Health Consultation

NELSON TUNNEL-COMMODORE WASTE ROCK PILE
SUPERFUND SITE

CREEDE, MINERAL COUNTY, COLORADO

EPA FACILITY ID: CON000802630

MARCH 13, 2009

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

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.

You May Contact ATSDR TOLL FREE at
1-800-CDC-INFO
or
Visit our Home Page at: http://www.atsdr.cdc.gov

HEALTH CONSULTATION

NELSON TUNNEL-COMMODORE WASTE ROCK PILE SUPERFUND SITE

CREEDE, MINERAL COUNTY, COLORADO

EPA FACILITY ID: CON000802630

Prepared By:

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

Table of Contents

Foreword

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

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

For additional information or questions regarding the contents of this health consultation or the CCPEHA, please contact the author of this document or Raj Goyal, the Principal Investigator of the program:

Thomas Simmons
Health Assessor
Colorado Cooperative Program for Environmental Health Assessments
Disease Control and Environmental Epidemiology Division
Colorado Department of Public Health and Environment
4300 Cherry Creek Drive South
Denver Colorado, 80246-1530
Phone: (303) 692-2961
FAX (303) 782-0904
Email: tom.simmons@state.co.us

Raj Goyal Ph.D
Principal Investigator
Colorado Cooperative Program for Environmental Health Assessments
Disease Control and Environmental Epidemiology Division
Colorado Department of Public Health and Environment
4300 Cherry Creek Drive South
Denver Colorado, 80246-1530
Phone: 303-692-2634
Fax: 303-782-0904
E-mail: raj.goyal@state.co.us

Summary and Statement of Issues

In September 2008, the Nelson Tunnel-Commodore Waste Rock Pile (NT-CWR) site was listed on the Environmental Protection Agency's National Priorities List of Superfund sites due to a combination of heavy metals contamination and potential physical hazards that could have an effect on human health and the environment. The NT-CWR site is an abandoned mining area in southwestern Colorado, approximately 1 mile north of the town of Creede in Mineral County. The site is located within the Willow Creek Watershed, which drains into the Rio Grande River. The NT-CWR site is also a part of the historic Creede Mining District, one of the largest silver producing mining areas in Colorado history. Former mining activities, which began in the 1870's and continued through the mid-1990s, have heavily impacted the Willow Creek Watershed. The major sources of contamination at the NT-CWR site consist of the Nelson Tunnel mine water drainage and the adjacent Commodore Waste Rock pile, both of which contain elevated levels of metals such as arsenic, cadmium, lead, and zinc.

Following a Preliminary Assessment of the Willow Creek Watershed by the Colorado Department of Public Health and Environment (CDPHE) in 1995, the Willow Creek Reclamation Committee (WCRC) was formed in 1999 with the overall goals of improving and restoring the Willow Creek Watershed while also preserving the historic mining heritage and structures of the district. The WCRC is a community-based group of citizens and local, state, and federal officials. To date the WCRC has conducted or directed a number of studies and reports aimed at quantifying and characterizing mining-related waste and its impact on the Willow Creek Watershed. In addition, a number of reclamation activities have been completed or are currently underway by, or in conjunction, with the WCRC.

The available environmental data and information collected to date indicates the NT-CWR site as the single largest contributor of mining-related waste in the entire watershed. It was determined that the NT-CWR site would best be addressed under the EPA's Superfund Program because of the size, scope, and complexity of the site. At this stage in the Superfund process, only a limited amount of environmental data has been collected that is strictly associated with the NT-CWR site since the focus of previous investigations by the WCRC and government agencies focused on the Willow Creek Watershed as a whole. Additional data collection is necessary to fully evaluate the potential public health implications of the site. Due to the limited amount of environmental data and time requirements of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), the CDPHE, in cooperation with the ATSDR, conducted this initial health consultation to evaluate the major potential health impacts related to the NT-CWR site. This initial evaluation focused on acute, or short-term, exposures to recreational users or visitors since this seems to be the predominantly occurring exposure scenario.

After a thorough review of the available data, it was concluded that the NT-CWR site poses an indeterminate public health hazard for past, current, and future exposures because of a limited amount of environmental data, uncertainties associated with actual land-use, and the actual extent of contamination from the NT-CWR site. Based on the data that is currently available, acute noncancer health hazards from exposure to contaminated surface water and sediment do not appear to be a significant concern. However, acute exposure to arsenic and copper found in surface soils at the CWR pile is of potential health concern for pica children, based on the limited available data. This scenario is considered a potential exposure pathway since the CWR pile is somewhat secured by fencing. It is recommended that additional environmental data and land use information be collected to fill these critical data gaps for future health consultations. In addition, opportunities for exposures to physical and chemical hazards should be reduced by considering various strategies (e.g., remediation activities and/or institutional controls).

Purpose

Under CERCLA (Superfund), the Agency for Toxic Substances and Disease Registry (ATSDR) is required to conduct a public health assessment or consultation when a site is proposed to the National Priorities List (NPL). CDPHE has a cooperative agreement with ATSDR to conduct public health assessments and consultations at NPL and other sites in Colorado. In this capacity, CCPEHA is conducting a preliminary health consultation for the NT-CWR site.

The purpose of conducting this health consultation is tripartite:

1) Characterize the site background and environmental data that is currently available,
2) Determine any significant physical and chemical threats that the site poses to human health based on the data that is currently available and make recommendations for actions to protect public health, and
3) Identify data gaps and make the appropriate recommendations for additional data collection and analysis.

Background

The Nelson Tunnel/Commodore Waste Rock Pile (NT-CWR) site is located in the San Juan Mountains of southwestern Colorado, approximately 1 mile north of the town of Creede in Mineral County. The site is an abandoned mining area that was placed on the NPL on September 3, 2008 due to a combination of heavy metals contamination and potential physical hazards associated with the NT-CWR that could have an effect on human health and the environment. The NT-CWR site is one component of the historic Creede Mining District located within the Willow Creek Watershed.

The major sources of contamination at the site consist of the Nelson Tunnel mine drainage and the adjacent Commodore Waste Rock Pile, both of which contain elevated levels of metals such as arsenic, cadmium, lead, and zinc. Detailed site background and history can be found in CDPHE 1995, EPA 2005, and WCRC website. This section describes the pertinent site history and site description for this evaluation.

Site History

The NT-CWR site is part of one the largest silver mining districts in Colorado history, which dates back over a hundred years. Early prospecting, in what is know known as the Creede Mining District, began around 1865 with the explorations of Charles Baker. The first notable mining claim in the district was staked in 1889 when a party of prospectors, including Nicholas Creede, discovered the Holy Moses Vein along East Willow Creek (EPA 2005). News of this discovery spread rapidly and soon the population in the area swelled to over 10,000. The rail line was expanded from Wagon Wheel Gap to what is now known as North Creede in 1891 and by 1892 over two million dollars in silver had been shipped down valley (Creede 2008). Most of the historic mining of lead, silver, and zinc in the area took place one to three miles north of Creede along the banks of East and West Willow Creeks.

A series of floods and fires, coupled with the declining price of silver threatened the economic vitality of the mining community for years and the population fluctuated wildly. In mid 1980's, the last remaining mine in the district closed due to another drop in the price of silver. Today, the population of Creede is less than 400 and the town has returned to its early tourism roots. Historic mining sites, fascinating geologic features, Gold Medal fly-fishing, and an abundance of other recreational opportunities in the area are the main tourist draws. The Bachelor Loop is a popular driving tour of many of the historic mining sites in the Creede Mining District. Although nearly all mining activity in the area has ceased, it is clear that mining remains an integral component of Creede's legacy that the community cherishes. At the same time, many of the historic mining sites have been shown to have had a negative impact on the environment. After 100 years of silver production, the Creede Mining District is now undergoing environmental cleanup.

In 1995, a preliminary assessment and characterization of the Willow Creek Watershed was conducted by the Colorado Department of Public Health and Environment to determine the eligibility of the historic mining sites for restoration under the CERCLA. After collecting 111 samples, data indicated that large volumes of source material containing high metal concentrations were available for release to the surface water pathway (CDPHE, 1997). The citizens of Creede initially rejected the idea of the Superfund designation primarily because of the stigma and negative impacts associated with the listing on the community. In 1999, the Willow Creek Reclamation Committee (WCRC), a community-based group of citizens and local, state, and federal officials, was formed to guide remedial activities within the watershed. The primary goals of the WCRC are to restore and improve the Willow Creek Watershed as a whole while at the same time preserving Creede's mining history. To date, the WCRC has successfully reclaimed a number of historic mining areas within the Creede Mining District and reclamation activity within the Willow Creek Watershed is ongoing. The WCRC has been recognized on a national scale because of the successful working relations and accomplishments for this type of remedial group. In 2005, an Aquatic Resource Assessment of the Willow Creek Watershed was prepared by the EPA for the WCRC (EPA, 2005). In 2007, URS Operating Services (UOS) conducted a sampling event for the EPA in the Willow Creek area in order to determine the extent of metal contamination associated with the NT-CWR site for the purpose of making further decisions about proposing the NT-CWR site to the National Priority List. In September 2008, the NT-CWR site listing on the NPL was final. To date, a number of technical studies (over 25) have been conducted on the Willow Creek Watershed, which proved useful in this evaluation. The large majority of these reports has been conducted by, or in conjunction with, the Willow Creek Reclamation Committee (WCRC) and can be found at www.willowcreede.org.

In general, the available reports were used for site background and history, environmental data, and site characterization including major sources of contamination within the watershed.

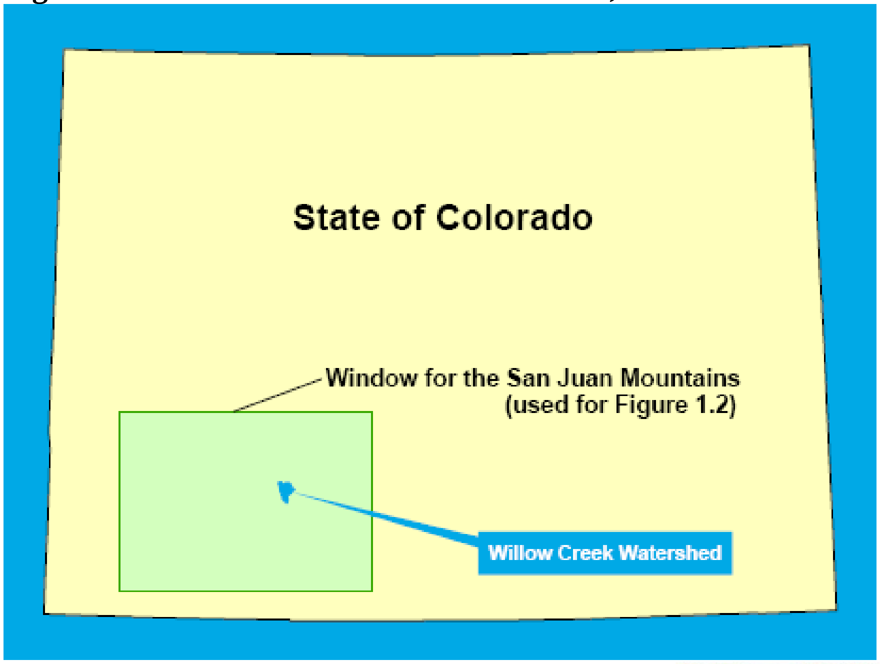
Site Description

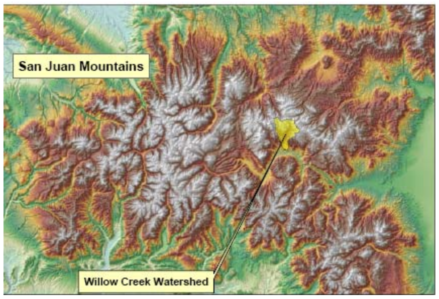
The NT-CWR is part of the historic Creede Mining District, located within the Willow Creek Watershed. The Willow Creek Watershed drains an area of nearly 40 square miles and consists of Willow Creek and its tributaries, East and West Willow Creek (Figure 1). The headwaters of East Willow Creek and West Willow Creek originate near the Continental Divide at an elevation of greater than 12,000 feet above mean sea level. Both creeks flow through very steep and narrow canyons until they merge into Willow Creek just above the town of Creede. Willow Creek then flows through town in a concrete and rock flume, constructed by the Army Corp of Engineers in the 1950's to control flood events. South of town, Willow Creek forms a braided stream for approximately 2 miles before it joins with the Rio Grande River through two primary channels. Near this area, the Rio Grande River is a Gold Medal fly-fishing habitat, and fish kills have been reported in the past from mining related contamination.

There are at least 30 historic mining sites located within a 6 square mile area north of Creede (Figure 2). The majority of these mines are positioned within 1-3 miles north of Creede along the major producing mineral veins in the district, the Amethyst Vein (West Willow) and the Holy-Moses Vein (East Willow). The NT-CWR site is one the most southerly sites along West Willow about a mile north of Creede. The total area of the NT-CWR site is estimated at 5 acres and the waste rock pile itself is thought to occupy at least 2 acres. Major features of the site consist of the Commodore Tunnel, Commodore

Waste Rock Pile, the Nelson Tunnel, and a number of historic mining structures. At the top of the site from north to south, West Willow Creek makes a slight jog to the west as it traverses the waste rock pile. Mining activities and waste have reshaped the canyon and the natural path of the creek. At ground level, the upper portions of the site are relatively flat and give way to steep faces to the east and west. On the eastern face, there is a large loading bin and the road. Across the road begins the Commodore Waste Rock Pile. West Willow Creek bisects the site and flows through and adjacent to the waste rock pile. The waste rock pile is stabilized by wood cribbing and is susceptible to erosion into the creek. The Commodore Tunnel is located along the western face and, at times, flows into West Willow Creek. Higher on the western face, additional mine waste and workings are visible. Currently, the creek is conveyed through a steel flume, which isolates the creek from the mine workings to some degree. Just past the flume, the creek drops approximately 50 feet to the canyon floor (See Site Photos).

Figure 1. Willow Creek Watershed Location, Source: EPA 2005





The lower portion of the site is steeper and the toe of the waste rock pile forms the eastern shoreline of West Willow Creek. The Nelson Tunnel is located across the creek to the west. The Nelson Tunnel was constructed in 1899 to drain and connect the mine workings along the Amethyst Vein and is estimated at over 15,000 feet in length. The tunnel discharges approximately 250 gallons per minute of acid mine drainage directly into West Willow and has been identified as the single largest contributor of heavy metals in the entire district (USGS 2004). High on the western face, an old ore cart track, used to transport ore from the complex to the mills below, remains. Below the waste rock pile and tunnel, the creek jogs back to the east before it joins with East Willow Creek and flows through Creede.

Figure 3. Nelson Tunnel

Source: EPA 2005

Site Visit

For the purpose of this health consultation, CCPEHA personnel (T. Simmons) conducted two site-scoping visits: one on September 12, 2008 and one on October 1, 2008. These visits were conducted with CDPHE personnel familiar with the area. During both visits there was fencing surrounding the onsite sources and access is not allowed to the public (see Site Photos taken during these scoping visits). No trespassing activities were witnessed within the fenced area during the site visits. The NT-CWR site is amongst the most popular stops along the Bachelor Loop and a number of tourists were observed near the site taking photos and rock hunting. Physical hazards such as mine openings exist at various locations in the watershed as a result of past mining activities and work is ongoing to secure these openings. Some physical hazards were present within the fenced portion of the site (e.g. open mine tunnels, unmarked drop-offs, and flood hazards).

Demographics

U.S. Census data predicts that Creede currently has approximately 400 year round residents (U.S. Census, 2000), nearly ½ of the total population of Mineral County. The Creede webpage states that during the summer months, the population grows to nearly 800 with the seasonal influx of residents (Creede 2008). The population is split fairly even between males and females with a median age of 44.8 years compared to the national median of 35.3 years.

Community Health Concerns

As part of the health consultation process, ATSDR and CCPEHA specifically seeks to evaluate community health concerns regarding site-related contamination and exposures. The majority of information regarding community health concerns has been gathered by CCPEHA personnel through meetings and visits with the WCRC personnel including community representatives and discussions with site managers and other officials involved with the site and/or community. In September 2008, EPA and CDPHE personnel conducted interviews with community members. The information gathered during these interviews indicates that the community is primarily concerned with clean up from an ecological and historical perspective and not necessarily human health. Most individuals expressed specific concerns regarding stabilization of the Commodore Waste Rock (CWR) pile to avoid another blowout event like the 2005 flood event and reclamation of water quality in West Willow Creek. Another major concern of the community was that the historical structures be preserved during any clean-up activities. In terms of health concerns, the community did express some concern of overall health and the incidence of cancer in the community, but not necessarily related to the NT-CWR site. When asked specifically if they felt they had any health problems related to the site, the large majority responded no, although there was some concern of the wind-generated fugitive dusts from the Willow Creek floodplain.

