Final Remedial Investigation Report

Flat Creek / IMM Superfund Site

MINERAL COUNTY, MT

Operable Unit 1

September 15, 2011

Prepared for USEPA by CDM

RESPONSE ACTION CONTRACT
FOR REMEDIAL, ENFORCEMENT OVERSIGHT, AND NON-TIME
CRITICAL REMOVAL ACTIVITIES AT SITES OF RELEASE OR
THREATENED RELEASE OF HAZARDOUS SUBSTANCES
IN EPA REGION VIII

U. S. EPA CONTRACT NO. EP-W-05-049

REMEDIAL INVESTIGATION REPORT

FLAT CREEK/IMM SUPERFUND SITE
MINERAL COUNTY, MONTANA

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Acronyms

ALM	Adult Lead Methodology
ASARCO	American Smelting and Refining Company
AT	averaging time
ATSDR	Agency for Toxic Substances Disease Registry
bgs	below ground surface
BLL	blood lead level
BW	body weight
C	concentration in air
CDC	Centers for Disease Control
CDM	CDM Federal Programs Corporation
CEIC	Census and Economic Information Center
CERCLA	
CERCLIS	Comprehensive Environmental Response, Compensation, and Liability Information System
CLP	Contract Laboratory Program
Cmax	maximum concentration
COPC	chemical of potential concern
CTE	central tendency exposure
cy	cubic yards
DEQ	Montana Department of Environmental Quality
DI	daily intake
DIL	daily intake averaged over a lifetime
DQOs	data quality objectives
DUAR	data usability and assessment report
EC	exposure concentration in air
ED	exposure duration
EF	exposure frequency
EPA	Environmental Protection Agency
EPC	exposure point concentration
°F	degrees Fahrenheit
FI	Fractional Intake from the site
FS	feasibility study
GIS	geographic information system
GPS	global positioning satellite
GSD	geometric standard deviation
gpm	gallons per minute
HI	hazard index
HIF	human intake factor
HHRA	human health risk assessment
HQ	hazard quotient
I90	U.S. Interstate 90
IMM	Iron Mountain Mine
ICP-AES	Inductively Coupled Plasma Atomic Absorption Spectroscopy
IEUBK	Integrated Exposure Uptake Biokinetic model
IMM	Iron Mountain Mine

IR	intake rate
IRIS	Integrated Risk Information System
IVBA	in vitro bioaccessability
LOAEL	lowest-observed-adverse-effect-level
LOD	level of detection
MCL	EPA's maximum contaminant level
MCEHP	Mineral County Environmental Health and Planning
MDL	method detection limit
MDPHHS	Montana Department of Public Health and Human Services
MDSL	Montana Department of State Lands
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
MSL	mean sea level
NOAEL	no-observed-adverse-effect-level
NPL	National Priorities List
OUs	operable units
OU1	residential and commercial properties and roadways in the Town of Superior
OU2	the rest of the site which includes the IMM property with the mill site and the stream corridor between the IMM and OU1
OU3	waste repository
P10	The probability that a blood lead value will exceed 10 ug/dL
PA	preliminary assessment
PbB	blood lead concentration
PEF	particulate emission factor
ppm	parts per million
PRGs	preliminary remediation goals
PRPs	potentially responsible parties
PWS	Public Water Supply
QA/QC	quality assurance/quality control
RBA	relative bioavailability
RBC	risk-based concentration
RfC	reference concentration
RfD	reference dose
RI	remedial investigation
RME	reasonable maximum exposure
ROD	record of decision
RSLs	Region 9 Regional Screening Level for residential soils
SAPs	sampling and analysis plans
SI	site inspection
SF	slope factor
TAL	Target Analyte List
TCLP	Toxicity Characteristic Leaching Procedure
TCRA	Time Critical Removal Action
the site	Flat Creek/IMM Site
TWA	time-weighted average
UCL	upper confidence limit

µg/dL	micrograms per deciliter
µg/L	micrograms per liter
UOS	URS Operating Systems
UR	unit risk
USACE	U.S. Army Corps of Engineers
USFS	U.S. Forest Service
WOE	weight of evidence
XRF	X-ray fluorescence

Section 1 Introduction

In 2009, the U.S, Environmental Protection Agency (EPA) directed CDM Federal Programs Corporation (CDM) to perform a remedial investigation (RI) of the Flat Creek/Iron Mountain Mine (IMM) Site (the site). The scope was subsequently expanded to include a feasibility study (FS) and post-RI/FS support. This RI report for the site is consistent with current EPA guidelines for conducting RIs under Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (EPA 1988). The Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS) identification number for the site is MT0010106206.

1.1 Site Location and Layout

The site is located in and around the community of Superior, in western Montana, approximately 47 miles east of the Idaho border (Exhibit 1-1) at latitude 47.192 and longitude -114.892. It includes the Clark Fork River and Flat Creek within its boundaries. The nearest community is St. Regis, Montana, which is 14 miles to the west. The nearest city is Missoula, Montana, which is 58 miles to the east. Superior is located at exit 47 of U.S. Interstate 90 (I-90) and has an area of 1.18 square miles. Most of Superior lies north and west of I-90 and south and east of the Clark Fork River. Prior to being listed on EPA's National Priorities List (NPL), the site was known as the Superior Waste Rock site.

Exhibit 1-1. Site Location Map

The site contains three operable units (OUs). OU1 is the residential and commercial properties and roadways in the Town of Superior (Figure 1-1). OU2 is the Flat Creek Drainage which includes the IMM property, related mill sites, and the stream corridor between the IMM and OU1. OU3 is a Montana-owned property located in Wood Gulch approximately 3.5 miles west of Superior. The property is the planned site for construction of a mine waste repository that will be used to dispose of mine tailings and tailings-contaminated soils generated from the cleanup of OU1 and OU2. The initial construction of the repository will be performed by EPA and is planned for summer 2011. Future use and additional development of the repository will be shared between EPA and other stakeholders, including the Montana Department of Environmental Quality (DEQ) and the U.S. Forest Service (USFS).

1.1.1 Site Background

The IMM is the primary source for contamination at the site. It operated from 1909 to 1930 and again from 1947 to 1953, producing silver, gold, lead, copper, and zinc ores.

The now abandoned property includes tunnels, tailings, and the remnants of a mill and other mine buildings. The tailings from the mine contain elevated concentrations of metals. While the mine was in operation, tailings were disposed of along Flat Creek using gravity drainage. Those tailings have been distributed along Flat Creek as far as its confluence with the Clark Fork River.

The IMM covers approximately three acres of property and consisted of a 200-ton mill and approximately 500 feet of tunnel. Tunnels were developed at the 200-foot, 400-foot, 700-foot, and 1,600-foot levels, with the main haulage level at 1,600 feet. The mill also accepted ore from the Dillon Mill and the Belle of the Hills, which were located up gradient of the IMM in Hall Gulch. The IMM reportedly used flotation methods to separate the metals.

Although a waste rock and tailings piles still exist on site, most of the tailings were washed down onto the Flat Creek floodplain (EPA 2009). Tailings have also been imported into Superior by the local government and various individuals for use as fill material in yards, roadways, and other locations (e.g., the school track).

1.1.2 Regulatory and Government Involvement

Regulatory and government activities at the site began with the State of Montana in the early 1990s. A forest fire caused significant deforestation which resulted in a large runoff event that caused the release of significant volumes of contaminated tailings and other mine wastes to Flat Creek. This, along with reports that mine wastes had been used for fill at various properties in Superior, raised the threat profile of the site and resulted in EPA involvement.

The following briefly lists the regulatory and other associated activities that have occurred at the site:

- **1993 – Abandoned Mines Investigation.** The Montana Department of State Lands (MDSL) conducted an abandoned mine investigation to determine the potential health risks associated with the IMM site. Concentrations of many metals were found at elevations significantly above background.

- **1998 – Initial Reclamation Activities.** The IMM's owner removed some tailings from Flat Creek and placed them in an impoundment that was then covered and revegetated. Additional tailings along the creek were revegetated in place.

- **1998 – Drinking Water Testing.** The town government became concerned about the potential public health effects from the IMM after a water sample from the town's well two miles downstream of the mine tested above EPA's maximum contaminant level (MCL) for antimony

- **August 2000 – Documented Release and Request from Montana Department of Environmental Quality (DEQ).** A lightning storm ignited wildfires that burned more than 9,000 acres in the drainage (EPA 2009). On September 2, a high rainfall event resulted in a debris flow (including tailings) that swept into and down Flat Creek. Due to concern that tailings would be mobilized, DEQ requested that EPA conduct a Preliminary Assessment (PA), and Site Inspection (SI) at IMM, Flat Creek, and Superior.

- **July 2001 - PA/SI.** EPA conducted a Focused SI at the mine and in portions of Superior where importation of tailings was suspected. Elevated concentrations were detected for lead, arsenic, antimony, cadmium, and manganese (URS Operating Systems [UOS] 2001). Soil samples were collected from the high school track and residential properties in Superior. Samples from the track were elevated for various metals, including lead and arsenic, as were samples from a residential property and a right-of-way in a residential neighborhood (see Section 3).

- **February 2002 – Blood and Urine Testing.** Mineral County collected blood lead and urine samples from individuals living in Superior to evaluate exposure to arsenic. No effects of exposure were found.

- **June 2002 – Additional Sampling.** As a result of elevated concentrations of target analytes, additional sampling was conducted in 2002 by EPA's Removal Branch. Soil samples were collected from 64 residential properties, 20 right-of-ways, and 10 city/county and open space properties within and around Superior (UOS 2002) (see Section 3).

- **August 2002 – General Notice Letter and Action Memorandum.** EPA issued a general notice letter to the potentially responsible parties (PRPs) on August 21, 2002. EPA also drafted an Action Memorandum to support the removal action of the tailings used as fill in Superior because of possible health and environmental problems (EPA 2009). EPA established health-based risk benchmarks of 3,000 parts per million (ppm) for lead and 400 ppm for arsenic for a removal action.

- **August through November 2002 - Time Critical Removal Action (TCRA).** Based on the 2001 and 2002 sampling events, EPA's Removal Branch conducted a TCRA to remove soils exceeding risk benchmarks (see Section 3).

- **2004 DEQ – Montana State Superfund List.** In 2004, DEQ added the IMM site to its State Superfund List.

- **May 2007 - PA.** An additional PA was prepared to update the 2001 PA using the data generated in the TCRA and observations made during a 2-day site reconnaissance in April 2007 to determine if there were still "targets associated with soil exposure."

- **December 24, 2008 – NPL Request Letter**. The Mineral County Board of Commissioners requested in a letter that Montana Governor Schweitzer support the addition of the site to EPA's NPL.

- **January 6, 2009 – NPL Request Letter.** Montana Governor Schweitzer relayed in a letter to EPA that he supported a NPL listing of the site.

- **January 22, 2009 – NPL Confirmation Letter.** In a letter to Governor Schweitzer, EPA indicated that they would proceed with the proposed listing.

- **April 2009 – NPL Proposal.** The site was proposed for addition to the Superfund NPL in April 2009, and a 60-day comment period ended in June 2009.

- **June 2009 – RI (initial field season).** EPA began an RI of the site in June 2009. This entailed an environmental screening of shallow soils in residential and commercial properties in OU1 (Sections 4 and 5).

- **September 23, 2009 – NPL Listing.** The site was officially added to the NPL.

- **December 2009 – American Smelting and Refining Company** (**ASARCO) Bankruptcy Completed.** The bankruptcy settlement of the ASARCO IMM site was completed.

- **January 2010 – Public Health Assessment Completed.** The Agency for Toxic Substances Disease Registry (ATSDR) finalized its report entitled *Public Health Assessment for Flat Creek IMM (aka Superior Waste Rock), Superior, Mineral County, Montana*.

- **July and August 2010 - RI (second field season)**. EPA completed a second field season at the site as part of the RI. This included sampling of the majority of the remaining residential and non-residential properties in town, as well as alleys (Sections 4 and 5).

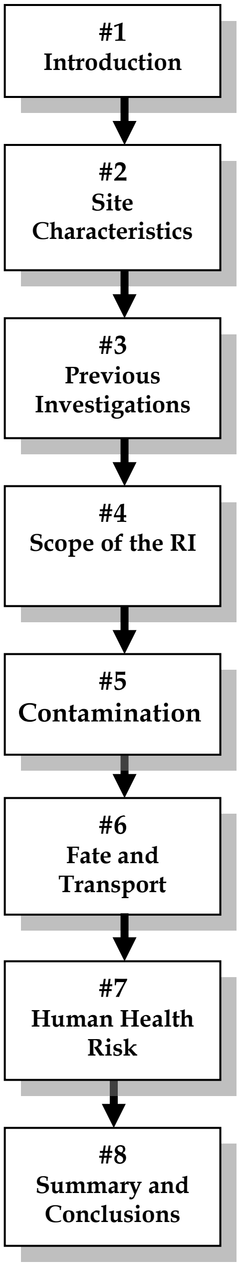
- **July and August 2010 – Second TCRA**. Based on the 2009 and 2010 sampling results, EPA's Removal Branch conducted a second TCRA to remove soils exceeding 3,000 ppm of lead or 400 ppm of arsenic.

- **April 2011 – Human Health Risk Assessment (HHRA).** EPA completed a HHRA for OU1 in support of the RI (Section 7).

- **May 2011 – RI Report**. EPA completed a draft RI report characterizing the nature and extent of shallow soil contamination in the OU.

- **June 2011** – FS Report. EPA completed a draft FS report evaluating alternative remedial actions for the cleanup of OU1.

- **September 2011 –** EPA finalized the RI and FS reports, incorporating comment from the DEQ and the Superior Technical Assistance Committee (STAC).



Upcoming activities include the preparation of a proposed plan for cleanup and record of decision (ROD). After the cleanup parameters are set in the ROD, EPA will begin a remedial design of the properties to be cleaned up and will undertake a remedial action to implement the clean up. EPA will also continue to work with other stakeholders to construct the mine waste joint repository for final disposal of the excavated materials.

1.2 Report Organization

The following information is included in this RI report:

- **Section 1 - Introduction.** Provides a brief description of the site location and layout, and a summary of mining and regulatory activities conducted to date at the site.

- **Section 2 - Physical Characteristics of the Site**. Description of the physical characteristics of the site, including: climate, surface water, geology, hydrogeology, hydrology, land use, demographics, and general description of mine waste.

- **Section 3 – Scope of Previous Site Investigations and Clean Up**. Overview of site investigations and removal activities completed by other agencies and entities.

- **Section 4 – Scope of the RI.** Overview of the RI, including: goals, scope, sampling, surveying, and data validation.

- **Section 5 - Nature and Extent of Contamination.** Describes the nature and extent of contamination, focusing on the residential soils, non-residential soils, and alleys.

- **Section 6 - Fate and Transport**. Contaminants of concern, contaminant sources, mechanisms of migration and transport, human health threat, and persistence.

- **Section 7 - Risk Assessment**. Presents the HHRA for OU1. The ecological risk assessment will be conducted under OU2, along with an HHRA for OU2.

- **Section 8 – Summary and Conclusions**. Summarizes the nature and extent of contamination, fate and transport, and risk assessment. Provides conclusions and suggestions for future work.

Section 2 Site Physical Characteristics

2.1 Site Setting

The Town of Superior, Montana (OU1) is located adjacent to exit 47 on U.S. Interstate 90 (Figure 2-1). The elevation of Superior is 2,762 feet above mean sea level (MSL). There are over 88 mountain summits and peaks in Mineral County, and Superior is surrounded by the mountains of the Bitterroot Range. Within a mile of town, there are mountains with elevations of over 4,400 feet above MSL. Within four miles, elevations are as high as 6,400 feet MSL. The Clark Fork River runs through the community in a northwesterly direction. The Clark Fork is part of the Columbia River Basin watershed and ultimately drains to Lake Pend Oreille in northern Idaho. Flat Creek, a tributary to the Clark Fork River, drains the watershed north of Superior. Its confluence with the Clark Fork River is near River Street in Superior.

The IMM (OU2) is the source for the tailings and waste rock found in Superior, but is not included in this RI. The IMM is located approximately 3.5 miles north of Superior at the confluence of Hall Gulch and Flat Creek at latitude 47° 14’25” North and longitude 114° 51’ 10” West. It covers an area of approximately 3 acres, and is at approximately 3,400 feet above MSL. The mine is surrounded by the Lolo National Forest. Vegetation generally consists of cedar, spruce, fir, and willow trees (MDSL 1993).

2.2 Community

The Town of Superior was established in 1869, and was reportedly named after the hometown of its founders (Superior, Wisconsin) (Wikipedia 2011). The post office was established in 1871. The economy was driven by gold mining and then logging. The town made history again in 1908, when the Superior Hotel received the first Bibles to be placed in hotel rooms by *The Gideons* (Wikipedia 2011).

There are no local media outlets that originate on or near the site. The newspaper closest to the site is the Mineral Independent published in Plains, Montana. The nearest television stations are in Missoula (KPAX, which is KO3DT, Channel 3 in Superior) and (KECI, which is K11FF Channel 11 in Superior). There are no local stations and most people use a satellite dish to receive a television signal.

2.2.1 Local Government

The Town of Superior (postal zip code 59872) is the County Seat of Mineral County, so there is a full range of community government and local services available. The county’s website is www.co.mineral.mt.us. Mineral County departments or offices based in Superior include: Appraisal and Audit; County Attorney; County Clerk and Recorder; Courts and Probation; Custodian; Disaster and Emergency Services; Environmental Health, County Planner, Sanitarian; County Extension; Fair Board; Family Services; Health; Roads; Schools; Sherriff; Treasurer; Weed District; and Welfare. Other local services include the: Mineral County Public Library, Western

Montana Mental Health Center, and the Mineral Community Hospital. There is also a 24-hour help line (Mineral County Help line) that provides help for people in crisis, with an emphasis on women who are victims of domestic and sexual violence.

The governing body for Mineral County is the three-member Board of Commissioners. Each commissioner serves a six-year term. The commissioners meet on the first Monday and Tuesday of the month, the second Wednesday and all subsequent Wednesdays of the month, and the last working day of the month. The commissioners' meeting agenda is managed by the county clerk and recorder.

2.2.2 Education

The Superior Public School District has three schools, all of which are located in the Town of Superior, Montana, as described below:

- **Superior Elementary School**. This school is located at 1003 5th Avenue East. It serves approximately 192 students in Grades K though 6.
- **Superior Middle School**. This school is located at 410.5 Arizona Avenue. It serves approximately 53 students in grades 7 and 8.
- **Superior High School.** This school is located at 410 Arizona Street. It serves approximately 141 students in Grades 9 through 12.

The student to teacher ratio in the district is reported to be fairly low (12 to 1). The student population is predominantly white (93 percent), with 55 percent male and 45 percent female. Of the 40 staff members, 31 are full-time teachers (20 elementary and 11 secondary).

2.2.3 Demographics

Demographic data for Superior are derived from the 2010 census and are published by the Montana Department of Commerce’s Census and Economic Information Center (CEIC). As of the 2010 census (CEIC, 2011), Mineral County had a population of 4,223 which is a 9 percent increase over the 2000 census. Mineral County is ranked 39th in population of 53 Montana counties.

In Superior, the 2010 census showed a population of 812, which is a 9 percent drop below the 2000 census. Detailed census data from 2010 are not yet available. Based on the 2010 census there were 410 housing units in Superior. There were 239 children over the age of 3 years enrolled in school, and 95 percent of the population over 5 years of age spoke English only.

Complete demographics from the 2010 census are not yet available, so the 2000 census statistics are provided below. In 2010, half of the adult population was married, and the medium household income in 2000 was $25,333. A total of 61 percent of workers worked for private industry, 27 percent worked for government, and 11 percent were self-employed. The most commonly cited employers in 2000 were: educational, health, and social services (25 percent); agriculture, forestry, fishing and hunting, and mining (14 percent); arts, entertainment, recreation, accommodation, and food services (11 percent); and retail trade (9 percent).

2.3 Land Use and Ownership

According to the Montana Cadastral Mapping Program website, there are approximately 700 properties within the area investigated as part of the RI. This area extends beyond the boundaries of the town of Superior, as access forms were received from residents beyond the town limits.

Within OU1, land ownership is primarily comprised of privately-owned residential parcels (85 percent) versus non-residential (15 percent). These numbers are based on the results of the effort in the RI to obtain access from all residential properties. The non-residential properties include municipal, state, or federal land that is used for open space, roadways, or buildings (e.g. schools). A small percentage of properties are privately-owned for commercial purposes (e.g., gas stations, shops, etc.). Figure 2-2 shows the residential versus non-residential properties in OU1.

2.4 Climate

Climate data from the Western Regional Climate Center (WRCC 2010) for the Superior, Montana station (# 248043) indicate the weather at the site is typical of the climate in western Montana. The area has a relatively cool and dry continental climate. Due to its lower elevation, temperatures in Superior are warmer year round than in many parts of western Montana. The lowest average minimum temperature is in January (17.7 degrees Fahrenheit (°F)) and the highest average maximum temperature is in July (87°F). The regional temperature is marked by wide seasonal and diurnal variations. In winter, temperatures often drop below zero °F with extended periods of sub-freezing temperatures. In summer, highs often exceed 90°F. There is a greater than 50 percent probability of first frost by September 20 and last frost by May 19.

The average annual snowfall for the area is 36.4 inches. Local mountains are generally blanketed in snow from November through March. Average annual precipitation is 16.77 inches and is delivered relatively evenly throughout the year. Average precipitation is highest in June (1.96 inches) and lowest in July (0.87 inches). Summer thunderstorms frequently produce high winds, intense rainfall, and occasional hail.

2.5 Geology

The general geology of the Superior region is characterized by Proterozoic age bedrock of the Belt Supergroup, with Quaternary age alluvial sediments within the Clark Fork River basin. Quaternary age deposits are also intermittently present within area stream and drainage channels (Lonn 2007).

The Osburn fault trends from northwest to southeast across the IMM area. Bedrock to the northeast of the fault consists of the Helena Formation and the Revett formation, which generally consist of quartzite with thin beds of siltite and argillite. An anticline runs through these formations approximately parallel to the fault strike. To the southwest of the Osburn fault are the younger rocks of the Wallace Formation. The Wallace Formation consists of dolomitic quartzite and siltite with discontinuous interbeds of argillite (Campbell 1960).

Quaternary-age, undivided alluvium and colluvium is present within the confluence of Hall Gulch and Flat Creek. The sediments may include mixtures of gravel, sand and silt with talus and slope wash (Lonn 2007).

