	Elk Creek	0.0003[a]	1.95E-02	2.03E-01	2.09E-03	2.17E-02
Cadmium	Elk Creek	0.0002[a]	1.94E-02	2.01E-01	2.08E-03	2.16E-02
Chromium	Elk Creek	0.003[b]	1.10E-04	1.15E-03	1.18E-05	1.23E-04
Copper	Elk Creek	0.01[e]	7.81E-04	8.12E-03	8.37E-05	8.70E-04
Iron	Elk Creek	0.7[c]	3.17E-03	3.29E-02	3.39E-04	3.53E-03
Manganese	Elk Creek	0.14[b]	4.11E-03	4.27E-02	4.40E-04	4.58E-03
Thallium	Elk Creek	0.000066[b]	1.55E-03	1.61E-02	1.66E-04	1.73E-03
Vanadium	Elk Creek	0.001[d]	1.13E-03	1.17E-02	1.21E-04	1.25E-03
Zinc	Elk Creek	0.3[a]	2.15E-03	2.23E-02	2.30E-04	2.39E-03
Aluminum	Coal Creek	1[a]	1.39E-03	1.45E-02	1.49E-04	1.55E-03
Arsenic	Coal Creek	0.0003[a]	2.76E-02	2.87E-01	2.96E-03	3.07E-02
Cadmium	Coal Creek	0.0002[a]	5.55E-03	5.77E-02	5.94E-04	6.18E-03
Chromium	Coal Creek	0.003[b]	1.64E-04	1.71E-03	1.76E-05	1.83E-04
Iron	Coal Creek	0.7[c]	2.89E-03	3.01E-02	3.10E-04	3.22E-03
Manganese	Coal Creek	0.14[b]	1.93E-03	2.01E-02	2.07E-04	2.15E-03
Mercury	Coal Creek	0.0003[b]	4.92E-03	5.11E-02	5.27E-04	5.48E-03
Thallium	Coal Creek	0.000066[b]	8.58E-04	8.92E-03	9.19E-05	9.56E-04
Vanadium	Coal Creek	0.001[d]	9.85E-04	1.02E-02	1.06E-04	1.10E-03
Zinc	Coal Creek	0.3[a]	6.20E-04	6.45E-03	6.65E-05	6.91E-04

[a] ATSDR Chronic Oral Minimal Risk Level (MRL), [b] EPA Integrated Risk Information System (IRIS) Oral Reference Dose (RfD), [c] EPA Provisional Oral Value, [d] National Center for Environmental Assessment (NCEA) Oral Value, [e] EPA Health Effects Assessment Summary Table (HEAST)

Hazard Quotients (HQs) are derived by dividing the exposure dose in Table A3 by the health-based guideline for that contaminant. HQs>1 indicate potential risk.

Table 17. Intentional Ingestion of Surface Water Hazard Quotients

COPC	Exposure Unit	Health-Based Guideline (mg/kg-day)	CTE Recreational Child HQs	RME Recreational Child HQs	CTE Recreational Adult HQs	RME Recreational Adult HQs
Arsenic	Onsite	0.0003[a]	3.96E-03	4.12E-02	1.70E-03	1.76E-02
Cadmium	Onsite	0.0002[a]	1.09E-01	1.13E+00	4.68E-02	4.86E-01
Manganese	Onsite	0.14[b]	9.35E-03	9.72E-02	4.01E-03	4.17E-02
Thallium	Onsite	0.000066[b]	1.80E-02	1.87E-01	7.71E-03	8.02E-02
Zinc	Onsite	0.3[a]	3.34E-02	3.47E-01	1.43E-02	1.49E-01
Arsenic	Elk Creek	0.0003[a]	8.22E-03	8.55E-02	3.52E-03	3.66E-02
Cadmium	Elk Creek	0.0002[a]	3.47E-02	3.61E-01	1.49E-02	1.55E-01
Manganese	Elk Creek	0.14[b]	2.25E-03	2.34E-02	9.64E-04	1.00E-02
Zinc	Elk Creek	0.3[a]	4.37E-03	4.54E-02	1.87E-03	1.95E-02
Arsenic	Coal Creek	0.0003[a]	1.07E-02	1.11E-01	4.57E-03	4.75E-02
Fluoride	Coal Creek	0.05[a]	1.35E-02	1.40E-01	5.77E-03	6.00E-02
Manganese	Coal Creek	0.14[b]	1.21E-03	1.26E-02	5.17E-04	5.38E-03
Thallium	Coal Creek	0.000066[b]	8.30E-03	8.63E-02	3.56E-03	3.70E-02

[a] ATSDR Chronic Oral Minimal Risk Level (MRL), [b] EPA Integrated Risk Information System (IRIS) Oral Reference Dose (RfD)

Hazard Quotients (HQs) are derived by dividing the exposure dose in Table A4 by the health-based guideline for that contaminant. HQs>1 indicate potential risk

HQ's greater than 1 are highlighted in red.

Table 18. Age-Adjusted Theoretical Cancer Risk from Incidental Ingestion of Surface Water

Carcinogen	Exposure Unit	Exposure Point Concentration (μg/L)	CTE Age-Adjusted Theoretical Cancer Risk	RME Age-Adjusted Theoretical Cancer Risk
Arsenic	Onsite	1.3	7.00E-09	2.27E-07
Arsenic	Elk Creek	2.7	1.45E-08	4.71E-07
Arsenic	Coal Creek	3.5	1.88E-08	6.11E-07

Table 19. Age-Adjusted Theoretical Cancer Risk from Incidental Ingestion of Sediments

Carcinogen	Exposure Unit	Exposure Point Concentration (mg/kg)	CTE Age-Adjusted Theoretical Cancer Risk	RME Age-Adjusted Theoretical Cancer Risk
Arsenic	Onsite	157	8.45E-07	2.74E-05
Arsenic	Elk Creek	64.08	3.45E-07	1.12E-05
Arsenic	Coal Creek	90.64	4.88E-07	1.58E-05

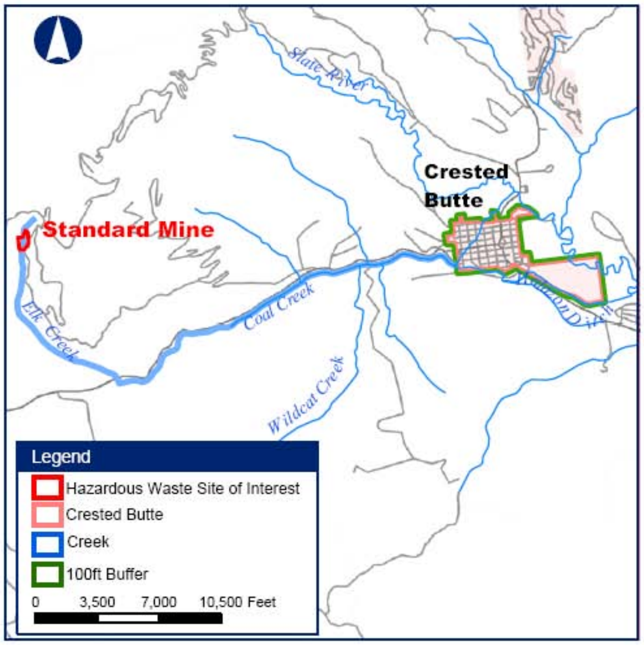
Table 20. Combined Age-Adjusted Theoretical Cancer Risk from Incidental Ingestion of Surface Water and Sediment

Carcinogen	Exposure Unit	CTE Age-Adjusted Theoretical Cancer Risk	RME Age-Adjusted Theoretical Cancer Risk
Arsenic	Onsite	8.52E-07	2.76E-05
Arsenic	Elk Creek	3.60E-07	1.17E-05
Arsenic	Coal Creek	5.07E-07	1.64E-05

Figure 1. Site Location and Demographic Information (from ATSDR 2006)

Figure 1. Site Location and Demographic Information

Standard Mine
Gunnison National Forest, CO
EPA Facility ID: CO0002378230



Base Map Source: Geographic Data Technology, May 2005.
Site Boundary Data Source: ATSDR Public Health GIS Program, May 2005.
Coordinate System (All Panels): NAD1983 StatePlane Colorado Central FIPS 0805 Feet

Site Location: Gunnison County, CO

Demographic Statistics Within Specified Distance of Site*	Within Town Boundary
Total Population	1,538
White Alone	1,495
Black Alone	4
Am. Indian & Alaska Native Alone	14
Asian Alone	11
Native Hawaiian & Other Pacific Islander Alone	0
Some Other Race Alone	7
Two or More Races	7
Hispanic or Latino**	42
Children Aged 6 and Younger	74
Adults Aged 65 and Older	29
Females Aged 15 to 44	464
Total Housing Units	936

Demographics Statistics Source: 2000 U.S. Census
* Calculated using an area-proportion spatial analysis technique
** People who identify their origin as Hispanic or Latino may be of any race.