Overall, it should be noted that mining has been a part of Creede's heritage since the late 19^{th} century. The common sentiment of the community seems to be that the mining contaminants have been around for decades and no noticeable impact on public health has been observed. It was noted during community interviews that miners lived a difficult life, which included many other health hazards aside from the metal contaminants (e.g., smoking, drinking, and work-related physical hazards). However, the community is deeply interested in restoring the Willow Creek Watershed to improve the ecological impacts of mining-related contaminants. Additional information about community interviews will be documented in the formal Community Involvement Plan being prepared by the EPA and CDPHE personnel.

Discussion

The overall goal of the public health consultation process is to determine if site-related contamination poses a public health hazard and to make recommendations to protect public health if need be. The first steps include an examination of the currently available environmental data and how individuals could be exposed to contaminants. If exposure pathways to contaminants of potential concern exist, exposure doses are estimated and compared to health-based guidelines established by the ATSDR and EPA. This is followed by an in-depth evaluation if the estimated exposure doses exceed health-based guidelines.

Environmental Data

As mentioned previously throughout this document, the NT-CWR site is a newly listed site on the NPL and only a limited amount of environmental data that is strictly associated with the site is currently available. However, a number of studies have been conducted on the Willow Creek Watershed as a whole. Three primary environmental data sets have been identified for use in this evaluation: 1) an EPA sampling event conducted by UOS in 2007 that served as the basis for the NPL listing, 2) the CDPHE 1995 Combined Assessment and Preliminary Investigation of East and West Willow Creeks (CDPHE 1997) and 3) Surface water sampling results published by the Willow Creek Reclamation Committee in 2004 that includes their surface water sampling activities between 1999-2002 (WCRC 2004).

The public health consultation process includes an examination of past, current and future health hazards when data is available to evaluate the public health implications during those timeframes. In this evaluation, the UOS 2007 data set was used to assess current exposures and the 1995 CDPHE and 1999-2002 surface water data collected by WCRC were used to evaluate past exposures.

The environmental data sets identified for use in this evaluation include three types of exposure media: surface water, sediment, and surface soil (source). Surface water data was collected in all 3 reports and spans from 1995-2007. Sediment and surface soil data was only available from the 1995 and 2007 reports. The same metals and testing methods were not identical in all 3 events. Therefore, there are an uneven number of samples for some metals. The most recent sampling event consisted of only 11 collocated surface water and sediment samples (including 1 duplicate) and 2 surface soil samples collected from the Commodore Waste Rock Pile. Spatially, the 10 sampling locations span from just above the site to the Rio Grande River approximately 4 miles away. Contaminant levels vary considerably in the overall sampling area of the 2007 study and the CDPHE and WCRC data helped to improve what is known about contaminant levels.

Overall, the amount of available environmental data remains low and additional data collection is necessary to improve the reliability in assessing the potential health hazards associated with exposure to site-related contaminants. General trends of all the environmental data sets used in this evaluation are discussed by environmental medium in greater detail in Appendix A. The following discussion highlights major findings of each data set by environmental medium.

Surface Water

Overall, the surface water data from all of the aforementioned reports indicates a high level of contamination stemming from the site, which gradually decreases with distance from the site as the additional water and changing stream conditions dilute and deposit heavy metals contaminants.

EPA's surface water data collected by UOS during the most recent sampling event of 2007 spans from just above the site to just downstream of Willow Creek on the Rio Grande River. A total of 10 samples and 1 duplicate were collected and analyzed for the Contract Laboratory Program's (CLP) Target Analyte List (TAL) of metals. The location of surface water samples mirrored some of the sampling locations established by the WCRC (the surface water sampling locations of the WCRC study between 1999 and 2002). Major surface water contaminants found onsite in 2007 include cadmium (max = 183 ppb), lead (max = 1020 ppb), manganese (max =18300 ppb), and zinc (69600 ppb). Contaminant levels in other areas of the site are included in Table 1.

The WCRC surface water samples were collected in 1999-2002 throughout the Willow Creek Watershed since the focus of the WCRC sampling is to address the whole watershed, not just the NT-CWR site. Data was extracted from this report that was consistent with the surface water sampling locations in the other reports used in this evaluation. The spatial distribution of the WCRC data included locations from just above the site to the Wagon Wheel Gap on the Rio Grande River (approximately 10 miles southeast of the site). The samples were analyzed for both total and dissolved metal concentrations of aluminum, arsenic, barium, cadmium, copper, iron, lead, manganese, selenium, and zinc as well as a variety of other water quality and field parameters. The selection of metal analytes was based on a preliminary characterization effort conducted by MFG in 1999. Over 100 surface water samples for most contaminants were analyzed from the 29 sampling locations selected for use in this evaluation. Some contaminants were not analyzed in all of the surface water samples from a particular location if they were not found in previous samples (from the same location).

Major surface water contaminants found onsite in this sampling event include cadmium (max = 905 ppb), copper (max= 932 ppb), lead (max = 1509 ppb), manganese (max =19500 ppb), and zinc (153700 ppb). Contaminant levels in other areas of the site are included in Table 2.

Similarly, the 1995 sampling event by CDPHE included surface water collection from the entire Willow Creek Watershed to determine the areas' eligibility for CERCLA cleanup. This data set consists of collocated surface water and sediment data, and 2 surface soil samples collected from the CWR Pile. Nineteen surface water and sediment samples were selected for use in this evaluation. All samples were analyzed for CLP TAL metals.

The selected data from the report also includes the area along West Willow Creek just upstream of the site to the Wagon Wheel Gap on the Rio Grande River. Surface water data collected from East Willow Creek and the Windy Gulch was also reviewed since it is possible that these inflows have also impacted some areas of concern in this evaluation. However, these inflows were not distinctly considered from a public health perspective because the source of contaminants in East Willow Creek and the Windy Gulch is not the NT-CWR site. Major surface water contaminants found onsite in this sampling event include cadmium (max = 293 ppb), copper (max= 287 ppb), lead (max = 464 ppb), manganese (max =16300 ppb), and zinc (19800 ppb). These onsite levels appear to be lower than those of the UOS 2007 and WCRC 2004 data sets. The complete 1995 CDPHE surface water sampling results are included in Table 3.

Sediment

Sediment samples were collected in the UOS 2007 and CDPHE 1995 sampling events in the same location of surface water samples. Sediment samples from the both reports were analyzed by CLP TAL metals and span from just above the site to the Wagon Wheel Gap on the Rio Grande River. A total of 20 sediment samples were evaluated from a public health perspective and an additional 10 sediment samples were reviewed from areas like West Willow Creek upstream of the site, East Willow Creek, and the Windy Gulch. Overall, there are a limited number of sediment samples available from the overall area of potential concern, particularly current sediment samples. There appears to be an increasing trend in sediment contaminant levels with distance from the site, the opposite of that seen for surface water, which appears to decrease with distance for the site.

In the UOS 2007 data, the primary sediment contaminants include arsenic (max = 249 ppm), cadmium (max = 51.2 ppm), lead (max = 7980 ppm), and manganese (max = 5410 ppm) (Table 4).

In the CDPHE 1995 data, the primary sediment contaminants include arsenic (max = 96.9 ppm), cadmium (max = 47.9 ppm), lead (max = 2360 ppm), and manganese (max = 2380 ppm). These concentrations appear to be somewhat lower than those of the UOS 2007 data (Table 5).

Surface Soil

All surface soil data is presented in Tables 6 and 7. Two surface soil samples were collected from the CWR pile during both the 2007 and 1995 sampling events for a total of 4 surface soil samples. The samples were analyzed for CLP TAL metals by certified laboratories and the results show elevated levels of a number of heavy metals were present in the CWR pile. The levels of contamination between samples vary greatly. This is not unexpected from a mine waste rock pile the size of the CWR pile, which is estimated to encompass approximately 2 acres. In 2005, a relatively major flood event occurred in the Willow Creek Watershed that washed portions of the CWR pile downstream. The extent of contaminant spread is currently unknown since no surface soil samples have been collected from banks downstream of the site. Thus, there is a data gap for surface soil to the south of the site.

In the 2007 UOS sampling event, high levels of arsenic (max = 450 ppm), cadmium (max = 270 ppm), lead (max = 23400 ppm), manganese (max = 15000 ppm), and zinc (55400 ppm) were found in surface soils on the CWR pile (Table 6).

In the 1995 CDPHE sampling event, high levels of arsenic (max = 446 ppm), cadmium (max = 38 ppm), lead (max = 21000 ppm), manganese (max = 2390 ppm), and zinc (3550 ppm) were found in surface soils on the CWR pile (Table 7). It should be noted that levels of cadmium and manganese based on the 1995 data appear to be significantly lower than those of the 2007 UOS data.

Exposure Evaluation

Since exposure scenarios and concentrations of contaminants vary widely from the site to the Wagon Wheel Gap area (distal extent of available data), the overall area of contamination was subdivided into Exposure Units 1-6 (Figures 4 and 5).

Exposure Unit 1 (EU1) refers to the onsite area from just upstream of the Commodore Tunnel and waste rock pile to just downstream of the waste rock pile toe. The reasoning behind designating EU1 as a distinct exposure unit includes highly contaminated source areas not found in other areas and restricted access to source material. A perimeter fence with locked gates borders the eastern edge of the CWR pile, between the site and the road. On the west, a steep ridge limits access to the site and upper levels of the Commodore workings. Primary sources within EU1 include the Nelson Tunnel (NT) and the Commodore Waste Rock Pile (CWR). Secondary sources include waste rock piles located at the upper levels of the Commodore mine workings and the Commodore Tunnel. Tertiary sources of contaminants in this area include heavy metals from upstream sources along West Willow Creek, most notably the Last Chance/Amethyst workings. West Willow Creek, which bisects the site from north to south, is the major transport mechanism of heavy metal contaminants within EU1. Surface water flow (West Willow Creek) runs through and erodes the CWR pile and the Nelson Tunnel discharges contaminated ground water directly to West Willow Creek.

Exposure Unit 2 (EU2) includes the area along West Willow Creek below EU1 to the confluence of East and West Willow Creek. This area was distinguished due to the impact of source materials, relatively limited access, and it is upstream from any potential mining contaminants stemming from East Willow Creek. EU2 includes portions of the Commodore Waste Rock Pile that have been washed downstream in previous flood events, particularly the 2005 flood. In addition, this area is highly impacted by the outflow from the Nelson Tunnel. Below EU1, West Willow Creek flows through an old railcar flume, which passes under the road prior to meeting East Willow Creek. The slope of the banks in this area limits access to West Willow Creek in the uppermost sections of

EU2, but accessibility increases toward the confluence with East Willow Creek. However, in theory, the uppermost portions of EU2 and the lower reach of EU1 could be accessed from the south along the banks of West Willow Creek.

Exposure Unit 3 (EU3) is the mainstem of Willow Creek below the confluence of East and West Willow Creeks to the concrete flume that conveys Willow Creek through Creede. This area has been impacted from mining related contaminants from the site as well as East Willow Creek and the Windy Gulch. EU3 is fairly accessible and includes road, ice skating rinks, and the fire station, museum, and community center. It is likely that surface soil contaminants exist in this area from previous flood events and human transport, particularly along the banks of Willow Creek. This area also includes surface water and sediment contamination from both West and East Willow and the Windy Gulch. EU3 was designated as a distinct exposure unit because of the increase accessibility, contributions of mining related contaminants from other sources, and the possibility of more frequent exposures occurring in this area.

Exposure Unit 4 (EU4) includes the portion of Willow Creek contained within the concrete flume. This area was distinguished primarily because of the decreased likelihood of exposures occurring and the fact that no notable sediment or surface soil exists in the flume. The concrete flume was constructed in the 1950’s by the Army Corp of Engineers to decrease the potential hazards associated with flooding on the residents of Creede. The flume, constructed of concrete and rock, is not particularly inviting for recreational use or otherwise. Homes and businesses are located along nearly the entire reach of the flume. However, it does not appear that residents would be impacted by this stretch of Willow Creek unless a flood event, which over topped the flume, occurred. It should be noted that the flume did withstand the flood event in 2005. There is no notable accumulation of sediment in the flume and it is fairly safe to assume that most solid particles have been washed through the flume to the floodplain below Creede. Overall, human activity in this area appears to be low although at least some interaction with surface water in EU4 could be expected as in acute exposures.

Exposure Unit 5 (EU5) is the Willow Creek floodplain below Creede. Willow Creek, below EU 4, diverges into a braided stream of multiple channels that empty to the Rio Grande River in two primary channels (“West and East”). There is a diversion ditch that carries water from Willow Creek to the Wason Ranch, presumably for irrigation purposes. The Emperious Tailings pile is the only known source of heavy metal contaminants in EU5 aside from mining contaminants that have been transported by Willow Creek. EU5 was considered separately due to the relatively moderate concentrations of heavy metals and high accessibility to the area, which corresponds to an increased probability of human exposure.

Exposure Unit 6 (EU6) includes the section of the Rio Grande River just upstream of Willow Creek inflow to the Wagon Wheel Gap roughly 10 miles SE of the site on the Rio Grande River. This section of the Rio Grande River is rated as a Gold Medal flyfishery.

Homes, ranches, Creede's day care center, and cabin rentals are located along the banks of the Rio Grande. It is likely that recreational activity such as wading, fishing, and tubing is high in EU6.

Conceptual Site Model

A Conceptual Site Model identifies and describes all potential exposure pathways, or ways that individuals come into contact with site-related contaminants. An exposure pathway consists of 5 elements and is described as complete, potential, or incomplete based on the presence or likelihood of these elements actually occurring. There are 5 primary environmental media of potential concern at the NT-CWR site: surface water, surface soil, sediment, ground water, and fish tissue. Exposure scenarios and pathways for each medium are summarized in Tables 8 and 9 for the Nelson Tunnel and Commodore Waste Rock Pile and are discussed below.

Surface Water Exposure Pathways

Surface water throughout the Willow Creek Watershed has been heavily impacted by mining-related contamination. Individuals are exposed to surface water in a variety of ways, the most important of which is ingestion and dermal exposure. Individuals do use surface water bodies for drinking water when other sources of water are not readily available. This is particularly true for campers. However, this does not appear to be occurring at the NT-CWR site because there are no camping areas downstream of the site. The more likely exposure to surface water is incidental ingestion while wading, swimming, or fishing. In addition, dermal exposure occurs during these activities as well. However, dermal exposure is typically not considered a relevant pathway of exposure to metal contaminants because of the limited ability of metals to cross the skin barrier and actually enter the body, which limits the exposure dose.

Surface Soil Exposure Pathways

For use in this evaluation, surface soil refers to native soils, waste rock, and tailings present at the surface to a depth of 1 ft. below ground surface (bgs). It is recognized that these materials are likely to vary widely in both composition and levels of contamination. However, the different materials are intermingled and it is likely that mining contamination is present throughout the area with the highest levels of contaminants located in hot spots such as the Commodore Waste Rock Pile. In terms of exposure, individuals contact surface soil contaminants in the same manner as waste rock and tailings. Thus, classifying waste rock or mine tailings into a special category is not necessary for this evaluation, since spatial association is the only distinguishing factor. Moreover, the surface soil data used in this evaluation was only collected from the Commodore Waste Rock Pile (EU1). No surface soil samples from EU2-EU6 have been identified.

Individuals are primarily exposed to surface soil contaminants through incidental ingestion of soil particles. Incidental ingestion of surface soil occurs in a number of ways, not the least of which is hand to mouth activity. Other potential pathways of exposure to contaminated soil include dermal (skin) exposures and inhalation of particulates. For metal contaminants, such as at this site, dermal exposures and inhalation of suspended particulate matter are not considered particularly important when evaluating potential health hazards unless extenuating factors exist at the site. As mentioned previously, metals have a limited ability to pass through the skin and enter the body, so the actual dose is also limited. To generate health concerns from the inhalation of soil particles typically requires either an extremely high concentration of metals or an activity that creates a large disturbance, such as trailing an ATV. Neither condition seems to be the case at the NT-CWR site, particularly on the CWR pile. However, the arid to semi-arid climate and high winds coupled with the large amount of surficial mining waste does increase the likelihood of exposure. No air samples collected in the area have been identified to date. At this time, inhalation of fugitive dusts is considered a potential exposure pathway that should be further evaluated as more information and data regarding this pathway becomes available. Thus, incidental ingestion was the only exposure pathway evaluated in this consultation for surface soil contaminants. It should be noted that exposure to surface soil can only be evaluated for EU1 unless additional data collection takes place.