2.6 Hydrogeology/Hydrology

Water bearing units in the Superior area include the alluvial sediments within the Clark Fork River basin and fractured bedrock. Groundwater yields from the fractured bedrock are highly variable. Well yields for wells within the fractured bedrock average approximately 10 gallons per minute (gpm) (LaFave 2006a). Well yields within the alluvial basin may yield approximately three times this amount. Wells are uncommon within the bedrock aquifer in the direct vicinity of the IMM site. Wells in the alluvial valley near Superior may number as high as 11 to 30 wells per section in some areas (Warren 2007.) The potentiometric surface of wells within both the bedrock aquifer and the alluvial aquifer typically ranges between 2,650 and 2,700 feet above MSL in the Superior area. Groundwater flow is typically toward the Clark Fork River within the alluvial basin (LaFave 2006a). Groundwater flow within bedrock is dominated by fracture networks and is variable.

Background concentrations of nitrates are typically less than 2.0 milligrams per liter (mg/L) and arsenic concentrations less than 5.0 mg/L in both the bedrock and alluvial aquifers. Water quality is good with respect to total dissolved solids, with concentrations typically less than 500 mg/L throughout the region (LaFave 2006b).

2.7 Groundwater Use

Since the early 1900s, the majority of town residents have been connected to the public water supply (PWS). Previously, the PWS source for the town of Superior was a spring adjacent to Flat Creek. However, the Mountain Water Company (former PWS owner) discontinued use of Flat Creek Spring in 1997 when antimony was detected at concentrations above the MCL (EPA 2001b, DEQ 2004b). Currently, the spring is not in use, but it is maintained as an emergency drinking water source (UOS 2001). Although named “Flat Creek Spring”, the spring surfaces at a higher elevation than Flat Creek (EPA 2001b). As a “gravity flow spring”, it arises from area groundwater (DEQ 2004b).

Ownership of the PWS was transferred from the Mountain Water Company to the town of Superior in October 2000. The current PWS has a total of 430 connections. There are three production wells for this system (Figure 2-1): Well 1, Well 2, and Well

3. The wells are located within the city limits of Superior and are drilled into the confined aquifer at depths of 105.5 feet below ground surface (bgs) (Well 1), 118 feet bgs (Well 2), and 214 feet bgs (Well 3). Well water is treated, and the town of Superior tests these wells for water quality in accordance with federal standards.

Most residents living in the town of Superior receive drinking water from the PWS, but a few homes on the north side of town obtain water from private wells. In general, these private wells draw water from the deep aquifer (more than 85 feet bgs), which is believed to be confined. However, several homes do have wells that draw water from less than 85 feet bgs (DEQ 2003). It is not known whether these wells are currently used as a drinking water source.

There is also one residence located north of the town limits that is not served by the PWS. This family draws drinking water from two distinct sources—a private groundwater-fed well and a diversion from Flat Creek, approximately 2 miles south of the IMM site (EPA 2002a).

2.8 General Description and Distribution of Mine Waste Materials

Contamination from the now abandoned IMM includes tailings that contain elevated concentrations of metals. While the mine was in operation, tailings were disposed of along Flat Creek, which is a tributary to the Clark Fork River and runs through the town of Superior. Tailings have also been imported by individuals into Superior for use as fill material in yards, roadways, and other locations (e.g., the school track).

2.8.1 Source Tailings

The Flat Creek tailings piles are mill tailings that were deposited into the creek by flooding or facility processes (MDSL 1993). In 1993, there were 8 tailings piles containing approximately 370 cubic yards (cy) extending along a 1.2 mile length of Flat Creek (UOS 2001). Most of the tailings in the Flat Creek floodplain are poorly vegetated, and vary in depth between 4 inches and 7 feet (UOS 2002). In 2001 the largest continuous section of tailings was sampled and was estimated to cover an area exceeding 61,000 square feet with depths of up to 7 feet (UOS 2002). Tailings were noted to vary in depth and distribution along the creek bed between sample locations IM-SO-06 and IM-SO-07 (Schultz Ranch location), but to be continuous and visually consistent. Six samples were collected from tailings piles in and near the creek. Four of the samples were from sizeable piles: IM-SO-04, IM-SO-05, IM-SO-06, and IM-SO-07 (UOS 2001). Concentrations for hazardous substances found in these samples are summarized in Exhibit 2-1. These parameters were all present in concentrations more than three times expected background for the area.

Instances of a reddish color have been reported to be associated with the tailings, along with a lack of vegetation in the contaminated areas. There does not appear to be a reliable visual marker for contaminated versus uncontaminated soils at the low levels anticipated for remedial decision making.

Exhibit 2-1. Hazardous Substances Associated with the Source

Parameter	Sample No.	Concentration (ppm)	Parameter	Sample No.	Concentration (ppm)
Antimony (<10 ppm)	IM-SO-04	4,500	Lead (<15 ppm)	IM-SO-04	24,000
	IM-SO-05	1,280		IM-SO-05	7,800
	IM-SO-06	1,520		IM-SO-06	9,990
	IM-SO-07	3,000		IM-SO-07	55,600
Arsenic (<100 ppm)	IM-SO-04	24,800	Manganese (<500 ppm)	IM-SO-04	4,270
	IM-SO-05	9,350		IM-SO-05	2,210
	IM-SO-06	2,320		IM-SO-06	4,200
	IM-SO-07	3,530		IM-SO-07	5,530
Cadmium (no data)	IM-SO-04	75	Zinc (<45 ppm)	IM-SO-04	9,590
	IM-SO-05	5.9		IM-SO-05	1,200
	IM-SO-06	34.7		IM-SO-06	5,930
	IM-SO-07	161		IM-SO-07	25,200

Based on table in UOS 2009
() = background concentration from (Shacklette, 1984)

2.8.2 Waste Tailings in the Community

Various investigations have noted that it was a common practice in the 1950s and 1960s for tailings from the IMM site to be hauled into town for use as roadbed, driveways, and fill material for low-lying areas. The tailings were also reportedly sometimes used along the edges of properties to suppress weed growth. These tailings were readily available near and below the mill, as well as along Flat Creek (EPA 2009). The tailings were sought after because they were well sorted, no rocks or boulders, and they compacted and drained well. Local residents reported that they saw the tailings being used by town government for road projects and for the high school track, and that they felt that there were no problems associated with their use.

The 2001 Focused SI found elevated concentrations of metals including lead, arsenic, antimony, cadmium, and manganese (UOS 2001). Sampling was limited, but contamination was noted at the high school track, a residential property, and a residential right-of-way in Superior.

During the 2009 community interviews that were conducted for preparation of the community involvement plan, people were asked if they could suggest areas where waste might be located, to assist EPA in focusing the investigation. Suggestions for where to look for mine waste included:

- **Driveways in general**. Comments included "USFS driveway" and "driveways and some lawns on Fourth Avenue." "People were using it in the 60s, because it was used at the high school track." The material was sought after because it worked well as a subgrade material.

- **Uptown section of town north of the river.** Comments included "behind the NAPA store off Mullan Road – deep," "old hotel on hill," "alley by former drug store/now sandwich shop," "T intersection on Mullan and River Roads," "old railroad grade north of river and Mullen Road," "Cenex station," and "floodplain of Flat Creek 1953 flood on north side of river."
- **Recreational areas**. Comments about recreational areas included: "Behind the fair grounds, between freeway and rodeo grounds by chutes (the high school track straightaway went into fairgrounds)" and "local parks."
- **River Street area**. Comments included "River Street (saw tailings while filling in a hole)," "the old school," "pharmacy," "bank (on land that used to be the athletic field) and the area between the bank and the school," and "courthouse to the river, when they built the street in 1950 the WPA would use it for a finish course prior to pouring the sidewalk."
- **Diamond Road area**. "County shop and City shop" and "Town Pump addition."

Section 3 Scope of Previous Investigations and Cleanup

Most of the early work at the site focused on the IMM site (what is now OU2). Work in Superior (now OU1) began with EPA's involvement in 2002. Previous investigations and cleanups at OU1 and the remainder of the site are briefly summarized below.

3.1 State of Montana

As noted in Section 1, the MDSL conducted an abandoned mine investigation to determine the potential health risks associated with the IMM site. Results of the investigation were documented in the Priority Sites Summary Report (MDSL 1993). Concentrations of many metals were found at elevations significantly above background at the mill site. Arsenic, copper, mercury, lead, zinc, cadmium, manganese, and antimony were present in soils in concentrations more than three times background levels (UOS 2002). No samples were taken in Superior (OU1).

In 1998, the town government became concerned with the potential health risks associated with the IMM because of a level of antimony above the MCL in a sample from the drinking water supply obtained approximately two miles downstream of the IMM. The drinking water supply has been described as both a developed spring and an adit. It is reported to consist of a single perforated concrete pipe that is buried adjacent to Flat Creek and embedded in rock (UOS 2007). A resident reportedly described the adit as two tunnels where perforated pipe was placed and the tunnels then collapsed. The pipes were then connected to the pipe lying parallel to Flat Creek (UOS 2007). In 1997, a liner was placed over this pipe and a disinfectant system was installed downgradient of the adit (UOS 2007).

On September 28, 2000, DEQ collected a sample from the drinking water supply for Superior. Antimony was not detected in the sample with method detection limit (MDL) of 0.005 mg/L. The MDL is below the MCL of 0.006 mg/L (DEQ 2000). This water supply is currently maintained as a backup.

As mentioned in Section 1.1.2, a heavy rain on September 2, 2000 following a forest fire resulted in a debris flow (including tailings) that swept into and down Flat Creek. Due to concern that tailings would be mobilized, DEQ requested that EPA conduct a PA and SI at the IMM, on Flat Creek itself, and in Superior. Based on the results of the PA/SI, DEQ added the IMM site to its State Superfund List in 2004.

3.2 Town of Superior/Mineral County

In February 2002, Mineral County Environmental Health and Planning (MCEHP) collected blood lead and urine arsenic samples from individuals living in Superior (ATSDR 2010) to evaluate exposure to arsenic. Those results are described below:

- **Urine**. Urine arsenic is the most reliable method for measuring arsenic exposure. However, because it reflects only recent exposure (a few days), the measurement provides only a small window for assessment of arsenic exposure. Urinary arsenic levels in unexposed individuals are normally less than 10 micrograms per liter (µg/L), and total arsenic levels below 50 µg/L are expected for those without occupational or dietary exposures (NRC 1999**)**. Seventeen Superior residents were tested for urinary arsenic (ATSDR 2010), and all concentrations were below the detection limit of 5 µg/L. This indicates no exposure to unusual arsenic concentrations a few days prior to their urine collection.

- **Blood Lead**. The Centers for Disease Control and Prevention (CDC) considers a blood lead level (BLL) of 10 micrograms per deciliter (µg/dL) to be a level of concern for children. There were 66 Superior residents tested for lead exposure. All blood lead concentrations were less than 10 µg /dL (ATSDR 2010).

Although the concentrations seen in urine and blood are not indicative of environmental exposure, the ATSDR believes that the results do not represent peak exposures, such as those that might occur with summertime outdoor activities. Thus, the February samples cannot be used to address overall arsenic and lead exposure (ATSDR 2010).

In March 2002, Mineral County and the Superior School District joined the town in a lawsuit against ASARCO alleging that tailings from the IMM along Flat Creek just north of Superior had polluted a municipal well and soils in the town, county, and school district where the tailings were used as fill. The county posted signs warning visitors of the possible danger (Missoulian 2002).

3.3 ASARCO

ASARCO was one of the last owners of the IMM site. As a result of the MDSL investigation, ASARCO removed some tailings from Flat Creek in 1998 and placed them in an impoundment that was then covered and revegetated (ASARCO 1999). Additional tailings along the creek were revegetated in place to minimize disruption to the creek. There are no post-remediation sampling data available to confirm the success or extent of these remediation activities (UOS 2002).

EPA issued a general notice letter to ASARCO and other PRPs for the IMM site on August 21, 2002. EPA also drafted an Action Memorandum to support the removal action of the tailings used as fill in Superior because of possible health and environmental problems (EPA 2009). EPA established health-based risk benchmarks of 3,000 ppm for lead and 400 ppm for arsenic for a removal action.

ASARCO declared bankruptcy and, in December 2009, the bankruptcy settlement of the ASARCO Montana properties was completed. The Montana settlement was part of a larger settlement that allowed ASARCO to emerge from bankruptcy as a subsidiary of Grupo Mexico. The total settlement within Montana was $138 million, of which $100 million was for cleanup of the ASARCO smelter in East Helena (Missoulian 2009). The State of Montana and the USFS received $1.9 million of clean-up money from the bankruptcy claim (Missoulian 2009). The money received is only available for cleaning up the mining and milling areas of the site (OU2). It cannot be used for OU1.

3.4 ATSDR

ATSDR became involved with the IMM site in 2002. A town of Superior resident contacted ATSDR to request that the agency initiate communication with Mineral County. In response, ATSDR worked with the EPA, the Montana Department of Public Health and Human Services (MDPHHS), and the MCEHP to create a fact sheet for the community. ATSDR reviewed soil and water sample results from Flat Creek, performed a site visit of the area, and communicated with local residents.

ATSDR reports that it has received several letters from concerned community members with questions about exposures to heavy metals and other contaminants associated with the IMM site, the Flat Creek floodplain, and the town of Superior (ATSDR 2010). In September 2008, ATSDR staff conducted a site visit to meet with ATSDR's petitioner to discuss the site. ATSDR staff also met with county staff and toured the site and possible contamination source areas (visible waste tailings along Flat Creek and on the mine property) (ATSDR 2008). In July 2009, ATSDR joined EPA staff at a public meeting held in Superior. EPA staff discussed the comment period on the proposed Superfund listing, the EPA community involvement plan, and the upcoming EPA sampling of residential properties.

ATSDR finalized its report in January 2010 entitled *Public Health Assessment for Flat Creek IMM (aka Superior Waste Rock), Superior, Mineral County, Montana*. The draft report was issued in July 2009 and public comments were received until August 2009. The assessment looked at the possibility of both short- and long-term health risks from past, current, and future contact with the waste tailings contamination. The report found that frequent contact with waste tailings on the IMM site, the Flat Creek floodplain, and the town of Superior could harm human health. Concentrations of arsenic and lead are of public health concern if residents, particularly children, repeatedly contact areas affected by waste tailings in and around Superior.

Results included:

- **Soil.** Arsenic and lead levels are of public health concern for children and adults who repeatedly contact areas affected by waste tailings on the IMM site and Flat Creek floodplain. Because the contaminated areas at the IMM site and floodplain area are posted with warning signs, ATSDR expects recreational activities in these areas to be infrequent. In town, heavy metals detected in soil at most residential and non-residential areas are not at levels of health concern. However, four residences tested have lead levels and two of these four residences have arsenic levels that could be problematic for children who play regularly in the soil. The potential also exists that additional properties in town that were not tested might contain waste tailings.

- **Flat Creek.** Harmful health effects are not expected for children and adults who have skin contact or drink small amounts of Flat Creek surface water while wading and fishing. Using creek water for drinking, showering, bathing, cooking, and washing dishes is not expected to cause harmful health effects. Nonetheless, scientists found that levels of antimony and lead in the creek exceed regulatory guidelines, and the creek has occasionally been used as a drinking water source. ATSDR recommends efforts to reduce drinking water exposures when chemical levels are above regulatory guidelines. Children who drink one liter or more of Flat Creek water per day could have blood lead levels of concern.

- **Hall Gulch.** Surface water in the Hall Gulch area would be at levels of public health concern if the water were drunk frequently. However, ATSDR would not expect people to drink or wade in this shallow, reddish-brown surface water.

- **Drinking water**. Chemicals found in water from city wells, Flat Creek Spring, and one private well tested were not at levels of public health concern. However, in the past, antimony levels in Flat Creek Spring and the private well exceeded regulatory guidelines. ATSDR did not have enough data to evaluate water from private wells on the north side of town.

ATSDR recommended further efforts to minimize exposure to the contamination and continued work with the community to determine which areas of town should be studied further. Many of these recommendations were specific to OU2, not OU1.

ATSDR’s specific recommendations were:

- Waste and tailings-contaminated areas at the mine site and floodplain area should continue to be posted with warning signs advising the public that the soil contains arsenic and lead, which may pose a risk to public health.

- Remedial actions should be considered to minimize exposure to waste tailings contamination, such as removal of waste tailings deposits on the mine site and floodplain area.

- Additional characterization of town soil should be conducted to confirm the success or extent of the 2002 TCRA.

- Additional characterization of the four residential yards should be conducted to determine whether the detected soil arsenic and lead levels are truly representative of each yard.

- Additional efforts, such as another mail-out to town residents or a town hall meeting, should be conducted to determine which areas of town need further characterization.

- Hall Gulch should continue to be posted with warning signs informing the public that water coming out of the adit has levels of metals that may pose a health risk.

- Efforts to reduce drinking water exposures from Flat Creek intakes should be made because antimony and lead levels in the creek water are above regulatory guidelines.

- Flat Creek Spring should be tested before it is used as an emergency public water supply to ensure antimony levels are below regulatory guidelines.

- Private wells on the north side of town should be tested if it is determined they draw water from the shallow aquifer.

- Residents should be made aware of prudent public health measures they can take to reduce exposures and to protect themselves, their families, and visitors.

3.5 U.S. EPA

3.5.1 2001 Preliminary Investigation/Site Inspection

The EPA conducted a Focused SI in July 2001 at the mine and in portions of Superior where importation of tailings was suspected (UOS 2001). In Superior, this focused on collection of soil samples from a limited number of private driveways and roads and from public properties such as the school track and the county fairgrounds. Eleven soil samples collected from the high school track were compared a background sample collected at a local park. Most of the samples had concentrations of the following analytes at least three times above the background sample: antimony; arsenic; cadmium; calcium; copper; lead; manganese; mercury; silver; and zinc. The most elevated were: antimony (34.4 to 1,050 ppm), arsenic (79.4 ppm to 1,690 ppm), lead (423 ppm to 8,500 ppm), and mercury (0.32 ppm to 12.4 ppm) (OUS, 2001).

Potential targets for the surface soil pathway identified in 2001 included the local residents living where elevated metals were located. Potential targets for the high school track include the 383 elementary and high school students who attend school in the Superior School District (UOS 2001).

3.5.2 July 2002 Additional Sampling

Elevated concentrations in samples collected in 2001 led to additional sampling in 2002 as part of a removal assessment. Sampling was completed between June 3 and 13, 2002 (UOS 2002). Exhibit 3-1 lists the types of properties included in the 2002 sampling event.

Soil samples were collected from 64 residential properties, 20 right-of-ways, and 10 city/county and open space properties within and around Superior, Montana. A total of ten residential properties originally identified for sampling were not completed because of the distance from the town of Superior, denial of access, or change in ownership.

Exhibit 3-1. Properties Sampled in 2002 as Part of the Removal Assessment

Residential	1st St (100 block)	2nd Ave W (300, **400,** 500 blocks)	3rd Ave E (200, 300, **400** blocks)
	3rd St (300 block)	600 block alley btwn 4th & 5th Ave	4th Ave E (100 block)
	4th St (200, 300, block)	600 block alley btwn 5th & 6th Ave	5th Ave E (600 block)
	6th Ave E (600 block)	7th St (100 block)	Cedar St (100, 200, 300 block)
	Flat Creek (300 block)	Illinois Ave (400 block)	Maple St (400 block)
	Main St (**200**, 300, 400 block)	400 block alley btwn Spruce & Pine St	Pike St (500 block)
	Riverside Rd (200 block) west alley	Riverside Rd (300, 800 block)	400 block alley btwn Spruce & Alder
	5th Ave E (500 block)	Spruce St (300, **400** block)	
Non-Residential	Maple (304, 306, 307, 311)	Alder St (205, 300, 404)	Montana Ave (309)
	Diamond Rd (169, 400)	Arizona Ave (306, 404)	Mullan Rd W (23, 33, **43**, 106, 146)
	Flat Creek Rd (**225**)	4th Ave E (615, 627, 639, 801, 903)	Old Mullan Rd (319)
	Cedar St (106, 202, 208)	5th St (203)	River St N (102, 205)
	6th Ave East (618)	Main St (205, **208**, 311, 400, **500**, 502, 604)	Riverside Rd (209, 403)
	5th Ave E (604, 612, 620, 628, 631)	Spruce St (**201**, 210, 211, 213)	2nd Ave W (**403**)
	1st St (107, 202, **206**, 211)	2nd Ave E (310)	3rd Ave E (405, 500, 510)
	3rd Ave W (**106**, 206, 305)	Illinois Ave (403)	Iron Mtn Heights (307, **407**)
	Eva Horning Park	High School & **Track**	**East of River St and Johnson Lane**
	Little Park	Elementary School	SW corner of River St and Johnson
	VFW property	Westside Field	**City Shop**
	Fairgrounds		

Properties in bold font had concentrations above 400 ppm lead.
Removals were done at properties that are underlined.
Samples collected in June 2002 and reported in the May 2007 PA report (UOS 2007)

A total of 635 soil samples were collected (UOS 2002). The samples were analyzed on site for metals by field x-ray fluorescence (XRF). Ten percent of the total (64 samples) was sent for Target Analyte List (TAL) metals analysis as confirmation of field results. Four soil samples were also selected for Toxicity Characteristic Leaching Procedure (TCLP) analysis of TAL metals. Five samples were submitted for lead and arsenic speciation and in vitro bioavailability. Confirmation sample results and TCLP sample results were validated in accordance with the criteria contained in EPA guidance.

Sampling areas were divided into three groups: residential properties, road right-of-ways, and city or county properties or open spaces. Composite surface samples were collected between 0 and 3 inches bgs at each location. At least one deeper sample was collected if surface concentration was above 100 ppm arsenic or 500 ppm lead. Depth samples were collected at a depth of 9 to 12 inches using the same method as described for the surface samples.

Sampling details from the 2002 report are provided below:

- **Residential properties.** Samples were collected from properties that contained a structure where persons reside or business properties that contain areas that may be contaminated. Sample quantities were determined by the size of the property. For a standard lot (5,000 square feet) or smaller, the area was considered one sampling zone. A minimum of two composite surface samples were collected from each zone. Additional samples were collected for play areas, discolored material, or stressed vegetation. A sample was also collected from the driveway at most properties. If elevated concentrations of lead (500 ppm or greater) or arsenic (100 ppm or greater) were detected, additional samples were collected (UOS 2002). Large residential properties were divided into zones.

- **Road right-of-ways.** Samples were collected from right-of-ways or alleys where elevated concentrations were suspected. Discrete surface samples were collected at 50-foot intervals on each side of the street or down the approximate center line of alleys. Sample locations were random unless discolored material or areas with stressed or no vegetation were observed. If elevated metals concentrations were detected, additional samples (surface and depth) were collected.

- **Open space.** Samples were collected from large properties not used for residential purposes. This included: parking lots, parks, city or county property, and vacant lots. Properties were divided into zones, and one composite surface sample was collected from each. If metals concentrations were elevated, additional grab samples were collected to delineate the area.

Appendix A provides the lead and arsenic results for the 2002 sampling. In summary:

- **Residential properties.** Nine residential locations had samples above 500 ppm or arsenic above 100 ppm. The estimated volume of material at each property ranges from 0.15 cy to 21 cy. Property owners indicated that the material was generally used to minimize vegetative growth, reduce dust, or fill in low spots on the property.