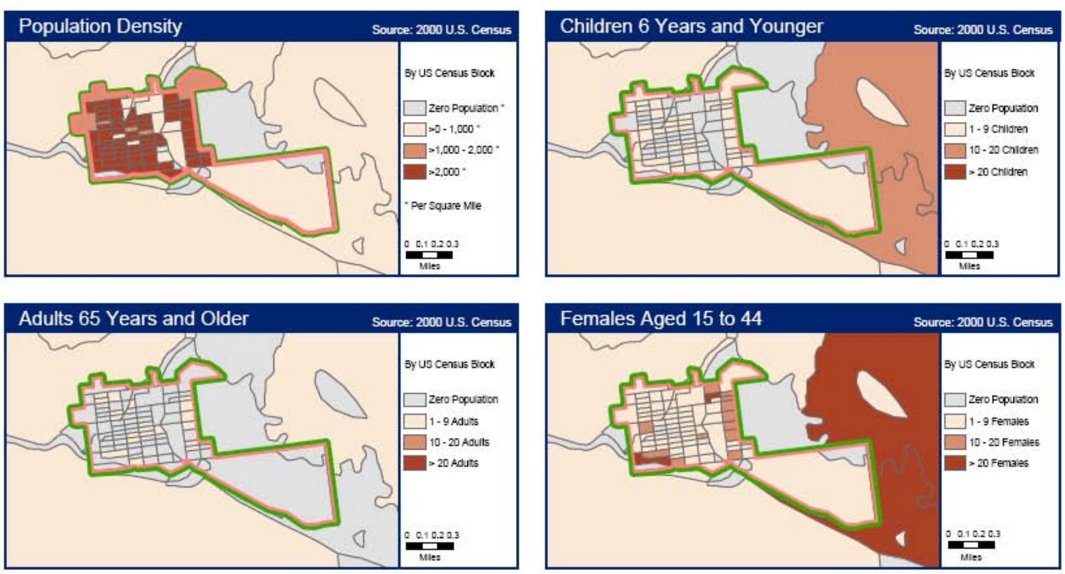


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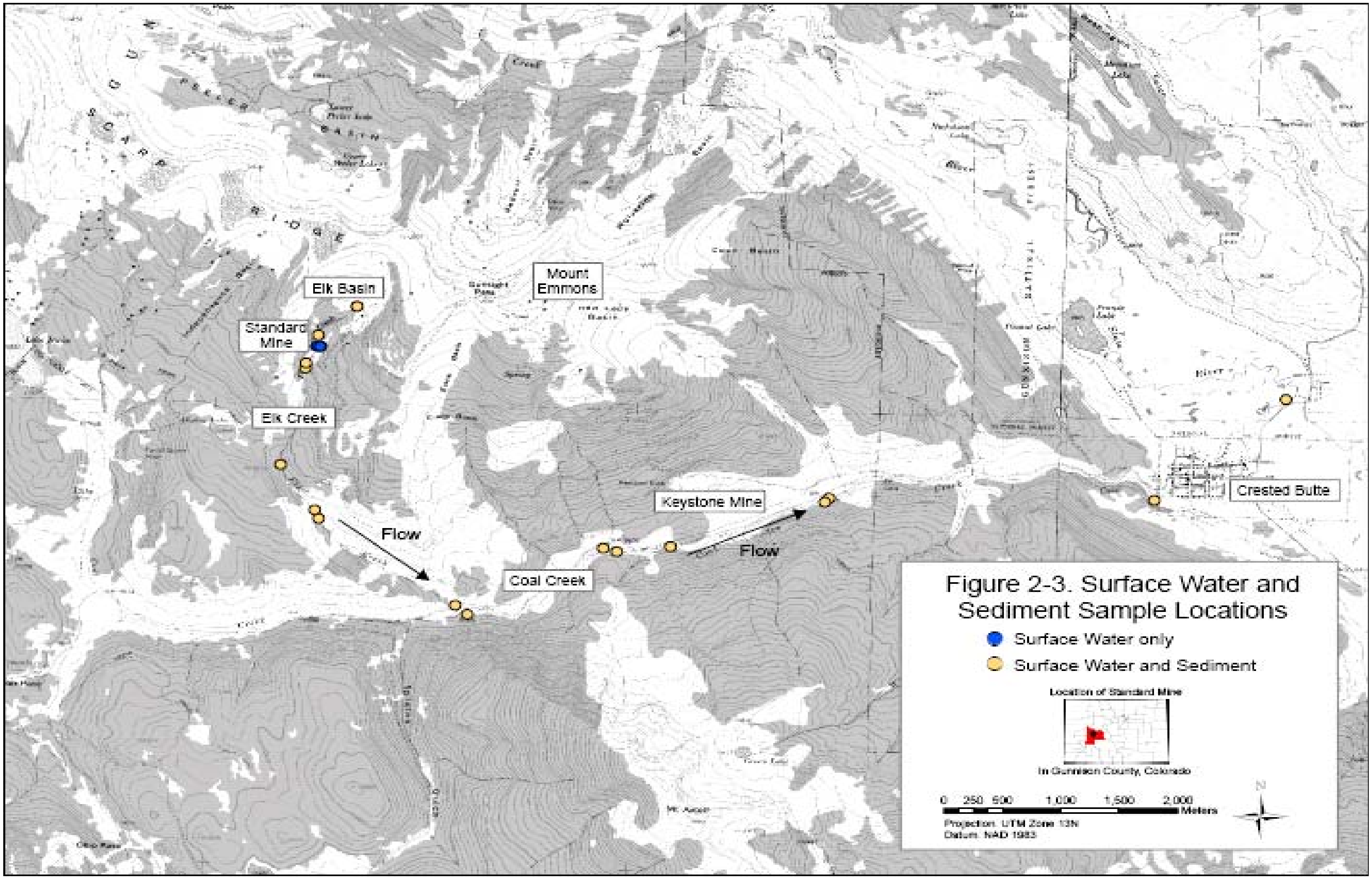
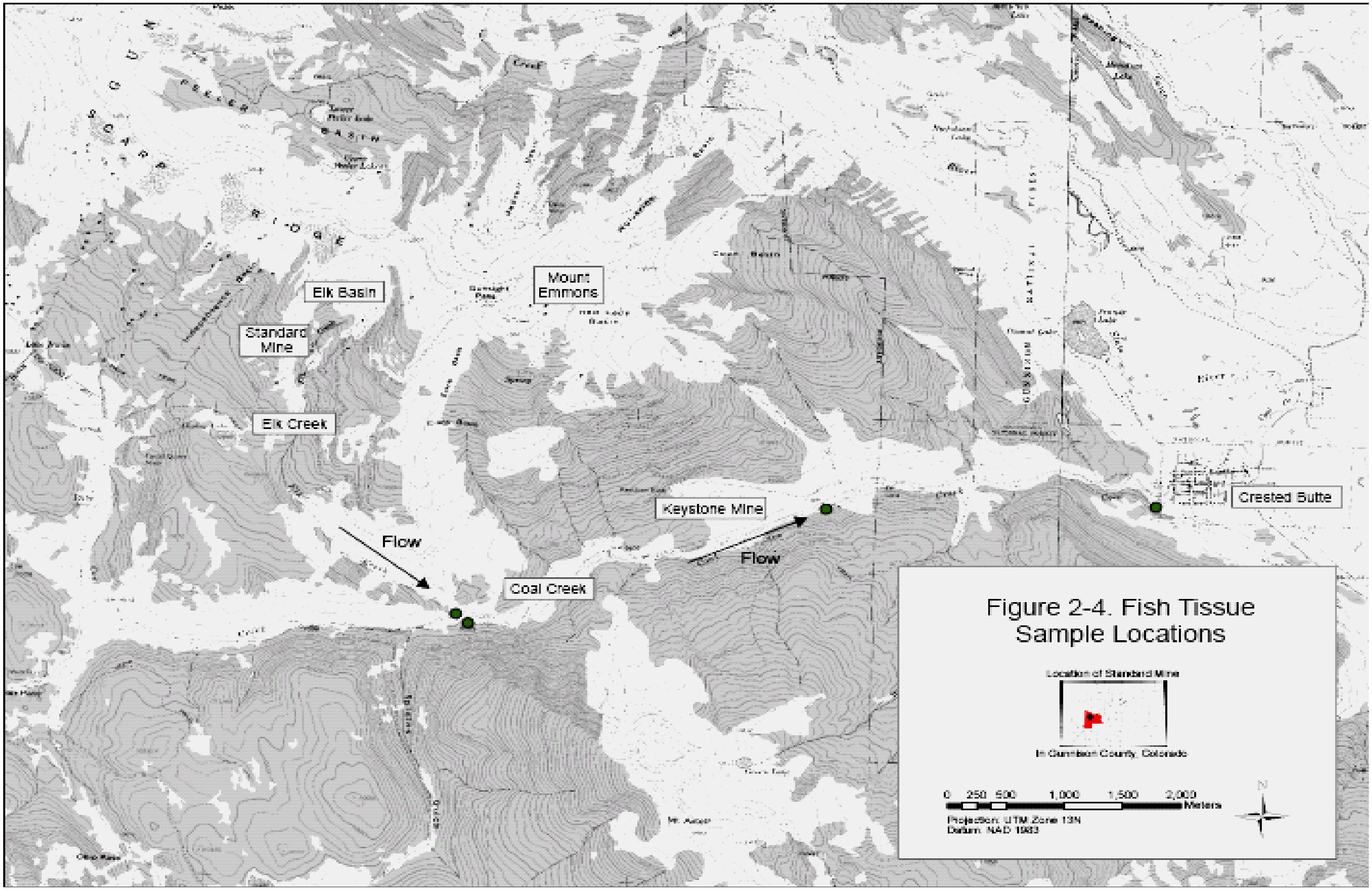
Figure 2. Surface Water and Sediment Sampling Locations



Source: SRC 2007

Figure 3. Fish Sampling Locations



Source: SRC 2007

Appendix A. Detailed Exposure Dose Information for all Non-Lead COPCs

Appendix A1. Exposure Dose Assumptions

To calculate exposure doses, assumptions have to be made regarding various exposure parameters such as frequency of activity, duration of exposure to site-related contaminants, and the amount of a particular substance that is taken in by an individual during a given activity. Generally, default parameters that are established by the EPA and ATSDR are used in health consultations when site-specific data is unavailable. In this case, many of the default parameters overestimate potential exposures to on-site contaminants because the location and rugged terrain of the site limits the number and types of people that typically visit. A land use survey that was described previously in this document was conducted by the EPA to determine the types of activities that occur at the site and how often. The survey was advertised in the local newspaper and announced at public meetings, yet only a small percentage of the surrounding population responded. A number of activities were identified in the survey with a wide range in frequency and duration of exposure. To the extent possible, this data was used for the exposure assumptions used to calculate exposure doses. Personal judgment and the default exposure parameters were also used when necessary.