Sediment Exposure Pathways

The available data indicates that mining related contaminants have impacted sediments. Sediment samples have been collected from each EU evaluated in this consultation. Similar to surface soil, individuals are primarily exposed to sediment through incidental ingestion and dermal exposure. Again, dermal exposure to metal contaminated sediments is generally not considered significant in terms of public health and incidental ingestion was the only pathway evaluated in this consultation.

Ground water Exposure Pathways

Ground water occurs in two primary types of geologic formations in the Willow Creek Watershed, unconsolidated surficial deposits and deeper volcanic rocks and associated fluvial deposits (EPA 2005). Unconsolidated surficial deposits have been significantly impacted by historical mining activities. The town of Creede obtains its municipal water supply from 3 wells located near the Rio Grande, in the area upstream of the confluence with Willow Creek, and therefore, outside of the influence of contaminants originating from the Willow Creek watershed. In March 2004, the WCRC published a report on the available ground water data from a number of shallow monitoring wells, primarily located in the Willow Creek Floodplain. The report indicates a number of heavy metal contaminants at levels of potential concern in terms of human health, namely cadmium, manganese, lead, and zinc. The Emperious Tailings pile may be the most significant source of contamination to these wells. The EPA 2005 report indicates that there are few if any, domestic wells in the Willow Creek Watershed as per a survey conducted with the Colorado State Engineers Office. Two domestic wells were identified in North Creede along East Willow Creek, which is outside the scope of this evaluation. The main area of concern in regards to potential domestic use wells begins in the Willow Creek floodplain and extends to the Rio Grande Valley downstream of Willow Creek. At this time, it is unknown if wells exist in this area, if they are used for domestic use, and if they have been impacted by mining related contamination. This is considered a potential exposure pathway that cannot be evaluated at this time because it is not known if domestic wells exist in the floodplain and if they do exist, no data has been made available to evaluate. However, in the future, this pathway should be revisited in order to determine if domestic well drilling in the area should be prohibited through land use controls.

Fish Consumption Exposure Pathway

In September, 1999, the United States Fish and Wildlife Service examined the fish populations in West Willow, East Willow, Willow Creek, and the Rio Grande River near Willow Creek. Only two brown trout were found in Willow Creek near the confluence with the Rio Grande River (fish probably migrated from the Rio Grande). Brook trout were found throughout East Willow Creek, but only one brown trout was identified. Brook trout are more resistant to the toxic effects of heavy metals than are brown trout. Brook and brown trout were found in the upper portions of West Willow Creek above the NT-CWR site, but no fish were found in the reach below the site. Trout are relatively abundant in the Rio Grande River. Thus, the main area of concern for fish consumption is EU6. Aside from the evaluation of population density, no tissue samples have been collected to date to determine the metal concentrations. It is possible that fish in EU6 have accumulated some heavy metals from the historic mining operations in the district, which could present a health concern for anglers. Without fish tissue samples, the degree of metal contaminants in fish and the potential health hazards associated with catching and consuming these fish cannot be evaluated. It should also be noted that the Colorado Division of Wildlife has take restrictions on Rainbow and Brown Trout in this reach of the Rio Grande River. This is considered a potential pathway that cannot be evaluated at this time because the available information is insufficient.

Exposure Assumptions

This initial evaluation of the NT-CWR site focuses on the major potential health hazards associated with site-related contamination because of a limited amount of environmental, land-use, and potential exposure pathway data, all of which should be examined in more detail as additional information is gathered and assessed. The currently available information from discussions with members of WCRC, state, and federal officials, as well as through visual observations during site visits, indicates that the predominant exposure scenario of concern would be rock hunters and other tourists sifting through potentially contaminated areas. This suggests acute or short term, exposures that would occur over 1-2 days. No residents live onsite and it is not believed that residents of Creede visit the areas regularly and interact with mining-related materials. There is no information to indicate that recreational users visit the areas under consideration for camping or any other activity where they would be there for long periods (1-2 days maximum). Therefore, the chief exposure scenario of concern in this evaluation was limited to acute exposures to surface soil, surface water, and sediment by what will be referred to as recreational users.

As mentioned previously, the primary pathways identified in the CSM are incidental ingestion of surface water, sediment, and surface soil. To estimate the dose from each pathway, a number of exposure assumptions must be made. Many of the exposure assumptions used in the dose estimation are established by the EPA from the Exposure Factors Handbook and related documents (EPA 1997, EPA 2002). In this case, the main difference between the dose calculations for each pathway is the ingestion rate, or amount consumed of each substance. The incidental ingestion rates for surface soil and surface water have been documented. However, no similar values for sediment have been agreed upon. One half of the standard default assumptions for soil ingestion were used to evaluate sediment exposures primarily because it was assumed that individuals do not spend as much time in surface water as they do on land. The actual sediment ingestion rate could be higher or lower than the values used in this evaluation. To be consistent with the ATSDR guidelines, acute exposure doses for surface soil also include a special condition known as Pica behavior, in which individuals, typically children, ingest large amounts of soil. Pica values used in this evaluation have been established by the ATSDR. Additional information regarding exposure assumptions and exposure dose estimation can be found in Appendix B.

Selection of Contaminants of Potential Concern

To identify contaminants of potential concern (COPCs), the available environmental data was divided by EU and screened with comparison values established by the ATSDR. The comparison values (CVs) used in this evaluation are derived for residential exposure scenarios including consumption of drinking water and residential exposure to surface soil. No screening values have been established by ATSDR or the EPA for sediment. Therefore, soil CVs are typically used to screen sediment contaminants in lieu of a specific CV for this medium. The use of these CVs is considered conservative in that it is unlikely individuals are being exposed to site-related contaminants at the NT-CWR site on the same scale as a residential exposure scenario. Therefore, if the maximum concentration of a particular contaminant is below the CV, it is dropped from further evaluation. If the maximum concentration of the contaminant is above the CV, it is generally retained for further analysis as a COPC. However, exceeding the CV does not indicate that a health hazard exists; only that additional examination is warranted. The complete list of CVs used is provided in Table 10.

The screening level assessment of the available data indicates a number of COPCs from each environmental medium and EU considered in this evaluation. Unless it has been explicitly noted in the following text, each COPC was retained for further analysis. The screening results are discussed by environmental medium below.

<u>Surface Water COPC Selection</u>

COPC Selection for Current Exposures based on the 2007 UOS Data

A number of COPCs were identified in surface water based on the 2007 UOS data set (Table 11). As mentioned previously only a limited amount of sampling data was collected overall. The data set included 10 surface water samples from EU1, EU2, EU3, and EU6 and 1 duplicate sample.

The maximum detected concentration of surface water COPCs in EU1 include arsenic (6.3 ppb), cadmium (183 ppb), lead (1020 ppb), manganese (18300 ppb), thallium (17.4 ppb), and zinc (69600 ppb). In EU2, contaminant concentrations decreased and cadmium (20.3 ppb), lead (124 ppb), manganese (422 ppb), and zinc (4200 ppb) were selected as COPCs. Below the confluence with East Willow Creek in EU3, there was a slight decrease in the contaminant concentrations, but overall the concentrations appear fairly consistent with the concentrations found in EU2 during this sampling event. Cadmium (17.8 ppb), copper (384 ppb), lead (101 ppb), manganese (349 ppb), and zinc (3630 ppb) were selected as COPCs in EU3. It should be noted that copper was selected as a COPC in the surface water at EU3 only and the difference between the total concentration and dissolved concentration of copper is remarkable (384 ppb vs. 2.4 ppb), which could indicate an erroneous analytical result. However, copper was retained as a COPC since it is not certain if this is indeed an error. No surface water data was collected in the concrete flume through Creede (EU4) or in the Willow Creek floodplain below Creede (EU5) during this sampling event. In the area below Willow Creek on the Rio Grande River (EU6), cadmium and lead were the only COPCs selected at maximum concentrations of 4.1 ppb and 36.2 ppb.

COPC Selection for Past Exposures based on the 1999 – 2002 WCRC Surface Water Data

COPCs were identified in each exposure unit and the overall pattern of the data seems to mimic that seen in the UOS 2007 data set in that contaminant concentrations generally decrease with distance from the site. Similar COPCs were identified in the WCRC data and the UOS data as well, but the maximum concentrations of contaminants were generally higher in the WCRC data.

In EU1, the maximum concentrations of arsenic, cadmium, copper, lead, manganese, and zinc exceeded the screening values. The same COPCs were identified in EU2 with the exception of copper. However, the maximum concentration of each contaminant was much lower in EU2 than found onsite as shown in Table 11. The maximum concentration of arsenic, cadmium, lead, manganese, and zinc also exceeded the screening value in EU3. Again the maximum concentration of most COPCs has decreased. Arsenic was found at a higher concentration in EU3 than in EU2, but arsenic was only detected 2 times in EU2 and EU3 out of approximately 23 samples. Since ½ the detection limit of the analytical method (3.8 ppb) exceeds the screening value, arsenic is a known human carcinogen, and it was detected 2 times, arsenic was retained as a COPC. It is likely that arsenic is only present in low concentrations (< 8 ppb) in these areas based on this data set. In the Willow Creek floodplain (EU5), the same contaminants were identified as COPCs, but the maximum concentrations had increased to levels similar to EU2. This could indicate additional sources of contamination. Below Willow Creek on the Rio Grande (EU6), the maximum concentration of cadmium was equal to the screening value.

However, cadmium was not retained as a COPC for this data set since it is unlikely to present a health hazard at residential exposure conditions much less the acute health hazards being considered in this evaluation.

COPC Selection for Past Exposures Based on CDPHE 1995 Surface Water Data
Contaminants of potential concern were identified in the surface water of each EU in this evaluation except EU 4. The primary COPCs are cadmium and lead, which is consistent with the UOS 2007 and WCRC 1999 – 2002 data. In EU1, the maximum detected concentration of arsenic, cadmium, copper, lead, manganese, thallium, and zinc exceed the screening value. The same COPCs were found in EU2 at similar concentrations as those found in EU1. Maximum detected concentrations of cadmium and lead exceeded the screening value in EU3, EU5, and EU6. Table 11 is a comparison of the COPC selection process for each data set.

Sediment COPC Selection

COPC Selection for Current Exposures based on UOS 2007 Sediment Data
Elevated metal concentrations in sediment were also identified in the UOS 2007 sampling event. Above the site, fairly high amounts of arsenic and lead were found in the sediment at concentrations of 71.2 ppm and 1100 ppm, respectively. However, because these samples were collected above the site, the contamination is most likely from a different source. Therefore, these data points were not used in the assessment. It was noted here only to indicate levels of contamination above the site. Arsenic and lead were selected as COPCs in onsite sediment (EU1) at maximum concentrations of 55.3 and 1260 ppm, respectively. The maximum concentration of manganese also exceeded the screening value at 3520 ppm in onsite sediment. In EU2, arsenic (175 ppm), cadmium (16.1 ppm), copper (126 ppm), and lead (3860 ppm) were selected as COPCs. Manganese concentrations (5410 ppm) exceeded the screening value in EU3 sediments along with arsenic (249 ppm), cadmium (51.2 ppm), copper (220 ppm), and lead (7980 ppm). As shown, this data set indicates that contaminant levels in sediment increase with distance from the site, which is the opposite trend of that seen in surface water. No sediment data was collected from EU4 and EU5. In EU6, sediment data was collected during this sampling event and arsenic (182 ppm), cadmium (29.1 ppm), copper (136 ppm), lead (4450 ppm), and manganese (3010 ppm) were selected as COPCs. Table 12 is a comparison of the COPC selection process for each data set.

COPC Selection for Past Exposures based on CDPHE 1995 Sediment Data
The maximum concentration of arsenic, cadmium, and lead was greater than the screening value in each EU that sediment data was available (EU 2, 3, 5, and 6). The manganese concentration in sediment also exceeded the screening value in EU5. Similar to the UOS 2007 data, contaminant concentrations generally increase with distance from the site. This is not the case for arsenic which remained fairly steady in EU 2, 3, and 5 and decreased in the Rio Grande below the site (EU6). The sediment COPCs are summarized in Table 12 by EU.

Surface Soil COPCs

COPC Selection for Current Exposures based on UOS 2007 Surface Soil Data

Two surface soil samples (0-12 inches deep) were collected during the 2007 UOS sampling event. The data shows a large number of contaminants exceeding the screening value at relatively high concentrations. Aluminum, arsenic, barium, cadmium, copper, lead, manganese, thallium, vanadium, and zinc were all selected as surface soil COPCs in EU1. Maximum detected values of the COPCs are shown in Table 13. These were the only surface soil samples available from this sampling event.

COPC Selection for Past Exposures based on CDPHE 1995 Surface Soil Data

Two surface soil samples were collected from the CWR pile during the 1995 CDPHE sampling event. The maximum concentration of aluminum, antimony, arsenic, barium, cadmium, copper, lead, manganese, thallium, vanadium, and zinc exceed the screening values and were retained as COPCs. Surface soil COPC selection is presented in Table 13.

Public Health Implications

The metal contaminants that exceed the respective screening values (COPCs) are evaluated further by estimating exposure doses and comparing these doses with known health-based guidelines. As discussed in the Conceptual Site Model, the primary focus of this evaluation is to consider acute exposures of recreational visitors (i.e. those individuals that visit the site for short periods of time). It is unknown at this time if other exposure scenarios may exist; however there is a high degree of certainty that the acute recreational exposure scenario is the predominantly occurring scenario. This preliminary evaluation may result in either an under- or over-estimation of health hazards if the exposure assumptions are either less or more than the actual exposures. A Toxicological Evaluation of major contaminants with acute health guidelines (arsenic and copper) is provided in Appendix C.

In general, COPCs for surface water, sediment, and surface soil include arsenic, cadmium, copper, lead, manganese, thallium, and zinc. It is, however, important to note that acute exposures are evaluated only for arsenic and copper because no acute health guidelines are available for cadmium, manganese, thallium, and zinc. These remaining metals are qualitatively evaluated by comparing the estimated acute exposure doses with long-term health guidelines in order to gauge the potential for health hazards. In addition, lead exposures are not evaluated because no lead uptake models exist to assess acute lead exposures.

Incidental Ingestion of Surface Water

Current Exposures Based on 2007 UOS Surface Water Data

COPCs for surface water include arsenic, cadmium, copper, lead, manganese, thallium, and zinc. The estimated acute exposure doses of child and adult recreational users for incidental ingestion of arsenic and copper in surface water are significantly below the acute health-based guidelines in all exposure units (EUs) (Table 14).

Acute exposures to cadmium, lead, manganese, and thallium cannot be evaluated because these contaminants do not have health-based guidelines based on acute exposure scenarios. However, the estimated acute exposure doses for child recreational users in EU1 exceed the long-term health-based guidelines for cadmium, manganese, thallium, and zinc (Table 14).

Past Exposures Based on 1999-2002 WCRC Surface Water Data

The COPCs selected from this data set includes arsenic, cadmium, copper, manganese, and zinc. The acute exposure doses from incidental ingestion of arsenic and copper are below the health-based guidelines in all EUs.

Acute exposures to cadmium, lead, manganese, and thallium cannot be evaluated because these contaminants do not have health-based guidelines based on acute exposure scenarios. However, the estimated acute exposure doses in EU1 exceed the chronic health-based guidelines for both recreational children (for cadmium, manganese, and zinc) and adults (for cadmium). In EU2, the estimated acute exposure dose for recreational children exceeds the long-term health-based guideline only for cadmium (Table 15).

Past Exposures Based on 1995 CDPHE Surface Water Data

COPCs for surface water include arsenic, cadmium, copper, lead, manganese, thallium, and zinc. The estimated acute exposure doses of child and adult recreational users for incidental ingestion of arsenic and copper in surface water are significantly below the acute health-based guidelines in all exposure units (Table 16).

Acute exposures to cadmium, lead, and manganese cannot be evaluated because these contaminants do not have health-based guidelines based on acute exposure scenarios. For recreational children, the estimated acute exposure doses for cadmium and manganese exceed the long-term health-based guidelines in EUs 1 and 2. The recreational adult estimated acute exposure doses for cadmium in EU1 and EU2 exceed the long-term health-based guidelines (Table 16).

Summary of Current and Past Surface Water Exposures

The evaluation of current and past exposures to surface water in all EUs indicates that significant noncancer adverse health effects are not likely for recreational children or adults from 1-day acute exposure to arsenic and copper in surface water. However, this conclusion is based on a limited amount of surface water data, particularly current data. Past and current acute exposures to all contaminants are considered an indeterminate public health hazard because of the uncertainties associated with the evaluation of contaminants with no acute health-based guidelines (cadmium, lead, manganese, thallium, and zinc) and the limited availability of sampling data.