- **Road right-of-ways.** Five right-of-ways had concentrations of lead above 500 ppm or arsenic above 100 ppm. Each area was relatively small with estimated volumes of material ranging between 0.5 and 35 cy. No significantly elevated levels of arsenic were identified. The right-of-way originally identified during the 2001 sampling activities appeared to be cleaned up with a small amount of tailing material left (approximately 1.2 cy).

- **Open space.** Three open space properties had elevated concentrations of metals. The high school track, the fairgrounds, and the city shop had concentrations of lead above 500 ppm, and the high school track also had concentrations of arsenic above 100 ppm. Estimated volumes of contaminated material were: fairgrounds, 175 cy; high school track, 3,111 cy; and city shop, 120 cy.

- **TCLP**. All four of the samples sent for TCLP analysis had concentrations of lead above the regulatory limit (5 mg/L).

- **Bioavailability**. Five samples were submitted for lead and arsenic speciation and in vitro bioavailability. Samples were selected from the high school track, the fairgrounds, the residence at 106 3rd Avenue West, the residence at 407 Iron Mountain Heights, and the residence at 403 2nd Avenue West. These samples were selected because of the high concentrations of lead and/or arsenic detected on the XRF. The data were provided for the HHRA in 2010.

3.5.3 2002 TCRA

In August of 2002, EPA drafted an Action Memorandum to support the removal action of the tailings. Based on the site investigation and removal assessment sample results, the mine tailings that were used as fill in several areas in Superior were proposed to be removed because of potential health and environmental risk. Using the analytical results, EPA established health-based risk benchmarks of 3,000 ppm lead and 400 ppm for arsenic. The soil would be removed to a depth of 12 inches, except for vegetable gardens where the removal would be as much as 24 inches (UOS 2002).

In 2002, EPA conducted a TCRA to remove soils exceeding 3,000 ppm of lead or 400 ppm of arsenic. Waste rock materials were removed from 4 driveways, 3 right-of-ways, the much of the high school track, a residential fence line (201 Spruce Street), and a portion of the Mineral County fairgrounds (Figure 3-1). The removal did not include tailings and contaminated soils on a property owned by the USFS, as that agency indicated it would conduct the removal on its property.

According to the removal progress reports from August through December 2002 (UOS 2002), the soil was removed to a maximum depth of 12 inches. Although no vegetable gardens were encountered, removal depth in those locations was to be 24 inches. Confirmation samples were collected in the excavated areas. The excavated areas were backfilled with clean materials of similar composition, or a combination of cleaned, compacted gravel with 4 inches of asphalt on the surface.

The mine tailings were excavated and staged separately from the contaminated soils for disposal purposes. An estimate of 6,500 cy of both mine tailings (4,000 cy) and contaminated soils (2,500 cy) were excavated. The materials were staged at the Mineral County Airport until final treatment and disposal. On October 11, 2002, the U.S. Army Corps of Engineers (USACE) provided EPA with a potential process to treat the materials and a design of a repository (100 by 400 feet in size) to be located approximately 2,100 feet from the end of the airport runway. Construction of the repository began on October 22, 2002. By the end of the month, the repository had been dug and the contaminated soils had been placed therein. On October 30, 2002, the county provided EPA with a letter indicating that they had agreed to let EPA use the County airport ground as a permanent repository for the treated wastes.

Treatment (via solidification with Portland cement) of the tailings began in late October and was completed by November 5, 2002. Capping of the repository (with membrane and cover soil) was completed shortly thereafter. The areas used for staging of the contaminated materials were verified to be clean.

3.5.4 2007 Preliminary Assessment

An additional PA (UOS 2007) was prepared in May 2007 to update the 2001 PA and to determine if a potential risk was still present. EPA conducted a site walkover in April 2007 and a historical data review. No new samples were collected.

The walkover confirmed the previously observed presence of contamination, specifically:

- The IMM contains several waste piles, which have unrestricted access. These sources include a large waste rock pile and several tailing piles. The top of the largest tailings pile has some vegetation but is mostly open ground. A public health advisory notice for soil and water containing elevated levels of arsenic, antimony, and lead has been posted by the Mineral County Board of Health at the waste rock pile in Hall Gulch. The smaller waste rock/tailings piles that were previously located on the IMM property were not readily noted. The area may have been graded and now has a cover of vegetation.

- An adit is located upgradient of the waste rock pile and Hall Gulch, and discharge was observed running into Hall Gulch and flowing over the waste rock pile. A pH strip test in the field during the walkover showed a pH of 5. The water discharge is red/orange and flows in two directions: across the top of the waste rock/tailings pile, and along the western edge of the Hall Gulch drainage. The observed flow rate from the discharge was estimated to be about 10 gallons per minute. A sample collected in 1997 by ASARCO indicated the following concentrations of metals in the adit discharge: 57 µg/L of antimony, 1,600 µg/L of arsenic, and 12,300 µg/L of zinc. The antimony and arsenic values greatly exceeded the MCL for those elements and the zinc value greatly exceeded the recommended aquatic water quality criteria.

- Tailings from the IMM that had been used to surface the high school track, some private driveways and roads in Superior, and a portion of the county fairgrounds were remediated as part of a TCRA in 2002. Other locations sampled as part of the 2002 removal assessment but not remediated exceeded the EPA Region 9 PRGs.

- All of the waste sources are unrestricted to recreational activities. Other targets within Mineral County include threatened and endangered species: bald eagle (threatened); gray wolf (endangered); bull trout (threatened); and Canada lynx (threatened). Surface contamination of soils from use of mine waste tailings in town is still present at concentrations above acceptable limits.

3.5.5 NPL Listing

On December 24, 2008, the Mineral County Board of Commissioners requested in a letter that Governor Brian Schweitzer support the addition of the site to EPA's NPL. Governor Schweitzer relayed in a January 6, 2009 letter to EPA that he support a NPL listing of the site. In a January 22, 2009 letter to Governor Schweitzer, EPA indicated that they would proceed with the proposed listing. The site was proposed for addition to the Superfund NPL in April 2009, and a 60-day comment period ended in June 2009.

3.5.6 RI/FS

In 2009, EPA initiated an RI/FS for OU1. The RI included the screening of every property in Superior for which access could be obtained. The samples were screened for lead and arsenic using XRF and all samples above a screening level of 250 ppm of arsenic were sent for laboratory analysis. The scope and results of the RI are provided in Sections 4 and 5, respectively. The results were used to generate a HHRA (Section 7) and to prepare an FS.

3.5.7 2010 TCRA

EPA conducted a second TCRA to remove soils exceeding 3,000 ppm of lead or 400 ppm of arsenic at properties that were identified as a result of the 2009 field investigation for the RI. A total of 7,903 cy of contaminated soil were removed from 29 properties (Nguyen, 2011a). Areas removed included driveways and portions of the high school track and Mineral County fairgrounds that had not been removed in 2002. This volume also includes material generated by Mineral County's water line installation (650 cy) and the material excavated by the USFS at their property (600 cy) (Nguyen, 2011a). The wastes were treated with 2 percent Triple Super Phosphate (homogeneously derived from monocalcium phosphate n-hydrate and dicalcium phosphate n-hydrate), whenever materials exhibited a TCLP of more than 5 mg/L for lead.

The specific properties where removals were conducted and the concentrations of lead and arsenic at those locations are discussed in Section 5. Some details are not yet available as the removal report has not been issued by EPA for that TCRA.

3.6 Data Validation and Usability

The data collected by EPA during the 2001 PA/SI, the 2002 additional sampling in support of the TCRA, and the 2010 TCRA were all subject to standard data validation procedures specified under the EPA Contract Laboratory Program (CLP) National Functional Guidelines for inorganic data review (1994, 2004, and 2010).

Raw data were reviewed for completeness and transcription accuracy onto the summary forms. The data were generally found to be acceptable with qualifications as noted in the data tables. The data are useable for the purpose of the PA and can also be used in preparation of the RI. Data validation qualifiers used for these data are shown in Exhibit 3-2.

Exhibit 3-2. General Qualifiers Used for Inorganic Data

Qualifier	Description
R	Reported value is rejected. Resampling or reanalysis may be necessary to verify the presence or absence of the compound.
J	The associated numerical value is an estimated quantity because the quality control criteria were not met.
UJ	The reported amount is estimated because quality control criteria were not met. Element or compound was not detected.
U	The material was analyzed for, but was not-detected above the level of the associated value. The associated value is either the sample quantitation limit or the sample detection limit.

Section 4 Scope of the RI

4.1 Goals of the RI

The RI activities were intended to obtain sufficient data to characterize the nature and extent of mining-related contamination in surface and near surface soils in OU1. The data from the screening were used to identify properties that required emergency removal and to support preparation of the RI and FS reports, as well as the risk assessment, proposed plan, and ROD. Investigation of other media (i.e., groundwater, surface water, subsurface soils, air, or interior dust) and evaluation of ecological risk was not included in the RI for OU1.

As part of defining the data quality objectives (DQOs) for the RI, several principal study questions and their alternative actions were developed (Exhibit 4-1). Those questions guide the evaluations done in Section 5.

Exhibit 4-1. Principal Study Questions and Alternative Actions

Principal Study Questions	Alternative Actions
What are the concentrations of lead and arsenic in the shallow soils in residential and non-residential properties at OU1 as determined using the XRF?	Lead screening level not exceeded – archive sample
	Lead screening level exceeded – submit sample to the EPA CLP laboratory
What are the concentrations of mining-related contaminants in the shallow soils in residential and non-residential properties at OU1 as determined by the CLP laboratory?	Action level for lead or arsenic not exceeded, no threat determined, no further action needed
	Action level for lead or arsenic exceeded, threat determined, further investigation and/or remedial design warranted

CLP = EPA Contract Laboratory Program
XRF = X-ray fluorescence

There are two decision rules for the RI sampling:

- **Screening.** If a sample result exceeded the lead XRF screening level, the sample would be sent to the CLP laboratory for analysis. If not, the sample would be archived.
- **Characterization.** If a sample analyzed by the CLP laboratory has a result that exceeds the Montana arsenic action level or lead EPA Region 9 regional screening level for residential soils (RSL), the need for additional, post-RI sampling to adequately characterize the areas from which the sample was taken will be determined. If the sample does not exceed the action level, no further action is required.

Action levels used for the RI sampling came from two sources:

- Montana DEQ Action Level for Arsenic in Surface Soil, April 2005 (DEQ 2005)
- EPA RSLs for soils (formerly Region 9 Preliminary Remediation Goals) for lead (EPA 2008)

The XRF screening level used for lead was the RSL for lead with a conservative correction factor applied to take into account the field conditions of the samples and to avoid false negatives in the screening step. At the onset of sampling, the correction factor was 25 percent (resulting in a screening level of 300 ppm), with the understanding that it could be adjusted up or down after the initial week set of CLP samples results were received and comparisons could be made between field XRF and CLP results. After those comparisons were made, the screening level was subsequently reduced to 250 ppm for lead. The 250 ppm lead screening level was also used for the second round of sampling in 2010.

4.2 Scope of the RI

The RI activities were conducted over two field seasons (2009 and 2010) and included the sampling of most properties in Superior, Montana. The exceptions were a limited number of properties for which an owner could not be found, or where an owner refused access. Additionally, a limited number of properties were visited by the field team but were not sampled because there was no evidence of the potential for mine waste to have been imported to the property.

EPA originally also planned to screen 5 kilometers of roadbeds in the OU, but that activity was canceled because roadbeds were being sampled as part of a town-wide upgrade and replacement of the oldest municipal waste supply lines. Those water supply lines generally were buried in the road right-of-ways throughout town. The scope was expanded at the end of the 2010 field season to include screening of most alleys in the OU, which added to the overall knowledge of the nature and extent of contamination at the site.

4.3 Sampling

4.3.1 Sampling Strategy

The objective of the soil sampling was to determine whether or not mine waste had been imported to individual properties in Superior or if that material had been used in the construction of roadbeds. Sampling was limited to the upper 12 inches of soil at any given property. The number of samples collected and analyses performed are described in the following sections. Specifics of the sampling and the associated quality assurance/quality control (QA/QC) protocols were detailed in the various sampling and analysis plans (SAPs) for the site:

- *Sampling and Analysis Plan, 2009 Remedial Investigation, Flat Creek/IMM Superfund Site, Mineral County, Montana, July 28, 2009* (CDM, 2009).

- *Amendment to the 2009 Sampling and Analysis Plan, for the 2010 Remedial Investigation, Flat Creek/IMM Superfund Site, Mineral County, Montana, May 20, 2010* (CDM, 2010a).

- *Second Amendment to the 2009 Sampling and Analysis Plan, for the 2010 Remedial Investigation (Addition of Alley Sampling), Flat Creek/IMM Superfund Site, Mineral County, Montana, July 15, 2010* (CDM, 2010b).

Field work was fully documented in field logbooks in accordance with CDM standard operating procedures. Photographic documentation of sampling locations was conducted and the field crew recorded global positioning satellite (GPS) coordinates of each sample location. Sampling point locations were estimated to known points and recorded on sketches of the yards. Because it was not known which (if any) yards would require remediation, only basic sketches of the residential property features were made. All GPS coordinates of sample locations are being managed in the geographic information system (GIS) in Helena, Montana. Copies of field logbooks, sketches, photos, and GPS coordinates are provided in Appendix B.

4.3.2 Access and Community Involvement

Work at all properties was dependent upon obtaining prior, voluntary consent for access to sample. To obtain access from as many people as possible in Superior, the following activities were preformed:

- In March 2009, a fact sheet was prepared that explained the contamination, potential health threats, upcoming NPL listing process, opportunities for a Technical Assistance Group and Community Advisory Group, and site contacts.

- In April 2009, EPA discussed the project and the need for access with local officials at the town council meeting.

- On June 15, 2009, a fact sheet was prepared and mailed to the entire community that explained the work to be conducted in 2009 and encouraged local property owners to grant access.

- In June and July 2009, EPA conducted a series of interviews with local citizens to obtain information for the community involvement plan. The plan was issued to the public in May 2010.

- An advertisement was placed in the Mineral Independent on June 25 and July 4, 2009 advertising the July 8, 2009 public meeting.

- On July 8, 2009, EPA announced the field sampling at a public meeting and explained how and why access should be granted.

- On August 3, 2009, EPA opened a field office to serve as a base for the field crew and to provide local citizens with a place to obtain and return access forms. The field office was staffed by a local citizen. The field office remained open during the 2009 and 2010 field events.

- During the week of August 3, 2009, representatives from EPA, DEQ, and CDM walked door-to-door in the community to explain the project and obtain access from local property owners. Approximately 90 percent of the residential properties in town were canvassed during that activity.

- On April 30, 2010, an additional fact sheet was distributed to the community summarizing the results of the 2009 field work and letting residents know that additional sampling would be done in 2010 to accommodate residents who could not be included in the 2009 field program.

- On May 12, 2010 EPA held a second town meeting to discuss the upcoming field season and urge residents to provide access for sampling.

- On July 21, 2010, an advertisement was placed in the Mineral Independent to give a deadline for granting access.

- On October 18, 2010, a fact sheet was distributed to the community summarizing the results of the 2010 field work and the schedule for the rest of the project.

Access forms were received for 644 properties, and all properties for which an access form was received were assigned a unique property identification number (Table 4-1). However, not all of the identification numbers have samples associated with them and not all properties for which access was obtained were sampled. The reasons that an identification number was not used or a particular property may not have been sampled included:

- The property identification number was a duplicate of another previously assigned number (usually the case when a property owner and a tenant both submitted an access form, when joint property owners each submitted an access form, or when an owner did not know the actual street address of their property).

- The property was observed by the field crew to be too far outside of the town boundaries to be relevant to the site.

- The property was undeveloped and undisturbed and there was no reason to suspect the importation of mine waste as fill.

4.3.3 Individual Property Sampling

EPA's objective in the 2009 sampling event was to obtain access for and sample up to 300 properties. Sampling originally focused on residential properties, but was expanded to include any property for which access was provided (e.g., commercial, municipal, or other non-residential properties). Non-residential properties that were sampled included: schools, churches, parks, the county fairgrounds, a gas station, various businesses, banks, and government offices.

A total of 588 properties were sampled in 2009 and 2010. This included 313 properties in 2009 and 275 in 2010. These included 500 residential and 88 non-residential properties (Table 4-2). Figure 4-1 shows the properties where samples were collected for the RI.

Sampling locations were selected using the following steps:

- For the typical residential property, four sampling areas were usually established. Some properties (e.g., a smaller property that lacked a side yard) required fewer sampling areas, and other properties (e.g., municipal properties such as the high school or hospital) were much larger and had more sampling areas.
- Sampling areas were identified with a letter (generally A, B, C, or D) appended to the property ID.
- For each sampling area, five aliquot locations were determined. For an average yard (with 4 sampling areas), there were a total of 20 aliquot locations for each sampling area.
- One surface (0 to 2 inches) composite and two subsurface (2 to 6 inches and 6 to 12 inches) composite samples were made for each sampling area using the individual aliquot samples from within that sampling area. Sampling pits for each aliquot were excavated using hand tools and actual sampling was conducted using pre-cleaned disposable plastic trowels.
- Provisions were made to allow the collection of grab samples, as needed, from locations that appeared suspicious in the field. It was anticipated that those samples might come from areas which the field team identified as potential fill areas or areas that appeared to contain mine waste based on color or other visual cues.

Typical sampling configurations are shown in Exhibit 4-2. All material was collected in accordance with the SAP. Hand tools were used to excavate holes for sample collection. Approximately 500 grams (about one quarter of a 1-gallon zipper top bag) were collected for each soil sample. Samples were thoroughly mixed within the bag. Field work was documented in field logbooks and photographic documentation of sampling locations was conducted.

4.3.4 Roadway Sampling

The 2009 SAP specified sampling of the roadways, but this activity was deleted from the scope by EPA at the start of the 2009 field season because roadways were being sampled by others as part of a community-wide upgrade and replacement of the municipal water supply lines.

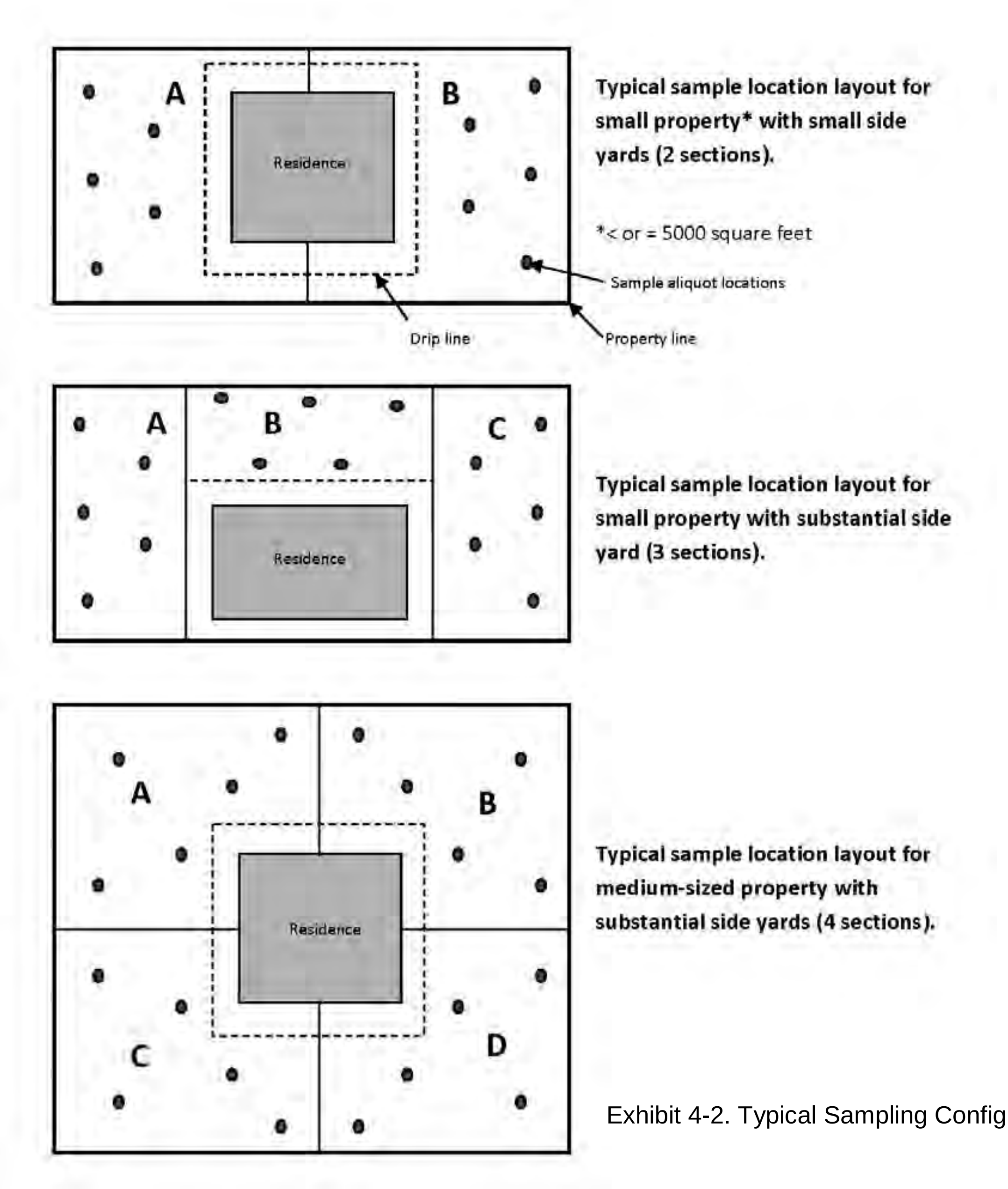


Exhibit 4-2. Typical Sampling Configurations

The engineering firm responsible for this sampling effort in 2008 and 2009 was Anderson Montgomery Consulting Engineers. The scope and results of that sampling are not presented in this RI. In general, the road beds were sampled by coring at regular intervals, and five individual samples were composited for 100-foot sections of the road. The sampling depth intervals were generally 0 to 6 inches, with some samples noted at 12 to 18 inches. In 2008, road segments included: Main Avenue, intersection of Sixth Avenue and Sherlaw Street, Diamond Road, West Riverside Avenue, and Mullan Road. The results were analyzed to ensure that any hazardous wastes encountered during excavation for the waterline replacements would be handled appropriately. Other road segments were sampled and analyzed in 2009.

Mineral County reported (Read, 2011) that contaminated materials encountered during the waterline replacement were disposed at the municipal landfill in Missoula, Montana or at the temporary repository being used by EPA's Removal Branch in Superior. EPA's Removal Branch (Nguyen, 2011a) reported that approximately 650 cy of contaminated soils from the waterline project were accepted in the temporary repository at the airport in 2010.