Three primary receptors were identified that are considered "typical" users for this consultation. The primary receptors are hikers, campers, and ATV riders. These receptors were identified in the land use survey and are considered representative of all potential users (i.e. hiker exposures closely resemble mountain biking exposures, ATV riders closely resemble motorcycle riders, etc.). A wide range of potential exposure conditions was also identified in the land use survey. To account for the varying exposure parameters mentioned in the survey, a central tendency (CTE) or average (50^{th} percentile of the population distribution) exposure condition and a reasonable maximum exposure (RME) condition (high-end or above the 90^{th} percentile of the population distribution) were used for each receptor. The exposure parameters are listed in the tables below for each receptor. Generally speaking, the exposure frequency for CTE was 5 days per year over a period of 2 years for children and 9 years for adults. RME was assumed to occur 52 days per year over 6 years for children and 30 years for adults. Default exposure assumptions for CTE and RME soil ingestion were used as the baseline for this pathway. Hiker exposures were adjusted (fraction ingested from contaminated source) since nearly all respondents of the survey indicated that most people would just be passing through the site on their way to other areas and not hanging around the site for long periods of time. The inhalation pathway was only examined for ATV riders since other receptors are not expected to generate a significant amount of dust. The EPA's exposure factors handbook was the reference for the inhalation rate that was used in this consultation, which is for moderate activities (Table A4). Theoretical cancer risks were calculated using an age-adjusted equation that combines child and adult cancer risk into one equation. The exposure dose equations are listed in Appendix A2.

Table A1. Recreational Use Exposure Parameters

Exposure Pathway	Exposure Parameter	Units	Receptor			
			Child		Adult	
			CTE	RME	CTE	RME
General	Body Weight (BW)	kg	15	15	70	70
	Exposure Frequency (EF)	days/yr	5	52	5	52
	Exposure Duration$_{Non\text{-}cancer}$ ($ED_{Non\text{-}cancer}$)	years	2	6	9	30
	Exposure Duration$_{Cancer}$ (ED_{Cancer})	years	N/a	N/a	9	30
	Averaging Time$_{Non\text{-}cancer}$ ($AT_{Non\text{-}cancer}$)	days	730	2190	3285	10950
	Averaging Time$_{Cancer}$ (AT_{Cancer})	days	N/a	N/a	25550*	25550*
Incidental Ingestion of Surface Water	Ingestion Rate$_{Non\text{-}cancer}$ ($IRW_{Non\text{-}cancer}$)	L/day	0.100	0.100	0.050	0.050
	Ingestion Rate$_{Age\text{-}adjusted\ Cancer}$ (IRW_{adj})	L*yr/kg*day	N/a	N/a	0.018	0.057
Incidental Ingestion of Sediment	Ingestion Rate$_{Non\text{-}cancer}$ ($IRS_{Non\text{-}cancer}$)	mg/day	100	100	50	50
	Ingestion Rate$_{Age\text{-}adjusted\ Cancer}$ (IRS_{adj})	mg*yr./kg*day	N/a	N/a	18.33	57.14
Intentional Ingestion of Surface Water	Ingestion Rate	L/day	1	1	2	2

Fish Consumption Theoretical Cancer Dose Calculation

Theoretical Cancer Risk = Fish Tissue Arsenic EPC / RBC * 1E-06

Incidental Ingestion of Sediment Dose Calculation

Dose = $(C_{sed} * IR * EF * CF) / BW$

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

Ingestion of Surface Water Dose Calculation

Dose = $(C_{SW} * IR * EF * CF) / BW$

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

Age-Adjusted Sediment and Water Ingestion Cancer Dose

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

Where: $IRS_{adj} = [(ED_{child} * IRS_c) / BW_c] + [(ED_{adult} * IRS_a) / BW_a]$

Table A2. Incidental Ingestion of Surface Water Non-Cancer Exposure Dose Results

COPC	Exposure Unit	Exposure Point Concentration (µg/L)	CTE Recreational Child Dose (mg/kg-day)	RME Recreational Child Dose (mg/kg-day)	CTE Recreational Adult Dose (mg/kg-day)	RME Recreational Adult Dose (mg/kg-day)
Arsenic	Onsite	1.3	1.19E-07	1.23E-06	1.27E-08	1.32E-07
Cadmium	Onsite	23.9	2.18E-06	2.27E-05	2.34E-07	2.43E-06
Manganese	Onsite	1433	1.31E-04	1.36E-03	1.40E-05	1.46E-04
Thallium	Onsite	1.3	1.19E-07	1.23E-06	1.27E-08	1.32E-07
Zinc	Onsite	10964	1.00E-03	1.04E-02	1.07E-04	1.12E-03
Arsenic	Elk Creek	2.7	2.47E-07	2.56E-06	2.64E-08	2.75E-07
Cadmium	Elk Creek	7.6	6.94E-07	7.22E-06	7.44E-08	7.73E-07
Manganese	Elk Creek	344.7	3.15E-05	3.27E-04	3.37E-06	3.51E-05
Zinc	Elk Creek	1434	1.31E-04	1.36E-03	1.40E-05	1.46E-04
Arsenic	Coal Creek	3.5	3.20E-07	3.32E-06	3.42E-08	3.56E-07
Fluoride	Coal Creek	736.8	6.73E-05	7.00E-04	7.21E-06	7.50E-05
Manganese	Coal Creek	185	1.69E-05	1.76E-04	1.81E-06	1.88E-05
Thallium	Coal Creek	0.6	5.48E-08	5.70E-07	5.87E-09	6.11E-08

µg/L: micrograms contaminant per liter surface water
mg/kg-day: milligram of contaminant per kilogram body weight per day
The Hazard Quotients (HQs) presented in Table 13 are derived by dividing the exposure doses presented in this table by the health-based guideline for that contaminant. HQs>1 indicate potential risk

Table A3. Incidental Ingestion of Sediment Non-Cancer Exposure Dose Results

COPC	Exposure Unit	Exposure Point Concentration (mg/kg)	CTE Recreational Child Dose (mg/kg-day)	RME Recreational Child Dose (mg/kg-day)	CTE Recreational Adult Dose (mg/kg-day)	RME Recreational Adult Dose (mg/kg-day)
Aluminum	Onsite	33900	3.10E-03	3.22E-02	3.32E-04	3.45E-03
Arsenic	Onsite	157	1.43E-05	1.49E-04	1.54E-06	1.60E-05
Cadmium	Onsite	34.2	3.12E-06	3.25E-05	3.35E-07	3.48E-06
Chromium	Onsite	7	6.39E-07	6.65E-06	6.85E-08	7.12E-07
Copper	Onsite	1720	1.57E-04	1.63E-03	1.68E-05	1.75E-04
Iron	Onsite	82300	7.52E-03	7.82E-02	8.05E-04	8.37E-03
Manganese	Onsite	10400	9.50E-04	9.88E-03	1.02E-04	1.06E-03
Zinc	Onsite	6890	6.29E-04	6.54E-03	6.74E-05	7.01E-04
Aluminum	Elk Creek	10141	9.26E-04	9.63E-03	9.92E-05	1.03E-03
Arsenic	Elk Creek	64.08	5.85E-06	6.09E-05	6.27E-07	6.52E-06
Cadmium	Elk Creek	42.42	3.87E-06	4.03E-05	4.15E-07	4.32E-06
Chromium	Elk Creek	3.62	3.31E-07	3.44E-06	3.54E-08	3.68E-07
Copper	Elk Creek	342.1	3.12E-05	3.25E-04	3.35E-06	3.48E-05
Iron	Elk Creek	24268	2.22E-03	2.30E-02	2.37E-04	2.47E-03
Manganese	Elk Creek	6296	5.75E-04	5.98E-03	6.16E-05	6.41E-04
Thallium	Elk Creek	1.12	1.02E-07	1.06E-06	1.10E-08	1.14E-07
Vanadium	Elk Creek	12.32	1.13E-06	1.17E-05	1.21E-07	1.25E-06
Zinc	Elk Creek	7049	6.44E-04	6.69E-03	6.90E-05	7.17E-04
Aluminum	Coal Creek	15232	1.39E-03	1.45E-02	1.49E-04	1.55E-03
Arsenic	Coal Creek	90.64	8.28E-06	8.61E-05	8.87E-07	9.22E-06
Cadmium	Coal Creek	12.15	1.11E-06	1.15E-05	1.19E-07	1.24E-06
Chromium	Coal Creek	5.4	4.93E-07	5.13E-06	5.28E-08	5.50E-07
Iron	Coal Creek	22169	2.02E-03	2.11E-02	2.17E-04	2.26E-03
Manganese	Coal Creek	2957	2.70E-04	2.81E-03	2.89E-05	3.01E-04
Mercury	Coal Creek	16.15	1.47E-06	1.53E-05	1.58E-07	1.64E-06
Thallium	Coal Creek	0.62	5.66E-08	5.89E-07	6.07E-09	6.31E-08
Vanadium	Coal Creek	10.79	9.85E-07	1.02E-05	1.06E-07	1.10E-06
Zinc	Coal Creek	2038	1.86E-04	1.94E-03	1.99E-05	2.07E-04

mg/kg: milligrams contaminant per kilogram sediment
mg/kg-day: milligram of contaminant per kilogram body weight per day
The Hazard Quotients (HQs) presented in Table 14 are derived by dividing the exposure doses presented in this table by the health-based guideline for that contaminant.
HQs>1 indicate potential risk.