Incidental Ingestion of Sediment
No formal sediment ingestion rates have been established by the EPA or the ATSDR. Therefore, ½ the default ingestion rate for soil was used to evaluate sediment ingestion (i.e. 100 mg/day for children and 50 mg/day for adults). It should be noted that the actual sediment ingestion rate could be higher or lower than the values used in this evaluation.

Current Exposures Based on 2007 UOS Sediment Data
COPCs for sediment include arsenic, cadmium, copper, and manganese. The estimated acute exposure doses of child and adult recreational users for incidental ingestion of arsenic and copper in sediment are significantly below the acute health-based guidelines in all exposure units (Table 17).

Acute exposures to cadmium and manganese cannot be evaluated because these contaminants do not have health-based guidelines based on acute exposure scenarios. However, the estimated dose for cadmium and manganese exceeded the long-term health-based guidelines for children only in EU3 (Table 17).

Past Exposures Based on 1995 CDPHE Sediment Data
COPCs for sediment include arsenic, cadmium, and manganese. The estimated acute exposure doses of child and adult recreational users for incidental ingestion of arsenic and copper in sediment are significantly below the acute health-based guidelines in all exposure units (Table18).

Acute exposures to cadmium and manganese cannot be evaluated because these contaminants do not have health-based guidelines based on acute exposure scenarios. However, the estimated acute exposure doses of cadmium for children exceed the long-term health-based guideline in EU3 and EU5 (Table 18).

Summary of Sediment Exposures
Past and current acute exposures (1-day) to arsenic and copper in sediment are below a level of concern, but are based on a very limited amount of sampling data. Lead was found at fairly high levels (ranges from 66.4 – 7980 ppm) in sediment of all EUs. However, no lead models are currently available to evaluate acute exposures. Since acute exposures to cadmium, lead, and manganese cannot be evaluated due to a lack of acute health-based guidelines and there is uncertainty associated with the limited amount of sampling data available, past and current acute exposures to all contaminants in sediment are considered an indeterminate public health hazard.

Incidental Ingestion of Surface Soil (Potential Pathway)
Surface soil sampling data is limited to the Commodore Waste Rock pile. The waste rock is currently located behind a 6 ft fence with a locked gate. However, it is possible that some individuals bypass the fence or gate and enter the site. Again, this is considered a potential exposure pathway. Three potential exposure scenarios were considered for

incidental ingestion of surface soil: 1) standard default ingestion rate of 200 mg/day for children, 2) Pica ingestion rate of 5000 mg/day for children, and 3) standard default ingestion rate of 100 mg/day for adults.

Current Exposures Based on 2007 UOS Soil Data

Surface soil data collected during the UOS 2007 sampling event is limited to 2 samples collected from the Commodore Waste Rock Pile. Surface soil COPCs include aluminum, arsenic, barium, cadmium, copper, lead, manganese, thallium, vanadium, and zinc. The estimated exposure doses exceed the health-based guideline of some contaminants for each incidental ingestion scenario as shown in Table 19. At the standard default and pica ingestion rates used for recreational children, the estimated acute exposure dose for arsenic and copper are above the health-based guideline. The same is true for the default ingestion rate for recreational adults for copper.

At this point, the estimated acute doses that exceed the appropriate health-based guideline are further evaluated by comparing with known acute health effects levels such as the No-Observed-Adverse-Health-Effect-Level (NOAEL) and Lowest-Observed-Adverse-health Effect-Level (LOAEL) described in the scientific literature.

The ATSDR Acute Oral MRL for arsenic is based on a LOAEL value of 0.05 mg/kg-day, derived from a study in which humans were accidentally exposed to arsenic-contaminated soy sauce in Japan (ATSDR 2007). No acute NOAEL was established in this study. The study included over 200 cases of arsenic poisoning associated with soy sauce consumption, estimated to contain 0.1 mg As/mL of soy sauce. Researchers estimated the daily dose of arsenic at 0.05 mg/kg body weight over a 2-3 week period. The primary health effects that were initially observed included edema of the face (flushed), and gastrointestinal and upper respiratory symptoms. These symptoms were followed by skin lesions and neuropathy in some cases. A number of blood, liver, kidney, and cardiovascular health effects were also noted in the study. In comparison to the estimated doses in this evaluation, the LOAEL value for arsenic was only exceeded at the pica ingestion rate. The estimated doses, at the default ingestion rate, for recreational children and adults were approximately one order of magnitude (10-fold) lower than the LOAEL value. Thus, significant acute noncancer adverse health effects are not likely at the default ingestion rates, especially considering the reduced bioavailability of arsenic from soils.

The ATSDR Acute Oral MRL for copper is based upon a NOAEL value of 0.0272 mg/kg-day and a LOAEL value of 0.0731 mg/kg-day observed in a study conducted by Pizarro et al. (1999). The study was designed to determine acute gastrointestinal health effects of copper by administering graded levels of copper sulfate to 60 healthy adult women. The women were divided into 4 groups (*n* = 15) that were given either no copper, 1 mg/L (0.0272 mg/kg-day), 3 mg/L (0.0731 mg/kg-day), or 5 mg/L (0.096 mg/kg-day) for a two-week period followed by 1 week of rest between groups (doses based on 66 kg body weight). Gastrointestinal health effects were recorded by the subjects on specially prepared reporting forms. It was found that there was a statistically significant association between gastrointestinal symptoms such as nausea, abdominal cramps, and vomiting at levels higher than 3 mg/L (0.0731 mg/kg-day).

In relation to the estimated exposure doses for copper from incidental ingestion of soil in this evaluation, only at the pica ingestion rate does the dose exceed the LOAEL value of 0.0731 mg/kg-day. The estimated dose for pica behavior is 0.49 mg/kg-day. This dose is greater than the dose levels of the study indicating that gastrointestinal health effects would be likely at this dose level. The estimated exposure dose for young children at the default ingestion rate is close to, but does not exceed the NOAEL value for copper (0.020 mg/kg-day versus 0.0272 mg/kg-day). Although, the estimated exposure dose for young children at the standard default rate does not exceed the NOAEL value, it is of potential concern because research has shown that children may be more susceptible to the toxic health effects of copper (Knobeloch *et al*, 1994). Overall, the available data are inconclusive to assess accurately whether there are age-related differences in gastrointestinal toxicity of copper (ATSDR, 2004). However, it appears that significant acute noncancer adverse health effects are not likely, especially, considering the reduced bioavailability of copper from soils in comparison to water used in the critical study by Pizarro et al (1999).

Overall, acute current exposures to arsenic and copper are considered an indeterminate public health hazard due the availability of very limited data. However, the available data indicate some potential health concern because the estimated acute doses exceed health guidelines for arsenic and known health effects levels for copper in human studies. Acute health hazards are not evaluated for aluminum, antimony, barium, cadmium, lead, manganese, thallium, vanadium, and zinc because no acute health guidelines are available. Thus, acute exposures to these metals are considered an indeterminate public health hazard. For both children and adults, estimated acute exposure doses exceed long-term health guidelines for cadmium, manganese, thallium, and zinc.

<u>Past Exposures Based on 1995 CDPHE Soil Data</u>

COPCs for soil include aluminum, arsenic, antimony, barium, cadmium, copper, lead, manganese, thallium, vanadium, and zinc. In general, the maximum concentration of contaminants found in 1995 was typically lower than in 2007, meaning the corresponding doses based on the 1995 data are also lower. Notable exceptions include the estimated doses for aluminum, antimony, and copper, which were higher than the 2007 doses.

At the standard and pica ingestion rates for children, the estimated acute exposure doses of arsenic and copper exceed the health-based guidelines as shown in Table 20. It is estimated that adult recreational users are exposed to acute dose of copper above the acute health-based guidelines. For past exposures based on the 1995 data, arsenic and copper doses exceed the health-based guidelines and can be examined further in relation to known health-effect levels. For both children and adults, estimated acute exposure doses exceed long-term health guidelines for only cadmium. Past acute health hazards cannot be evaluated for aluminum, antimony, barium, cadmium, lead, manganese, thallium, vanadium, and zinc because no acute health guidelines are available. Thus, acute exposures to these metals are considered an indeterminate public health hazard.

As discussed above in detail for the evaluation of current exposures based on the UOS 2007 surface soil data, the known health effect levels (LOAEL) of acute exposure to arsenic and copper are 0.05 mg/kg-day and 0.0731 mg/kg-day, respectively (Table 20). shows that the estimated exposure doses for both copper and arsenic significantly exceed the acute health effect levels at the pica ingestion rate for children, but are lower than the acute health effect levels at the standard ingestion rate for both children and adults. It should be noted, however, that the estimated dose for children approaches the NOAEL value for copper at the standard ingestion rate (0.025 mg/kg-day vs. 0.027 mg/kg-day). Thus, there is potential for significant acute non-cancer adverse health effects of arsenic and copper for pica children if the opportunity exists for onsite soil exposures.

Some uncertainties and limitations regarding the evaluation of surface soil hazards in 1995 include accessibility to the CWR pile and the limited number of surface soil samples available. It is unknown when the fence that currently limits access to the CWR pile was installed. If no fence was in place, this could mean that access to the site was much easier in the past, which increases the probability of exposure, particularly considering the pica ingestion scenario. Currently, incidental ingestion of surface soil is considered only as a potential exposure pathway due to limited accessibility to the CWR site. This assumption was also made for past exposures to surface soil in this evaluation, but may need to be revisited as additional information becomes available in the future. In addition, the estimated exposure doses are based on only 2 surface soil samples from the CWR pile. It is very likely that the concentration of contaminants varies greatly in a waste rock pile the size of the CWR pile and it is unclear where exactly the samples were collected from. Exposure to surface soil could be likely or unlikely at the 1995 sample locations (i.e if samples were collected from the top of the waste rock pile where exposure is likely or if the samples were collected from the slope of the waste rock pile where exposure is unlikely). With these factors in mind, health hazards associated with exposure to surface soil contaminants at the NT-CWR site cannot be fully evaluated.

Overall, acute past exposures to arsenic and copper are considered an indeterminate public health hazard due the availability of very limited data. However, the available data indicate potential for health concern because the estimated acute doses exceed known health effects levels for arsenic and copper in human studies.

Future Exposures

All future exposures are considered indeterminate public health hazards because of the unavailability of information regarding the future land use. In addition, there are uncertainties associated with future changes in the current state of the NT-CWR site because of physicals hazards such as floods, etc. It is unlikely that future cleanup at the site will be conducted outside of EU1. Therefore, future exposures may remain constant with regard to soil and sediment. However, it is expected that surface water concentrations will be reduced as a result of the remedy and therefore risk posed by exposure to surface water are expected to be reduced.

Limitations

This is not intended to be an in-depth discussion of all uncertainties. Rather, the focus is to highlight the major assumptions and limitations that are unique to this evaluation. Overall, the uncertainties discussed below are likely to over- or underestimate exposures and health hazards. The magnitude of this uncertainty is unknown.

- Multiple mining sources exist in the Creede Mining District which are impacting the environmental media.
- Available sampling data for past and current exposures for all media of potential concerns are very limited (1 or 2 samples per sampling location).
- No data are available for ground water and fish.
- Exposure scenarios are not well defined and site-specific exposure investigations are needed in order to determine exposure pathways and if there is potential for chronic exposure scenarios. Therefore only acute recreational exposures are evaluated at this time.
- Acute exposures could not be evaluated for metals with no acute health guidelines (e.g., cadmium, lead, manganese, thallium, and zinc). Acute exposures could only be evaluated for copper and arsenic. Thus, cumulative health hazards due to multiple metals could not be evaluated.
- The assumption of 100% metal bioavailability from soils is a conservative assumption because of the reduced availability of metals from soils. Thus, health hazards for soil are likely to be overestimated. In addition, the occurrence of pica behavior under the recreational scenario is unlikely, but possible. To some extent, surface water exposures may also be overestimated because they are based on total metal levels.

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.

Children were considered separately in this evaluation and were found to have higher potential for acute noncancer health hazards than adults due to the greater dose of hazardous substance per unit body weight. Children are also more likely to participate in pica behavior, which also increases the acute health hazards from arsenic and copper exposure.

Conclusions

The primary metals of concern at the NT-CWR site are arsenic, copper, cadmium, lead, and manganese in soils, surface water, or sediment. At the time of this health consultation, the populations with opportunities for exposure are believed to be recreational visitors mainly for rock hunting, and persons trespassing on the site.

Overall, the site poses an indeterminate public health hazard for past, current, and future exposures because of a limited amount of environmental data, uncertainties associated with actual land-use, and the actual extent of contamination from the NT-CWR site. The major limiting factor of this evaluation is the inability to determine contributions from the NT-CWR site due to multiple mining sources (over 30) in the Creede Mining District and the availability of very few samples (1 or 2 per location) from surface water, sediment, and surface soil. One of the largest data gaps is surface soil data downstream of the site. In addition, acute health hazards to contaminants other than arsenic and copper could not be evaluated due to the unavailability of acute health guidelines. It is noteworthy that the limited available data indicates some potential concern for acute noncancer health hazards from 1-day exposure to arsenic and copper in soil, especially for pica children on site (EU1).

Besides chemical contaminants, physical hazards were also present on the site and are being addressed by EPA.

Recommendations

To fill the environmental data gaps identified in this evaluation and enable a more complete assessment of the public health impacts from the site, the following recommendations are made:

- The fence surrounding the onsite sources should be kept in good condition to prevent access to the site. In addition, security should be improved, particularly with regard to children and adults trespassing on the site.

- Continue activities to address physical hazards (e.g. unstable slope areas, unmarked drop offs, etc.) to prevent opportunities for accidents.

- Opportunities for exposures to metal contaminated areas should be reduced by considering remediation activities or institutional controls.

- EPA should provide to CCPEHA any additional environmental data or information that may warrant further public health evaluation.

- In order to conduct a more comprehensive health evaluation in the future, the following additional environmental data are needed:
    - Collect additional surface soil data downstream of the site sequentially to determine the extent of metal contaminants from the NT-CWR site,

    - Determine if any ground water wells are being used for domestic purposes, particularly at the Wason Ranch and Creede Day Care Center;

    - Collect additional surface water data, particularly in EU2 – EU3 (below the site to the concrete flume).

    - Collect additional sediment data downstream of the site,

    - Fish tissue data from the Rio Grande River area (EU6) needs to be collected if this pathway is to be evaluated, and,

    - Determine if more frequent exposures are occurring in EU5 and EU6 since residents are located in these areas.

Public Health Action Plan

The Public Health Action Plan (PHAP) describes the actions to be undertaken in the future to reduce exposure to site-related contamination. The CCPEHA will work in conjunction with CDPHE and EPA site project managers to carry out the PHAP as describe below.

- CCPEHA will review any additional surface water, sediment, ground water, fish tissue, and surface soil data that is collected in the future upon request and/or necessity and determine an appropriate public health response (e.g., health consultation, technical assistance).

- CCPEHA will provide input to EPA and CDPHE on identifying strategies to prevent trespassing by children and adults on the site.

- CCPEHA will conduct the appropriate health education activities including the presentation of the findings of this evaluation in a public meeting, distributing the document to the community through local information repositories, and the production of fact sheets to relay this information to the public in an easy-to-interpret format.

- Due to the proximity of residential community to the site, there might be public health concern associated with remedial or other site activities. The CCPEHA will address these concerns by determining an appropriate response (e.g., health consultation, technical assistance, health education and outreach)

Author and Reviewers

Thomas Simmons
Health Assessor
Environmental Epidemiology Section
Colorado Dept. of Public Health and Environment
Phone: 303-692-2961
Fax: 303-782-0904
E-mail: tom.simmons@state.co.us

CDPHE Designated Reviewer:

Raj Goyal Ph.D
Principal Investigator
Environmental Epidemiology Section
Colorado Dept. of Public Health and Environment
Phone: 303-692-2634
Fax: 303-782-0904
E-mail: raj.goyal@state.co.us

ATSDR Designated Reviewer:

Jennifer Freed, MPH
Technical Project Officer
Division of Health Assessment and Consultation
Agency for Toxic Substances and Disease Registry

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 2007). *Toxicological Profile for Arsenic*, August 2007. Available on the Internet at: http://www.atsdr.cdc.gov/toxprofiles/tp2.html, Accessed January 2009.

Agency for Toxic Substances and Disease Registry (ATSDR 2004). *Toxicological Profile for Copper*, September 2004. Available on the Internet at: http://www.atsdr.cdc.gov/toxprofiles/tp132.html, Accessed January 2009.

Colorado Department of Public Health and Environment, Hazardous Materials and Waste Management Division (CDPHE 1997). *Comprehensive Analytical Results Report, East and West Willow Creek*, approved May 1997.