4.3.5 Alley Sampling

At the end of the 2010 field season, the decision was made to collect a representative number of alley samples while the field team was mobilized. The alleys are generally unpaved, and the potential exists for dusty conditions during certain activities or high wind events. The objective of the sampling was to provide additional information on overall potential for exposure to mine waste to residents of Superior. The sampling focused on surface and near surface layer of materials that could potentially be disturbed by people (especially children) in typical daily activities (e.g., walking, running, riding bicycles). It was not intended to provide information about the extent of contamination at depth.

Because mine waste is known to exist in significant quantities beneath paved streets in Superior, institutional controls may eventually be put in place as part of any remedy to minimize exposure in instances when street paving is breeched. Those same controls could apply to alleys.

The alley sampling was described in an amended SAP signed by EPA on July 15, 2010 (CDM, 2010b). Thirty-three alleys were screened and thirty were sampled. A total of 162 alley composite samples were collected and screened with the XRF (Table 4-3). Locations were selected using the following steps:

- Each alley was divided into a number of sampling sections. The average 15- by 300-foot alley was divided into three sections (A, B, and C) of roughly 100 by 15 feet. Some alleys had only two sections (A and B).
- For each section, five aliquot locations were determined. The five aliquots were collected from the center of the alley and were roughly equally-spaced from one another.
- One surface (0- to 2-inch interval) composite sample and one subsurface composite sample (2- to 6-inch interval) was made for each sampling section using the individual surface aliquot samples from within that section.
- In addition to the sections identified above, any area within an alley that looked as if it might contain mine waste was to be sampled as an opportunistic sample.

All CDM protocols related to sample collection, documentation, handling, XRF screening, and analysis in the original 2009 SAP and May 2010 SAP amendment applied to the alley samples. Alley samples are identified in the database with the letters "AL." The locations of the alley samples are shown in Figure 4-2.

4.4 Screening by XRF

The DQOs in the 2009 SAP (CDM 2009b) identified a concentration of 400 ppm of lead as the default cleanup value for residential soils at most Superfund sites. Because of the high number of samples expected to be generated over the two field seasons, it was necessary to have a screening process that focused laboratory resources while still providing the level of accuracy required to make risk management decisions. Each of the 7,209 samples collected were screened using field XRF to identify which would be submitted to the laboratory for further analysis. Lead concentrations in the XRF analysis were used for screening criteria. Arsenic concentrations were not used to select samples for further analysis.

A site-specific correction factor was applied to the 400 ppm lead default cleanup value in order to develop a conservative XRF screening level. Initially, that correction factor was 25 percent and the screening level for lead was 300 ppm. All samples over that concentration were submitted to EPA's CLP laboratory for analysis.

During the first week of sampling, to provide data for the statistical analysis of the XRF protocol, 126 samples screened by XRF were sent for laboratory analysis. This represents 75 percent of the shallow samples collected and an additional 30 subsurface samples. After the laboratory concentrations had been compared to the XRF screening concentrations, the screening level was adjusted to 250 ppm for lead. That level was used throughout the remainder of the 2009 and 2010 field seasons. In addition to the samples that were submitted to the CLP laboratory because they exceeded the lead screening level, 5 percent of the samples that do not exceed the action level were also submitted as a QA check on the XRF process.

During the first week of field work, all XRF analyses were made in the CDM field office. Thereafter, samples were transported to CDM's Helena office weekly and analyzed there in accordance with SW 846 method 6200, field portable XRF spectrometry for the determination of elemental concentrations in soil and sediment.

The steps for XRF analysis throughout the two sampling events were:

- Samples were received and relinquished as noted in the field log book with proper chain of custody documentation.
- Manufacturer's QC protocol, specifications, and calibration requirements as well as EPA Method 6200 were followed for operation of the XRF unit. Standard material with known concentrations was analyzed before and after each set of 20 samples analyzed to ensure instrument efficacy.

- No further sample preparation was performed, and samples were analyzed directly through the sample bag. Analysis was performed in accordance with the manufacturer's specifications for direct read XRF analysis.

- Each sample was analyzed for a minimum of 60 counts for each reading. The samples were analyzed in their zipper-top plastic bags and were not dried or sieved. Initially, two readings were taken for each parameter (lead and arsenic) for each sample. Each reading was recorded in a field log book, and the highest result for each sample determined whether the sample was submitted for CLP analysis. After several hundred samples had been screened, an evaluation showed no significant benefit in obtaining two results per sample and the protocol was altered to eliminate the duplicate screening of each sample for each parameter.

- Sample results were downloaded daily and saved in spreadsheets.

4.5 Analysis by CLP Laboratory

Samples that exceeded the XRF screening criteria were sent to the CLP laboratory for the standard TAL metals and metalloids. A total of 1,012 samples from 345 properties were submitted to the CLP laboratory over the course of the 2009 and 2010 field seasons (Table 4-2). Only 279 samples were analyzed by the CLP laboratory because they exceeded screening levels. Most samples were submitted for laboratory analysis for reasons including:

- As part of the 5 percent of non-elevated samples to be analyzed for QA purposes
- As part of the first week of samples shipped for XRF statistical analysis
- To obtain more information on samples near an elevated sample
- To address a concern noted in the field
- As a conservative measure to address occasional issues that arose regarding the XRF or recording of the results

Sample container requirements, preservatives, and holding times are listed in Exhibit 4-3 for both the field XRF and the CLP analysis. All samples that were not sent to the CLP laboratory were archived for one year to allow for future analysis, if needed.

Exhibit 4-3 Summary of Field and Analytical Protocols

Matrix	Measurement Endpoint	Preser-vation	Holding Time	Container Size/ Analytical Requirement	Analytical Method and Reference
Surface and Sub-surface Soils and Waste Material	CLP Analytical Lab: TAL metals/ metalloids: *(aluminum, antimony, arsenic, barium, beryllium, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, nickel, potassium, selenium, silver, sodium, thallium, vanadium, zinc)*	Cool to 4°C ± 2°C	6 months	8-ounce glass jars	CLP SOW ILM05.4 or ISM01.2
	XRF: *(arsenic and lead)*			1-gallon zipper top bag	EPA Method 6200

TAL = Target Analyte List
CLP = Contract Laboratory Program
XRF – X-ray fluorescence

4.6 Data Validation and Usability

Data collected in 2009 and 2010 were evaluated for usability separately after the results from each sampling event were received from the CLP laboratory. A data usability and assessment report (DUAR) was prepared for each sampling year:

- *Data Usability Assessment Report, 2009 Remedial Investigation, Flat Creek/IMM Superfund Site, Mineral County, Montana,* May 2011 (CDM 2010a).
- *Data Usability Assessment Report, 2010 Remedial Investigation, Flat Creek/IMM Superfund Site, Mineral County, Montana,* May 2011 (CDM 2011).

The purpose of the DUAR is to evaluate the data collected and determine whether they meet the DQOs outlined in the appropriate work plans and SAPs for the site.

Those documents were:

- *Final Work Plan for Remedial Investigation at the Flat Creek/IMM Superfund Site, Mineral County, Montana,* June 2009 (CDM 2009a).
- *Sampling and Analysis Plan, 2009 Remedial Investigation, Flat Creek/IMM Superfund Site, Mineral County, Montana*, July 28, 2009 (CDM, 2009b).
- *Work Plan Revision 1, WAF 5 Flat Creek/IMM Superfund Site*, May 2010 (CDM 2010b)
- *Amendment to the 2009 Sampling and Analysis Plan, for the 2010 Remedial Investigation , Flat Creek/IMM Superfund Site, Mineral County, Montana,* May 20, 2010 (CDM 2010c).
- *Second Amendment to the 2009 Sampling and Analysis Plan, for the 2010 Remedial Investigation (Addition to Alley Sampling), Flat Creek/IMM Superfund Site, Mineral County, Montana*, July 15, 2010 (CDM, 2010d).

Samples were collected and analyzed in accordance with the appropriate work plan and SAP. Any deviations from those documents were addressed in the DUAR. The deviations did not have an adverse impact on the project objectives.

The data generated during the 2009 and 2010 sampling event is usable as reported with the data validation qualifiers added, with the exception of a subset of the 2010 sample results for antimony that were rejected during the validation process. The recovery of antimony in the matrix spikes in sample delivery groups MH2ZR5, MH3035, and MH3075 was below QC criteria. Fifty-nine undetected antimony results were rejected. While these results are not usable for project purposes, antimony results in surface and near surface soils are not likely to be drivers for cleanup decisions at this site.

Over 99 percent of the collected data is suitable for its intended use as stated in the work plans and SAP addendums. The reporting limits met the expected limits as documented in the SAP (CDM 2009b) and SAP addendums. The achievement of the completeness goals for number of samples collected, and the number of sample results acceptable for use provides sufficient quality data to support project decisions.

Section 5 Nature and Extent of Contamination

This section presents the results of the 2009 and 2010 field investigations at the site. Results are divided into the following categories:

- Residential properties
- Non-residential properties
- Alleys

As discussed in Section 4, samples having XRF readings in excess of 250 ppm lead by XRF screening were submitted to the CLP laboratory for further analysis. In addition, 5 percent of the remaining samples were also submitted for QA purposes. All XRF data are provided in Appendix C and CLP data are provided in Appendix D.

For properties having only screening by XRF, only lead results are discussed, other parameters were not used to screen samples for submittal for CLP laboratory analysis. For properties having samples that were sent for CLP analysis, the lead and arsenic results are discussed in detail. The general tiers used to categorize the CLP and XRF results for the purposes of discussions are:

- **Low (less than 400 ppm lead and 100 ppm arsenic).** At mining-related sites in Montana, residential cleanup levels in recent years have used a 400 ppm concentration for lead and a 100 ppm concentration for arsenic. The lead concentration references the lead model default used in the HHRA for lead. The arsenic concentration is the lower end of the EPA's acceptable level (1E-04) for cancer risk.

- **Moderate (between 400 ppm and 1,200 ppm lead and 100 and 400 ppm arsenic**). These concentrations are within the range that would potentially require cleanup but would not generally present an immediate risk.

- **High (greater that 1,200 ppm lead and 400 ppm arsenic).** These concentrations are reflective of an elevated level of risk that might trigger emergency removal by EPA's Removal Group. In the past, removals were triggered by 400 ppm arsenic or 3000 ppm lead, but interest was expressed within the agency in identifying properties that were greater than 1,200 ppm lead, which is identified by EPA's 2003 *Superfund Lead-Contaminated Residential Sites Handbook* for Tier 1 properties (non-play areas).

5.1 Residential Properties

5.1.1 XRF Screening Results

Most (500 of 588) properties included in the RI screening are classified as residential. The remaining 88 locations are non-residential. Samples from 488 of the residential properties were screened using XRF. This included 3,371 samples in 2009 and 2,667 samples in 2010, for a total of 6,038 samples (not including duplicates). Samples were equally distributed between the three depth intervals (0 to 2 inches, 2 to 6 inches, and 6 to 12 inches). Results for those samples are provided in Appendix C.

A typical residential property included 4 sampling locations (aka - quadrants) and 3 depths from each quadrant for an average of 12 samples per property. Some properties had slightly fewer or more sampling locations, depending on the size and layout of the property. Samples were also occasionally taken from discrete piles of soils or other areas that appeared to have a potential for mine waste to be present.

The level of detection (LOD) for lead and arsenic using the Niton XL3T field XRF was approximately 7 ppm and 6 ppm, respectively. These LODs are well below the screening levels used at the site. A total of 35 percent of the samples (2,122 samples) were below LOD for lead and 82 percent (4,932 samples) were below LOD for arsenic (Exhibit 5-1). Lead concentrations by XRF for the 3,916 samples that were above the LOD ranged from 7.6 to 43,210 ppm. The highest concentration came from the 2- to 6-inch interval at RY506 and was more than four times higher than the next highest concentration (9,704 ppm). The average lead concentration by XRF for all samples greater than LOD was 117 ppm (Exhibit 5-1). In the 1,106 samples that had arsenic concentrations greater than LOD, the concentration ranged from 6.1 to 4,836 ppm, with an average of 61 ppm. As with lead, the sample from RY506 had the highest concentration for arsenic. The next highest concentration was 2,841 ppm.

Exhibit 5-1. Summary of Residential XRF Screening

Parameter	**Results less than LOD**		**Results greater than LOD**				
	Number of Samples	**Percent of total**	**Number of Samples**	**Percent of total**	**Low**	**High**	**Average**
Arsenic	4932	82	1106	18	6.06	4,836	61.0
Lead	2122	35	3916	65	7.57	43,210	119.9

Data from 488 properties and 6,038 samples collected in 2009 and 2010
XRF – x-ray fluorescence
LOD = level of detection

As discussed in Section 4, a screening level of 250 ppm lead by XRF was used to provide a conservative estimate of which samples would have concentrations above 400 ppm for lead if analyzed by the laboratory. Samples below250 ppm lead by XRF (and thus below 400 ppm by laboratory analysis) were considered to be in the “low concentration” category and would be unlikely to require additional investigation or cleanup. Those samples were archived after screening. Arsenic concentrations were not used to select samples for further analysis. A total of 97 percent of the samples screened by XRF were in the low concentration category (less than 250 ppm by XRF) on the basis of their lead concentration.

The 198 samples with XRF reading above 250 ppm for lead were sent to the laboratory for further analysis. The other samples were submitted to the laboratory for reasons outlined in Section 4-5. A QA concern with XRF data from 15 properties (RY374, RY391, RY501 through RY504, RY552 through RY560, and RY566) resulted in the data from those properties being removed from the XRF database, and those samples were sent to the laboratory for analysis. Data for samples from three additional properties (RY354, RY355, and RY356) were also sent to the laboratory due to issues with downloading from the XRF analyzer.

5.1.1 Lead and Arsenic Analysis by CLP Laboratory

A total of 826 samples from 154 residential properties were submitted for laboratory analysis. The distribution of samples by depth was: 0 to 2 inches, 316 samples (38 percent); 2 to 6 inches, 261 samples (32 percent); and 6 to 12 inches, 249 samples (30 percent). The results of the analysis for lead and arsenic are discussed below. Results for other parameters are discussed in Section 5.1.3. Note that entire properties are categorized according to tier so that all associated samples for a property, that were sent to the CLP laboratory, are placed in the category determined by the sample with the highest concentration.

5.1.1.1 Properties with Low Concentrations

Results for 102 of the 154 residential properties with samples sent for laboratory analysis showed concentrations less than 400 ppm for lead and 100 ppm for arsenic (Tables 5-1 and 5-2, respectively). When all samples for a property met the low concentration criteria, the property was designated as low concentration. A total of 556 samples from 258 sampling locations were included in this category. Samples were generally well-distributed across the three depth intervals.

The concentrations for lead in these samples ranged from 1.1 to 309 ppm, with an average of 33.5 ppm. Arsenic concentrations ranged 0.45 to 66.7 ppm, with an average of 6 ppm. The locations of the properties in this category are shown on Figure 5-1. The concentrations of lead and arsenic at the lower ends of these ranges are likely indicative of natural background concentrations in the area. Concentrations at the high end of these ranges may be the result of variations in natural conditions, limited amounts of mine waste, or other sources (e.g., lead paint).

5.1.1.2 **Properties with Moderate Concentrations**

At 22 of the 154 residential properties with CLP results, concentrations at one or more of the sampling locations were in the moderate category for lead (400 to 1,200 ppm) and/or arsenic (100 to 400 ppm) (Exhibit 5-2). Properties are categorized on the basis of their highest lead or arsenic concentration. Thus, any locations with a high concentration for either parameter were placed in the high category instead of the moderate category.

Tables 5-3 and 5-4 show *all* the CLP laboratory results for lead and arsenic, respectively for the samples sent for laboratory analysis for a given property. There were 90 samples in this moderate category. Lead concentrations ranged from 14 to 1,120 ppm, with an average of 372 ppm (Table 5-3). Arsenic concentrations ranged from 3 to 369 ppm, with an average of 53 ppm (Table 5-4). About 40 percent (9 of 22) of the properties in this category had moderate concentrations of *both* lead and arsenic (RY061, RY144, RY160, RY193, RY271, RY284, RY485, RY597, and RY616).

Exhibit 5-2 shows only the sampling location(s) that placed a property in the moderate category, as a result of one or more depths with a moderate lead and/or arsenic sample. Samples from other locations on the property are not shown because the concentrations were low either by the initial XRF screening and/or by the CLP laboratory analysis.

Exhibit 5-2. Residential Sample Locations in Moderate Concentration Category

Sample Location	**Category by Depth** lead (*arsenic*)			**Type**
	0 to 2”	2 to 6”	6 to 12”	
RY007A	Low	Low	Mod (*Low*)	Y
RY008A	Low (*Mod*)	Low	Low	Y
RY023A	Mod (*Low*)	Low	Mod (*Low*)	Y
RY023B	Low	Low	Mod (*Low*)	Y
RY026C	Low	Low (*Mod*)	Low	B
RY061E	Low	Low	Low (*Mod*)	Y
RY089I	Mod (*Low*)	Low	Low	D
RY095B	Mod (*Low*)	Mod (*Low*)	Low	Y
RY095C*	Low	Low	Mod (*Low*)	Y
RY108E	Low	Mod (*Low*)	Low	B
RY109A	Low	Low	Mod (*Low*)	Y
RY144D	Low	Low (*Mod*)	Mod	D
RY160B	Mod	Low)	Low	Y
RY193C	Low	Low	Mod	Y
RY193D	Mod (*Low*)	Low	Low	D
RY234D	Low	Low	Low (*Mod*)	D
RY251D*	Low	Low (*Mod*)	Low)	D
RY271D	Low	Mod	Mod (*Low*)	D
RY277D	Low	Mod (*Low*)	Low	D
RY284A	Mod	Mod (*Low*)	Low	Y
RY352C	Low	Mod (*Low*)	Mod (*Low*)	B
RY483B	Mod (*Low*)	Low	Low	Y
RY483D	Low	Low	Mod (*Low*)	D
RY485F	Mod	Low	Low	D
RY597D	Low	Mod	Low	D
RY616A	Low	Mod	Low	Y

*Property included in emergency removal due to high XRF reading.
All concentrations in ppm.
One category shown indicates both arsenic and lead are in same category
Y = yard, D = driveway, B = bare area

Approximately 81 percent (18 of 22) of the properties in the moderate category had moderate lead concentrations. This included 22 of 48 sampling locations (RY007-A, RY023-A and B, RY061-E, RY089-I, RY095-B and C, RY108-E, RY109-A, RY144-D, RY160-B, RY193-C and D, RY271-D, RY277-D, RY284-A, RY352-C, RY483-B and D, RY485-F, RY597-D, and RY616-A). The remaining four properties had low lead concentrations, but moderate arsenic concentrations (Table 5-3). The moderate concentrations were found in all three depths, although no pattern in their vertical distribution was evident. Only five locations had elevated lead in two depths. The remaining locations had moderate concentrations in only one depth.

Slightly less than 60 percent (13 of 22) of the properties in the moderate category had moderate arsenic concentrations. These concentrations were seen in 13 of the 48 sampling locations (Exhibit 5-2). The remaining properties had low arsenic concentrations, but moderate lead concentrations (Table 5-4).

The moderate concentrations were found in 13 yards, 10 driveways, and 3 bare areas (Exhibit 5-2). The locations of properties in the moderate concentration category are shown on Figure 5-2. As expected, these properties are broadly dispersed throughout the community, and there is no clear pattern of spatial distribution evident. This is consistent with the assumption that the waste was imported to individual properties on a case-by-case basis for use as driveway fill or as base material for buildings. The concentrations of lead and arsenic at the higher end of the moderate ranges are likely the result of mine waste. Concentrations at the lower end of the moderate ranges may also result from other sources related to the use of the property (e.g., lead paint).

5.1.1.3 Properties with High Concentrations

At 30 of the 154 residential properties, laboratory results for one or more sampling locations placed that property in the high category for lead (greater than 1,200 ppm) and/or arsenic (greater than 400 ppm) (Exhibit 5-3). There were 176 samples in this category. Lead concentrations in this entire group ranged from 26 to 36,800 ppm, with an average of 1,852 ppm. Arsenic concentrations ranged from 3 to 1,880 ppm with an average of 239 ppm. Over half (21) of properties in this high category had high concentrations of *both* lead and arsenic.

Exhibit 5-3 shows only the sampling location(s) that placed the property in the high category, as a result of one or more depths with a high lead and/or arsenic sample. Samples from other locations on the property are not shown because the concentrations were either in the low or moderate category.

A total of 18 of the locations with high concentrations were driveways, and half of those driveway locations had elevated concentrations at one or more depths. Mine waste was visible during the sampling at five driveway locations. An almost equal number (17) of high concentrations were reported in yard sampling locations. Waste was either visible or suspected in eight of these samples. As with the driveway locations, about half of the yard locations had elevated concentrations at multiple depths. The remaining four high locations were bare areas.

Tables 5-5 and 5-6 show *all* the CLP laboratory results for lead and arsenic, respectively for the samples sent for laboratory analysis for a given property. High lead was reported at 30 properties in 38 of 74 sampling locations. The concentrations in those 38 sampling locations range from 106 to 36,800 ppm, with an average of 3,335 ppm (Table 5-5). High arsenic concentrations were reported at 20 properties in 25 of the 54 sampling locations on those properties. Arsenic concentrations in those 25 sampling locations range from 16 to 1,880 ppm, with an average of 541 ppm (Table 5-6).

Exhibit 5-3. Residential Sample Locations in High Concentration Category

Sample Loc.	**Category by Depth** lead (*arsenic*)				**Sample Loc.**	**Category by Depth** lead (*arsenic*)			
	0 to 2”	2 to 6”	6 to 12”			0 to 2”	2 to 6”	6 to 12”	
RY006D*	High	Mod	Low	D	RY125D*	Mod	High	Mod (*High*)	D
RY021D	Low	Low	High (*mod)*	D	RY130B	High (*Mod*)	Low	Low	Y
RY030D*	Low (*mod)*	High	Low	D	RY140B	Low	High	High (*Mod*)	Y
RY030E	Low	High	Low	Y	RY140C*	Low	High	Low	Y
RY036D	High	Mod	Mod	D	RY148B*	High	High	High (*Mod*)	Y
RY043B*	Low	High	Low	Y	RY176E	Low	High (*low*)	Low	Y
RY045D*	High	Low	Low	B	RY198D*	High	High (*Mod*)	Low	D
RY053C*	Mod	High	High	D	RY240B*	Low	High	Low	Y
RY084C*	High	Mod	Mod	Y	RY240D*	Low	Mod	High	D
RY086A	High (*Mod*)	High (*Mod*)	Low	Y	RY257C	High (*Mod*)	Low	Low	Y
RY086D*	High	High	High	D	RY303D*	High	Mod	High	D
RY091D*	High (*Mod*)	Mod	High (*Mod*)	D	RY304C*	Low	High	High (*Mod*)	Y
RY091E	High (*Mod*)	Low	Low	D	RY338C*	High	High	High	D
RY092C	Mod	High (*mod*)	High (*Mod*)	Y	RY387D*	High	Mod (*Low)*	Mod (*Low*)	D
RY094F*	High (*Mod*)	High (*Mod*)	High (*Mod*)	B	RY422D	High	Mod (*Low)*	Low	D
RY101A*	Low	Low	High	Y	RY506D	Mod (*Low)*	High (*Mod*)	Mod (*Low*)	D
RY101C*	High	High	Mod	Y	RY506F*	High (*Mod*)	High	High (*Mod)*	Y
RY101D	High	Mod (*Low)*	Low	D	RY523C	High	High	High (*Mod*)	B
RY102D*	High	High	Mod (*Low)*	D	RY600A	High	High	High (*Mod)*	Y

*Emergency removal conducted in 2010 All concentrations in ppm
One category shown indicates both arsenic and lead are in the same category
Y = yard, D = driveway, B = bare area

The locations of the properties in the high category are shown on Figure 5-2. As with the moderate category, there was no pattern evident in the spatial distribution of the properties with high concentrations of lead or arsenic. The elevated lead and arsenic concentrations in these samples are almost certainly due to the presence of mine waste that was brought to the property as fill material.