Table A4. Intentional Ingestion of Surface Water Exposure Dose Results

COPC	Exposure Unit	Exposure Point Concentration (μg/L)	Health-Based Guideline (mg/kg-day)	CTE Recreational Child Dose	RME Recreational Child Dose	CTE Recreational Adult Dose	RME Recreational Adult Dose
Arsenic	Onsite	1.3	0.0003[a]	1.19E-06	1.23E-05	5.09E-07	5.29E-06
Cadmium	Onsite	23.9	0.0002[a]	2.18E-05	2.27E-04	9.35E-06	9.73E-05
Manganese	Onsite	1433	0.14[b]	1.31E-03	1.36E-02	5.61E-04	5.83E-03
Thallium	Onsite	1.3	0.000066[b]	1.19E-06	1.23E-05	5.09E-07	5.29E-06
Zinc	Onsite	10964	0.3[a]	1.00E-02	1.04E-01	4.29E-03	4.46E-02
Arsenic	Elk Creek	2.7	0.0003[a]	2.47E-06	2.56E-05	1.06E-06	1.10E-05
Cadmium	Elk Creek	7.6	0.0002[a]	6.94E-06	7.22E-05	2.97E-06	3.09E-05
Manganese	Elk Creek	344.7	0.14[b]	3.15E-04	3.27E-03	1.35E-04	1.40E-03
Zinc	Elk Creek	1434	0.3[a]	1.31E-03	1.36E-02	5.61E-04	5.84E-03
Arsenic	Coal Creek	3.5	0.0003[a]	3.20E-06	3.32E-05	1.37E-06	1.42E-05
Fluoride	Coal Creek	736.8	0.05[a]	6.73E-04	7.00E-03	2.88E-04	3.00E-03
Manganese	Coal Creek	185	0.14[b]	1.69E-04	1.76E-03	7.24E-05	7.53E-04
Thallium	Coal Creek	0.6	0.000066[b]	5.48E-07	5.70E-06	2.35E-07	2.44E-06

μg/L: micrograms contaminant per liter surface water
mg/kg-day: milligram of contaminant per kilogram body weight per day
The Hazard Quotients (HQs) presented in Table 15 are derived by dividing the exposure doses presented in this table by the health-based guideline for that contaminant. HQs>1 indicate potential risk.

Appendix B. Lead Health Risk Assessment

Lead is naturally occurring element found at low levels in soils. However, lead is ubiquitous in the environment as a result of industrial operations, which have resulted in substantially higher levels in many areas of the state. For example, lead levels in surface soils in the Standard Mine area ranges between 0.22 ppm and 64,000 ppm. These lead levels and the exposure point concentration of 6746 ppm at the Standard Mine are significantly higher than the EPA and CDPHE lead screening level of 400 ppm. Therefore, lead uptake modeling is required for the recreational exposure scenario at the Standard Mine.

<u>Exposure Assessment</u>

Lead exposure can occur via multiple pathways (air inhalation and ingestion of water, food, and soil). Therefore, exposure to lead is assessed based on total exposure through all pathways rather than site-specific exposures. However, a primary human exposure pathway to lead is through ingestion of soil and dust. Current knowledge of lead pharmacokinetics indicates that risk values derived by standard procedures would not truly indicate the potential risk, because of the difficulty in accounting for pre-existing body burdens of lead. Lead bioaccumulates in the body, primarily in the skeleton. Lead body burdens vary significantly with age, health status, nutritional state, maternal body burden during gestation and lactation, etc. For this reason, and because of the continued apparent lack of threshold, it is still inappropriate to develop reference values for lead.(CDC, 2004: http://www.cdc.gov/nceh/lead/spotLights/changeBLL.htm, EPA IRIS 2004). Therefore, estimation of exposure and risk from lead in soil also requires assumptions about the level of lead in other media, and also requires use of pharmacokinetic parameters and assumptions that are not needed traditionally. Thus, EPA has adopted a method that entails modeling total lead exposure (uptake/biokinetic) by incorporating input data on the levels of lead in soil, dust, water, air, and diet from multiple sources in addition to site soils. These models are discussed in later sections.

Lead has particularly significant effects in children, well before the usual term of chronic exposure can take place (EPA 2004). Children under 6 years old have a high risk of exposure because of their more frequent hand-to-mouth behavior and they absorb more lead than adults (CDC 1991). Pregnant women and women of child bearing age should also be aware of lead in their environment because lead ingested by a mother can affect the fetus. Thus, the population of most concern is young children for residential and recreational use, and pregnant women for nonresidential use (e.g., occupational and recreational.

<u>Health Effects/Blood Lead Levels of Concern</u>

It is important to note that risks of lead exposure are not based on theoretical calculations and are not extrapolated from data on lab animals or high-dose occupational exposures. Health effects of lead are well known from studies of children. Lead affects virtually every organ and system in the body and exhibits a broad range of health effects. The most sensitive among these are the central nervous system, hematological, and cardiovascular systems, and the kidney. However, it is particularly harmful to the developing brain and nervous system of fetuses and young children (CDC, 1991, ATSDR, 2007). It should be noted that many health effects of lead may occur without overt signs of toxicity: most poisoned children have no symptoms. Extremely high levels of lead in children (BLL of 380 ug/dL) can cause coma, convulsions, and even death. Lower levels of blood lead cause effects on the central nervous system, kidney, and hematopoietic system. Blood lead levels as low as 10 μg/dL, which do not cause distinct symptoms, are associated with decreased intelligence and impaired neurobehavioral development (CDC, 1991). Blood lead levels of 10 μg/dL or greater is considered elevated but there is no demonstrated safe level of lead in blood. A growing body of research has shown that there are measurable adverse neurological effects in children at blood lead concentrations as low as 1 μg/dL (EPA, 2003a). EPA believes that effects may occur at blood levels so low that there is essentially no threshold or "safe" level of lead (EPA IRIS, 2004). Although the concentration of lead in blood is an important indicator of risk, it reflects only current exposures. Lead is also accumulated in bone. Recent research suggests that lead concentrations in bone may be related to adverse health effects in children.

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

Health Risk Assessment

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

The IEUBK Model for Young Children (Age 0-7 years) Camping with Parents

The IEUBK model is designed to estimate the percentage of children that could have elevated blood lead levels as a result of exposure to lead in sediment and surface water. Please note that surface water exposures are considered for children aged 2-7 years. The model calculates the expected distribution of blood lead and estimates the probability that any random child might have a blood lead value over 10 μg /dL. As shown in Table B1, Blood lead levels were estimated for children exposed 52 days/year, 20 days/year, or 12 days/year to the weighted sediment lead concentrations of 1955, 864, 437, 608, or 342 ppm, based on the site EPC of 4943 ppm and the background levels of lead at home (default assumption of 200 ppm). Thus, under the camping exposure scenario and using the calculated weighted on-site sediment and surface water lead concentrations, the IEUBK model predicts elevated blood lead levels (above 10 μg /dL) in 19.0 to 85.0 % of young children for exposure frequencies of 12, 20, and 52 days/year evaluated in this investigation (Table B1). Therefore, exposure to lead is considered a "*public health hazard*" for young children, based on the current average use (up to 12 days/year), above-average use (13 to 20 days/year), and the potential heavy use scenarios (>20 days/year) under the EPA default assumptions used in the model, including the soil ingestion rate of 85 to 135 mg/day (Table B4). These conclusions do not change even by using a less conservative value of 1.4 (vs. default of 1.6) for the GSD.

However, it seems reasonable to assume that exposure to sediment contributes to a 50% of the total soil ingested by children (i.e., half of the IEUBK default values for soil ingestion). As shown in Table B2, using the soil ingestion rate of 42 mg/day to 67 mg/day (½ the default values), the IEUBK model predicts elevated blood lead levels (above 10 μg /dL) in 8.6 to 59.2 % of young children for exposure frequencies of 12, 20, and 52 days/year evaluated in this investigation (Table B2). Thus, exposure to lead in sediment and surface water is considered a "*public health hazard*" for young children based on the average, above- average, and potential heavy use scenarios. These conclusions change to "no apparent public health hazard for the average use scenario of 12 days/year based on the GSD of 1.4 and the averaging time of 365 days. However, the conclusion of no apparent public health hazard are uncertain because of the uncertainty associated with using the GSD of 1.4 which was not derived for this particular site and the EPA TRW encourages using default values in the absence of site-specific data.

The ALM Model for Outdoor Adults

The ALM model is designed to express the probability that the fetal blood lead concentration will be greater than the target blood lead value of 10 μg//dL. Table B3 shows results of the ALM using the default input parameters and site-specific surface soil lead concentration of 4943 ppm (Table B5). For recreational activities involving the high-end soil exposures (50 mg/day soil ingestion rate), the probability that fetal blood lead will exceed target blood lead level of 10 μg//dL ranges from 2.4% to 60.5% based on the exposure frequencies of 52, 20, or 12 days/year. As already noted, based on the Technical Review Workgroup (TRW) recommendation, 3 months of exposure duration (and a minimum EF of 1day/week) is required to achieve a quasi-steady state blood lead concentration. Therefore, the minimum exposure frequency of 12 days per year is evaluated in this investigation. Therefore, exposure to lead is considered a "*no apparent public health haza*rd" for outdoor adults (pregnant women) in this assessment under the EPA default assumptions used in the model. Only the potential heavy use scenario with the exposure frequency of 52 days/year with the averaging time of 140 days results in greater than a 5% probability of fetal blood lead exceeding 10 μg/dL target level (i.e., 19.7%) and can be considered a "public health hazard". However, the conclusions of public health hazard, based on the exposure frequency of 52 days/year and the averaging time of 140 days/year, are uncertain because of the uncertainty associated with a determination whether the duration of site exposure could reasonably produce a body burden of lead that results in an adverse health effect.