Creede Chamber of Commerce (Creede 2008). *Town of Creede Website, last revision 11/25/2008*. Available on the Internet at: http://www.creede.com/, Accessed March 5, 2009.

URS Operating Services, (UOS 2007). *HRS Support Documentation and Sampling Event*, March 20, 2007.

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, National Center for Environmental Assessment (EPA 1997). *Exposure Factors Handbook,* August 1997. Available on the Internet at: http://www.epa.gov/ncea/efh/report.html, Accessed January 2009.

U.S. Environmental Protection Agency, Office of Emergency and Remedial Response (EPA 1989). *Risk Assessment Guidance for Superfund*, December 1989.

U.S. Environmental Protection Agency, Region 9 (EPA 2008). *Preliminary Remediation Goals (Regional Screening Values),* last update September 2008. Available on the Internet at: http://www.epa.gov/region09/superfund/prg/, Accessed January 2009.

U.S. Environmental Protection Agency (EPA 2009). *Integrated Risk Information System*, last update January 2009. Available on the Internet at: http://cfpub.epa.gov/ncea/iris/index.cfm, Accessed January 2009.

U.S Environmental Protection Agency (EPA 2008). Nelson Tunnel/Commodore Waste Rock Pile Superfund Webpage, last update December 15, 2008. Available on the Internet at: http://www.epa.gov/region8/superfund/co/nelsoncommodore/, Accessed January 2009.

U.S Environmental Protection Agency, Ecosystems Protection Program (EPA 2005). *Aquatic Resources Assessment of the Willow Creek Watershed*, August 2005.

Willow Creek Reclamation Committee (WCRC 2004). *Report on Surface Water and Mine Water Sampling and Monitoring in Willow Creek Watershed (1999-2002)*, March 2004.

Tables, Figures, and Site Photos

Table 1. UOS 2007 Surface Water Data Set (in μg/L)

Analyte	Sample Number									
	NT-SW-1 (WW u/s site)	NT-SW-2 (EU 1)	NT-SW-3 (EU 2)	NT-SW-4 (EW u/s confluence)	NT-SW-5 (EU 3)	NT-SW-6 (EU 3)	NT-SW-8 (EU 3)	NT-SW-9 (RG u/s Willow)	NT-SW-10 (EU 6)	NT-SW-11 (EU 3)
Aluminum	262	675	88	135	88	96.1	136	258	88	136
Antimony	ND	ND	ND	3	ND	ND	ND	ND	ND	ND
Arsenic	ND	6.3	1.5	ND	1.4	0.99	ND	ND	1.4	ND
Barium	21	16.8	30.3	6.6	27.8	17	17.4	17.1	21	17.4
Beryllium	ND	3.8	ND	ND	ND	ND	ND	ND	ND	ND
Cadmium	3.6	183	20.3	568	17.8	9	8.3	ND	4.1	8.3
Calcium	13000	184000	21200	5900	19300	11000	11000	7990	12200	10700
Chromium	ND	2.2	ND	ND	0.76	ND	ND	1.7	2.5	ND
Cobalt	ND	40.4	ND	ND	1.3	6.6	1.7	2.9	ND	3.8
Copper	4.4	43.7	7.7	ND	7.1	3	384	ND	7	3.8
Iron	193	1560	80.8	77.2	71	76.9	88.4	288	50.1	88.4
Lead	8.6	1020	124	4.7	101	35.8	39.8	1.8	36.2	39.8
Magnesium	1570	12500	2120	670	1930	1130	1130	1340	1310	1130
Manganese	14.3	18300	422	8.1	349	110	110	24.2	59.7	110
Mercury	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Nickel	ND	15	ND	ND	ND	ND	ND	ND	ND	ND
Potassium	516	10100	747	347	683	552	547	1010	733	537
Selenium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Silver	ND	ND	ND	1.1	ND	ND	ND	ND	ND	ND
Sodium	2590	45500	4770	2090	4270	3000	2940	2430	3640	2970
Thallium	ND	17.4	ND	ND	ND	ND	ND	ND	ND	ND
Vanadium	1.8	4.5	3	3.6	2	3.4	3	3.4	1.2	ND
Zinc	179	69600	4200	131	3630	1800	1500	8	548	1500

Values in Red indicate possible erroneous result

Table 2. 1999-2002 Willow Creek Reclamation Committee Surface Water Sampling Results (in μg/L)

Analytes	Exposure Unit 1				Exposure Unit 2				Exposure Unit 3			
	Range	Mean	Median	*n*	Range	Mean	Median	*n*	Range	Mean	Median	*n*
Aluminum	7.5 - 4021	730.7	344	26	91 - 730	252.1	220	11	71 – 578	194.6	180.5	14
Arsenic	3 - 74	18.4	7.5	24	4.0 - 7.5	7.2	7.5	11	7.5 – 47	14.4	7.5	14
Barium	ND - 452	118.6	23.5	8	N/a	N/a	N/a	0	37	N/a	N/a	1
Cadmium	0.075 - 905.3	133.3	63	27	13.9 - 31.3	21.6	18	12	6.1 – 24.1	12.2	13.0	14
Copper	5 - 932	117.5	47	27	9.0 - 23	15.7	13.6	12	4 – 21	8.9	7	15
Iron	32 - 1780	745.5	412	26	140 - 745	237.7	211	11	84 – 517	190.6	132.5	14
Lead	0.5 - 1509	418.8	300	27	66 - 210	107.3	99.0	12	1.5 – 70	40.1	40	15
Manganese	239 - 19500	8890	11595	26	212 - 1407	950.6	1270	11	68 – 832	357.8	245	14
Selenium	1 - 6	3.7	3.9	4	1 – 1	1	1	2	1 – 2	1.2	1	5
Zinc	1549 - 153700	32972	7718	27	1593 - 9506	5554	5688	12	762 - 6340	2872	2846	15

Table 2 cont.

Analytes	Exposure Unit 5				Exposure Unit 6			
	Range	Mean	Median	*n*	Range	Mean	Median	*n*
Aluminum	151 – 1349	364.3	273	26	123 – 216	160	140	3
Arsenic	3 – 19	7.6	7.5	26	7.5 – 7.5	7.5	7.5	3
Barium	28 – 33	N/a	N/a	2	N/a	N/a	N/a	0
Cadmium	7.2 – 30.5	14.2	13.2	26	0.33 – 2.02	0.67	0.38	6
Copper	4 – 32	10.2	9	26	0.5 – 1.3	0.75	0.5	6
Iron	70 – 327	164.4	120.5	26	206 - 309	242.3	212	3
Lead	25 – 327	60.9	43.5	26	1.5 – 6	3	1.5	3
Manganese	91 – 1391	456.5	409.5	26	5 – 31.8	22.3	30.1	3
Selenium	1 – 3	1.75	1.5	4	N/a	N/a	N/a	0
Zinc	1181 - 9448	3219	2780	26	82 - 361	220.8	221.0	8

Table 3. June 1995 CDPHE Surface Water Sampling Results (in μg/L)

Sample Number	Exposure Unit	Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead	Magnesium	Manganese	Mercury	Nickel	Potassium	Selenium	Silver	Sodium	Thallium	Vanadium	Zinc
SW-07	WW u/s Site	533	ND	ND	15.8	ND	5.9	9000	ND	ND	5.8	335	14.8	982	22.1	ND	1.4	718	4.4	0.5	2970	ND	ND	356
SW-08	WW u/s Site	468	ND	ND	17	ND	5.5	8500	ND	ND	5.4	289	13.5	953	18.5	ND	1.4	681	4.4	0.5	2760	ND	ND	348
SO-07	1	1080	ND	4	39.8	2.1	293	42500	ND	15.5	287	214	464	4600	16300	ND	1.4	4360	7.1	5.6	21200	4.9	ND	19800
SO-07 Dup	1	1090	ND	5.4	40.3	2.1	291	42200	ND	15.7	290	219	462	4660	16200	ND	1.4	4250	4.8	5.8	21600	4.7	ND	19800
SW-10	2	1070	ND	5.3	39.7	2.1	294	42700	ND	15.6	279	206	465	4590	16600	ND	1.4	4390	5.2	5.7	21300	4.7	ND	19900
SW-26	EW u/s WW	506	ND	ND	9.4	ND	2	7030	ND	ND	1.9	230	40.5	750	19.6	0.21	1.4	666	4.4	0.5	2990	ND	0.88	274
SW-27	3	590	ND	ND	13.3	ND	6.3	7090	ND	ND	5.7	263	20.9	828	131	ND	1.4	659	4.4	0.5	2810	ND	1	890
SW-28	3	628	ND	ND	13.6	ND	6.1	8070	ND	ND	5.5	291	30.7	908	114	ND	1.4	735	4.4	0.5	3160	ND	0.8	834
SW-29	3	530	ND	ND	23.4	ND	8.5	9930	ND	ND	6.8	257	25.2	1030	223	ND	1.4	773	4.4	0.5	3150	ND	0.53	1040
SW-30	5	673	ND	ND	32.1	ND	8.4	9710	ND	ND	6.9	386	42.1	1060	216	ND	1.4	813	4.4	0.5	3350	ND	1.1	1100
SW-31	5	588	ND	ND	18.8	ND	8.4	9330	ND	ND	6.7	279	24.6	1010	164	ND	1.4	750	4.4	0.5	3190	ND	0.73	1190
SW-32	5	513	ND	ND	17.6	ND	8.8	9460	ND	ND	8.7	223	23.9	1020	238	ND	1.4	751	4.4	0.5	3310	ND	0.95	1290
SW-33	5	606	ND	ND	21.3	ND	8.5	9310	ND	ND	8.9	289	22.6	1000	140	ND	1.4	747	4.4	0.5	3230	ND	0.82	1260
SW-34	5	637	ND	ND	19.8	ND	8.5	8420	1.0	ND	8.8	300	26.9	950	201	ND	1.4	717	4.4	0.5	3130	ND	1.1	1250
SW-35	RG u/s Willow	369	ND	ND	18.8	ND	ND	7560	1.7	ND	1.5	414	ND	1170	33.8	ND	210	1070	4.4	0.5	3120	ND	1.6	7.2
SW-36	RG u/s Willow	671	ND	ND	21.8	ND	ND	7960	2.0	ND	1.3	636	8.9	1260	40.2	ND	511	1110	4.4	0.5	3030	ND	1.6	14.6
SW-37	6	269	ND	ND	18.6	ND	3.8	8720	ND	ND	4.9	300	12	1090	105	ND	3.3	847	4.4	0.5	3310	ND	1.1	628
SW-38	6	549	ND	ND	20.1	ND	1.1	8470	ND	ND	2.2	559	18.6	1230	54.9	ND	1.4	1040	4.4	0.5	3080	ND	1.7	146
SW-39	6	923	ND	ND	21.7	ND	ND	8020	ND	ND	ND	742	6.7	1290	49.3	ND	1.4	1150	4.4	0.5	3130	ND	1.9	67.8
SW-40	RG past WWG	607	ND	ND	20.2	ND	ND	8000	0.9	ND	ND	666	5.1	1210	43	ND	1.4	1190	4.4	0.5	3590	ND	1.9	77.5

Table 4. UOS 2007 Sediment Sampling Results (in mg/kg)

Analyte	Sample Number									
	NT-SE-1 (WW u/s site)	NT-SE-2 (EU 1)	NT-SE-3 (EU 2)	NT-SE-4 (EW u/s confluence)	NT-SE-5 (EU 3)	NT-SE-6 (EU 3)	NT-SE-7 (Windy Gulch)	NT-SE-8 (EU 3)	NT-SE-9 (RG u/s Willow)	NT-SE-10 (EU 6)	NT-SE-11 (EU 3)
Aluminum	3680	3640	3150	2840	3220	4560	4210	4650	4530	7450	3270
Antimony	5.3	2.9	6.5	3.0	5.0	4.0	3.5	0.48	0.57	1.7	1.9
Arsenic	71.2	55.3	175	36.7	249	206	85.3	91.9	1.8	182	102
Barium	142	352	229	190	527	926	2570	274	102	658	465
Beryllium	0.34	0.72	0.43	0.26	0.53	0.68	0.96	0.53	0.28	0.81	0.48
Cadmium	4.6	3.8	16.1	6.3	51.2	32.3	28.1	15.5	0.2	29.1	18.8
Calcium	2730	1760	2680	1540	2640	3670	2570	7400	2980	2660	2390
Chromium[*]	1.7	1.4	0.91	1	1.1	1.4	2.9	1.3	2.6	2.8	0.84
Cobalt	3.1	5.8	2.4	2.8	3.1	5.3	7.2	6.8	4	8	5.9
Copper	22.6	31.4	126	14.2	220	220	79.5	70.4	5.5	136	91.7
Iron	11300	16300	10500	6280	12000	13500	8880	11900	11300	16700	9170
Lead	1100	1260	3860	427	7390	7980	690	4060	4.4	4450	4200
Magnesium	1310	1260	1510	1300	1460	1760	1090	2150	1560	2240	1380
Manganese	1040	3520	1300	379	4360	5410	8870	4240	496	3010	3230
Mercury	0.026	0.14	0.081	0.015	0.064	0.094	0.15	0.038	0.0031	0.098	0.051
Nickel	1.3	1	0.94	1	0.94	1.4	7	1.4	2	2.4	0.87
Potassium	1027	946	565.2	662.5	478.7	759.9	1083	1086	797.6	1012	650.7
Selenium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Silver	5.1	38.9	9.6	0.92	16.1	16.2	8.8	9.2	ND	15.4	17.6
Sodium	143.6	135.7	47	102.4	51	89.81	106.8	137.2	230.9	110.7	77.76
Thallium	ND	2.4	ND	ND	ND	2.6	2.6	ND	ND	2.1	ND
Vanadium	16.3	18	8.5	14.6	9.7	2.2	16.2	17.7	23	26.3	12.9
Zinc	594	691	3510	1020	11500	8100	3940	4060	25.5	4770	4300

Values in Red indicate possible data anomaly

Table 5. June 1995 CDPHE Sediment Sampling Results (in mg/kg)

Sample Number	Exposure Unit	Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead	Magnesium	Manganese	Mercury	Nickel	Potassium	Selenium	Silver	Sodium	Thallium	Vanadium	Zinc
SE-07	WW u/s Site	6860	ND	1.1	114	ND	ND	3440	1.6	9	7.9	17100	9.7	3220	990	ND	1.7	1150	2.2	ND	269	ND	24	39.7
SE-08	WW u/s Site	2390	1.6	63.6	70.5	ND	8.4	1440	ND	1.6	29.2	5220	283	681	244	ND	ND	558	ND	3.5	359	ND	6.6	443
SE-10	2	2810	6.5	104	165	0.42	9.1	2360	ND	3.5	29.2	9750	982	1170	468	ND	ND	814	ND	6.6	309	ND	14.1	848
SE-26	EW u/s WW	5500	4.4	96.9	327	0.79	28.4	3310	ND	5.1	101	12200	1440	1790	1300	0.22	ND	1210	ND	5.3	710	ND	17.4	2420
SE-27	3	3870	0.78	26.7	74.8	ND	11.2	2230	1.5	3.9	13.5	6890	1450	1730	630	ND	ND	865	ND	1.1	467	ND	14.6	1710
SE-28	3	6890	1.9	76.8	311	ND	38.4	3280	3.1	5.7	158	11700	1710	1850	1740	ND	ND	1410	ND	6.4	1200	ND	17.6	4260
SE-29	3	3830	1.7	54.6	178	ND	17.2	1890	1.4	4.8	48.2	8990	1730	1620	1430	ND	ND	984	1.1	1.8	573	1.1	15.9	2020
SE-30	5	6220	2.3	75	786	0.63	21.3	2320	2.3	6	78.4	10700	1580	2070	1630	ND	ND	1340	1.5	4.7	708	2.1	18.1	2530
SE-31	5	3660	1.2	52	320	ND	30.7	8250	1.5	4.4	50	6470	1150	1430	1450	ND	ND	731	ND	2.1	723	ND	12.3	2390
SE-32	5	1880	ND	35.3	63.8	0.38	6.6	1180	1.1	3.3	17.7	7800	1040	722	931	ND	ND	494	1.4	1.6	531	ND	14.1	958
SE-33	5	6480	ND	49.7	267	1.8	47.9	1870	1.9	5.8	157	7150	1820	1280	2380	ND	ND	865	1.6	3.9	2370	ND	12.6	5470
SE-34	5	2500	ND	51.3	230	0.32	7.9	1170	1.3	3.6	27.3	6390	1060	929	985	ND	ND	603	ND	3.5	508	ND	13.2	1350
SE-35	RG u/s Willow	4550	ND	82	214	0.57	18.6	1910	1.5	6.6	60.1	9580	2360	1710	2010	ND	ND	998	1.4	3.8	838	ND	18.2	2610
SE-36	RG u/s Willow	3630	ND	2.6	80.1	ND	0.12	2670	2.5	4.6	5.1	10300	4.8	1370	311	ND	1.4	792	1.4	ND	198	ND	23.7	28.9
SE-37	6	4420	ND	2.1	139	ND	0.16	3500	2.1	4.7	7.2	10700	5.8	1810	436	ND	1.6	907	ND	ND	298	ND	24.4	30.7
SE-38	6	7440	ND	34.3	216	0.78	17.2	2940	3.1	7.2	64.4	12200	1220	1990	1750	ND	ND	1220	1.9	2.6	1000	ND	25.2	2680
SE-39	6	4740	ND	4.7	115	0.41	2.1	3430	3.3	5.9	8.1	13800	68.4	1720	573	ND	1.1	1010	ND	ND	423	ND	30.8	267
SE-40	6	4780	ND	5.1	105	0.37	1.5	5460	4	5.5	6.9	12700	66.4	1550	472	ND	1.2	953	2	ND	299	ND	31.8	230

ND: Not Detected
WW: West Willow, EW: East Willow, RG: Rio Grande, WWG: Wagon Wheel Gap

Table 6. UOS 2007 Surface Soil Results (in mg/kg) for CWR pile.