5.1.2 2010 Emergency Removals

Emergency removals were conducted by EPA's Removal Branch at the 25 residential properties (Exhibit 5-4). Most (21) were properties where a high field XRF reading was confirmed by a laboratory results. Two of the properties (RY095 and RY251) had high XRF results for lead, but low CLP results. Two other properties (RY092 and RY345) did not have lead readings above 3,000 ppm in the screening, but they abutted excavations at RY091 and RY053, respectively. The emergency removal was carried over into the adjacent soils at these two properties, with the consent of the property owners on the basis of XRF reading seen during excavation (Nguyen 2011b). No data was available on which sampling areas were removed at those two locations.

Within the 23 properties listed in Table 5-7, there were 24 sampling locations with concentrations of lead greater than 3,000 ppm or arsenic greater than 400 ppm in at least *one* of the depth intervals. The concentrations of lead in the remediated properties ranged from 143 to 36,800 ppm, with an average of 3,720 ppm, and arsenic ranged from 16 to 1,880 ppm, with an average of 496 ppm.

Excavations in a given area were conducted to a minimum depth of 12 inches, which was the deepest interval for which screening data were collected in the RI. Confirmation samples were taken from the bottom of the excavation. If concentrations were elevated in the confirmation samples, the removal group used field discretion to determine if the excavation should be advanced further. In gardens, excavations were advanced to 24 inches. The maximum depth (e.g. the fairgrounds) was 36 inches, at which point the excavation was stopped to avoid damaging fence posts (Nguyen 2011b). All excavations were backfilled with clean soil.

Exhibit 5-4. Residential Properties with Emergency Removals in 2010

Sample Location	Category	
	Lead	Arsenic
RY006D	High	High
RY030D	High	High
RY043B	High	Mod
RY045D	High	High
RY053C	High	High
RY084C	High	High
RY086D	High	High
RY091D	High	Mod
RY092	Low	Low
RY094F	High	Mod
RY095C	Mod	Low
RY101A&C	High	High
RY102D	High	High
RY125D	High	High
RY140B&C	High	High
RY148B	High	High
RY198D	High	High
RY240B&D	High	High
RY251D	Low	Mod
RY303D	High	High
RY304C	High	High
RY338C	High	High
RY345	Low	Low
RY387D	High	High
RY506F	High	High

High: >1200 ppm lead or >400 ppm arsenic,
Mod: 400 to 1200 ppm lead OR 100 to 400 ppm arsenic,
Low: <400 lead or <100 arsenic

The removals significantly reduced the overall concentrations of lead and arsenic at the properties in the high category. However, areas of high contamination (greater than 1,200 ppm of lead or 400 ppm of arsenic) still remain in one sampling location from each of 14 properties (Figure 5-3). Those areas were not excavated because lead concentrations were less than 3,000 ppm. Although the removal report has not been issued, it is believed that EPA excavated sampling area RY140-B as the concentration of lead at (2,880 ppm) was very close to the 3,000 ppm cutoff and they were removing the adjacent sampling area. This will be confirmed after the removal report is issued.

Reasons for high concentrations to be present after the removals were conducted at the site are:

- **Concentrations were not high enough to trigger emergency removal in this sampling location.** Removals were conducted at other more highly contaminated sampling locations on five properties (RY030, RY086, RY091, RY101, and RY506).
- **Concentrations were not high enough to trigger emergency removal at the property.** Concentrations were high, but not high enough to trigger an emergency removal at seven properties (RY021, RY036, RY092, RY130, RY176, RY257, and RY422).
- **Concentrations were not known at the time of the removals.** High laboratory results for two properties (RY523, and RY600) had not been received at the time of the removals.

Lead concentrations at the remaining high locations range from 106 to 17,800 ppm, with an average of 2,158 ppm (Table 5-5). Arsenic concentrations at those locations range from 91 to 737 ppm, with an average of 393 ppm (Table 5-6).

Of these 14 remaining high properties, the distribution of contamination is:

- Six driveways (RY021-D, RY036-D, RY091-E, RY101-D, RY422-D, and RY506-D)
- Five yard locations (RY030-E, RY086-A, RY092-C, RY130-B, and RY257-C)
- Three bare locations in a yard or borders of yards with alleys (RY176-E, RY523-C, and RY600-A)

5.2 Non-Residential Properties

Only 88 of the 588 (15 percent) of the properties sampled at the site in the 2009 and 2010 field season were non-residential. They included properties such as: medical offices, a shopping center, a motel, a bar, a gas station, a restaurant, asphalt parking lots, businesses located in residential-type homes, various shops, open lots located in predominantly commercial areas, storage units, fuel distribution outlets, parks, schools, churches, the hospital, and the fairgrounds. Although the current use of these properties is non-residential, Superior has no zoning and it is possible that they could become residential properties in the future.

5.2.1 XRF Screening Results

All 1,171 samples from non-residential properties were screened using the XRF analyzer. This included 477 samples in 2009 and 694 samples in 2010 (Exhibit 5-5). Samples were equally distributed between the three depth intervals (0 to 2 inches, 2 to 6 inches, and 6 to 12 inches). The number of sampling locations on the non-residential properties ranged from 1 to 19. These properties were generally much larger than the typical residential property. Samples were also occasionally taken from discrete piles of soils or other areas that appeared to have a potential for mine waste to be present.

The same screening level (250 ppm lead by XRF) was used for non-residential properties to provide a conservative estimate of which samples would have concentrations above 400 ppm for lead if analyzed by the laboratory. As with residential samples, non-residential samples below 250 ppm by XRF were considered to be in the "low concentration" category and would be unlikely to require additional investigation or cleanup. Those samples were archived after screening.

Exhibit 5-5. Summary of XRF Screening of Non-Residential Properties

Parameter	Results less than LOD		Results greater than LOD				
	Number of Samples	Percent of Total	Number of Samples	Percent of Total	Low (ppm)	High (ppm)	Average (ppm)
Arsenic	763	65	408	35	6.9	2,973	90.6
Lead	335	29	836	71	8.7	13,397	228.1

Data from 488 properties and 6038 samples collected in 2009 and 2010
XRF – X-ray fluorescence
LOD = level of detection

The majority of samples (93 percent or 1,090) screened by XRF were in the low concentration category on the basis of their XRF reading, and 335 samples (29 percent) were below the LOD for lead. Lead concentrations by XRF for all non-residential samples above the LOD ranged from 8.7 to 13,397 ppm, with an average of 228 (Appendix C). For the 81 samples that exceeded the 250 ppm lead screening level, concentrations of lead ranged from 262 to 13,397 ppm, with an average of 1,873 ppm. For arsenic, 763 samples (65 percent) were below the LOD, and concentrations above the LOD ranged from 6.9 to 2,973 ppm, with an average of 90.6 ppm. Arsenic concentrations were not used to select samples for further analysis.

The 81 samples that exceeded the lead screening level were sent to the CLP laboratory for further analysis (Section 5.2.2). Approximately 5 percent of the remaining samples were also sent for QA purposes. The result for RY392 was invalid and was not recorded. That sample was sent to the CLP laboratory for analysis.

5.2.2 Lead and Arsenic Analysis by CLP Laboratory

A total of 162 samples from 39 non-residential properties (Table 5-8) were submitted for laboratory analysis. These samples represent approximately 20 percent of the total samples sent to the laboratory. As noted above, 81 samples were sent to the laboratory because they exceeded the screening level for lead. The remainder was sent for QA purposes or for reasons relating to issues with the XRF.

Seven of the properties are owned by Mineral County and three are owned by the USFS. The remaining properties are privately owned and used for commercial purposes. The distribution of samples by depth was: 0 to 2 inches, 64 samples (32 percent); 2 to 6 inches, 64 samples (32 percent); and 6 to 12 inches, 73 samples (36 percent). The results of the analysis for lead and arsenic are discussed below. Results for other parameters are discussed in Section 5.3.

5.2.2.1 **Properties with Low Concentrations**

Approximately half (20 of 39) of the non-residential properties had laboratory concentrations that placed them in the low category (less than 400 ppm for lead and 100 ppm for arsenic) (Figure 5-4). Those properties are: RY082, RY106, RY107, RY113, RY221, RY317, RY319, RY325, RY383, RY392, RY393, RY403, RY407, RY412, RY418, RY433, RY480, RY484, RY522, and RY598. Three of these properties are municipal properties (Eva Horning Park, town maintenance shop, and a vacant lot). These properties included 29 sampling locations and a total of 52 samples.

Lead concentrations in the 52 samples from this group ranged from 8 to 343 ppm, with an average of 131 ppm (Table 5-9). Arsenic concentrations ranged from 3 to 41 ppm, with an average of 12.5 ppm (Table 5-10). As with the residential properties, the concentrations of lead and arsenic at the lower end of the ranges for these non-residential properties are likely indicative of natural background concentrations in the area. Concentrations at the higher end of the ranges may be the results of variations in natural conditions, limited amounts of mine waste, or other sources (e.g. lead sources such as paint, gasoline, or auto batteries).

5.2.2.2 **Properties with Moderate Concentrations**

Only 18 percent (7 of the 39) of the non-residential properties (Exhibit 5-6) had CLP laboratory results that placed them in the moderate category (400 to 1200 ppm lead *or* 100 to 400 ppm arsenic) (Figure 5-5). These were all commercial properties, and they included 20 sampling locations. Lead concentrations for all 47 samples from properties in the moderate category ranged from 80.8 to 1,160 ppm, with an average of 326 ppm (Table 5-11). Arsenic concentrations in the moderate category ranged from 9.6 to 191 ppm, with an average of 42 ppm. As with the residential sampling, all sample locations are assigned a category on the basis of their highest sample results.

Exhibit 5-6. Non-residential Properties in Moderate Concentration Category

Sample Location	**Category by Depth** lead (*arsenic*)		
	0 to 2”	2 to 6”	6 to 12”
RY097C	Mod(*Low)*	Low	Low
RY099B	Mod(*Low)*	Low	Low
RY100A	Mod(*Low)*	Mod(*Low)*	Mod(*Low)*
RY100B	Low	Low	Mod(*Low)*
RY136B	Low	Mod(*Low)*	Mod(*Low)*
RY366A	Low	Low	Mod(*Low)*
RY366D	Low (*Mod)*	Low	Mod(*Low)*
RY369B	Low	Mod(*Low)*	Low
RY386A	Low (*Mod)*	Mod(*Low)*	Mod(*Low)*
RY386B	Low (*Mod)*	Mod(*Low)*	Low
RY386D	Mod(*Low)*	Low	Low

Mod: 400 to 1200 ppm lead or 100 to 400 ppm arsenic
Low: <400 ppm lead or <100 ppm arsenic
One category shown indicates both arsenic and lead are in same category

In the 11 sampling locations that had moderate concentrations, lead ranged from 106 to 1,160 ppm, with an average of 430 ppm (Table 5-11). These moderate concentrations of lead were found in all three depths.

Most of the arsenic concentrations in this category were low. The exceptions were RY366-D and RY386-A and –B. Arsenic concentrations in those three elevated sampling locations ranged from 24 to 191 ppm, with an average of 93 ppm (Table 5-12). The moderately elevated concentrations of lead and arsenic at these properties are likely the result of mine waste, but could also result from other sources related to the use of the property.

5.2.2.3 Properties with High Concentrations

Approximately 32 percent (12 of 39) of the non-residential properties (Exhibit 5-7) sent for laboratory analysis had CLP results that placed them in the high category (greater than 1,200 ppm of lead or greater than 400 ppm of arsenic). Four of these properties are owned by Mineral County (library, high school, fairgrounds, and hospital). The other properties are privately-owned in commercial use. There were a total of 31 sampling locations in this category. Lead concentrations in the 63 samples in this category ranged from 64 to 20,400 ppm with an average of 2,432 ppm. Arsenic concentrations in this category ranged from 5.4 to 3,370 ppm, with an average of 397 ppm.

Exhibit 5-7. Non-Residential Properties in High Category

Sample Location	**Category by Depth** lead (*arsenic*)		
	0 to 2”	2 to 6”	6 to 12”
RY098A	Mod	High (*Mod*)	High (*Mod*)
RY111B	Low	Low	High
RY112A*	Low	Low	High
RY115A*	High	High	High
RY115E	Mod	High	Mod
RY118O*	High	Mod	Mod (*High*)
RY118P*	High	High	High
RY146B	Low	Low	Low (*High*)
RY213B	Mod	Mod	High (*Mod*)
RY289G*	High	High	Low
RY332B*	Low	Mod (*Low*)	High (*Mod*)
RY398A	Mod (*Low*)	High (*Low*)	High (*Low*)
RY398B	Mod (*Low*)	High	Mod
RY402A	High (*Low*)	Low	Low
RY627B	High	High	High (*Mod*)
RY627C	High (*Mod*)	High	High
RY627D	Low	High	High (*Mod*)

*Emergency removal conducted in 2010.
Mod: 400 to 1200 ppm lead or 100 to 400 ppm arsenic
Low: <400 ppm lead or <100 ppm arsenic
One category shown indicates both arsenic and lead are in same category

Lead concentrations were high in 16 of the 31 sampling locations (RY098-A; RY111-B; RY112-A; RY115-A and -E; RY118-O and -P; RY213-B; RY289-G; RY332-B; RY398-A and -B; RY402-A; and RY627-B, -C, and -D). Concentrations of lead in those 16 sampling locations ranged from 174 to 20,400 ppm, with an average of 3,733 ppm (Table 5-13). At 12 of the 15 elevated sampling locations, high lead concentrations were present in two or more depth intervals. There was no pattern in the distribution by sample depth.

Arsenic concentrations were high in 12 of the 31 sampling locations (RY111-B; RY112-A; RY115-A and -E; RY118-O and -P; RY146-B; RY289-G; RY398-B; and RY627-B, -C, and -D). Concentrations in those samples ranged from 28 to 3,370 pm, with an average of 764 ppm (Table 5-14).

The locations of the 12 non-residential properties in this high concentration category are shown on Figure 5-5. As with the residential properties, the results confirm the assumptions made in the site model that mine waste was brought to the site on a property by property basis for use as fill in driveways or in other areas (e.g., the school track and the fairgrounds). The clustering of elevated concentrations in Mullan Road businesses is likely due to the large volume of mine waste that was reportedly imported for use in for construction of Mullan Road in the 1950s.

5.2.2.4 **2010 Emergency Removals**

EPA conducted emergency removals in 2010 at four of the non-residential properties to remove the highest concentrations of lead (Exhibit 5-8). The emergency removals were targeted at residential properties with concentrations of lead greater than 3,000 ppm. However, some non-residential properties were also included to take advantage of the mobilization of the removal contractor. Those non-residential properties were generally those having concentration of lead greater than 3,000 ppm where exposure to children or other sensitive populations was likely.

Exhibit 5-8. Non-Residential Properties with EPA Emergency Removals in 2010

Sample Location	Description	Date	Volume Removed (cy)
RY112A	High school track	8/9/10	550
RY115A	Fairgrounds	7/26/10	690
RY118O&P	Hospital	*	*
RY332B	Mullan Rd business	7/26/10	1,640

*Not available until EPA's removal report is issued
cy = cubic yards

The non-residential removals conducted by EPA in 2010 included one sampling area at the high school track (RY112-A), two at the fairgrounds (RY115-A and -E), two at the hospital (RY118-O and -P), and one at a vacant lot on Mullan Road (RY332-B) (Figure 5-6). The USFS also remediated a small area of contamination at one of their properties (RY289-G) under EPA oversight. Lead concentrations at the sampling locations targeted for removal by EPA ranged from 190 to 20,400 ppm, with an average of 6,162 ppm (Table 5-15). Arsenic concentrations in those sample locations ranged from 28 to 3,370 ppm, with an average of 940 ppm.

Excavations in a given area were conducted to a minimum depth of 12 inches, which was the deepest interval for which screening data were collected in the RI. Confirmation samples were taken from the bottom of the excavation. If concentrations were elevated in the confirmation sample, the removal group used field discretion to determine if the excavation should be advanced further. In gardens, excavation was advanced to 24 inches. In some locations (e.g., the fairgrounds) the excavation was advanced as far as 36 inches. The excavation was then backfilled with clean soil.

The removals reduced the overall concentrations of lead and arsenic at the properties in the high category. However, high lead concentrations remain in nine sampling locations at six properties. Lead concentrations at those locations range from 174 to 13,900 ppm, with an average of 2,822 ppm (Table 5-13). High arsenic concentrations remain in 6 sampling locations on 4 properties. Concentrations at those locations range from 34 to 2,620 ppm, with an average of 596 ppm (Table 5-14). These high arsenic locations also have high lead.

Reasons for high concentrations to be present after the removals were conducted at the site are:

- **Concentrations were not high enough to trigger emergency removal at the property.** Concentrations were high, but not high enough to trigger an emergency removal at four properties (RY098, RY111, RY213, and RY398).
- **Concentration was not known at the time of the removals.** High laboratory results for one property (RY402) had not been received at the time of the removals.
- **Concentration was not included because of its industrial nature.** One property (RY627) is a fenced, industrial parking area and yard for Blackfoot Energy and EPA chose not to conduct an emergency removal because of a lack of exposure to the public.

Of the 6 remaining high properties where removals were not conducted, the distribution of contamination is:

- Two driveways (RY098-A, south drive and RY146-B, upper drive)
- Three yard locations (RY111-B, behind the library; RY398-A and -B, SE yard and field at Hilltop Hotel)
- Four bare locations (RY402-A, bare lot and RY627-B, -C, and- D, bare yard areas of Blackfoot Energy)

5.2.3 Alleys

Alley sampling was added to the end of the 2010 field season to take advantage of the field crew being mobilized after all residential properties had been sampled. As described in Section 4.3.5, an amendment was made to the SAP to allow for sampling that would provide additional information of potential sources of exposure to residents, especially children who might ride bicycles or play in the alleys near their homes or schools.

Thirty alleys (162 samples) were included in the 2010 sampling event (Figure 4-2). Each alley was divided into two to three sampling locations (A and B and sometimes C). Five individual sampling points were chosen from each sampling location, and the materials collected were composited into a single sample for that sampling location (e.g., AL002-A). Finally, each sampling location was sampled at two depth intervals: 0 to 2inches and 2 to 6 inches (e.g., AL002-A 002006). A total of 162 composite alley samples were screened using XRF.

As with residential and non-residential samples, alley samples below 250 ppm by XRF were considered to be in the “low concentration” category and would be unlikely to require additional investigation or cleanup. Those samples were archived after screening. In almost all locations sampled, surface and near surface alley soils appeared to be unaffected by mine-related contamination and concentrations were in the low category.

Only one alley sampling location (AL033-B) had XRF readings above 250 ppm for lead. That location is immediately behind the 4 Aces Bar, in a commercial area of town. There are no nearby residential properties. The lead concentration in that sample was 2,240 ppm in the 0- to 2-inch interval and 5,215 ppm in the 2- to 6-inch interval. The arsenic concentration in that sample was 250 ppm in the 0- to 2-inch interval and 1,031 ppm in the 2- to 6-inch interval.

The remaining alley samples were in the low concentration category on the basis of their XRF reading. When sample location AL033-B is removed from the data set, the lead concentrations by XRF in the rest of the alley samples ranged from below LOD to 227 ppm, with an average of 34 ppm (Appendix C). Arsenic concentrations by XRF ranged from below LOD to 46 ppm, with an average of 5 ppm. No alley samples were sent for laboratory analysis, and no sampling locations were included in the emergency removals.

5.3 Comparison of CLP Results for All TAL Parameters to Background

CLP laboratory results were obtained for 20 parameters besides lead and arsenic (Appendix D). Those parameters are: aluminum, antimony, barium, beryllium, cadmium, calcium, chromium, cobalt, copper, iron, magnesium, manganese, nickel, potassium, selenium, silver, sodium, thallium, vanadium, and zinc.

Exhibit 5-9 provides the range and average concentration for each parameter for all properties. Concentrations for most parameters are below the EPA’s Regional Screening Levels (RSLs). Only six parameters (antimony, arsenic, cadmium, lead, vanadium, and zinc) exceeded their respective RSLs.

Because so many samples were collected at the site, it was possible to calculate site-specific background concentrations for those parameters that exceeded the RSLs (Exhibit 5-9). The background concentrations were calculated using yard-wide averages. This provided a better understanding of natural conditions at the site.

For the parameters that had exceedances of the RSLs, there were generally also numerous exceedances of the background concentration. The exception was vanadium, which exceed the RSL in 87 percent of samples, but exceeded the background range in only 3 percent of samples. This suggests that vanadium exceedances of the RSL are related to local background soil conditions and not mine-related contamination.

Exhibit 5-9. Summary of CLP Data of TAL Metals in Relation to Background and RSLs

Parameter	**Range of Concentrations**			**OU-specific background**	**RSL***	**Exceedances (percent of samples)**	
	Low	**High**	**Ave**			**Background**	**RSL**
antimony	0.22	13,000	70.4	0.3 to 10.4	31	30%	16%
arsenic	0.45	3,370	80.2	0.86 to 8.9	0.39	45%	100%
cadmium	0.01	172	3.0	0.01 to 1	70	34%	1 sample
lead	1.1	36,800	572	2.2 to 9.3	400	68%	20%
vanadium	1.8	31.6	9.9	4.6 to 16.5	5.5	3%	87%
zinc	7	27,500	514	12.9 to 38.2	23,000	70%	1 sample
Parameters with no exceedances of RSLs							
aluminum	1,700	26,000	6,733	Not calculated	77,000	Not calculated	None
barium	0.5	1,090	126		15,000		
beryllium	.017	.84	0.37		160		
cobalt	0.55	14.1	4.6		23		
copper	1.6	1,190	20		3,100		
iron	1,910	**66,600**	10,918		55,000		
manganese	63	3780	418		1,800		
nickel	0.95	17	6.5		3,800		
selenium	0.31	5.9	2.4		390		
silver	0.9	500	4.1		390		

All concentrations in milligrams per kg (mg/kg) (ppm)
Bold font indicated exceedance of background or RSL (Region 9 Regional Screening Level for residential soils)
RSLs= EPA Regional Screening Levels for soils

Two parameters (cadmium and zinc) exceeded RSLs in only one sample from one property (RY115-A). This sample (fairgrounds) had the second highest concentration of lead on site and one of the top 10 highest concentrations of arsenic. The property was addressed by EPA's emergency removal in 2010. No other samples had concentrations near the RSLs for cadmium or zinc. This indicates that cadmium and zinc are related to the mine waste, but as a minor constituent that only exceed the RSLs in rare instances, when concentrations of the primary indicators (lead and arsenic) are very high.