Uncertainty in Risks Predicted by the IEUBK and ALM Lead Models

Reliable estimates of exposure and risk using the IEUBK and ALM models depend on site-specific information for a number of key parameters, including lead concentration in outdoor soil (fine fraction) and indoor dust, soil ingestion rate, individual variability in child blood lead concentrations called Geometric Standard Deviation (GSD), and the rate and extent of lead absorption from soil. Therefore, uncertainties are discussed qualitatively here. For example, lead risks may be over- or underestimated based on the unavailable site-specific relative bioavailability of lead from soil. In assessing risks from lead exposure, the EPA assumes 60% relative bioavailability of lead in soils, which is a measure of the difference in absorption between different forms of chemical or between different dosing vehicles (e.g., lead in water, or soil). However, in the absence of site-specific data, it is prudent to use the default bioavailability assumption in order to ensure public health protection. In summary, without site-specific data, there will be uncertainty about how well the risk estimates predicted by computer modeling based on the default parameters reflect the true conditions at a site.

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

References for Appendix B

ATSDR (2007). Toxicological Profile for Lead.

CDC (1991). Preventing lead poisoning in young children. Atlanta, GA: Us Depaertment of Health and Human Services, PHS, Centers for Disease Control and Prevention. (http://www.cdc.gov/nceh/lead/publications/books/plpyc/contents.htm Environmental Protection Agency (EPA, 2002).

User's Guide for the Integrated Exposure Uptake Biokinetic Model for Lead in Children (IEUBK). OSWER Directive 9285.7-42. EPA 540-K-01-005. USEPA, Office of Emergency and Remedial Response, Washington, DC.

Environmental Protection Agency (EPA, 2003a). *America's Children and the Environment: Measures of Contaminants, Body Burden and Illnesses, Second Edition*.

Environmental Protection Agency (EPA 2003b). *Recommendations of the Technical Review Workgroup for Lead for an Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil*. EPA-540-R-03-001. USEPA, Technical Review Workgroup, Washington, DC.

Environmental Protection Agency, Integrated Risk Information System (EPA IRIS 2004). *Lead and Compounds*. http://www.epa.gov.iris.

Table B1. The IEUBK Model Estimated Risk to Young Children (0-84 months) from Exposure to On-Site Sediments and Surface Water (24-84 months) During Seasonal Camping with Parents: Percentage of Children that Exceed the Target Average Blood Lead Level of 10 μg/dL for variable exposure frequency and averaging time, Based on the Default Assumptions of Soil Ingestion rate (i.e., 85 mg/day to 135 mg/day).

Exposure Frequency [a] (Days/Year)	Averaging Time [b] (Days/Year)	Weighted Site Soil Lead Concentration [c] (PPM)	Age Group (Months)	Geometric Mean PbB Concentration (μg/dL)	Percent of Population > 10 μg/dL
52	140	1955	0-84	16.27	85.0*
52	365	864	0-84	10.24	52.0*
20	140	864	0-84	10.24	52.0*
20	365	437	0-84	7.31	25.2*
12	140	608	0-84	8.54	36.8*
12	365	342	0-84	6.59	18.8*

Note: Please see Table B4 for details of exposure/input parameters for the IEUBK model. It should be noted that a variable GSD of 1.4 (vs. default of 1.6) did not change the conclusions for different categories of exposure frequency as presented in the last column of %population >10μg /dL(data not shown).

*Indicates blood lead levels exceed EPA's goal of 5% (i.e., No hypothetical child to have more than a 5% chance of exceeding a blood lead level of 10μg /dL).

[a] For example, Exposure Frequency of 52 days/year = 2.7 days/week for 4 weeks/month over 5 months.

[b] Averaging Time of 140 days = 7days/week x 4 week/month x 5months, and the "washout" period of the 7 months is not considered based on the assumption that the exposure to high lead during the exposure season of 5 months could reasonably produce a body burden of lead that results in adverse health effects. Note that the AT of 365 days/year was also used in order to address the effect of the 7 months of the year when site exposure does not occur, and the uncertainty associated with a determination whether the duration of site exposure could reasonably produce a body burden of lead that results in an adverse health effect. Note that based on the TRW recommendation, 3 months of exposure duration (and a minimum EF of 1day/week) is adequate to achieve a quasi-steady state blood lead concentration.

[c] Weighted Site Soil Lead concentration calculated in accordance with the intermittent exposure guidance (EPA, 2003b), based on the site EPC of 4943 ppm and the assumption of home lead concentration of 200 ppm (default for the IEUBK model). For example, lead site concentration of 1955 ppm is calculated as follow:
F_{site} = 52 days/140 days = 0.37
F_{home} = 1-0.37 = 0.63
Lead site = 0.37 x 4943 (lead EPC) = 1829 ppm
Lead home = 0.63 x 200 ppm (default) = 126 ppm
Lead site weighted (PbS w) = 1829+126 = 1955 ppm

Table B2. The IEUBK Model Estimated Risk to Young Children (0-84 months) from Exposure to On-Site Sediments and Surface Water (24-84 months) During Seasonal Camping with Parents: Percentage of Children that Exceed the Target Average Blood Lead Level of 10 μg/dL for variable exposure frequency and averaging time, Based on ½ the Default Assumption of soil ingestion rate (i.e., 42 mg/day to 67 mg/day).

Exposure Frequency [a] (Days/Year)	Averaging Time [b] (Days/Year)	Weighted Site Soil Lead Concentration [c] (PPM)	Age Group (Months)	Geometric Mean PbB Concentration (μg/dL)	Percent of Population > 10 μg/dL
52	140	1955	0-84	11.16	59.2*
52	365	864	0-84	7.36	25.7*
20	140	864	0-84	7.36	25.7*
20	365	437	0-84	5.65	11.3*
12	140	608	0-84	6.35	16.7*
12	365	342	0-84	5.25	8.6*, [d]

Note: Please see Table B3 for details of exposure/input parameters for the IEUBK model.

*Indicates blood lead levels exceed EPA's goal of 5% (i.e., No hypothetical child to have more than a 5% chance of exceeding a blood lead level of 10μg /dL).

[a] For example, Exposure frequency of 52 days/year = 2.7 days/week for 4 weeks/month over 5 months.

[b] Averaging Time of 140 days = Explanation as per Table B1
[c] Weighted Site Soil Lead concentration calculated as shown in Table B1
[d] This value changes to 2.8% (i.e., acceptable levels < 5%) based on the GSD of 1.4.

Table B3. The ALM Model Results for Adults Recreational Activities With The Average Exposure to Sediments (50 mg/day): Probability of Fetal Blood Lead (PbB) >10 μg /dL and the 95th Percentile PbB among Fetuses of Adult Recreationalists

Exposure Frequency [a] **(days/year)**	**Averaging Time** [b] **(days/year)**	**95th percentile fetal PbB (μg/dL)**	**Probability of fetal PbB >10 μg/dL**
52	140	10.0	19.7%*
52	365	9.7	4.6%
20	140	9.7	4.6%
20	365	6.6	1.3%
12	140	7.7	2.3%
12	365	5.8	0.8%

Note: Please see Table F5 for details of exposure/input parameters for the ALM model. Indicates fetal blood lead levels exceed EPA's goal of 5% (i.e.,EPA's goal is that the probability of a fetal blood lead concentration exceeding health based level of 10μg /dL is less than or equal to 5%).

[a] For example, Exposure frequency of 52 days/year = 2.7 days/week for 4 weeks/month over 5 months.
[b] Averaging Time of 140 days = 7days/week x 4 week/month x 5months, and the "washout" period of the 7 months is not considered based on the assumption that the exposure to high lead during the exposure season of 5 months could reasonably produce a body burden of lead that results in adverse health effects. Note that the AT of 365 days/year was also used in order to address the "washout" effect of the 7 months of the year when site exposure does not occur, and the uncertainty associated with a determination whether the duration of site exposure could reasonably produce a body burden of lead that results in an adverse health effect

Table B4. Default Input Parameters for the IEUBK Model for exposure to Residential Children

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

Table B5. Input Parameters for the ALM Model for Adult Outdoor Recreational Activities

Exposure Variable	Equation 1		Description of Exposure Variable	Units	Using Equation 1
	1*	2**			GSDi = Hom
PbS	X	X	Soil lead concentration	ug/g or ppm	4943
$R_{fetal/maternal}$	X	X	Fetal/maternal PbB ratio	--	0.9
BKSF	X	X	Biokinetic Slope Factor	ug/dL per ug/day	0.4
GSD_i	X	X	Geometric standard deviation PbB	--	2.1
PbB_0	X	X	Baseline PbB	ug/dL	1.5
IR_S	X		Soil ingestion rate (including soil-derived indoor dust)	g/day	0.05
IR_{S+D}		X	Total ingestion rate of outdoor soil and indoor dust	g/day	--
W_S		X	Weighting factor; fraction of IR_{S+D} ingested as outdoor soil	--	--
K_{SD}		X	Mass fraction of soil in dust	--	--
$AF_{S, D}$	X	X	Absorption fraction (same for soil and dust)	--	0.12
$EF_{S, D}$	X	X	Exposure frequency (same for soil and dust)	days/yr	5, 20, or 52 (site-specific)
$AT_{S, D}$	X	X	Averaging time (same for soil and dust)	days/yr	140 or 365 (site-specific)

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

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

Appendix C. Toxicological Evaluation

The basic objective of a toxicological evaluation is to identify what adverse health effects a chemical causes, and how the appearance of these adverse effects depends on dose. The toxic effects of a chemical also depend on the route of exposure (oral, inhalation, dermal) and the duration of exposure (acute, subchronic, chronic or lifetime). The major contaminants of concern identified in this consultation are lead and arsenic. Lead can affect nearly every system of the body with the main target organ systems being the nervous system. Lead health effects are particularly important for young children and pregnant mothers. Arsenic is classified as a Group 1 carcinogen by the International Agency for Research on Cancer (IARC) meaning that it is a known human carcinogen. 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 and the ATSDR has established oral reference dose (RfD) and minimal risk levels (MRL) 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 non-cancer adverse health effects during a lifetime of exposure to a particular contaminated substance. 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 Integrated Risk Information System an oral cancer slope factor of 1.5 per mg/kg/day for lifetime exposures to arsenic. 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 cancer 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.