Analyte	**Sample Number**	
	NT-SS-01	**NT-SS-02**
Aluminum	1460	5220
Antimony	5.9	ND
Arsenic	450	324
Barium	585	1250
Beryllium	0.32	1.6
Cadmium	270	57.4
Calcium	349	710
Chromium	1.2	0.67
Cobalt	2.7	1.6
Copper	574	1460
Iron	11300	23000
Lead	23400	18800
Magnesium	293	1670
Manganese	15000	4310
Mercury	1.1	0.081
Nickel	0.66	0.99
Potassium	1092	689.1
Selenium	1.6	ND
Silver	47.3	36.5
Sodium	39.04	ND
Thallium	13.5	2
Vanadium	5.4	12.9
Zinc	55400	8810

Table 7. June 1995 CDPHE Surface Soil Results (in mg/kg) for CWR pile

Analyte	Sample Number	
	SO-05	SO-06
Aluminum	3160	10100
Antimony	26.7	2.1
Arsenic	446	64.3
Barium	1390	205
Beryllium	ND	0.37
Cadmium	38	8.1
Calcium	376	2990
Chromium	3.2	5.8
Cobalt	ND	6.6
Copper	1880	86.4
Iron	24400	26700
Lead	21000	877
Magnesium	920	4170
Manganese	2390	754
Mercury	0.31	ND
Nickel	ND	ND
Potassium	634	2040
Selenium	3.1	2.5
Silver	96.6	5.2
Sodium	1130	510
Thallium	5.1	1.4
Vanadium	9.0	33.6
Zinc	3550	832

ND: Not Detected

Table 8. Conceptual Site Model for the Nelson Tunnel Source of the NT-CWR Site

Source	Transport Mechanism	Point of Exposure	Primary Environmental Medium Effected	Potentially Exposed Population	Route of Exposure	Pathway Designation and (Time Frame)
Nelson Tunnel	Surface Water	EU1: Onsite	Surface Water and Sediment	Recreational visitors	Dermal and Incidental Ingestion Exposures while wading/walking through W. Willow and shoreline sediments	Potential (Past, present, Future)
		EU2: d/s of Nelson Tunnel to Confluence with EW Creek	Surface Water and Sediment	Recreational Visitors	Dermal and Incidental Ingestion Exposures while wading/walking through W. Willow and shoreline sediments	Complete (Past, present, Future)
		EU3: d/s of Confluence of E&W Willow Creek to Concrete flume above Creede	Surface Water and Sediment	Recreational Visitors	Dermal and Incidental Ingestion Exposures while wading/walking through Willow Creek and shoreline sediments	Complete (Past, present, Future)
		EU4: Concrete Flume through Creede	Surface Water	Recreational Visitors	Dermal and Incidental Exposures while wading through Willow Creek	Complete (Past, present, Future)
		EU5: Willow Creek Floodplain	Surface Water, Sediment, and Surface Soil	Recreational Visitors	Dermal and Incidental Ingestion Exposures while wading/walking through Willow Creek Floodplain, shoreline sediments, and dried creek beds	Complete (Past, present, Future)
		EU6: Rio Grande River to Wagon Wheel Gap	Surface Water, Sediment, and Fish	Recreational Visitors	Dermal and Incidental Ingestion Exposures while wading/walking through the Rio Grande and shoreline sediments; fish consumption.	Complete (Past, present, Future)

Table 9. Conceptual Site Model for the CWR Source of the NT-CWR Site

Source	Transport Mechanism	Point of Exposure	Primary Environmental Medium Effected	Potentially Exposed Population	Route of Exposure	Pathway Designation and (Time frame)
Commodore Waste Rock Pile	Surface Water, wind, and human activity	EU1: Onsite	Surface Water, Sediment, Surface Soil	Recreational Visitors	Dermal and Incidental Ingestion Exposures while wading/walking through W. Willow and shoreline sediments	Potential (Past, present, future)
		EU2: d/s of the CWR toe to Confluence with EW Creek	Surface Water, Sediment, Surface Soil,	Recreational Visitors	Dermal and Incidental Ingestion Exposures while wading/walking through W. Willow and shoreline sediments	Complete (Past, present, future)
		EU3: d/s of Confluence of E&W Willow Creek to Concrete flume above Creede	Surface Water, Sediment, Surface	Recreational Visitors	Dermal and Incidental Ingestion Exposures while wading/walking through Willow Creek and shoreline sediments	Complete (Past, present, future)
		EU4: Concrete Flume through Creede	Surface Water	Recreational Visitors	Dermal and Incidental Exposures while wading through Willow Creek	Complete (Past, present, future)
		EU5: Willow Creek Floodplain	Surface Water, Sediment, and Surface Soil	Recreational Visitors	Dermal and Incidental Ingestion Exposures while wading/walking through Willow Creek Floodplain, shoreline sediments, and dried creek beds	Complete (Past, present, future)
		EU6: Rio Grande River to Wagon Wheel Gap	Surface Water, Sediment, and Fish	Recreational Visitors	Dermal and Incidental Ingestion Exposures while wading/walking through the Rio Grande and shoreline sediments; fish consumption.	Complete (Past, present, future)

Table 10. Comparison Values for Heavy Metals

Contaminant	Surface Water (in μg/L or ppb)	Source	Sediment** (in mg/kg or ppm)	Source	Surface Soil (in mg/kg or ppm)	Source
Aluminum	10,000	cEMEG	50,000	cEMEG	2,000	PICA
Antimony	4.0	RMEG	20	RMEG	20	RMEG
Arsenic	3.0/0.045	cEMEG/PRG	20	cEMEG	10	PICA
Barium	2,000	cEMEG	10,000	cEMEG	400	PICA
Beryllium	20	cEMEG	100	cEMEG	100	cEMEG
Cadmium	2.0	cEMEG	10	cEMEG	10	cEMEG
Calcium	NA		NA		NA	
*Chromium**	30	RMEG	200	RMEG	200	RMEG
Cobalt	100	iEMEG	500	iEMEG	20	PICA
Copper	100	iEMEG	500	iEMEG	20	PICA
Iron	26,000	PRG	55,000	PRG	55,000	PRG
Lead	15	LTHA	400	PRG	400	PRG
Magnesium	NA		NA		NA	
Manganese	300	LTHA	1,800	PRG	1,800	PRG
Mercury	NA		6.7	PRG	6.7	PRG
Nickel	200	RMEG	1,000	RMEG	1,000	RMEG
Potassium	NA		NA		NA	
Selenium	50	cEMEG	300	cEMEG	300	cEMEG
Silver	50	RMEG	300	RMEG	300	RMEG
Sodium	NA		NA		NA	
Thallium	2.4	PRG	5.1	PRG	5.1	PRG
Vanadium	30	iEMEG	200	iEMEG	6.0	PICA
Zinc	3,000	cEMEG	20,000	cEMEG	600	PICA

cEMEG: Chronic EMEG, iEMEG: Intermediate EMEG, RMEG: R, PRG: Preliminary Remediation Goal. These values were used when ATSDR CVs were not available or when PRGs were more conservative than the CVs, PICA

* For chromium, the most conservative value was selected. Generally, this means hexavalent chromium or total chromium in a 1:6 ratio.

** PICA Values were not used to screen sediment samples.

Table 11. Selection of Surface Water Contaminants of Potential Concern (COPCs) by Exposure Unit (values in μg/L)

Exposure Unit	COPC	UOS 2007 Data Range *(n)*	CDPHE 1995 Data Range *(n)*	WCRC 1999-2002 Data Range *(n)*	CV (in μg/L)
Upstream of NT/CWR Site	Cadmium	3.6 (1)	5.5 - 5.9 (2)	0.05 – 16 (8)	2.0
EU1 (Onsite)	Arsenic	6.3 (1)	4 - 5.4 (2)	ND – 74 (24)	3.0
	Cadmium	183 (1)	291 - 293 (2)	7.4 – 905 (24)	2.0
	Copper	***43.7 (1)***	287 - 290 (2)	4 – 932 (27)	100
	Lead	1020 (1)	462 - 464 (2)	7 – 1509 (27)	15
	Manganese	18300 (1)	16200 - 16300 (2)	211 – 19500 (26)	300
	Thallium	17.4 (1)	4.7 - 4.9 (2)	NA	2.4
	Zinc	69600 (1)	19800 - 19800 (2)	1350 – 154000 (27)	3000
EU2 (toe of CWR pile to the WW/EW confluence)	Arsenic	***1.5 (1)***	5.3 (1)	ND – 4 (11)	3.0
	Cadmium	20.3 (1)	294 (1)	13.9 – 31.3 (12)	2.0
	Copper	***7.7 (1)***	279 (1)	***9 – 23 (12)***	100
	Lead	124 (1)	465 (1)	66 – 210 (12)	15
	Manganese	422 (1)	16600 (1)	212 – 1407 (11)	300
	Thallium	*ND*	4.7 (1)	NA	2.4
	Zinc	4200 (1)	19900 (1)	1593 – 9506 (11)	3000
EU3 (Willow below confluence to concrete flume)	Arsenic	***ND – 1.6 (4)***	***ND (3)***	ND – 8 (11)	3.0
	Cadmium	8.3 – 17.8 (4)	6.1 – 8.5 (3)	6.1 – 19.6 (11)	2.0
	Copper	ND – 384 (4)	***5.5 – 6.8 (3)***	***4 – 11 (11)***	100
	Lead	35.8 – 101 (4)	20.9 – 30.7 (3)	34 – 70 (12)	15
	Manganese	100 – 349 (4)	***114 - 223 (3)***	81 – 832 (11)	300
	Zinc	1500 – 3630 (4)	***834 – 1040 (3)***	762 – 6340 (12)	3000
EU4 (Concrete Flume)	N/a	None	None	None	N/a
EU5 (Below flume to Rio Grande)	Arsenic	None	***ND (5)***	ND – 19 (26)	3.0
	Cadmium	None	8.4 – 8.8 (5)	7.2 – 30.5 (26)	2.0
	Lead	None	22.6 – 42.1 (5)	25 – 327 (26)	15
	Manganese	None	***140 – 238 (5)***	91 – 1391 (26)	300
	Zinc	None	***1100 – 1290 (5)***	1181 – 9448 (26)	3000
EU6 (Below Rio Grande to Wagon Wheel Gap)	Cadmium	4.1 (1)	ND – 3.8 (3)	0.33 – 2.02 (6)	2.0
	Lead	36.2 (1)	6.7 – 18.6 (3)	***ND – 6 (3)***	15

Bold Italic values indicate that the data is below the respective comparison value for that data set.
ND = Not Detected

Table 12. Selection of Sediment Contaminants of Potential Concern (COPCs) by Exposure Unit (values in mg/kg)

Exposure Unit	COPC	UOS 2007 Data Range (n)	CDPHE 1997 Data Range (n)	CV (in mg/kg)
Upstream of NT/CWR Site	Arsenic	71.2 (1)	63.6 – 104 (2)	20
	Lead	1100 (1)	283 – 982 (2)	400
EU1 (Onsite)	Arsenic	55.3 (1)	N/a	20
	Lead	1260 (1)	N/a	400
	Manganese	3520 (1)	N/a	1800
EU2 (toe of CWR pile to the WW/EW confluence)	Arsenic	175 (1)	96.9 (1)	20
	Cadmium	16.1 (1)	28.4 (1)	10
	Lead	3860 (1)	1440 (1)	400
EU3 (Willow below confluence to concrete flume)	Arsenic	249 (4)	54.6 – 76.8 (3)	20
	Cadmium	51.2 (4)	17.2 – 38.4 (3)	10
	Lead	7980 (4)	1580 – 1730 (3)	400
	Manganese	5410 (4)	1430 – 1740 (3)	1800
EU4 (Concrete Flume)	N/a			
EU5 (Below flume to Rio Grande)	Arsenic	None	35.3 – 82 (5)	20
	Cadmium	None	6.6 – 47.9 (5)	10
	Lead	None	1040 - 2360 (5)	400
	Manganese	None	931 – 2380 (5)	1800
EU6 (Below Rio Grande to Wagon Wheel Gap)	Arsenic	182 (1)	4.7 – 34.3 (4)	20
	Cadmium	29.1 (1)	1.5 – 17.2 (4)	10
	Lead	4450 (1)	66.4 – 1220 (4)	400
	Manganese	3010 (1)	472 – 1750 (4)	1800

Table 13. Selection of Surface Soil Contaminants of Potential Concern (COPCs) (CWR Pile)

Location	COPC	2007 UOS Data (in mg/kg)	1995 CDPHE Data (in mg/kg)	CV (in mg/kg)	PICA (in mg/kg)
EU1 (Commodore Waste Rock Pile)	Aluminum	1460 – 5220 (2)	3160 – 10100 (2)	50000	2000
	Antimony	ND – 5.9 (2)	2.1 – 26.7 (2)	20	20
	Arsenic	324 – 450 (2)	64.3 – 446 (2)	20	10
	Barium	585 – 1250 (2)	205 – 1390 (2)	10000	400
	Cadmium	57.4 – 270 (2)	8.1 – 38 (2)	10	10
	Copper	574 – 1460 (2)	86.4 – 1880 (2)	500	20
	Lead	18800 – 23400 (2)	877 – 21000 (2)	400	400
	Manganese	4310 – 15000 (2)	754 – 2390 (2)	1800	1800
	Thallium	2 – 13.5 (2)	1.4 – 5.1 (2)	5.1	5.1
	Vanadium	5.4 – 12.9 (2)	9 – 33.6 (2)	200	6.0
	Zinc	8810 – 55400 (2)	832 – 3550 (2)	20000	600

Table 14. Estimated Exposure Doses from Surface Water based on UOS 2007 Sampling Results

COPC	Exposure Unit	Health-Based Guideline	Source of Health-Based Guideline	Recreational Child (100 mL/event)	Recreational Adult (50 mL/event)
Arsenic	1	5.00E-03	ATSDR Acute Oral MRL	4.20E-05	4.50E-06
Cadmium	1	2.00E-04	ATSDR Chronic Oral MRL	**1.22E-03**	1.31E-04
Manganese	1	2.40E-02	EPA IRIS (water)	**1.22E-01**	1.31E-02
Thallium	1	8.00E-05	EPA IRIS (Thallium Carbonate)	**1.16E-04**	1.24E-05
Zinc	1	3.00E-01	ATSDR Intermediate Oral MRL	**4.64E-01**	4.97E-02
Cadmium	2	2.00E-04	ATSDR Chronic Oral MRL	1.35E-04	1.45E-05
Manganese	2	2.40E-02	EPA IRIS (water)	2.81E-03	3.01E-04
Zinc	2	3.00E-01	ATSDR Intermediate Oral MRL	2.80E-02	3.00E-03
Cadmium	3	2.00E-04	ATSDR Chronic Oral MRL	1.19E-04	1.27E-05
Copper	3	1.00E-02	ATSDR Acute Oral MRL	2.56E-03	2.74E-04
Manganese	3	2.40E-02	EPA IRIS (water)	2.33E-03	2.49E-04
Zinc	3	3.00E-01	ATSDR Intermediate Oral MRL	2.42E-02	2.59E-03
Cadmium	6	2.00E-04	ATSDR Chronic Oral MRL	2.73E-05	2.93E-06