The TAL analysis provides a total chromium result, and EPA no longer has an RSL for total chromium. Only 10 percent of the samples exceed the site-specific background concentrations for chromium (1.2 to 9.8 mg/kg), and those sample locations generally also had elevated concentrations of lead and arsenic.

These findings confirm results of previous sampling events in identifying antimony, arsenic, and lead as the primary indicators of mine-related contamination at the site. Elevated concentrations of antimony are almost always seen in conjunction with elevated concentrations of lead and/or arsenic.

Section 6 Contaminant Fate and Transport

6.1 Chemicals of Potential Concern

The chemicals of potential concern (COPCs) identified for OU1 are metals in mining-related wastes and soils contaminated with those waste. These were screened and selected through the Superfund risk assessment process (see Section 7) based on:

- Frequency of detection in greater than 5 percent of the historical samples
- Potential toxicity to human health (less toxic substances were eliminated from evaluation)
- Screening level toxicity criteria
- Input from EPA Region VIII toxicologists

Based on the risk assessment work (see Section 8), the COPCs for solid media are antimony, arsenic, and lead. This section discusses the sources, characteristics, and potential transport and fate of the COPCs. The focus of OU1 is the mine waste in the upper foot of soils. The remainder of site media will be addressed under a separate OU.

6.2 Sources of Contaminants in OU1

The source of contaminants in OU1 is the IMM mine north of town (in OU2). As discussed previously, mine waste was readily available for no cost, the source was near to town, and the material packed well and was well sorted and graded. It was widely used on private properties (e.g., in driveways) and on non-residential properties (as road base, as a base course under sidewalks, as a base for the school track and in areas where fill material was needed for to create level areas (e.g., parks and the fairgrounds). The material was also reported to be used to suppress weed growth at locations where properties bordered alleys or roads.

Much of the material for the roads was imported in the 1950s and 1960s when significant road building was done in the community. Material for the track was imported in the 1960s. Importation for driveways and other small areas has occurred sporadically thereafter.

6.3 Mechanisms of Contaminant Migration and Transport

There are four primary mechanisms for migration of COPCs at the site:

- Migration in soil
- Wind erosion
- Migration in surface water

- Migration in ground water

6.3.1 Migration Potential in Soil

Elements and compounds added to soil will normally be retained near the soil surface. Movement of elements into other media (i.e., groundwater, surface water, or the atmosphere) should be limited, as long as the retention capacity of the soil is not exceeded. The extent of movement of an element in the soil system is related to the physical and chemical properties of the soil as well as the elements and compounds in the waste materials. Based on experience at other mining-related sites, it is unlikely that the COPCs are migrating through the soil profile and accumulating at depth.

6.3.2 Migration Potential by Wind Erosion

The potential for release of COPCs to the air is limited to wind erosion of source materials and suspension of particulates in the form of fugitive dust. The potential for wind erosion increases as the particle size decreases. Wind is expected to be a transport mechanism when waste material is dry and exposed. The ground in this area is frozen, wet, or covered with snow during at least six months of the year. Therefore, windborne dust is not generated, and airborne transport is a mechanism of concern for only part of the year, and only for areas that are not vegetated.

Most of the major concentrations of mine waste that were imported the OU1 were used as backfill for streets or sidewalks, and they are covered with asphalt or cement. Areas of exposed, scattered mine waste that was a remnant of that road building process are present in vacant lots or bare areas near those roads. Some of this material is currently exposed, and could be impacted by wind erosion. In other cases, overlying vegetation protects the mine waste from erosion. For the locations where mine waste was brought in as fill for driveways, the material is exposed to the wind, but appears to be well-packed and large enough in particle size so that wind erosion is not evident.

6.3.3 Migration Potential in Surface Water

Releases of contaminants to surface water can occur when waste material or contaminated soil is exposed. If uncontrolled, solid waste material can erode into the storm water system, perennial tributaries, and potentially the Clark Fork River. Investigation of surface water was outside the scope of the RI for OU1. However, based on the data collected for OU1, there is no evidence as yet that the COPCs have migrated significantly via the surface water transport mechanism. No visual evidence of runoff was noted in the field.

6.3.4 Migration Potential in Groundwater

Investigation of groundwater was not included in the RI for OU1 and the migration potential for contaminants to groundwater has not been characterized. However, the mine waste materials were primarily imported for shallow use, other than those used for road base. The road base materials are essentially capped by the overlying asphalt which would limit infiltration of precipitation through the contaminated material. The driveways are uncapped and infiltration is possible. However, the individual driveways that are constructed of mine waste are scattered and do not present a concentrated source area for contamination of groundwater.

6.4 Contaminant Persistence

Geochemical processes and elemental/compound characteristics that control the transport and fate of the OU1 contaminants include precipitation, dissolution, sorption, complexation, ion exchange, oxidation/reduction, solubility, and speciation. In soil and sediment, arsenic and lead can be dissolved in the soil solution, held on inorganic soil constituents through adsorption or ion exchange, complexed with insoluble soil organic matter, and precipitated as pure or mixed solids (Smith et al. 1995). These metals will have different rates of migration depending on chemical conditions in site media. Under certain environmental conditions, metal compounds can be mobilized and transported through the vadose or perched water zones to groundwater, taken up by plants and aquatic organisms, become more available or toxic to human receptors, or dispersed through volatilization. Conversely, transformation by adsorption, ion exchange, complexation, or precipitation can prevent the movement of metal contaminants to groundwater. Thus, characteristics of the site media will affect metal form, mobility, migration, and fate.

6.4.1 Antimony

Antimony, in its pure metallic form, is a silvery-white brittle solid. Estimates of the amount of antimony in the crust are between 0.2 and 0.5 ppm. Antimony can be found in over 100 species of minerals, most commonly as stibnite. Although antimony resembles a metal, it has poor electrical and conductive properties and does not react chemically like a metal and is classified as semi-metallic. Man-made sources of antimony include waste incinerators and coal burning power stations. It is also emitted due to the combustion of petroleum products, particularly from car exhausts. Since antimony occurs naturally in the earth's crust, it is found in soils, sediments and natural waters, generally at low concentrations.

Antimony is stable under ordinary conditions and is not readily attacked by air or water. It reacts with strong oxidizers, acids, and halogenated acids. Little information is available on the transformations and transport of antimony in various environmental media (e.g. air, water, soil). The mobility of antimony in soils is not clearly understood. Some studies indicate that antimony is highly mobile, while others conclude that it strongly adsorbs to soil. In water, it usually adheres to sediments. Most antimony compounds show little or no tendency to accumulate in aquatic life.

6.4.2 Arsenic

Arsenic compounds in soils and sediments can undergo a complex series of transformations and “factors most strongly influencing these fate processes include oxidation-reduction conditions (Eh), pH, the presence of certain competing anions and complexing ions, clay and hydrous oxide contents, metal sulfide and sulfide ion concentrations, salinity, and the distribution and composition of the biota” (Smith et al. 1995). Although arsenic compounds are often strongly sorbed onto soil and sediment particles and therefore relatively immobile, migration can occur under specific conditions.

Arsenic occurs in nature in oxidation states of -3, 0, +3, and +5; however, only trivalent (As(III)) and pentavalent (As(V)) arsenic are important under most Eh-pH conditions. As(III) oxospecies are labeled arsenites, while As(V) oxospecies are termed arsenates. Each arsenic species behaves differently with respect to geochemical processes, as well as displaying varying degrees of toxicity. Arsenite is the more toxic form of arsenic (EPA 1992). For example, the arsenite species, H3AsO30, is 60 times more toxic to humans than the arsenate, HAsO42- (Houslow 1980), while also being 4 to 10 times more mobile (Deuel and Swoboda 1972).

Arsenic (V) compounds predominate in aerobic soils and sediments, while As(III) compounds predominate in slightly reduced soils/sediments (Smith et al. 1995). Arsine, methylated arsines, and arsenic metal predominate in highly reduced conditions. Arsine and methylated derivatives, which can occur through biotransformation processes, are highly volatile and will vaporize after formation. Under soil conditions of high organic matter, warm temperatures, adequate moisture, and other conditions conducive to microbial activity, the reaction sequence is driven toward methylation and volatilization (Woolson 1977). In this way, arsenic can be transferred from sediments back to the water column in aquatic systems and from soil to pore water in the vadose zone. In addition to adsorption, As(V) and As(III) compounds also can be removed from water through coprecipitation with iron oxides or by isomorphic substitution with phosphorus in minerals (Smith et al. 1995). Arsenic also appears to be more mobile under both alkaline and more saline conditions.

Transformations of arsenic in surface water and groundwater are similar to those occurring in soils and sediments. Arsenate is usually the primary form of arsenic in surface water; however, aquatic microorganisms can reduce arsenate to arsenite and a variety of methylated compounds. Arsenate also occurs in groundwater but typically sorbs onto iron-bearing minerals so arsenite is often the major component in the water, depending on the characteristics of the water and the surrounding geology (Smith et al. 1995).

Bioconcentration of arsenic can occur in aquatic organisms, primarily in algae and the lower invertebrates; however, biomagnification in aquatic food chains does not appear to be significant, although some fish and invertebrates contain high levels of arsenic compounds (Smith et al. 1995). Terrestrial plants may accumulate arsenic by root uptake from the soil or by absorption of airborne arsenic deposited on the leaves.

6.4.3 Lead

Lead is naturally present in all soils, generally in the range of 15 to 40 mg/kg. Sources of lead contamination include fall-out of atmospheric dust, industrial and municipal wastewater effluent, mineral fertilizers and pesticides, lead-based paints, and wastes from the mining, metallurgical, chemical, and petrochemical industries (USEPA 2007). In absolute numbers, lead is by far the most common inorganic contaminant found at

Superfund sites. For example, in 1996 lead contamination was found at 460 Superfund sites, compared to 306 with chromium contamination, 235 with arsenic, 226 with zinc, 224 with cadmium, 201 with copper, and 154 with mercury (EPA 1996).

Lead is generally stable in the environment, with very little being available for transport into surface water or groundwater. However, when lead is exposed to certain environmental conditions it will break down and become soluble in water. The fate of lead in soil is affected primarily by the processes of adsorption, ion exchange, precipitation, and complexing with organic matter (Smith et al. 1995).

Lead exists in one of three oxidation states, 0, +2, and +4. In natural aqueous environments, lead exists primarily in the +2 oxidation state. Under acidic conditions, the dominant species are Pb2+, and PbSO4 if sulfate is present. Lead carbonate species predominate at neutral and alkaline pHs. Natural compounds of lead are not usually mobile in normal surface or groundwater because the lead leached from ores (and waste rock and contaminated soil) is adsorbed by ferric hydroxide compounds or combines with carbonate or sulfate ions to form insoluble solid phases.

Movement of lead as particulates in the atmosphere is a primary environmental transport process for lead. Lead carried in the atmosphere can be precipitated by either wet or dry deposition. Photolysis of lead in the atmosphere occurs readily and is important in determining the form of lead entering aquatic and terrestrial systems.

The transport of lead in the aquatic environment is influenced by the speciation of the ion. Lead exists mainly as the divalent cation (Pb2+) in most unpolluted waters and becomes adsorbed onto particulate phases. However, in polluted water organic complexation is most important. Volatilization of lead compounds probably is not important in most aquatic environments.

Sorption processes appear to exert a dominant affect on the distribution of lead in the environment. Adsorption to inorganic solids, organic materials, and hydrous iron and manganese oxides usually controls the mobility of lead in aquatic systems and the lead remains with the solid phases. Soluble leads added to the soil reacts with clays, phosphates, sulfates, carbonates, hydroxides, and organic matter to form insoluble compounds such that lead solubility and, therefore, mobility is greatly reduced. At pH values above 6, lead is either adsorbed on clay surfaces or forms lead carbonate. The sorption mechanism most important in a particular system varies with geological setting, pH, oxidation/reduction potential, availability of ligands, dissolved and particulate ion concentrations, salinity, and chemical composition. The solubility of lead is low when carbonate, sulfate, and/or sulfide are present. Lead carbonate and lead sulfate control solubility of lead in aerobic conditions, and lead sulfide and the metal control solubility in anaerobic conditions. Lead is strongly complexed to organic materials present in aquatic systems and soil. Uptake of lead in plants is minimal compared to other metals; and, therefore, its availability to herbivorous and omnivorous organisms is limited.

Bioaccumulation of lead has been demonstrated for a variety of organisms. Microcosm studies indicate that lead is not biomagnified though the food chain. Biomethylation of lead by microorganisms can remobilize lead to the environment.

The OU1 contaminants are expected to generally remain in the soil matrix. Movement of the contaminants into other media (i.e., soil at depth, groundwater, surface water, or the atmosphere) should be limited, as long as there is retention capacity in the soil and the contaminated material is covered. The extent of movement of the contaminants in the soil system is related to the physical and chemical properties of the soil as well as the chemical properties of the elements or compounds, as discussed above. Based on the soil data there is no evidence that COPCs have migrated significantly through the soil profile and accumulated at depth. Groundwater and surface water will be investigated as part of OU2.

Section 7 Human Health Risk Assessment

7.1 Introduction

The HHRA provides an evaluation of the nature and magnitude of health risks posed to residents in Superior due to exposures to site-related contaminants in yard and driveway soils, assuming that no additional steps are taken to remediate the soils or to reduce human contact with contaminated soils. The HHRA was conducted for EPA by SRC, Inc. and has been incorporated in its entirety into the RI report. The results of the HHRA are intended to help inform risk managers and the public about potential risks to residents from contaminated soil and to help determine if there is a need for further action. The methods used to evaluate risks in this assessment are consistent with current guidelines for human health (EPA 1989, 1991a, 1991b, 1992, 1997, 2002a, 2002b, 2004) provided by the EPA for use at Superfund sites.

7.2 Conceptual Site Model

Figure 7-1 presents a conceptual model summarizing how area residents may be exposed to site-related contaminants in soils in their yards or driveways. Each of the exposure pathways are described below.

7.2.1 Incidental Ingestion of Outdoor Soil

Even though very few people intentionally ingest soil, area residents (especially children) may ingest small amounts of soil that adhere to their hands during outdoor work or play activities. Under most circumstances, contact is primarily with surface soil (0 to 2 inches), and exposure to subsurface soil generally does not occur unless some sort of excavation activity occurs that brings the subsurface soil to the surface. Quantification of hypothetical future exposure to subsurface soil is very difficult because neither the amount of soil brought to the surface nor the degree to which the subsurface soil becomes mixed with surface soil is known. For this reason, the current assessment focuses only on exposures to current surface soils. Section 8.2 describes how the future risk issues could potentially be addressed in the ROD.

7.2.2 Dermal Contact with Soil

Residents may have dermal exposure to contaminated soil while working or playing outdoors. Even though information is limited on the rate and extent of dermal absorption of metals in soil across the skin, most scientists consider that this pathway is likely to be minor in comparison to the amount of exposure that occurs by the oral route. This view is based on the recognition that most metals tend to bind to soils, reducing the likelihood that they would dissociate from the soil and cross the skin, and ionic species such as metals have a relatively low tendency to cross the skin even when contact does occur. For example, studies by Lowney (Lowney 2005) have shown that dermal absorption of arsenic from Colorado and New York soils was negligible. Thus, neither EPA's Integrated Exposure Uptake Biokinetic (IEUBK) model nor Adult Lead Methodology (ALM) includes a dermal exposure pathway. Recognizing that current methods and data are limited for attempting to quantify dermal absorption of chemicals from soil, dermal contact with soil and sediment is not evaluated quantitatively.

7.2.3 Ingestion of Indoor Dust

Outdoor soil may be tracked into homes by people or pets, or may enter homes by deposition of dust particles. Once inside, the soil becomes mixed into indoor dust, and humans may ingest the dust by hand-to-mouth contact. Most people spend a majority of time indoors, so this pathway can be significant, and is evaluated quantitatively.

7.2.4 Inhalation of Airborne Soil Particulates

Whenever contaminated soil is exposed at the surface, particles of contaminated surface soil may become suspended in air by wind or mechanical disturbance, and humans in the area could inhale those particles. Although the amount of airborne dust inhaled is usually minor compared to the amount ingested, some metals are carcinogenic when inhaled but not when ingested. Therefore, this pathway is evaluated in this assessment.

7.2.5 Ingestion of Homegrown Produce Items

Vegetables grown in contaminated soil may take up contaminants from the soil into the edible portion of the vegetable, which may then be ingested by area residents. However, there are no site-specific data on uptake of metals into vegetables, and studies at other sites suggest that this pathway is usually quite minor, especially if the vegetables are washed before ingestion. Therefore, this pathway is not evaluated quantitatively.

7.3 Selection of Chemicals of Potential Concern

COPCs are chemicals which exist in the environment at concentration levels that might be of potential health concern to humans and which are or might be derived, at least in part, from site-related sources.

The procedure used to indentify COPCs at this site consisted of the following steps:

1. List all chemicals detected by ICP-AES analysis in one or more samples of residential surface soil

2. Exclude any analyte detected in fewer than 5 percent of the samples

3. Calculate the risk-based concentration (RBC) for each contaminant in soil that would be of concern to a resident during an exposure of 30 years, considering both oral and inhalation exposure (Appendix E)

4. Compare the maximum detected (Cmax) value to the RBC. Exclude any analyte where Cmax < RBC. For the COPC selection, the RBCs used were 400 ppm for lead and 50 ppm for arsenic.

5. Retain all chemicals where Cmax ≥ RBC

The results are shown in Table 7-1. As seen, three chemicals were identified as COPCs that require further analysis:

- Antimony
- Arsenic
- Lead

Other chemicals are present at concentration levels that are sufficiently low that significant human health risk is not expected.

7.4 Evaluation of Exposure and Risk from Non-Lead COPCs

7.4.1 Exposure Assessment

Exposure is the process by which humans come into contact with chemicals in the environment. In general, humans can be exposed to chemicals in a variety of environmental media (e.g., soil, water, air, food), and these exposures can occur through several pathways (e.g., ingestion, dermal contact, inhalation).

7.4.1.1 **Basic Equations**

Ingestion Exposure

The amount of chemical ingested in soil may be quantified using the following equation:

$$DI = EPC \cdot (IR \cdot FI / BW) \cdot (EF \cdot ED / AT) \cdot RBA$$

where:

DI =Average daily intake of chemical (mg per kg of body weight per day).

EPC = Exposure point concentration of the chemical in the soil to which the person is exposed (mg/kg)

IR =Intake rate of soil (kg/day)

FI = Fraction of total intake derived from the contaminated area (unitless)

BW=Body weight of the exposed person (kg)

EF =Exposure frequency (days/year)

ED=Exposure duration (years)

AT =Averaging time (days). This term specifies the length of time over which the average dose is calculated. For a chemical which causes non-cancer effects, the averaging time is equal to the exposure duration. For a chemical that causes cancer effects, the averaging time is 70 years.

RBA=Relative bioavailability

The factors EF, ED, and AT combine to yield a factor between zero and one. Values near 1.0 indicate that exposure is nearly continuous over the specified averaging period, while values near zero indicate that exposure occurs only rarely.

The general equation for calculating dose can be written as:

$$DI = EPC \cdot HIF \cdot RBA$$

where:

HIF = Human Intake Factor. This term describes the average amount of soil ingested by the exposed person each day. The value of HIF is given by:

$$HIF = (IR \cdot FI / BW) \cdot (EF \cdot ED / AT)$$

The units of HIF are kg/kg-day for soil ingestion.

When the same individual may be exposed beginning as a child and extending into adulthood, exposure was calculated as the time-weighted average (TWA) lifetime exposure for evaluating non-cancer and cancer risks as recommended in EPA Guidance (EPA 1989). The equation is as follows:

$$HIF_{TWA} = [(IR \cdot FI \cdot EF \cdot ED/BW)_{child} + (IR \cdot FI \cdot EF \cdot ED/BW)_{adult}] / AT$$

Inhalation Exposures

Inhalation exposures are evaluated in accordance with the inhalation dosimetry methodology presented in EPA's *Risk Assessment Guidance for Superfund (RAGS) Part F: Inhalation Risk Assessment* (EPA 2009). The human intake equation does not include an inhalation rate (m^3/day) or body weight because the amount of chemical that reaches the target site is not a simple function of these factors. Instead, the interaction of the inhaled contaminant with the respiratory tract is affected by factors such as species-specific relationships of exposure concentrations to deposited/delivered doses and physiochemical characteristics of the inhaled contaminant (EPA 2009). Therefore, the inhaled exposure concentration (EC) for chronic exposures is calculated as:

$$EC = C \cdot (ET \cdot EF \cdot ED / AT)$$

where:

EC =Exposure Concentration (µg/m^3). This is the time-weighted concentration based on the characteristics of the exposure scenario being evaluated.

C =Concentration of the chemical in air (µg/m^3) to which the person is exposed.

ET =Exposure time (hours/day). This describes how long a person is likely to be exposed to the contaminated medium over the course of a typical day.

EF =Exposure frequency (days/year). This describes how often a person is likely to be exposed to the contaminated medium over the course of a typical year.

ED =Exposure duration (years). This describes how long a person is likely to be exposed to the contaminated medium during their lifetime.

AT =Averaging time (hours). This term specifies the length of time over which the time-weighted average concentration is calculated.

The general equation for exposure concentration can be written as:

$$EC = C \cdot TWF$$

where:

TWF = Time-Weighting Factor (unitless). The value of TWF is given by:

$$TWF = (ET \cdot EF \cdot ED / AT)$$

As described above, when the same individual may be exposed beginning as a child and extending into adulthood, exposure was calculated as the TWA lifetime exposure for evaluating non-cancer and cancer risks:

$$TWF = (ET \cdot EF \cdot ED)_{child} / AT \; + \; (ET \cdot EF \cdot ED)_{adult} / AT$$

Human Exposure Parameters

For every exposure pathway of potential concern, it is expected that there will be differences between different individuals in the level of exposure at a specific location due to differences in intake rates, body weights, exposure frequencies, and exposure durations. Thus, there is normally a wide range of average daily intakes between different members of an exposed population. Because of this, all daily intake calculations must specify what part of the range of doses is being estimated. Typically, attention is focused on intakes that are “average” or are otherwise near the central portion of the range, and on intakes that are near the upper end of the range (e.g., the 95th percentile). These two exposure estimates are referred to as Central Tendency Exposure (CTE) and Reasonable Maximum Exposure (RME), respectively.