The health-based guidelines and cancer slope factors used for this evaluation are listed below.

Oral Health-based Guidelines

Contaminant	Health-based Guideline (mg/kg-day)	Source
Aluminum	1.0	NCEA Provisional Value
Antimony	0.0004	EPA IRIS
Arsenic	0.0003	EPA IRIS
Barium	0.2	EPA IRIS
Cadmium	0.0002	ATSDR Chronic Oral MRL
Chromium	0.003	EPA IRIS
Copper	0.04	HEAST
Iron	0.7	NCEA Provisional Value
Manganese	0.02	EPA IRIS
Selenium	0.005	EPA IRIS
Silver	0.005	EPA IRIS
Thallium	0.000066	EPA Region 9 Cal-adjusted value
Vanadium	0.001	NCEA Provisional Value
Zinc	0.3	EPA IRIS

NCEA: National Center for Environmental Assessments
HEAST: Health Effects Summary Tables

Arsenic Cancer Slope Factors

Contaminant	Route of Exposure	Cancer Slope Factor (mg/kg-day^{-1})	Source
Arsenic	Oral	1.5	EPA IRIS

Appendix D. Standard Mine Community Land Use Survey

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Community Interviews for Determining
Land Use at the Standard Mine Site
Crested Butte, Colorado – July 27, 2006
Written by Libby Faulk of the EPA (Region 8)

Interview Summary and Area Statistics

Interviews were voluntary and done by phone, email, and in person. There were three public notices in the newspaper and fact sheets posted throughout the town to make the community aware of EPA's interest in information about recreational use at the Standard Mine. The following is a summary of the responses to the 9 questions as well as information on the demographics of those that responded:

Total Adult Responders – 29
20 to 29 – 4
30 to 39 – 2
40 to 49 – 6
50 to 59 – 8
60 to 69 – 1
70 to 69 – 1
No age given – 7

Number of Males responders – 11
Number of Female responders – 18

According to the 2000 U.S. Census, Crested Butte population breakout was the following:

Crested Butte town, Colorado Statistics and Demographics (US Census 2000)

	Number	Percent
Crested Butte Population:		
Sex and Age		
Female	681	44.54%
5 to 9 years	46	3.01%
15 to 19 years	56	3.66%
25 to 34 years	590	38.59%
45 to 54 years	207	13.54%
60 to 64 years	17	1.11%
75 to 84 years	7	0.46%

<u>Questions and Responses</u>

Current Land Use

1. What are the current land uses at the Standard Mine Site? (check all that apply)

- Residential
- Commercial/Industrial
- Recreational

- Other (Please specify)

All 29 responders believed recreational was one of the current land uses taking place at our around the Standard Mine Site. Of the responses received, 6 believed there was some level of commercial activity taking place in the area such as hiking tours. Of the responses received, 4 responders believed there's current residential use in the area.

2. For those land uses checked above, except residential, what type of activities do people engage in?

    - ATV and motorcycle riding
    - Hiking, mountain biking
    - Camping
    - Skiing, Snowmobiling
    - Fishing
    - Mining
    - Other (please specify)

Of the choices above, we received the following response:

- ATV and motorcycle riding – 14
- Hiking, mountain biking – 28
- Camping – 6
- Skiing, Snowmobiling – 17
- Fishing – 0
- Mining – 0
- Other (please specify)
    1. horseback riding
    2. rock hounding
    3. biomonitoring
    4. snowboarding
    5. hiking with dog who may be drinking the water
    6. One responder witnessed a jeep in the area.

3. How often do people engage in the activities checked above? (please specify for all activities checked above)

    - Number of hours per event
    - Number of days per year
    - Number of years

Many responders were not sure how long people spend time in the Standard Mine area but most responders felt that the time spent would be very little. The reason stated for this is because they believed most people would just be passing through the site and not hanging around the site itself. For those that did respond, they responded with the following:

- Number of hours per event – under 5 hours per event with the exception of one response that state 10 hours per event and another 24 hours or more. The person that responded with 24 hours or more has property in the area.
- Number of days per year
  - Under 5 days – 11
  - 6 to 10 days – 3
  - 11 to 15 days – 2
  - 16 to 20 days – 0
  - Over 20 days – 1

  * One person that responded stated she was up there 250 to 300 times per year.
- Number of years
  - 1 to 5 yrs. – 9
  - 6 to 10 yrs. – 3
  - 11 to 20 yrs. – 3
  - Over 20 yrs. – 5

General Comments Received:

- The numbers may be increasing because of the interest around the clean-up of the mine and people wanting to see what the ruckus is all about.
- For mountain bikers under an hour and for motorized users maybe more time.
- Some probably just pass right on through or turnaround because they missed the trail head to Copley Lake.

4. Do you bring your children with you? If so, what are their ages?

Of those that responded to this question, 12 do not have children. For those that have children, 11 of them said they do not take their children with them to that area and one said their child has only been to Copley Lake which is below the Standard Mine, another responder said she took her daughter there once at age 11 but she's now 28, and one responder said that her kids have been up in the area a long time ago but not recently. Her children are now ages 14 and 18. I did not get the ages of the children where the parents stated that they have never taken their children up to the Standard Mine site.

General Comments:

- The area of hiking is too steep for children to hike.

- Don't have any and have never seen any up there when I've been up there. It seems that the hike would be too steep for children.
- Too far up and steep.
- Only up to Copley Lake
- We shouldn't assume that children are not hiking in the area because there are quite a few families that do lots of hiking in the area.
- You'll see kids on ATVs and motorbikes riding around.

5. If you fish, where do you fish? (Please describe location of where on site fishing is occurring, for example, at the site itself, along Elk Creek below the site, Coal Creek).

No one responded as having fished in the area.

6. How many fish do you catch each year from this site? Do you eat all of the fish you catch? When you prepare the fish, do you prepare just the fillets or do you include other parts of the fish?

See response to #5 above.

Future Land Use

1. What do you think are the most likely land uses for the Standard Mine site in the future? (Check all that apply)

    - Residential
    - Commercial/Industrial
    - Recreational
    - Other (please specify)

All 29 responders believed that in the future, recreational use would continue to be the main use in and around the Standard Mine area. Of all the responders, 9 of the responders felt that residential development could occur in the area, 7 felt there could be commercial interest such as tours in the area.

2. For each of the land uses checked above, please explain the basis for your answer. For example, if residential land use is checked, is this based on zoning ordinances, county planning, recent property purchases, development plans, etc.

Many of the responses received to this question were the same from each responder. The comments received were the following:

- Continue to be the same recreational activities as is occurring in the area now.

- There could be an increase in commercial activity for touring in the area.
- The Township of Irwin is close by and growing and so residential development is bound to spill over into the Elk Basin area.
- There's private property in the area so there will probably be an increase in residential development at some point.
- You may see more tours for historical and educational purposes.
- Recreational only - Climate, location and elevation.
- Will depend on road improvements to the area that would make it more accessible.
- Doubts much due to steepness of the area and difficulty in getting to the mine site.
- Recreational only - Location, terrain, and precipitation.
- Recreational only – location, accessibility, and demand.

3. For those land uses checked above, except residential, what are the most likely activities you think people may engage in?

   - ATV and motorcycle riding
   - Hiking, mountain biking
   - Camping
   - Skiing, Snowmobiling
   - Fishing
   - Mining
   - Other (please specify)

Of the choices above, we received the following response:

- ATV and motorcycle riding – 17
- Hiking, mountain biking – 29
- Camping – 10
- Skiing, Snowmobiling – 19
- Fishing – 0
- Mining – 0
- Other (please specify)
  1. horseback riding
  2. biomonitoring
  3. educational tours (hiking)
  4. Jeeps 4-wheeling
  5. rock hounding
  6. hunting

General Comments Received:

- Camping may increase but probably around Copley Lake and not up at the mine site itself.

Other general suggestions or comments that responder's mentioned during the interviews or on their interview sheet were:

1. If the U.S.F.S would clearly mark the trail head to Copley Lake, less people would end up at the Standard Mine site.

2. Someone should evaluate the risk of hunting wildlife in and around the Standard Mine site because the elk and deer in the area probably drink out of the creek and pond. What would the mean for someone who eventually ate the elk or deer?

3. People probably don't typically come across the mine because it's not easy to stumble across.

4. There's a lot of private property in the area making it difficult to get to the site without crossing over someone's property.

5. There are gates in various areas making it difficult to get to the site.

6. We think that somewhere between 175 to 200 mountain bikers visit the Gunsight Pass/Standard Mine/Scarps Ridge area in a summer. If there was a more defined route from the top of Gunsight through the Standard Mine site down Elk Creek to Kebler the area would probably see more use. I think many folks believe there are private property issues through the area.

Appendix E. Lead ToxFAQs (ATSDR 2007)

Highlights

Exposure to lead can happen from breathing workplace air or dust, eating contaminated foods, or drinking contaminated water. Children can be exposed from eating lead-based paint chips or playing in contaminated soil. Lead can damage the nervous system, kidneys, and reproductive system. Lead has been found in at least 1,272 of the 1,684 National Priority List sites identified by the Environmental Protection Agency (EPA).