Notes: Bolded values exceed the health-based guideline

Table 15. Estimated Exposure Doses for Surface Water based on WCRC Sampling Results (1999-2002)

COPC	Exposure Unit	Health-Based Guideline	Source	Recreational Child (100 mL/event)	Recreational Adult (50 mL/event)
Arsenic	1	5.00E-03	ATSDR Acute Oral MRL	1.61E-04	1.72E-05
Cadmium	1	2.00E-04	ATSDR Chronic Oral MRL	**2.74E-03**	**2.94E-04**
Copper	1	1.00E-02	ATSDR Acute Oral MRL	1.76E-03	1.89E-04
Manganese	1	2.40E-02	EPA IRIS (water)	**1.50E-01**	1.60E-02
Zinc	1	3.00E-01	ATSDR Intermediate Oral MRL	**7.42E-01**	7.95E-02
Arsenic	2	5.00E-03	ATSDR Acute Oral MRL	2.67E-05	2.86E-06
Cadmium	2	2.00E-04	ATSDR Chronic Oral MRL	**2.11E-04**	2.26E-05
Manganese	2	2.40E-02	EPA IRIS (water)	1.06E-02	1.14E-03
Zinc	2	3.00E-01	ATSDR Intermediate Oral MRL	4.57E-02	4.90E-03
Arsenic	3	5.00E-03	ATSDR Acute Oral MRL	5.33E-05	5.71E-06
Cadmium	3	2.00E-04	ATSDR Chronic Oral MRL	9.20E-05	9.86E-06
Manganese	3	2.40E-02	EPA IRIS (water)	3.65E-03	3.91E-04
Zinc	3	3.00E-01	ATSDR Intermediate Oral MRL	2.55E-02	2.73E-03
Arsenic	5	5.00E-03	ATSDR Acute Oral MRL	3.67E-05	3.93E-06
Cadmium	5	2.00E-04	ATSDR Chronic Oral MRL	1.07E-04	1.14E-05
Manganese	5	2.40E-02	EPA IRIS (water)	3.68E-03	3.94E-04
Zinc	5	3.00E-01	ATSDR Intermediate Oral MRL	2.57E-02	2.75E-03
Cadmium	6	2.00E-04	ATSDR Chronic Oral MRL	1.33E-05	1.43E-06

Notes: Bolded values exceed the health-based guideline

Table 16. Estimated Exposure Doses for Surface Water based on 1995 CDPHE Sampling Results

COPC	Exposure Unit	Health-Based Guideline	Source	Recreational Child (100 mL/event)	Recreational Adult (50 mL/event)
Arsenic	1	5.00E-03	ATSDR Acute Oral MRL	3.60E-05	3.86E-06
Cadmium	1	2.00E-04	ATSDR Chronic Oral MRL	**1.95E-03**	**2.09E-04**
Copper	1	1.00E-02	ATSDR Acute Oral MRL	1.93E-03	2.07E-04
Manganese	1	2.40E-02	EPA IRIS (water)	**1.09E-01**	1.16E-02
Thallium	1	8.00E-05	EPA IRIS (Thallium Carbonate)	3.27E-05	3.50E-06
Zinc	1	3.00E-01	ATSDR Intermediate Oral MRL	1.32E-01	1.41E-02
Arsenic	2	5.00E-03	ATSDR Acute Oral MRL	3.53E-05	3.79E-06
Cadmium	2	2.00E-04	ATSDR Chronic Oral MRL	**1.96E-03**	**2.10E-04**
Copper	2	1.00E-02	ATSDR Acute Oral MRL	1.86E-03	1.99E-04
Manganese	2	2.40E-02	EPA IRIS (water)	**1.11E-01**	1.19E-02
Thallium	2	8.00E-05	EPA IRIS (Thallium Carbonate)	3.13E-05	3.36E-06
Zinc	2	3.00E-01	ATSDR Intermediate Oral MRL	1.33E-01	1.42E-02
Cadmium	3	2.00E-04	ATSDR Chronic Oral MRL	5.67E-05	6.07E-06
Cadmium	5	2.00E-04	ATSDR Chronic Oral MRL	5.87E-05	6.29E-06
Cadmium	6	2.00E-04	ATSDR Chronic Oral MRL	2.53E-05	2.71E-06

Notes: Bolded values exceed the health-based guideline

Table 17. Estimated Exposure Doses for Sediment based on UOS 2007 Sampling Results

COPC	Exposure Unit	Health-Based Guideline	Source	Recreational Child (100 mg/day)	Recreational Adult (50 mg/day)
Arsenic	1	5.00E-03	ATSDR Acute Oral MRL	3.69E-04	3.95E-05
Manganese	1	2.40E-02	EPA IRIS (water)	2.35E-02	2.51E-03
Arsenic	2	5.00E-03	ATSDR Acute Oral MRL	1.17E-03	1.25E-04
Cadmium	2	2.00E-04	ATSDR Chronic Oral MRL	1.07E-04	1.15E-05
Copper	2	1.00E-02	ATSDR Acute Oral MRL	8.40E-04	9.00E-05
Arsenic	3	5.00E-03	ATSDR Acute Oral MRL	1.66E-03	1.78E-04
Cadmium	3	2.00E-04	ATSDR Chronic Oral MRL	**3.41E-04**	3.66E-05
Copper	3	1.00E-02	ATSDR Acute Oral MRL	1.47E-03	1.57E-04
Manganese	3	2.40E-02	EPA IRIS (water)	**3.61E-02**	3.86E-03
Arsenic	6	5.00E-03	ATSDR Acute Oral MRL	1.21E-03	1.30E-04
Cadmium	6	2.00E-04	ATSDR Chronic Oral MRL	1.94E-04	2.08E-05
Copper	6	1.00E-02	ATSDR Acute Oral MRL	9.07E-04	9.71E-05
Manganese	6	2.40E-02	EPA IRIS (water)	2.01E-02	2.15E-03

Table 18. Sediment Estimated Exposure Doses for Sediment based on 1995CDPHE Sampling Results

COPC	Exposure Unit	Health-Based Guideline	Source	Recreational Child (100 mg/event)	Recreational Adult (50 mg/event)
Arsenic	2	5.00E-03	ATSDR Acute Oral MRL	6.46E-04	6.92E-05
Cadmium	2	2.00E-04	ATSDR Chronic Oral MRL	**1.89E-04**	2.03E-05
Arsenic	3	5.00E-03	ATSDR Acute Oral MRL	5.12E-04	5.49E-05
Cadmium	3	2.00E-04	ATSDR Chronic Oral MRL	**2.56E-04**	2.74E-05
Arsenic	5	5.00E-03	ATSDR Acute Oral MRL	5.47E-04	5.86E-05
Cadmium	5	2.00E-04	ATSDR Chronic Oral MRL	3.19E-04	3.42E-05
Manganese	5	2.40E-02	Chronic RfD EPA IRIS (water)	1.59E-02	1.70E-03
Arsenic	6	5.00E-03	ATSDR Acute Oral MRL	2.29E-04	2.45E-05
Cadmium	6	2.00E-04	ATSDR Chronic Oral MRL	1.15E-04	1.23E-05

Table 19. Surface Soil Estimated Exposure Doses and Associated Health-Based Guidelines (UOS 2007 Data)

COPC	EPC (mg/kg)	Health-Based Guideline (mg/kg-day)	HBG Source	Recreational Child (mg/kg-day)	Pica Child (mg/kg-day)	Recreational Adult (mg/kg-day)
Aluminum	5220	1.00E+00	1	6.96E-02		3.48E-02
Arsenic	450	5.0E-03	3	**6.00E-03**	**1.50E-01**	3.00E-03
Barium	1250	2.0E-01	1	1.67E-02		8.33E-03
Cadmium	270	2.0E-04	4	**3.60E-03**		**1.80E-03**
Copper	1460	1.0E-02	3	**1.95E-02**	**4.87E-01**	**9.73E-03**
Manganese	15000	2.4E-02	5	**2.00E-01**		**1.00E-01**
Thallium	13.5	8.0E-05	6	**1.80E-04**		**9.00E-05**
Vanadium	12.9	9.0E-03	7	1.72E-04		8.60E-05
Zinc	55400	3.0E-01	1	**7.39E-01**		3.69E-01

Notes: Bolded values exceed the health-based guideline
1) ATSDR Intermediate Duration Oral MRL
2) EPA IRIS, Oral RfD
3) ATSDR Acute Duration Oral MRL
4) ATSDR Chronic Duration Oral MRL
5) EPA IRIS, Oral RfD for manganese (water)
6) EPA IRIS, Oral RfD for thallium carbonate
7) EPA IRIS, Oral RfD for vanadium pentoxide
8) No acute NOAEL value for arsenic was identified. An acute NOAEL value for copper of 0.0272 mg/kg/day was selected by ATSDR for the MRL derivation.
9) Arsenic Acute LOAEL for ATSDR MRL = 0.05 mg/kg/day based on serious neurological, gastrointestinal and cardiovascular effects. Copper acute LOAEL for ATSDR MRL = 0.0731 mg/kg/day.

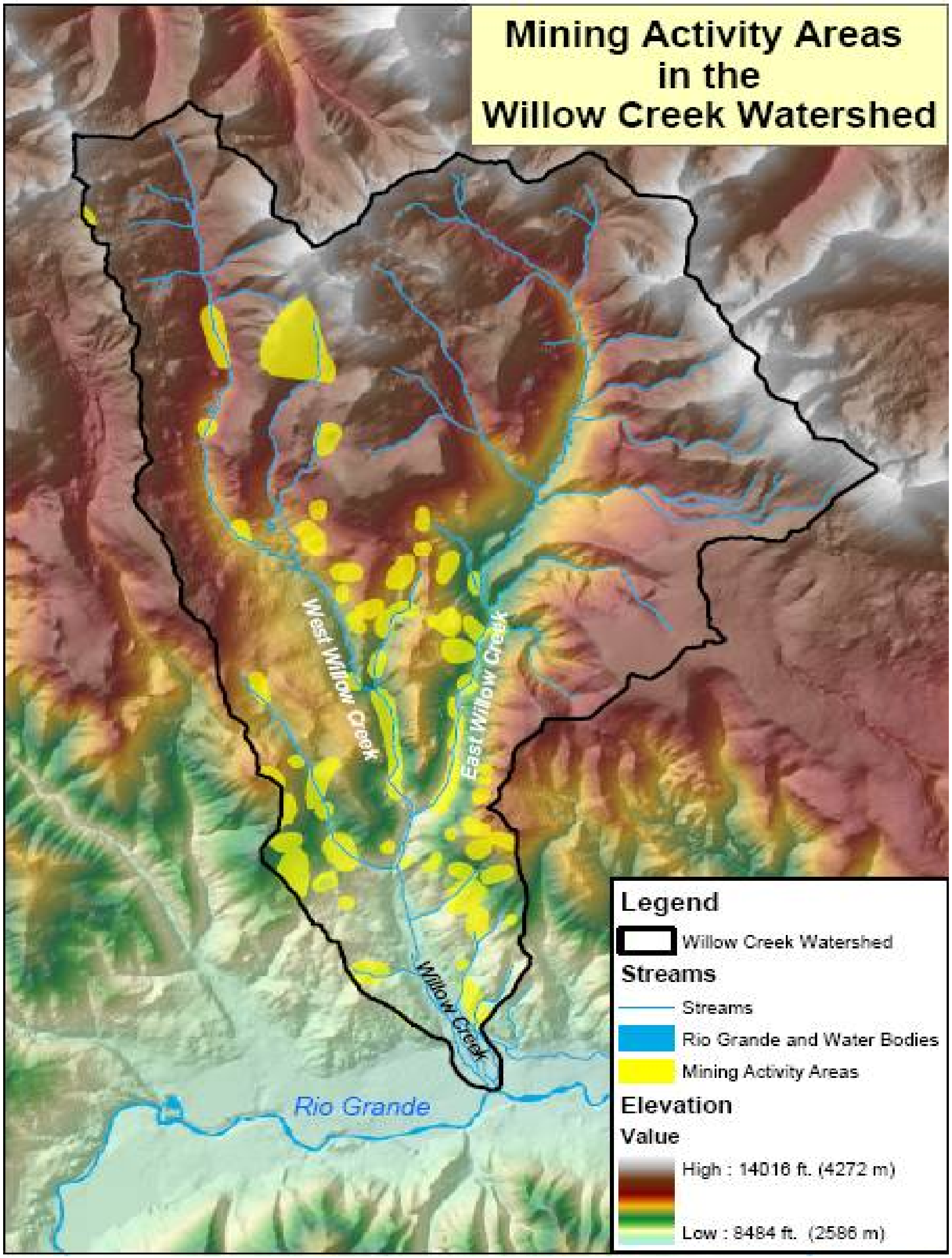
Table 20. Surface Soil Estimated Exposure Doses based on the 1995 CDPHE Data

COPC	Exposure Point Conc. (mg/kg)	Health-Based Guideline (mg/kg-day)	Source	Recreational Child (200 mg/event)	Pica Child (5000 mg/event)	Recreational Adult (100 mg/event)
Aluminum	10100	1.00E+00	ATSDR Intermediate Oral MRL	1.35E-01 mg/kg-day		6.73E-02 mg/kg-day
Antimony	26.7	4.00E-04	EPA IRIS	3.56E-04 mg/kg-day		1.78E-04 mg/kg-day
Arsenic	446	5.00E-03	ATSDR Acute Oral MRL	**5.95E-03 mg/kg-day**	**1.49E-01 mg/kg-day**	2.97E-03 mg/kg-day
Barium	1390	2.00E-01	ATSDR Intermediate Oral MRL	1.85E-02 mg/kg-day		9.27E-03 mg/kg-day
Cadmium	38	2.00E-04	ATSDR Chronic Oral MRL	**5.07E-04 mg/kg-day**		**2.53E-04 mg/kg-day**
Copper	1880	1.00E-02	ATSDR Acute Oral MRL	**2.51E-02 mg/kg-day**	**6.27E-01 mg/kg-day**	**1.25E-02 mg/kg-day**
Manganese	2390	2.40E-02	EPA IRIS (water)	**3.19E-02 mg/kg-day**		1.59E-02 mg/kg-day
Thallium	5.1	8.00E-05	EPA IRIS (Thallium carbonate)	6.80E-05 mg/kg-day		3.40E-05 mg/kg-day
Vanadium	33.6	9.00E-03	EPA IRIS (Vanadium pentoxide)	4.48E-04 mg/kg-day		2.24E-04 mg/kg-day
Zinc	3550	3.00E-01	ATSDR Intermediate Oral MRL	4.73E-02 mg/kg-day		2.37E-02 mg/kg-day

NOTE:

1) No acute NOAEL value for arsenic was identified. An acute NOAEL value for copper of 0.0272 mg/kg/day was selected by ATSDR for the MRL derivation.
2) Arsenic Acute LOAEL for ATSDR MRL = 0.05 mg/kg/day based on serious neurological, gastrointestinal and cardiovascular effects. Copper acute LOAEL for ATSDR MRL = 0.0731 mg/kg/day

Figure 2. Mining Activity Near the NT-CWR Site



Source: EPA 2005

Figure 4. NT-CWR Site Exposure Units 1-3

Source: Google Earth

Figure 5. NT-CWR Site Exposure Units 4 – 6

Source : Google Earth (2009)

Site Photos

Photo 1: Just to the south of the site looking northwest (West Willow Creek visible lower left, CWR pile on right)

Photo 2: Just south of site at road level (historic loading bin on right, CWR pile and cribbing lower middle, Upper Commodore workings center)

Photo 3: Upper Level of NT-CWR Site looking south (CWR pile on right)

Photo 4: Upper Level of NT-CWR Site looking West (Commodore Mine Tunnel shown near center, West Willow Creek is within the rocky bank just below the Commodore Tunnel)

Photo 5: EPA Emergency Response Contractors contouring West Willow Creek Bed (South of NT-CWR Site, Historic Ore Cart Track upper)

Appendices

Appendix A. Overall Trends of Environmental Data Used (1995-2007)

Surface water

The surface water data from all of the selected reports indicates a high level of contamination stemming from the site, which gradually decreases with distance from the site as the additional water and changing stream conditions dilute and deposit heavy metals contaminants. Above the site, the available data shows that cadmium and lead are present at elevated levels. The maximum detected concentrations of cadmium and lead above the site from all surface water data is 16 parts per billion (ppb) and 98 ppb, respectively. Thus, there appears to be another source(s) of cadmium and lead above the site. The available onsite surface water data was collected from the Nelson Tunnel, Commodore Tunnel, seeps located along the CWR pile, and West Willow Creek. Contaminant concentrations increase dramatically onsite with the Nelson Tunnel and CWR seep appearing to be the most contaminated. Onsite cadmium and lead concentrations increase to maximum detected concentrations of 905 ppb and 1509 ppb, respectively. High levels of arsenic, manganese and zinc were also detected in onsite surface waters at maximum concentrations of 74 ppb, 19,500 ppb, and 153,700 ppb, respectively.