Table 7-2 lists the CTE and RME exposure parameters and resultant HIF values used in this assessment for residents for oral and inhalation exposure. These values are based primarily on EPA default guidelines for residential exposure (EPA 1989, 1993). For the FI term, it is conservatively assumed that a child derives 100 percent of their soil intake while at home, while for an adult, it is assumed that 50 percent of the total intake occurs while at home.

Data Set Used to Evaluate Exposure

Each residential property was divided into sectors (usually four, depending on property size), and one composite sample of surface soil (0 to 2 inches) was collected from each sector. These samples were screened for metals using XRF and any sample with an XRF reading for lead greater than 250 to 300 ppm was sent for analysis by inductively coupled plasma atomic absorption spectroscopy (ICP-AES), along with a random set of 5 percent of all samples.

In general, results of XRF measurements are less accurate that ICP-AES results. A comparison of the ICP-AES values to the XRF values are shown in Figure 7-2. As seen, although there is a clear correlation, XRF results may vary substantially from the ICP-AES results, occasionally by more than a factor of 10. For this reason, ICP-AES data are preferred over XRF data whenever possible. However, because the samples sent for ICP-AES analysis are not random and provide data for only a subset of the properties at the site, the ICP-AES data alone are not sufficient to support a reliable risk assessment for the site. Rather, the data set used for risk assessment utilizes ICP-AES data combined with the XRF data (when no ICP-AES measurement was collected).

Based on this, the data selection rules used to identify the data set used for risk assessment were as follows:

1. Include only samples from residential properties
2. Include only samples collected from the 0- to 2-inch depth interval
3. Exclude all XRF data qualified with an XRF Error flag
4. Exclude all ICP-AES values that were assigned an R qualifier
5. Exclude all field duplicates
6. Exclude samples from sampling locations remediated in 2010. Replace the excluded value for such sampling locations with the mean concentration measured in clean fill (antimony, 1.2 ppm; arsenic, 7.4 ppm, and lead, 16.5 ppm)
7. When valid XRF and ICP-AES results are both available, use the ICP-AES value

Exposure Point Concentrations for Soil

In general, EPA assumes that residents are exposed to soil at random within the boundaries of the property. The driveway is treated as being equivalent to other areas of the yard.

Based on the assumption of random exposure over a yard, risk from a chemical is related to the arithmetic mean concentration of that chemical averaged over the entire yard. When the true arithmetic mean concentration cannot be reliably estimated from available data, EPA recommends use of the 95 percent upper confidence limit (95UCL) of the arithmetic mean at each exposure point as the exposure point concentration (EPC) when calculating exposure and risk at that location (EPA 1992). This approach is most important when evaluating the average concentration over a large area with widely varying concentrations. For a small area such as a residential property, variability and uncertainty are usually less than for a large area, so the mean rather than the UCL of the mean is used in this assessment as the EPC for each property.

Exposure Point Concentration for Air

No site-specific data are available on the concentration of COPCs in air. In the absence of measured values, the concentration of contaminants in air that would occur due to erosion of soil particles into air was estimated using the following equation:

$$EPC(air) = EPC(soil) \cdot PEF \cdot 1000$$

where:

EPC(air) = exposure point concentration of contaminant in air (ug/m^3)
EPC(soil) = exposure point concentration of contaminant in soil (mg/kg)
PEF = particulate emission factor (kg of soil per m^3 of air)
1000 = Conversion from mg to ug

The value of PEF recommended by EPA (2002a) is 1.36E+09 m^3/kg (7.35E-10 kg/m^3).

Relative Bioavailability

An accurate assessment of human exposure to ingested chemicals requires knowledge of the amount of chemical absorbed from the gastrointestinal tract into the body from site media compared to the amount of absorption that occurred in the toxicity studies used to derive the toxicity factors. This ratio (amount absorbed from site media compared to the amount absorbed in toxicity tests) is referred to as Relative Bioavailability (RBA).

In general, metals in soil at mining sites exist in the form of mineral particles that are not rapidly solubilized in gastrointestinal fluids when ingested, while toxicity studies often utilize readily soluble forms of the test chemical. Thus, oral RBA values for metals in soil are often less than 1.0.

In general, the preferred method for obtaining site-specific estimates of the RBA for a metal in soil is to measure the gastrointestinal absorption of that metal in animals dosed with site soils compared to that for a fully soluble form of the metal. However, such tests are costly and take considerable time to perform, and no such animal data are available for any soil samples from this site.

In the absence of reliable site-specific RBA data, one approach recommended by EPA Region 8 (EPA 2011) for estimating site-specific RBA values is to extrapolate from studies performed at other sites, focusing on sites where the predominate mineral phases in soil are similar to the site being evaluated. In the case of antimony, no RBA studies at other sites were located, so an RBA of 100 percent was assumed.

In the case of arsenic, numerous studies of RBA have been performed at other sites. At the Flat Creek site, the mineral forms of arsenic have been investigated in five samples (Drexler 2002). The predominant forms are arsenopyrite and complexes with iron and magnesium oxides (Drexler 2002). However, these mineral forms are not the predominant species in any of the samples reviewed by Region 8 (EPA 2005a), so reliable extrapolation based on mineral speciation is not possible in this case.

In the absence of site data or mineral-based extrapolation, Region 8 previously used a default RBA factor of 80 percent for arsenic in soil from mining and smelting sources. However, *in vivo* testing of arsenic in soil and mine waste has been conducted at sites in the Rocky Mountain West. In 26 test materials, the RBA of arsenic ranged from 8 percent to 61 percent with a mean of 34 percent. Similarly, bioavailability studies conducted (Roberts 2007) in Cynomolgus monkeys measured the bioavailability of arsenic in 14 soil samples from 12 different sites, including mining and smelting sites, pesticide facilities, cattle dip vat soil, and chemical plant soil. RBAs ranged from 5 percent to 31 percent. Based on this, EPA Region 8 has concluded that a RBA of 50 percent can be considered a generally conservative default value for arsenic in soil (EPA 2011). This value was selected for use at this site.

An alternative approach for estimating a site-specific RBA is to measure the *in vitro* bioaccessability (IVBA) of arsenic in one or more site samples. Although EPA has not yet established a method for deriving quantitative RBA values from IVBA data, IVBA values provide a semi-quantitative estimate of the range of likely RBA values. Drexler conducted IVBA testing for arsenic on five site soils. The measured IVBA values ranged from 6 percent to 35 percent, with an average of 18 percent. This supports the conclusion that a default oral RBA of 50 percent for arsenic in site soils is likely to be conservative. RBA for inhaled metals is assumed to be 100 percent in all cases.

7.4.2 Toxicity Assessment

7.4.2.1 Overview

The basic objective of a toxicity assessment is to identify what adverse health effects a chemical causes, and how the appearance of these adverse effects depends on exposure level. In addition, the toxic effects of a chemical frequently depend on the route of exposure (oral, inhalation, dermal) and the duration of exposure (subchronic, chronic, or lifetime). Thus, a full description of the toxic effects of a chemical includes a listing of what adverse health effects the chemical may cause, and how the occurrence of these effects depends upon dose, route, and duration of exposure.

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

Non-Cancer Effects

All chemicals can cause adverse health effects if given at a high enough dose. However, when the dose is sufficiently low, typically no adverse effect is observed. Thus, in characterizing the non-cancer effects of a chemical, the key parameter is the threshold dose at which an adverse effect first becomes evident. Doses below the threshold are considered to be safe, while doses above the threshold are likely to cause an effect.

Threshold dose is typically estimated from toxicological data (derived from studies of humans and/or animals) by finding the highest dose that does not produce an observable adverse effect, and the lowest dose which does produce an effect. These are referred to as the "No-observed-adverse-effect-level" (NOAEL) and the "Lowest-observed-adverse-effect-level" (LOAEL), respectively. The threshold is presumed to lie in the interval between the NOAEL and the LOAEL. However, in order to be conservative (health protective), non-cancer risk evaluations are not based directly on the threshold exposure level, but on a value referred to as the Reference Dose (RfD) for oral exposures or Reference Concentration (RfC) for inhalation exposures. The RfD and RfC are estimates (with uncertainty spanning perhaps an order of magnitude) of a daily exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime.

The RfD and RfC values are derived from a NOAEL (or a LOAEL if a reliable NOAEL is not available) by dividing by an "uncertainty factor". If the data are from studies in humans, and if the observations are considered to be reliable, the uncertainty factor may be as small as 1.0. However, the uncertainty factor is normally at least 10, and can be much higher if the data are limited. The effect of dividing the NOAEL or the LOAEL by an uncertainty factor is to ensure that the RfD or RfC is not higher than the threshold level for adverse effects. Thus, there is always a "margin of safety" built into an RfD and RfC values, and doses equal to or less than the RfD or RfC are nearly certain to be without any risk of adverse effect. Doses higher than the RfD or RfC may carry some risk, but because of the margin of safety, a dose above the RfD or RfC does not mean that an effect will necessarily occur.

Cancer Effects

For cancer effects, the toxicity assessment process has two components. The first is a qualitative evaluation of the weight of evidence (WOE) that the chemical does or does not cause cancer in humans.

EPA (EPA 2005b) currently uses a more flexible WOE narrative approach which includes the following main descriptions:

- **Carcinogenic to humans**. Applies when there is convincing epidemiologic evidence of a causal association between human exposure and cancer.
- **Likely to be carcinogenic to humans**. Applies when the WOE is adequate to demonstrate carcinogenic potential to humans but does not reach the WOE for the descriptor "Carcinogenic in Humans"
- **Suggestive evidence of carcinogenic potential**. Applies when the WOE is suggestive of carcinogenicity; a concern for potential carcinogenic effects in humans is raised, but the data are judged not sufficient for a stronger conclusion.
- **Inadequate information to assess carcinogenic potential.** Applies when the WOE is suggestive of carcinogenicity; a concern for potential carcinogenic effects in humans is raised, but the data are judged not sufficient for a stronger conclusion.

Exhibit 7-1. Qualitative Evaluation of Weight of Evidence

WOE	Meaning	Description
A	Known human carcinogen	Sufficient evidence of cancer in humans
B1	Probable human carcinogen	Suggestive evidence of cancer incidence in humans
B2		Sufficient evidence of cancer in animals, but lack of data or insufficient data in humans
C	Possible human carcinogen	Suggestive evidence of carcinogenicity in animals
D	Cannot be evaluated	No evidence or inadequate evidence of cancer in animals or humans
E	Not carcinogenic to humans	Strong evidence that it does not cause cancer in humans

WOE = Weight of evidence

- **Not likely to be carcinogenic to humans.** Applies when the available data are considered robust for deciding that there is no basis for human hazard concern.

Because EPA has not yet assigned narrative WOE categories to a number of carcinogenic chemicals listed in IRIS, the older version of the WOE categorization is retained for use in this assessment.

For chemicals which are classified in Group A, B1, B2, or C, the second part of the toxicity assessment is to describe the carcinogenic potency of the chemical. This is done by quantifying how the number of cancers observed in exposed animals or humans increases as the dose increases. Typically, it is assumed that the dose response curve for cancer has no threshold, arising from the origin and increasing linearly until high doses are reached. Thus, the most convenient descriptor of cancer potency is the slope of the dose-response curve at low doses (where the slope is still linear). This is referred to as the slope factor (SF), which has dimensions of risk of cancer per unit dose.

Estimating the cancer SF is often complicated by the fact that observable increases in cancer incidence usually occur only at relatively high doses, frequently in the part of the dose-response curve that is no longer linear. Thus, it is necessary to use mathematical models to extrapolate from the observed high dose data to the desired (but unmeasurable) slope at low dose. In order to account for the uncertainty in this extrapolation process, EPA typically chooses to employ the upper 95th confidence limit of the slope as the SF. That is, there is a 95 percent probability that the true cancer potency is lower than the value chosen for the SF. This approach ensures that there is a margin of safety in cancer as well as non-cancer risk estimates.

For inhalation exposures, EPA uses a unit risk (UR) value to describe cancer potency, which represents the upper-bound excess lifetime cancer risk estimated to result from continuous exposure to a chemical at a concentration of 1 ug/m^3 in air. For example, if the inhalation UR for a chemical were 2E-06 per ug/m^3, the risk to a person who was exposed to a concentration of 1 ug/m^3 for a lifetime would be 2E-06.

Exhibit 7-2. Effects and Toxicity Factors for Non-Lead COPCs

Effect	Parameter	Antimony	Arsenic
Non-cancer	Critical non-cancer effects	Decreased longevity Decreased blood glucose Altered cholesterol	Hyperpigmentation, keratosis, and possible vascular lesions
	Oral RfD *(mg/kg-day)*	***4.0E-04***	***3.0E-04***
	Inhalation Rfc *(mg/m3)*	***NA***	***1.50E-05***
Cancer	WOE Category	Not evaluated (D)	A
	Characteristic cancer effects	-	Inhalation: Lung cancer Oral: Skin cancer, other internal cancers (liver, kidney, lung, and bladder)
	Oral slope factor (mg/kg-day)-1	--	1.5
	Inhalation unit risk (ug/m3)-1	--	4.30E-03

RFD = reference dose
NA = not applicable

Human Toxicity Values

Toxicity values (RfD, RfC, SF and UR values) that have been established by EPA are listed in an on-line database referred to as "IRIS" (Integrated Risk Information System). In the absence of values or IRIS, other toxicity values are available from other sources, including EPA's Superfund Technical Assistance Center. A tabular summary of available values is maintained in the Regional Screening Table maintained by Oak Ridge National Laboratory (EPA 2010). The toxicity values used to derive screening level risk-based concentrations for all metals are shown in Appendix E, and the values for the non-lead COPCs (antimony and arsenic) are shown in Exhibit 7-2.

7.4.3 Risk Characterization

7.4.3.1 Basic Approach

Non-Cancer Effects

The potential for non-cancer effects from site-related exposures is evaluated by comparing the estimated exposure from site media to an exposure level that is believed to be safe (EPA 1989). This ratio is called a hazard quotient (HQ). If the HQ for a chemical is equal to or less than one, it is believed that there is no appreciable risk that non-cancer health effects will occur. If an HQ exceeds one, there is some possibility that non-cancer effects may occur, although an HQ above one does not indicate an effect will definitely occur. This is because of the margin of safety inherent in the derivation of all toxicity values. However, the larger the HQ value, the more likely it is that an adverse effect may occur. Non-cancer HQs for each chemical are calculated as described below.

For oral exposure, the potential for non-cancer effects is evaluated by comparing the estimated average daily oral intake of the chemical with the oral RfD for that chemical, as follows (EPA 1989):

$$HQ(oral) = DI / RfD$$

where:

DI=Daily Intake (mg/kg-day)

RfD=Oral Reference Dose (mg/kg-day)

For inhalation exposures, the potential for non-cancer effects is evaluated by comparing the time-weighted exposure concentration (EC) to the appropriate inhalation reference concentration (RfC) for that chemical, as follows (EPA 2009):

$$\text{HQ(inhalation)} = \text{EC} / \text{RfC}$$

where:

EC= Exposure concentration (mg/m^3)

RfC= Reference concentration (mg/m^3)

The total non-cancer risk from a chemical is then the sum of the HQ values by the oral and inhalation routes:

$$HQ(total) = HQ(oral) + HQ(inhalation)$$

If an individual is exposed to more than one chemical that causes effects on the same tissue or organ, an estimate of the total non-cancer risk is derived by summing the HQ values for those chemicals. This total is referred to as the Hazard Index (HI). If the HI value is less than one, non-cancer effects are not expected.

Cancer Effects

The excess risk of cancer from exposure to a chemical is described in terms of the probability that an exposed individual will develop cancer because of that exposure. Excess cancer risks are summed across all carcinogenic chemicals and all exposure pathways that contribute to exposure of an individual in a given population. The level of total cancer risk that is of concern is a matter of personal, community, and regulatory judgment. In general, the EPA considers excess cancer risks that are below 1E-06 to be so small as to be negligible, and risks above 1E-04 to be sufficiently large that some sort of remediation is desirable1. Excess cancer risks that range between 1E-04 and 1E-06 are generally considered to be acceptable (EPA 1991b), although this is evaluated on a case by case basis, and EPA may determine that risks lower than 1E-04 are not sufficiently protective and warrant remedial action.

For oral exposures, the excess risk of cancer is calculated as follows (EPA 1989):

$$Risk\ (oral) = 1 - exp(-DI_L \cdot SF)$$

where:

DI_L = Daily intake, averaged over a lifetime (mg/kg-day)

SF = Slope factor $(mg/kg\text{-}day)^{-1}$

In most cases (except when the product of $DI_L \cdot SF$ is larger than about 0.01), this equation may be approximated by the following:

$$Risk(oral) = DI_L \cdot SF$$

For inhalation exposure, the excess risk of cancer is calculated as follows (EPA 2009):

$$Risk(inhalation) = EC \cdot UR$$

where:

EC = Exposure Concentration (ug/m^3)

UR = Unit Risk $(ug/m^3)^{-1}$

The total cancer risk from a chemical is then the sum of the risks by the oral and inhalation routes:

$$Risk(total) = Risk(oral) + Risk(inhalation)$$

7.4.3.2 **Results**

Appendix F presents detailed calculations of exposure and risk for area residents exposed to non-lead COPCs in soil. Exhibit 7-3 summarizes the results.

Non-Cancer Effects

Data on antimony in surface soil were available at 345 residential properties. As shown, non-cancer risks from antimony are below a level of concern for CTE receptors at all locations, but risks are slightly above the level of concern (HQ = 2-3) at three locations (RY422, RY523, RY600) for RME receptors.

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1 Excess cancer risk can be expressed in several formats. A cancer risk expressed in scientific notation as 1E-06 is equivalent to 1 in 1,000,000 or 10^{-6}. Similarly, a cancer risk of 1E-04 is equivalent to 1 in 10,000 or 10^{-4}. For the purposes of this document, all excess cancer risks are presented in a scientific notation.

For arsenic, data were available at 518 properties. As shown, non-cancer risks are below a level of concern (HQ ≤ 1) at all properties, both for CTE and RME receptors.

Because antimony and arsenic do not act on the same target tissues (see Table 7-3), summation of non-cancer HQ values across chemicals is not appropriate.

Cancer Risks

Data on arsenic in surface soil were available at 518 residential properties. For the CTE receptor, estimated excess cancer risks from arsenic range from 6E-08 to 2E-05, with no properties that exceed 1E-04. For the RME receptor, estimated excess cancer risks range from 6E-07 to 2E-04, with two properties (RY036 and RY523) exceeding an estimated risk of 1E-04.

Exhibit 7-3. Estimated Risk from Non-Lead COPCs

COPC	Effect Category	Risk Level	Number of Properties	
			CTE	RME
Antimony	Non-cancer	HQ ≤ 1	345	342
		HQ =2 to 3	0	**3**
		HQ>3	0	0
Arsenic	Non-cancer	HQ ≤ 1	518	518
		HQ >1	0	0
	Cancer	<1E-06	479	2
		1E-06 to 1E-05	37	479
		1E-05 to 1E-04	2	35
		>1E-04	0	2

CTE=Central Tendency Exposure
RME – Reasonable maximum exposure
HQ = Hazard quotient

7.4.4 Uncertainty Assessment

Quantitative evaluation of the risks to humans from environmental contamination is frequently limited by uncertainty regarding a number of key data items, including concentration levels in the environment, the true level of human contact with contaminated media, and the true dose-response curves for non-cancer and cancer effects in humans. This uncertainty is usually addressed by making assumptions or estimates for uncertain parameters based on whatever limited data are available. Because of these assumptions and estimates, the results of risk calculations are themselves uncertain, and it is important for risk managers and the public to keep this in mind when interpreting the results of a risk assessment. The following sections review the main sources of uncertainty in the risk calculations performed at the site.

7.4.4.1 **Uncertainties in Exposure Assessment**

Uncertainties from Exposure Pathways Not Evaluated

As discussed above, residents may be exposed to site-related chemicals in soil by dermal contact and by ingestion of contaminants taken up from soil into home grown vegetables. The dermal pathway was not evaluated because current methods for estimating dermal uptake are too limited to support meaningful risk estimates. Likewise, Exposure from the consumption of garden vegetables could not be evaluated in this assessment because data were not available. However, dermal exposure to metals in soil is generally believed to be minor, and studies at other sites indicate that uptake of metals into vegetables is generally small, so omission of these pathways is likely to result in only a small underestimation of exposure and risk.

Uncertainties in Exposure Point Concentrations

In all exposure calculations, the desired input parameter is the true mean concentration of a contaminant within a medium, averaged over the area where random exposure occurs. In the case of area residents exposed to contaminants in soil, the exposure area is assumed to be equal to the yard. Because most yards had 4 or fewer samples for surface soil, estimates of the mean concentration may not be accurate in all cases, with the true mean being either higher or lower than the sample mean.

Uncertainties in Human Exposure Parameters

Accurate calculation of risk values requires accurate estimates of the level of human exposure that is occurring. However, many of the required exposure parameters are not known with certainty and must be estimated from limited data or knowledge. In general, when exposure data are limited or absent, the exposure parameters are chosen in a way that was intended to be conservative. Because of this, the values selected are thought to be more likely to overestimate than underestimate actual exposure and risk.

Uncertainties in Relative Bioavailability

The risk from an ingested chemical depends on how much of the ingested chemical is absorbed from the gastrointestinal tract into the body. This issue is especially important for metals in soil at mining sites, because some of the metals may exist in poorly absorbable forms, and failure to account for this may result in a substantial overestimation of exposure and risk. In the absence of data, the default approach is to assume that the RBA is 100 percent. This approach was used to evaluate risk from antimony, and it is considered likely that the assumption of 100 percent RBA will tend to overestimate the true risk. For arsenic, studies at other mining sites indicate that the RBA rarely exceeds 50 percent, and this value was used in this assessment. Available IVBA for arsenic at this site suggests the true RBA might be lower, so risks from arsenic are likely to be overestimated.

Uncertainties in Toxicity Values

Toxicity information for many chemicals is often limited. Consequently, there are varying degrees of uncertainty associated with toxicity values (i.e., SF, RfD, RfC, UR). For example, uncertainties can arise from the following sources:

- Extrapolation from animal studies to humans
- Extrapolation from high dose to low dose
- Extrapolation from continuous exposure to intermittent exposure

- Limited or inconsistent toxicity studies

In general, uncertainty in toxicity factors is one of the largest sources of uncertainty in risk estimates at a site. Because of the conservative methods EPA uses in dealing with the uncertainties, it is much more likely that the uncertainty will result in an overestimation rather than an underestimation of risk.