What is lead?

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

Lead has many different uses. It is used in the production of batteries, ammunition, metal products (solder and pipes), and devices to shield X-rays. Because of health concerns, lead from paints and ceramic products, caulking, and pipe solder has been dramatically reduced in recent years. The use of lead as an additive to gasoline was banned in 1996 in the United States.

What happens to lead when it enters the environment?

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

How might I be exposed to lead?

- Eating food or drinking water that contains lead. Water pipes in some older homes may contain lead solder. Lead can leach out into the water.

- Spending time in areas where lead-based paints have been used and are deteriorating. Deteriorating lead paint can contribute to lead dust.
- Working in a job where lead is used or engaging in certain hobbies in which lead is used, such as making stained glass.
- Using health-care products or folk remedies that contain lead.

How can lead affect my health?

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

How likely is lead to cause cancer?

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

How does lead affect children?

Small children can be exposed by eating lead-based paint chips, chewing on objects painted with lead-based paint, or swallowing house dust or soil that contains lead.

Children are more vulnerable to lead poisoning than adults. A child who swallows large amounts of lead may develop blood anemia, severe stomachache, muscle weakness, and brain damage. If a child swallows smaller amounts of lead, much less severe effects on blood and brain function may occur. Even at much lower levels of exposure, lead can affect a child's mental and physical growth.

Exposure to lead is more dangerous for young and unborn children. Unborn children can be exposed to lead through their mothers. Harmful effects include premature births, smaller babies, decreased mental ability in the infant, learning difficulties, and reduced growth in young children. These effects are more common if the mother or baby was exposed to high levels of lead. Some of these effects may persist beyond childhood.

How can families reduce the risk of exposure to lead?

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

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

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

Has the federal government made recommendations to protect human health?

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

EPA limits lead in drinking water to 15 µg per liter.

Reference

Agency for Toxic Substances and Disease Registry (ATSDR). 2007. Toxicological Profile for Lead *(Update)*. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

Where can I get more information?

For more information, contact:

Agency for Toxic Substances and Disease Registry
Division of Toxicology and Environmental Medicine
1600 Clifton Road NE, Mailstop F-32
Atlanta, GA 30333
Phone: 1-888-42-ATSDR (1-888-422-8737)
FAX: (770)-488-4178
Email: ATSDRIC@cdc.gov

For more information, contact:

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 F: 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 G. ATSDR Plain Language Glossary of Environmental Health Terms

Absorption: The process of taking in. For a person or an animal, absorption is the process of a substance getting into the body through the eyes, skin, stomach, intestines, or lungs.

Acute: Occurring over a short time [compare with chronic].

Acute exposure: Contact with a substance that occurs once or for only a short time (up to 14 days) [compare with intermediate duration exposure and chronic exposure].

Additive effect: A biologic response to exposure to multiple substances that equals the sum of responses of all the individual substances added together [compare with antagonistic effect and synergistic effect].

Adverse health effect: A change in body function or cell structure that might lead to disease or health problems

Ambient
Surrounding (for example, *ambient* air).

Analyte: A substance measured in the laboratory. A chemical for which a sample (such as water, air, or blood) is tested in a laboratory. For example, if the analyte is mercury, the laboratory test will determine the amount of mercury in the sample.

Antagonistic effect: A biologic response to exposure to multiple substances that is **less** than would be expected if the known effects of the individual substances were added together [compare with additive effect and synergistic effect].

Background level: An average or expected amount of a substance or radioactive material in a specific environment, or typical amounts of substances that occur naturally in an environment.

Biodegradation: Decomposition or breakdown of a substance through the action of microorganisms (such as bacteria or fungi) or other natural physical processes (such as sunlight).

Biologic indicators of exposure study: A study that uses (a) biomedical testing or (b) the measurement of a substance [an analyte], its metabolite, or another marker of exposure in human body fluids or tissues to confirm human exposure to a hazardous substance [also see exposure investigation].

Biologic monitoring: Measuring hazardous substances in biologic materials (such as blood, hair, urine, or breath) to determine whether exposure has occurred. A blood test for lead is an example of biologic monitoring.

Biologic uptake: The transfer of substances from the environment to plants, animals, and humans.

Biomedical testing: Testing of persons to find out whether a change in a body function might have occurred because of exposure to a hazardous substance.

Biota: Plants and animals in an environment. Some of these plants and animals might be sources of food, clothing, or medicines for people.

Body burden: The total amount of a substance in the body. Some substances build up in the body because they are stored in fat or bone or because they leave the body very slowly.

Cancer: Any one of a group of diseases that occur when cells in the body become abnormal and grow or multiply out of control.

Cancer risk: A theoretical risk for getting cancer if exposed to a substance every day for 70 years (a lifetime exposure). The true risk might be lower.

Carcinogen: A substance that causes cancer.

Central nervous system: The part of the nervous system that consists of the brain and the spinal cord.

CERCLA [see Comprehensive Environmental Response, Compensation, and Liability Act of 1980]

Chronic: Occurring over a long time [compare with acute].

Chronic exposure: Contact with a substance that occurs over a long time (more than 1 year) [compare with acute exposure and intermediate duration exposure]

Comparison value (CV): Calculated concentration of a substance in air, water, food, or soil that is unlikely to cause harmful (adverse) health effects in exposed people. The CV is used as a screening level during the public health assessment process. Substances found in amounts greater than their CVs might be selected for further evaluation in the public health assessment process.

Completed exposure pathway [see exposure pathway].

Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA): CERCLA, also known as Superfund, is the federal law that concerns the removal or cleanup of hazardous substances in the environment and at hazardous waste sites. ATSDR, which was created by CERCLA, is responsible for assessing health issues and supporting public health activities related to hazardous waste sites or other environmental releases of hazardous substances. This law was later amended by the Superfund Amendments and Reauthorization Act (SARA).

Concentration: The amount of a substance present in a certain amount of soil, water, air, food, blood, hair, urine, breath, or any other media.

Contaminant: A substance that is either present in an environment where it does not belong or is present at levels that might cause harmful (adverse) health effects.

Delayed health effect: A disease or an injury that happens as a result of exposures that might have occurred in the past.

Dermal: Referring to the skin. For example, dermal absorption means passing through the skin.

Dermal contact: Contact with (touching) the skin [see route of exposure].

Detection limit: The lowest concentration of a chemical that can reliably be distinguished from a zero concentration.

Disease prevention: Measures used to prevent a disease or reduce its severity.

Dose (for chemicals that are not radioactive): The amount of a substance to which a person is exposed over some time period. Dose is a measurement of exposure. Dose is often expressed as milligram (amount) per kilogram (a measure of body weight) per day (a measure of time) when people eat or drink contaminated water, food, or soil. In general, the greater the dose, the greater the likelihood of an effect. An "exposure dose" is how much of a substance is encountered in the environment. An "absorbed dose" is the amount of a substance that actually got into the body through the eyes, skin, stomach, intestines, or lungs.

Dose-response relationship: The relationship between the amount of exposure [dose] to a substance and the resulting changes in body function or health (response).

Environmental media: Soil, water, air, biota (plants and animals), or any other parts of the environment that can contain contaminants.

Environmental media and transport mechanism: Environmental media include water, air, soil, and biota (plants and animals). Transport mechanisms move contaminants from the source to points where human exposure can occur. The environmental media and transport mechanism is the second part of an exposure pathway.

EPA: United States Environmental Protection Agency.

Exposure: Contact with a substance by swallowing, breathing, or touching the skin or eyes. Exposure may be short-term [acute exposure], of intermediate duration, or long-term [chronic exposure].

Exposure assessment: The process of finding out how people come into contact with a hazardous substance, how often and for how long they are in contact with the substance, and how much of the substance they are in contact with.

Exposure-dose reconstruction: A method of estimating the amount of people's past exposure to hazardous substances. Computer and approximation methods are used when past information is limited, not available, or missing.

Exposure investigation: The collection and analysis of site-specific information and biologic tests (when appropriate) to determine whether people have been exposed to hazardous substances.

Exposure pathway: The route a substance takes from its source (where it began) to its end point (where it ends), and how people can come into contact with (or get exposed to) it. An exposure pathway has five parts: a source of contamination (such as an abandoned business); an environmental media and transport mechanism (such as movement through groundwater); a point of exposure (such as a private well); a route of exposure (eating, drinking, breathing, or touching), and a receptor population (people potentially or actually exposed). When all five parts are present, the exposure pathway is termed a completed exposure pathway.

Feasibility study: A study by EPA to determine the best way to clean up environmental contamination. A number of factors are considered, including health risk, costs, and what methods will work well.

Geographic information system (GIS): A mapping system that uses computers to collect, store, manipulate, analyze, and display data. For example, GIS can show the concentration of a contaminant within a community in relation to points of reference such as streets and homes.

Groundwater: Water beneath the earth's surface in the spaces between soil particles and between rock surfaces [compare with surface water].

Hazard: A source of potential harm from past, current, or future exposures.

Hazardous waste: Potentially harmful substances that have been released or discarded into the environment.

Health consultation: A review of available information or collection of new data to respond to a specific health question or request for information about a potential environmental hazard. Health consultations are focused on a specific exposure issue. Health consultations are therefore more limited than a public health assessment, which reviews the exposure potential of each pathway and chemical [compare with public health assessment].

Health education: Programs designed with a community to help it know about health risks and how to reduce these risks.

Health investigation: The collection and evaluation of information about the health of community residents. This information is used to describe or count the occurrence of a disease, symptom, or clinical measure and to evaluate the possible association between the occurrence and exposure to hazardous substances.

Health promotion: The process of enabling people to increase control over, and to improve, their health.

Indeterminate public health hazard: The category used in ATSDR's public health assessment documents when a professional judgment about the level of health hazard cannot be made because information critical to such a decision is lacking.