Below the site to the junction of West Willow and East Willow Creeks, contaminant concentrations in surface water begin to decrease rapidly based on the available data. Maximum detected concentrations of cadmium and lead are 294 ppb and 465 ppb. However, it should be noted that the maximum detected concentrations of cadmium and lead in this area appear to be inconsistent (i.e., outliers) with the rest of the data set in this area. This could be due to analytical and/or sampling errors, or seasonal variations such as shown in the WCRC report. West Willow and East Willow meet approximately 0.4 miles downstream of the site and form Willow Creek. Willow Creek flows for about 0.6 miles prior to entering the concrete flume above Creede. In this stretch of Willow Creek, contaminant levels are still elevated, but have continued to decrease. The maximum detected concentration of cadmium from all available data was 19.6 ppb and the maximum detected concentration of lead is 101 ppb. The Windy Gulch enters Willow Creek just above the concrete flume.

Willow Creek flows through the concrete flume through Creede and no surface water samples have been collected from this area. The lack of environmental data in this stretch of Willow Creek is not necessarily considered a significant data gap because the flume, constructed of concrete and rock, is rather uninviting for recreational use. Occasional recreational floats probably do occur, but there is no reason to believe the concentration of metals is greater than the concentration found upstream or downstream of the flume. In addition, water flowing through the flume moves at a steady pace, which appears to keep the creek bed in this area free of sedimentation (Site Visit 2008a b).

Below Creede, Willow Creek exits the flume and forms a braided stream in the Willow Creek floodplain. The Willow Creek floodplain is approximately 1.6 miles in length and Willow Creek enters the Rio Grande River in two primary channels. There appears to be an increase in the level of some metal contaminants in this area. The maximum detected concentration of cadmium was 30.5 ppb and the maximum detected concentration of lead was 327 ppb. Other mining areas, such as the Emperious Tailings Pile, may have also impacted water quality in the Willow Creek floodplain. It is outside the scope of this evaluation to determine the source of all mining related contaminants in the mining district. However, it is important to note that the NT-CWR site is not the only source of contamination, particularly in the Willow Creek floodplain, which has essentially accumulated metal contaminants from nearly all of the mining sites in the district.

Willow Creek enters the Rio Grande River and contaminant levels in surface water again plunge. Cadmium and lead are still present in the Rio Grande River below Willow Creek, but have decreased by nearly an order of magnitude. The maximum detected concentrations of cadmium and lead was 4.1 ppb and 36.2 ppb, respectively.

Sediment

Above the site, arsenic and lead were present at elevated levels with maximum detected concentrations of 104 parts per million (ppm) and 1100 ppm, respectively. Only one onsite sediment sample was available from the 2 reports and showed elevated levels of arsenic (55.3 ppm), lead (1260 ppm), and manganese (3520 ppm). One sample was collected from during both sampling events just upstream of where West Willow Creek meets East Willow Creek. The maximum detected concentration of arsenic and lead in this area was 175 ppm and 3860 ppm, respectively. Below the confluence of West Willow and East Willow Creeks in Willow Creek, the sediment data indicates an increasing trend in contaminant levels. Arsenic, cadmium, lead, and manganese were all present at elevated levels with respective maximum detected concentrations of 249 ppm, 51.2 ppm, 7980 ppm, and 5410 ppm.

There appears to be an increasing trend in sediment contaminant levels with distance from the site, the opposite of that seen for surface water, which appears to decrease with distance for the site. One explanation is that the solubility of metal contaminants could be changing because of the changing stream conditions like pH. In the Willow Creek floodplain below Creede, arsenic, cadmium, lead, and manganese were still present, but at lower concentrations. The respective maximum concentration of arsenic, cadmium, lead, and manganese in floodplain sediments was 82 ppm, 47.9 ppm, 2360 ppm, and 2380 ppm. Interestingly enough, the available surface water data in this area indicates an increase in contaminant levels (contaminants changing form). In the Rio Grande River below Willow Creek, the level of sediment contaminants increases again with maximum detected concentrations of arsenic, cadmium, lead, and manganese of 182 ppm, 29.1 ppm, 4450 ppm, and 3010 ppm, respectively. Further along the Rio Grande River, metal contamination in sediments appears to decrease rapidly with very low levels of contamination remaining by the Wagon Wheel Gap.

Surface Soil
Major surface soil contaminants at the CWR pile include arsenic, cadmium, lead, manganese, and zinc with maximum detected concentrations of 450 ppm, 270 ppm, 23400 ppm, 15000 ppm, and 55400 ppm, respectively. Each of these contaminants were detected in all 4 surface soil samples collected to date. The variability of the samples is shown below in Table A1.

Table A1. Surface Soil Data Summary

Contaminant	Minimum Concentration (in ppm)	Maximum Concentration (in ppm)	Mean Concentration (in ppm)	Median Concentration (in ppm)
Arsenic	64.3	450	321.1	385
Cadmium	8.1	270	93.4	47.7
Lead	877	23400	16019	19900
Manganese	754	15000	5614	3350
Zinc	832	55400	17148	6180

Appendix B. Exposure Dose Estimation

To determine if adverse health effects are likely to occur from exposure to mining related contaminants at the NT-CWR site, exposure doses are estimated. Exposure doses are only calculated for COPCs since the contaminants with concentrations below the Comparison Value are not likely to result in adverse health effects. Estimating the exposure dose requires assumptions to made regarding various exposure parameters such as the frequency of a particular activity, duration of exposure to site-related contamination, and the amount of a particular substance that is taken in by an individual during a given activity. Site-specific exposure information is always preferable when estimating exposure doses. In lieu of site-specific information, default exposure parameters that are established by the EPA and ATSDR are used in the exposure dose estimation. In this case, the many of the default parameters, particularly frequency and duration of exposure to site-related contamination, seem to exceed the actual site-related exposures. As mentioned previously in this evaluation, the primary exposure scenario of concern is acute exposures to surface water, sediment, and surface soil. The exposure assumptions used in this evaluation are presented below in Table B1.

Table B1. Exposure Assumptions

Exposure Pathway	Exposure Parameter	Symbol	Units	Receptor	
				Child	Adult
General	Body Weight	BW	kg	15	70
	Exposure Frequency	EF	days	1	1
Incidental Ingestion	Ingestion $Rate_{Soil}$	IRS	mg/day	200	100
	Pica Child Ingestion Rate (Soil)		mg/day	5,000	
	Ingestion $Rate_{Sediment}$	IRSed	mg/day	100	50
	Ingestions $Rate_{Water}$	IRW	L/day	0.100	0.050

Another critical component of the exposure dose estimation is the concentrations of chemicals that individuals are likely to be exposed to in a particular medium or the Exposure Point Concentration (EPC). Guidelines have been established by the EPA for determining the EPC. In Region 8, if there are less than 10 samples available for an analyte, the maximum detected concentration is used as the EPC since very little is known about the actual concentration in a particular medium and area. In situations where there are more than 10 samples for an analyte, the available data is inserted into a statistical software package designed to calculate EPCs called ProUCL. Generally speaking, the resulting EPC is the 95% Upper Confidence Limit on the mean (average) concentration assuming a normal distribution. The EPC used in this evaluation are presented in Tables B2 – B4 below.

Table B2. Surface Water Exposure Point Concentrations

COPC	Exposure Unit	UOS 2007 (Max. Value) (µg/L)	WCRC 1999-2002 (95% UCL) (µg/L)	CDPHE 1995 (Max. Value) (µg/L)
Arsenic	1	6.3	24.1	5.4
Cadmium	1	183	411.7	293
Copper	1	NS	264.7	290
Manganese	1	18300	22439	16300
Thallium	1	17.4	NS	4.9
Zinc	1	69600	111235	19800
Arsenic	2	NS	4	5.3
Cadmium	2	20.3	31.6	294
Copper	2	NS	NS	279
Manganese	2	422	1589	16600
Thallium	2	NS	NS	4.7
Zinc	2	4200	6856	19900
Arsenic	3	NS	8	NS
Cadmium	3	17.8	13.8	8.5
Copper	3	384	NS	NS
Manganese	3	349	547.1	NS
Zinc	3	3630	3825	NS
Arsenic	5	NS	5.5	NS
Cadmium	5	NS	16	8.8
Manganese	5	NS	552.1	NS
Zinc	5	NS	3848	NS
Cadmium	6	4.1	2	3.8

NS = Not Selected as a COPC

Table B3. Sediment Exposure Point Concentrations (maximum detected concentrations)

COPC	Exposure Unit	2007 UOS Sediment EPC (mg/kg)	1995 CDPHE Sediment EPC (mg/kg)
Arsenic	1	55.3	NS
Manganese	1	3520	NS
Arsenic	2	175	96.9
Cadmium	2	16.1	28.4
Copper	2	126	NS
Arsenic	3	249	76.8
Cadmium	3	51.2	38.4
Copper	3	220	NS
Manganese	3	5410	NS
Arsenic	5	NS	82
Cadmium	5	NS	47.9
Manganese	5	NS	2380
Arsenic	6	182	34.3
Cadmium	6	29.1	17.2
Copper	6	136	96.9
Manganese	6	3010	28.4

NS = Not Selected as a COPC

Table B4. Surface Soil Exposure Point Concentrations (CWR Pile) (maximum detected concentrations)

COPC	2007 UOS Sediment EPC (mg/kg)	1995 CDPHE Sediment EPC (mg/kg)
Aluminum	5220	10100
Antimony	NS	26.7
Arsenic	450	446
Barium	1250	1390
Cadmium	270	38
Copper	1460	1880
Manganese	15000	2390
Thallium	13.5	5.1
Vanadium	12.9	33.6
Zinc	55400	3550

NS = Not Selected as a COPC

Once these factors and assumptions have been determined, the exposure doses can be estimated with the following calculations.

Acute non-cancer Surface Soil Ingestion Dose

Non-cancer Dose = $(C_s$ *** IRS * EF * CF) / BW**

Where C_s = Soil Exposure Point Concentration (mg/kg)
CF = Conversion Factor ($1 * 10^{-6}$ kg/mg)

Acute non-cancer Sediment Ingestion Dose

Non-cancer Dose = $(C_{sed}$ *** IRSed * F * CF) / BW**

Where C_{sed} = Sediment Exposure Point Concentration (mg/kg)
CF = Conversion Factor ($1 * 10^{-6}$ kg/mg)

Acute non-cancer Surface Water Ingestion Dose

Non-cancer Dose = $(C_w$ *** IRW * F * CF) / BW**

Where C_w = Water Exposure Point Concentration (μg/L)
CF = Conversion Factor ($1 * 10^{-3}$ mg/μg)

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), the duration of exposure (acute, subchronic, chronic or lifetime), the health condition of the person, the nutritional status of the person, the life style and family traits of the person.

The major contaminants of concern identified in this consultation include arsenic, cadmium, copper, lead, manganese, thallium, and zinc.. It is important to note that estimates of human health risks may be based on evidence of health effects in humans and/or animals depending upon the availability of data. The toxicity assessment process is usually divided into two parts: the cancer effects and the non-cancer effects of the chemical. This evaluation addresses only acute noncancer health hazards based on the currently available land use information. It is, however, important to note that acute exposures are evaluated only for arsenic and copper because no acute health guidelines are available for cadmium, lead, manganese, thallium, and zinc.

Arsenic is a naturally occurring element. Exposure to high levels of arsenic may cause nausea, vomiting, diarrhea, abnormal heart rhythm, blood vessel damage, or a pins and needle sensation in hands and feet. Long-term exposure to low levels of arsenic may lead to a darkening of the skin and the appearance of small corns or warts on the palms, soles, and torso. Ingesting sufficient amount of arsenic also has been reported to increase the risk of developing cancer in the liver, bladder, kidneys, and lungs (ATSDR, 2007).

Copper is a metal that occurs naturally in the environment. It is an essential element for all known living organisms. Most copper compounds found in the environment are strongly attached to dust or soil or imbedded in minerals so they are not easily available to affect human health. Copper is not known to cause cancer. Long-term exposure to copper dust can irritate nose, mouth, and eyes, and cause headaches, dizziness, nausea, and diarrhea (ATSDR, 2004). Drinking water that contains higher than normal levels of copper may cause nausea, vomiting, stomach cramps, or diarrhea. Intentionally high intakes of copper can cause liver and kidney damage and even death (ATSDR, 2004).

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 health-based guidelines for the contaminants of potential concern for this evaluation are listed below.

Oral Health-based Guidelines for the contaminants of potential concern

Contaminant	Health-based Guideline (mg/kg-day)	Source
Aluminum	1.0	ATSDR Intermediate MRL; NCEA Provisional Value
Antimony	0.0004	EPA IRIS chronic RfD
Arsenic	0.005	ATSDR Acute MRL
Barium	0.2	ATSDR Intermediate MRL; EPA IRIS chronic RfD
Cadmium	0.001	ATSDR Chronic MRL (food)
Copper	0.01	ATSDR Acute MRL
Manganese	0.024	EPA IRIS (water) chronic RfD
Thallium	0.00008	EPA IRIS chronic RfD
Vanadium	0.009	EPA IRIS chronic RfD
Zinc	0.3	ATSDR Intermediate MRL; EPA IRIS chronic RfD

EPA IRIS: Chronic reference doses (RfDs) from EPA Integrated Risk Information System
NCEA: National Center for Environmental Assessments

Appendix D: 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 E. ATSDR Glossary of Public 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.

CAP [see Community Assistance Panel.]

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.

Case study
A medical or epidemiologic evaluation of one person or a small group of people to gather information about specific health conditions and past exposures.

Case-control study
A study that compares exposures of people who have a disease or condition (cases) with people who do not have the disease or condition (controls). Exposures that are more common among the cases may be considered as possible risk factors for the disease.

CAS registry number
A unique number assigned to a substance or mixture by the American Chemical Society Abstracts Service

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]

Cluster investigation
A review of an unusual number, real or perceived, of health events (for example, reports of cancer) grouped together in time and location. Cluster investigations are designed to confirm case reports; determine whether they represent an unusual disease occurrence; and, if possible, explore possible causes and contributing environmental factors.

Community Assistance Panel (CAP)
A group of people from a community and from health and environmental agencies who work with ATSDR to resolve issues and problems related to hazardous substances in the community. CAP members work with ATSDR to gather and review community health concerns, provide information on how people might have been or might now be exposed to hazardous substances, and inform ATSDR on ways to involve the community in its activities.

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.

Disease registry
A system of ongoing registration of all cases of a particular disease or health condition in a defined population.

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.

Epidemiology
The study of the distribution and determinants of disease or health status in a population; the study of the occurrence and causes of health effects in humans.

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 ground water); 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.

Exposure registry
A system of ongoing followup of people who have had documented environmental exposures.

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.

Ground water
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 Substance Release and Health Effects Database (HazDat)
The scientific and administrative database system developed by ATSDR to manage data collection, retrieval, and analysis of site-specific information on hazardous substances, community health concerns, and public health activities.

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.

Health statistics review
The analysis of existing health information (i.e., from death certificates, birth defects registries, and cancer registries) to determine if there is excess disease in a specific population, geographic area, and time period. A health statistics review is a descriptive epidemiologic study.

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.

Incidence
The number of new cases of disease in a defined population over a specific time period [contrast with prevalence].

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].

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.

Metabolism
The conversion or breakdown of a substance from one form to another by a living organism.

Metabolite
Any product of metabolism.

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].

Morbidity
State of being ill or diseased. Morbidity is the occurrence of a disease or condition that alters health and quality of life.

Mortality
Death. Usually the cause (a specific disease, a condition, or an injury) is stated.

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]

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

Plume
A volume of a substance that moves from its source to places farther away from the source. Plumes can be described by the volume of air or water they occupy and the direction they move. For example, a plume can be a column of smoke from a chimney or a substance moving with ground water.

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 health surveillance
The ongoing, systematic collection, analysis, and interpretation of health data. This activity also involves timely dissemination of the data and use for public health programs.

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.

Registry
A systematic collection of information on persons exposed to a specific substance or having specific diseases [see exposure registry and disease registry].

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
The number of units chosen from a population or an environment.

Solvent
A liquid capable of dissolving or dispersing another substance (for example, water, acetone or mineral spirits).

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 ground water].

Surveillance [see public health surveillance]

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].

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.

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

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

Alan Yarbrough
Team Lead
CAT, SPAB, DHAC, ATSDR