Ingestion: The act of swallowing something through eating, drinking, or mouthing objects. A hazardous substance can enter the body this way [see route of exposure].

Inhalation: The act of breathing. A hazardous substance can enter the body this way [see route of exposure].

Intermediate duration exposure: Contact with a substance that occurs for more than 14 days and less than a year [compare with acute exposure and chronic exposure].

In vitro: In an artificial environment outside a living organism or body. For example, some toxicity testing is done on cell cultures or slices of tissue grown in the laboratory, rather than on a living animal [compare with in vivo].

In vivo: Within a living organism or body. For example, some toxicity testing is done on whole animals, such as rats or mice [compare with in vitro].

Lowest-observed-adverse-effect level (LOAEL): The lowest tested dose of a substance that has been reported to cause harmful (adverse) health effects in people or animals.

Medical monitoring: A set of medical tests and physical exams specifically designed to evaluate whether an individual's exposure could negatively affect that person's health.

mg/kg: Milligram per kilogram.

Migration: Moving from one location to another.

Minimal risk level (MRL): An ATSDR estimate of daily human exposure to a hazardous substance at or below which that substance is unlikely to pose a measurable risk of harmful (adverse), noncancerous effects. MRLs are calculated for a route of exposure (inhalation or oral) over a specified time period (acute, intermediate, or chronic). MRLs should not be used as predictors of harmful (adverse) health effects [see reference dose].

Mutagen: A substance that causes mutations (genetic damage).

Mutation: A change (damage) to the DNA, genes, or chromosomes of living organisms.

National Priorities List for Uncontrolled Hazardous Waste Sites (National Priorities List or **NPL)**: EPA's list of the most serious uncontrolled or abandoned hazardous waste sites in the United States. The NPL is updated on a regular basis.

National Toxicology Program (NTP): Part of the Department of Health and Human Services. NTP develops and carries out tests to predict whether a chemical will cause harm to humans.

No apparent public health hazard: A category used in ATSDR's public health assessments for sites where human exposure to contaminated media might be occurring, might have occurred in the past, or might occur in the future, but where the exposure is not expected to cause any harmful health effects.

No-observed-adverse-effect level (NOAEL): The highest tested dose of a substance that has been reported to have no harmful (adverse) health effects on people or animals.

No public health hazard: A category used in ATSDR's public health assessment documents for sites where people have never and will never come into contact with harmful amounts of site-related substances.

NPL [see National Priorities List for Uncontrolled Hazardous Waste Sites]

Physiologically based pharmacokinetic model (PBPK model): A computer model that describes what happens to a chemical in the body. This model describes how the chemical gets into the body, where it goes in the body, how it is changed by the body, and how it leaves the body.

Pica: A craving to eat nonfood items, such as dirt, paint chips, and clay. Some children exhibit pica-related behavior.

Point of exposure
The place where someone can come into contact with a substance present in the environment [see exposure pathway].

Population: A group or number of people living within a specified area or sharing similar characteristics (such as occupation or age).

Potentially responsible party (PRP): A company, government, or person legally responsible for cleaning up the pollution at a hazardous waste site under Superfund. There may be more than one PRP for a particular site.

ppb: Parts per billion.

ppm: Parts per million.

Prevention: Actions that reduce exposure or other risks, keep people from getting sick, or keep disease from getting worse.

Public availability session: An informal, drop-by meeting at which community members can meet one-on-one with ATSDR staff members to discuss health and site-related concerns.

Public comment period: An opportunity for the public to comment on agency findings or proposed activities contained in draft reports or documents. The public comment period is a limited time period during which comments will be accepted.

Public health action: A list of steps to protect public health.

Public health advisory: A statement made by ATSDR to EPA or a state regulatory agency that a release of hazardous substances poses an immediate threat to human health. The advisory includes recommended measures to reduce exposure and reduce the threat to human health.

Public health assessment (PHA): An ATSDR document that examines hazardous substances, health outcomes, and community concerns at a hazardous waste site to determine whether people could be harmed from coming into contact with those substances. The PHA also lists actions that need to be taken to protect public health [compare with health consultation].

Public health hazard: A category used in ATSDR's public health assessments for sites that pose a public health hazard because of long-term exposures (greater than 1 year) to sufficiently high levels of hazardous substances or radionuclides that could result in harmful health effects.

Public health hazard categories: Public health hazard categories are statements about whether people could be harmed by conditions present at the site in the past, present, or future. One or more hazard categories might be appropriate for each site. The five public health hazard categories are no public health hazard, no apparent public health hazard, indeterminate public health hazard, public health hazard, and urgent public health hazard.

Public health statement: The first chapter of an ATSDR toxicological profile. The public health statement is a summary written in words that are easy to understand. The public health statement explains how people might be exposed to a specific substance and describes the known health effects of that substance.

Public meeting: A public forum with community members for communication about a site.

RCRA [see Resource Conservation and Recovery Act (1976, 1984)]

Receptor population: People who could come into contact with hazardous substances [see exposure pathway].

Reference dose (RfD): An EPA estimate, with uncertainty or safety factors built in, of the daily lifetime dose of a substance that is unlikely to cause harm in humans.

Remedial investigation: The CERCLA process of determining the type and extent of hazardous material contamination at a site.

Resource Conservation and Recovery Act (1976, 1984) (RCRA): This Act regulates management and disposal of hazardous wastes currently generated, treated, stored, disposed of, or distributed.

RFA: RCRA Facility Assessment. An assessment required by RCRA to identify potential and actual releases of hazardous chemicals.

RfD [see reference dose]

Risk: The probability that something will cause injury or harm.

Risk reduction: Actions that can decrease the likelihood that individuals, groups, or communities will experience disease or other health conditions.

Risk communication: The exchange of information to increase understanding of health risks.

Route of exposure: The way people come into contact with a hazardous substance. Three routes of exposure are breathing [inhalation], eating or drinking [ingestion], or contact with the skin [dermal contact].

Safety factor [see uncertainty factor]

SARA [see Superfund Amendments and Reauthorization Act]

Sample: A portion or piece of a whole. A selected subset of a population or subset of whatever is being studied. For example, in a study of people the sample is a number of people chosen from a larger population [see population]. An environmental sample (for example, a small amount of soil or water) might be collected to measure contamination in the environment at a specific location.

Sample size (*n*): The number of units chosen from a population or an environment.

Source of contamination: The place where a hazardous substance comes from, such as a landfill, waste pond, incinerator, storage tank, or drum. A source of contamination is the first part of an exposure pathway.

Special populations: People who might be more sensitive or susceptible to exposure to hazardous substances because of factors such as age, occupation, sex, or behaviors (for example, cigarette smoking). Children, pregnant women, and older people are often considered special populations.

Stakeholder: A person, group, or community who has an interest in activities at a hazardous waste site.

Statistics: A branch of mathematics that deals with collecting, reviewing, summarizing, and interpreting data or information. Statistics are used to determine whether differences between study groups are meaningful.

Substance: A chemical.

Substance-specific applied research: A program of research designed to fill important data needs for specific hazardous substances identified in ATSDR's toxicological profiles. Filling these data needs would allow more accurate assessment of human risks from specific substances contaminating the environment. This research might include human studies or laboratory experiments to determine health effects resulting from exposure to a given hazardous substance.

Superfund [see Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) and Superfund Amendments and Reauthorization Act (SARA)

Superfund Amendments and Reauthorization Act (SARA): In 1986, SARA amended the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) and expanded the health-related responsibilities of ATSDR. CERCLA and SARA direct ATSDR to look into the health effects from substance exposures at hazardous waste sites and to perform activities including health education, health studies, surveillance, health consultations, and toxicological profiles.

Surface water: Water on the surface of the earth, such as in lakes, rivers, streams, ponds, and springs [compare with groundwater].

Survey: A systematic collection of information or data. A survey can be conducted to collect information from a group of people or from the environment. Surveys of a group of people can be conducted by telephone, by mail, or in person. Some surveys are done by interviewing a group of people [see prevalence survey].

Synergistic effect: A biologic response to multiple substances where one substance worsens the effect of another substance. The combined effect of the substances acting together is greater than the sum of the effects of the substances acting by themselves [see additive effect and antagonistic effect].

Teratogen: A substance that causes defects in development between conception and birth. A teratogen is a substance that causes a structural or functional birth defect.

Toxic agent: Chemical or physical (for example, radiation, heat, cold, microwaves) agents that, under certain circumstances of exposure, can cause harmful effects to living organisms.

Toxicological profile: An ATSDR document that examines, summarizes, and interprets information about a hazardous substance to determine harmful levels of exposure and associated health effects. A toxicological profile also identifies significant gaps in knowledge on the substance and describes areas where further research is needed.

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

Tumor: An abnormal mass of tissue that results from excessive cell division that is uncontrolled and progressive. Tumors perform no useful body function. Tumors can be either benign (not cancer) or malignant (cancer).

Uncertainty factor: Mathematical adjustments for reasons of safety when knowledge is incomplete. For example, factors used in the calculation of doses that are not harmful (adverse) to people. These factors are applied to the lowest-observed-adverse-effect-level (LOAEL) or the no-observed-adverse-effect-level (NOAEL) to derive a minimal risk level (MRL). Uncertainty factors are used to account for variations in people's sensitivity, for differences between animals and humans, and for differences between a LOAEL and a NOAEL. Scientists use uncertainty factors when they have some, but not all, the information from animal or human studies to decide whether an exposure will cause harm to people [also sometimes called a safety factor].

Urgent public health hazard
A category used in ATSDR's public health assessments for sites where short-term exposures (less than 1 year) to hazardous substances or conditions could result in harmful health effects that require rapid intervention.

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.

Alan W Yarbrough

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