Uncertainties in Risk Estimates

Because risk estimates for a chemical are derived by combining uncertain estimates of exposure and toxicity, the risk estimates for each chemical are more uncertain than either the exposure estimate or the toxicity estimate alone.

7.5 Evaluation of Exposure and Risk from Lead

7.5.1 Overview

7.5.1.1 Use of Blood Lead as the Measure of Exposure and Risk

Risks from lead are evaluated using a different approach than for most other chemicals. First, because lead is widespread in the environment, exposure can occur by many different pathways. Thus, lead risks are usually based on consideration of total exposure (all pathways) rather than just site-related exposures. Second, because studies of lead exposures and resultant health effects in humans have traditionally been described in terms of blood lead level, lead exposures and risks are typically assessed by describing the levels of lead that may occur in the blood of exposed populations and comparing these to blood lead levels of potential health concern. For convenience, the concentration of lead in blood is usually abbreviated "PbB", and is expressed in units of micrograms per deciliter (μg/dL).

7.5.1.2 Blood Lead level of Concern

Concern over health effects from elevated blood lead levels is greatest for young children or the fetus of pregnant women. Reasons for this focus on young children or the fetus, include: 1) young children typically have higher exposures to lead-contaminated media per unit body weight than adults, 2) young children typically have higher lead absorption rates than adults, and 3) young children and fetuses are more susceptible to effects of lead. EPA identified 10 ug/dL as the concentration at which effects begin to occur that warrant avoidance, and has set as a goal that there should be no more than a 5 percent chance that a child will have a blood lead value above 10 ug/dL (EPA 1991c, 1994). Likewise, the CDC has established a guideline of 10 ug/dL in preschool children which is believed to prevent or minimize lead-associated cognitive deficits (CDC 2005). The probability of a blood lead value exceeding 10 ug/dL is referred to as P10.

Although the value of 10 ug/dL is based on studies in young children, it is generally assumed that the same value is applicable to a fetus *in utero*. Data suggest the ratio of blood lead level in a fetus to that of the mother is approximately 0.9 (Goyer 1990). Thus, the blood lead level in a pregnant female that would correspond to a blood lead level of 10 ug/dL in the fetus is:

PbB(mother) = 10 ug/dL / 0.9 = 11.1 ug/dL

7.5.2 Description of the IEUBK Model

The EPA has developed an IEUBK model to evaluate exposures from lead-contaminated media in children (EPA 1994). This model requires data on lead in soil, dust, water, air, and diet at a particular residence and on the average amount of these media ingested or inhaled by a child living at that residence. All of these inputs to the IEUBK model are central tendency point estimates. These point estimates are used to calculate an estimate of the central tendency (the geometric mean) of the distribution of blood lead values that might occur in a population of children exposed to the specified conditions. Assuming the distribution is lognormal, and given (as input) an estimate of the variability between different children (this is specified by the geometric standard deviation or GSD), the model calculates the expected distribution of blood lead values, and estimates the probability that any random child might have a blood lead value over 10 µg/dL.

7.5.3 IEUBK Model Inputs

Lead calculations were performed for each property using the IEUBK run in batch file mode. In this mode, property-specific inputs are provided to the model in a batch file format, and the model automatically calculates the probability (P10) of exceeding a blood lead of 10 ug/dL at each property.

Key inputs are:

- **Soil Lead**. Soil lead at each property is the average concentration for all surface soil samples from that property.
- **Dust Lead.** Indoor dust lead is assumed to be 70 percent of the value in yard soil. Studies at other sites suggest this is a conservative assumption (Brattin and Griffin 2011).
- **Age at Evaluation.** The age of the child being evaluated was specified as 50 months, because the blood lead value at 50 months is very nearly equal to the average blood lead value from age 0 to 6 years.
- **Water and Air.** Concentrations in water and air were model defaults (4 ug/L for water, 0.1 ug/m^3 for air)
- **RBA.** As discussed above for arsenic, the preferred method for obtaining site-specific estimates of RBA of lead in soil is to measure the gastrointestinal absorption in animals dosed with site soils compared to that for a fully soluble form of lead (e.g., lead acetate). However, such tests are costly and take considerable time to perform, and no such animal data are available for any soil samples from this site. An alternative approach is to measure the *in vitro* bioaccessability (IVBA) of lead in soil under specified test conditions. The IVBA

results for lead are well correlated with the *in vivo* RBA results for lead and can be used to estimate RBA values using the following equation[2] (EPA 2007):

$$RBA = 0.878 \cdot IVBA - 0.028$$

- EPA measured IVBA of lead in five site soils in 2002 (Drexler 2002) and in an additional set of 24 samples in 2011. Individual sample RBA values ranged from 48 percent to 89 percent, with a mean and standard deviation of 63 ± 10 percent. This value is not meaningfully different from the default value of 60 percent assumed by the IEUBK model, so the default of 60 percent was retained.
- **GSD**. The GSD employed was 1.6, which is the IEUBK model default. Studies at mining sites in Region 8 suggest this value is likely conservative (Marcus 1992, Griffin et al. 1999).

All other IEUBK input parameters were model defaults.

7.5.4 IEUBK Model Results

Appendix G presents detailed IEUBK model calculations of exposure and risk for area children exposed to lead from soil, dust and other sources. There is one property (Exhibit 7-4) where exposures of average children could likely to be of concern (GM PbB greater than 10 ug/dL), and there are five additional properties (a total of 11) where the probability of exceeding 10 ug/dL exceeds the health-based goal (P10 greater than 5 percent). Exposure of children to lead in soil at these properties is of potential concern and may warrant additional cleanup. Exposures to lead at the other 512 properties are likely to be within the acceptable risk range established by EPA (P10 less than 5 percent).

Exhibit 7-4. Estimated Risks from Lead

Parameter	Range	Count
GM (ug/dL)	<5	514
	5-10	3
	10-20	**1**
	>20	0
	Total	**518**
P10 (%)	<5	512
	5-10	**2**
	10-20	**2**
	>20	**2**
	Total	**518**

GM=Geometric mean
P10=probability that blood lead will exceed 10 ug/dL

7.5.5 Uncertainties in Lead Risk Evaluation

Quantification of risks to children from exposures to lead is subject to a number of data limitations and uncertainties. The most important factors at OU1 are summarized below.

7.5.5.1 Uncertainty in Childhood Exposure Parameters

Exposure to lead from site media occurs through ingestion of soil and dust. However, actual intake rates of soil and dust by children are difficult to measure, and may vary from location to location. This is a significant source of uncertainty.

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[2] Note that this equation is based on IVBA terms entered as fractions, not percentages.

7.5.5.2 Uncertainties in Exposure Point Concentrations

Ideally, the EPC for lead in soil would be the true yard-wide average concentration. At the site, the EPC for lead is usually based on about 3 to 6 samples per yard, although some properties have only 1 to 2 samples Because the true mean cannot be estimated with confidence from only a limited data set, the true mean may be either higher or lower than the yard mean.

The EPC for lead in indoor dust is assumed to be 70 percent of the concentration is soil. However, studies at other mining sites in the Rocky Mountain west reveal that this assumption is usually conservative, and that the actual concentrations in dust attributable to soil are often about 20 to 40 percent of that is soil (Brattin and Griffin 2011). Because a substantial fraction of children's exposure to lead is assumed to come from ingestion of indoor dust, it is likely that the contribution of lead in dust at this site is overestimated, and that actual blood lead values are likely to be lower than predicted.

7.5.5.3 Uncertainty in GSD

The GSD value is the most sensitive input to the IEUBK model. The GSD recommended as the default for the IEUBK model is 1.6 (EPA 1994). However, GSD values vary from site to site, depending on the number and magnitude of the exposure pathways and on the nature of the exposed population. Several blood lead studies that have been performed in the Rocky Mountain West have yielded GSD estimates ranging from 1.3 to 1.6 (Marcus 1992). In particular, analysis of two robust data sets from EPA Region 8 (Sandy City, Utah and Bingham Creek, Utah) estimated an uncertainty range from about 1.4 to 1.6 (Griffin et al. 1999). Thus, the GSD of 1.6 used in the IEUBK model represents a conservative estimate and may tend to overestimate risk. However, if a GSD value of 1.4 were assumed, the number of properties with P10 values greater than 5 percent would only decrease from 6 to 4, so this is not a major source of uncertainty at this site.

7.5.5.4 Uncertainty in Model Predictions

Even if the amount of lead ingested or inhaled at the site were known with confidence, the effect on blood lead would still be uncertain. The rate and extent of blood lead absorption is a highly complex physiological process, and can only be approximated by a mathematical model. Thus, blood lead values predicted by the IEUBK model should be understood to be uncertain, and are more likely to be high than low.

7.5.5.5 Uncertainty in Blood Lead Level of Concern

Effects of low-level lead exposure are generally subtle, and clinically significant effects can usually not be observed in individual children. Rather, evidence for effects of lead at low exposure comes mainly from large epidemiological studies where decreases in population average performance in various types of neurological or behavioral tests are interpreted as evidence of the adverse effects of lead. Some studies have provided evidence that effects can be detected at blood lead levels of around 2 ug/dL, and there is ongoing debate as to whether these effects are sufficiently meaningful to warrant identifying 2 ug/dL as the health based goal (e.g., see discussion in National Ambient Air Quality Standards for Lead, 73 Fed. Reg. 66975, November 12, 2008). However, current Superfund guidance indicates that action to clean up lead in soil is not needed unless the probability of having a blood lead level above 10 ug/dL exceeds 5 percent.

7.6 Summary

Mine waste from the IMM was used as fill at some residential properties in Superior. EPA has performed several rounds of investigation and cleanup to identify and remediate yards or driveways where concentrations of mine-related contaminants were above a level of potential concern to area residents.

In 2009, EPA initiated a RI at OU1 to characterize levels of contamination in the community in order to identify any cleanup actions that may be needed. Data on mining-related contaminants in soil were collected at almost all properties in Superior. The samples were analyzed for arsenic and lead by XRF, and most were also analyzed by XRF for a number of other metals. Samples with elevated lead (greater than 250 to 300 ppm) were analyzed for metals by ICP-AES. Based on the ICP-AES data, three COPCs for residents were identified: antimony, arsenic, and lead. Other mining related contaminants were not present at concentrations of potential health concern.

The combined XRF/ICP-AES data set was used to evaluate risks to residents from these COPCs, using the ICP-AES data in preference to the XRF data whenever possible. The results indicate that residual risks from contaminated soil are within EPA's usual guidelines for all three COPCs at most properties.

Exhibit 7-5. Summary of Risks

Index	Property ID	Antimony HQ		Arsenic Cancer Risk		Lead	
		CTE	RME	CTE	RME	GM (ug/dL)	P10 (%)
1	RY036	0.4	1	2E-05	**2E-04**	4.4	4.1
2	RY086	0.2	1	8E-06	8E-05	4.8	**5.8**
3	RY101	0.3	1	2E-05	1E-04	6.1	**14.6**
4	RY257	0.2	1	7E-06	6E-05	6.1	**14.3**
5	RY422	1	**2**	6E-06	5E-05	4.8	**6**
6	RY523	1	**2**	2E-05	**2E-04**	**10.9**	**57.4**
7	RY600	1	**3**	1E-05	1E-04	8.3	**34.2**

CTE=Central Tendency Exposure
RME – Reasonable maximum exposure
GM= Geometric mean
P10=probability that blood lead will exceed 10 ug/dL
Bold text indicates an exceedances of EPA's risk-based goals

For antimony, all properties are below a level of concern for CTE receptors, while three are slightly above a level of concern (HQ = 2-3) for RME receptors. For the non-cancer effects of arsenic, all properties are below a level of concern for both CTE and RME receptors. For the cancer effects of arsenic, all properties are below a risk of 1E-04 for the CTE receptor. For the RME receptor, two properties have excess cancer risk estimates of 2E-04, which slightly exceeds the upper end of EPA's risk range (1E-04) (Exhibit 7-5). These results indicate that risks to most residents from non-lead COPCs are likely to be within EPA's risk range (HQ ≤ 1, cancer risk ≤ 1E-04).

For lead, one property (RY523) (Exhibit 7-5) is predicted to be of potential unacceptable risk to average children (GM PbB greater than 10 ug/dL), and there are five additional properties (a total of six) where the calculated probability of exceeding 10 ug/dL exceeds the health-based goal (P10 greater than 5 percent).

Based on the findings, the remedial actions taken to date at residential properties in Superior appear largely successful, and there are only seven properties where additional soil cleanup actions may be warranted. Risks at these properties are summarized in Exhibit 7-5. Results in bold exceed EPA's risk-based goals.

Section 8 Summary and Conclusions

8.1 Summary

8.1.1 Regulatory Actions

EPA conducted a PA/SI at the site in 2001, at the request of the local government and the DEQ. As a result of that PA/SI, additional sampling and a TCRA were conducted in 2002. Wastes removed were stockpiled in a temporary repository on property at the local airport. The PA was updates in 2007 in preparation for potential listing on the NPL. The listing occurred in 2009, which is when the RI began. A subsequent TCRA was conducted in 2010 on the basis of the initial result obtained from the 2009 field events. A permanent repository (OU3) has been designed and is currently under public review.

8.1.2 Nature and Extent of Contamination

The results of the RI confirm the original understanding of the contaminant model for the site. Mine waste tailings were transported to town on an individual basis by land owners or government entities for use as fill material. There is no recognizable, spatial pattern to the distribution of the contamination in the upper 12 inches of soils at the site. However, clusters of contamination are seen in areas where the material was brought in for use in construction of Mullan and River Roads. There are numerous reports of significant use of mine waste as road base in those areas. However, the scope of the RI focused on individual properties and did not include confirmation of those reports.

Mine waste material from the IMM was free, relatively easy to obtain, and had physical properties that made it desirable for use in driveways, road beds, and as fill for building pads. These same physical characteristics made it undesirable for areas such as gardens or children's play areas (e.g., sand boxes). As a result, it was not seen in those areas during the RI field sampling events. It was also reportedly used along the sides of properties to keep down the growth of weeds, and it was seen along the edges of some properties.

The RI included screening by XRF of all properties for which access was granted and for which there was at least a reasonable expectation that material might have been imported. Large, open fields that appeared to be unaltered were not included in the sampling. EPA estimates that over 95 percent of all properties in town were screened as part of the RI. This is more than sufficient to characterize the nature and extent of contamination in local soils. In addition, most of the alleys in town were also screened to provide information on locations that had the potential to generate dust.

The screening included XRF analysis of all collected samples. Samples greater than 250 ppm for lead by XRF were submitted for TAL analysis by the EPA CLP laboratory. At least 5 percent of all remaining samples were also submitted for QA purposes. Samples were sent in as needed to account for special request or issues at a property.

The 2009 and 2010 sampling events included over 90 percent of all properties in town. A total of 7209 samples from 588 properties were screened by XRF. Most (500) were residential properties. The screening included 6,197 residential samples and 1,174 non-residential samples. A total of 1,012 samples from 345 properties were submitted to the laboratory. This represents 14 percent of all samples collected and 59 percent of all properties screened. Only 279 (4 percent of all samples collected or 27 percent of the samples sent to the laboratory) of those samples were submitted because of lead concentrations above the 250 ppm screening level.

The results show that most properties (88 percent) in Superior are in the low concentration category (less than 400 ppm of lead and less than 100 ppm of arsenic), either because of XRF readings or CLP results. A total of 29 properties (5 percent) (22 residential and 7 non-residential) had moderate concentrations of lead (400 to 1,200 ppm) or arsenic (100 to 400 ppm). Only 42 properties (7 percent) (30 residential and 12 non-residential) had concentrations in the high category for lead (greater than 1,200 ppm) or arsenic (greater than 400 ppm).

Contamination is scattered across town, rather than clustered in specific areas. This confirms the reports that contamination was brought in generally on a yard-by-yard bases for use as fill material in driveways or other areas of individual properties. The mine waste was also used in municipal road construction and on municipal properties such as the school track and the fairgrounds.

Emergency removals were conducted at the 28 sampling locations (25 residential and 5 non-residential) on 29 properties (25 residential and 4 non-residential) in 2010. The removals addressed concentrations greater than 3,000 ppm of lead or 400 ppm of arsenic. While the removals significantly reduced the overall concentrations of lead and arsenic at the site as a whole and at individual properties, moderate to high concentrations remain. These concentrations do not present an immediate unacceptable risk, but are likely to be addressed in the risk management decisions made for the site.

8.1.3 Fate and Transport

The COPCs for OU1 are relatively immobile and stable in soils and soil will normally be retained near the soil surface. Under the right conditions, they can be dissolved in the soil solution, held on inorganic soil constituents through adsorption or ion exchange, complexed with insoluble soil organic matter, and precipitated as pure or mixed solids. Metal compounds can be mobilized and transported through the vadose or perched water zones to groundwater, taken up by plants and aquatic organisms, or become more available or toxic to human receptors. Conversely, transformation by adsorption, ion exchange, complexation, or precipitation can prevent the movement of metal contaminants to groundwater. Thus, characteristics of the site media will affect metal form, mobility, migration, and fate.

Movement of the COPCs into other media (i.e., groundwater, surface water, or the atmosphere) should be limited, as long as the retention capacity of the soil is not exceeded. The extent of movement of an element in the soil system is related to the physical and chemical properties of the soil as well as the elements and compounds in the waste materials. Based on experience at other mining-related sites, it is unlikely that the COPCs are migrating through the soil profile and accumulating at depth.

The potential for release of COPCs to the air is limited to wind erosion of source materials and suspension of particulates in the form of fugitive dust. Wind is expected to be a transport mechanism when waste material is dry and exposed. Wind erosion is mitigated by the presence of covers, such as vegetation, asphalt, or concrete. In instances where the material is not covered and has a relatively small particles size (e.g., areas of exposed, scattered mine waste), some of the material is currently exposed, and could be impacted by wind erosion. For the locations where mine waste was brought in as fill for driveways, the material is exposed to the wind, but appears to be well-packed and large enough in particle size so that wind erosion is not evident. The ground in this area is frozen, wet, or covered with snow during at least six months of the year. Therefore, windborne dust is not generated, and airborne transport is a mechanism of concern for only part of the year, and only for areas that are not vegetated.

Releases of contaminants to surface water or groundwater were not characterized within the scope of OU1, but will be addressed in OU2. No visual evidence of such releases were observed. The largest areas of mine waste (e.g., the road bed materials) are essentially capped by the overlying asphalt which would limit infiltration of precipitation through the contaminated material. The driveways are uncapped and infiltration is possible. However, they are scattered and are not likely to present a concentrated source area for contamination of groundwater.

8.1.4 Risk Assessment

The HHRA identified antimony, arsenic, and lead as the COPCs for OU1. Risk was assessed for residential properties using only the analytical data for the surface depth interval (0 to 2 inches). Exposures were based on a yard-wide average for each property.

The highlights of the HHRA results are:

- For lead, exposures at six residential properties (RY086, RY101, RY257, RY422, RY523, and RY600) exceeded EPA's risk based goal of a 5 percent probability that blood lead in children would exceed 10 ug/dL.
- Human health risks have been reduced significantly by the number of properties at which EPA conducted emergency removals.
- For antimony, there were no residential properties above a level of concern for people with average exposure levels. However, there were three properties (RY422, RY523, and RY600) where non-cancer risks from antimony slightly exceeded EPA's level of concern to people with reasonable maximum exposures.
- For arsenic, there were no residential properties of concern for non-cancer risks, but there were two properties (RY036 and RY523) where estimated cancer risk to

people with reasonable maximum exposure slightly exceeded EPA's risk based goal of 1E-04.

- Taken together, seven residential properties were identified where exposures to antimony, arsenic and/or lead exceed EPA's heath-based goals and where additional remedial action may be warranted (RY036, RY086, RY101, RY257, RY422, RY523, and RY600).

8.2 Considerations for Risk Management Decisions

The HHRA analyzes data to describe the likelihood of harm to human health. Risk management uses the HHRA in conjunction with other information to make regulatory decisions. During the risk management process EPA takes into account input from its regulatory stakeholders and also considers precedent at sites in the same state or region to arrive at acceptable cleanup decisions. Risk-based action levels are not set in the HHRA, but are part of the risk management process. Other factors relating to cleanup are also evaluated, such as the percentage of a property to be remediated, remediation depth, and contaminants to be addressed.

The following provides relevant information for the risk management process.

8.2.1 Residential Properties

To support the risk management process, the RI has identified 28 additional residential properties (beyond the 7 properties identified in the HHRA) (Exhibit 8-1) that may warrant remediation. The factors behind the identification of these properties are:

- **Sampling locations vs. yards.** Many properties have one or more sample locations with concentrations that exceed 400 ppm of lead and/or 100 ppm of arsenic, but where the yard-wide average is not exceeded. Thus, those yards are not identified for remediation in the HHRA. However, in recent years, DEQ and EPA have shown a preference for moving away from use of the entire yard as the exposure point and have used the smaller area represented by the individual sampling location to make cleanup decisions. Using surface sampling locations would add 13 properties.

- **Below surface depths.** The HHRA assessed only the upper two inches of soil, which does not account for future risk. Residents could disturb the soils from the 2 to 12 inches for which data are available with only minor home improvement activities, such as digging a flowerbed, installing a vegetable garden, or building a play area or patio. Many properties have concentrations of lead or arsenic in the subsurface that exceed at a depth that exceed 400 ppm of lead and/or 100 ppm of arsenic. Those yards are not identified for remediation in the HHRA. Addressing this deeper contamination would add 22 properties.

Exhibit 8-1. Potential Additional Residential Properties to be Remediated

Index	Property ID	Sampling Area > 400 ppm Lead			Sampling Area > 100 ppm Arsenic		
		Depth Interval (inches)			Depth Interval (inches)		
		0-2	2-6	6-12	0-2	2-6	6-12
1	RY007			A 439			
2	RY008				A 133		
3	RY021		E 544	D 1,820			
4	RY023	A 523		A 431 B 678			
5	RY026					C 274	
6	RY043				E 144		E 111
7	RY061			E 1,030			
8	RY089	I 445					
9	RY091				E 298		
10	RY092	C 904 D 617	C1,860	C 1,500 D 588			
11	RY095	B 592	B 856				
12	RY102		B 410	B 1,020			
13	RY108		E 631				
14	RY130	B 1,410			B 139		
15	RY144			D 637		D 369	D 106
16	RY148		C 476			C 114	
17	RY160	B 789			B 180		
18	RY176		E 2,190				
19	RY193	D 519		C 533			C 133
20	RY234						D 326
21	RY271		D 481	D 1,030			D 221
22	RY277		D 525				
23	RY284	A 1,020	A 506		A 157		
24	RY352		C 452	C 488			
25	RY483	B 502		D 577			
26	RY485	F 434			F 104		
27	RY597			D 1,120		D 253	
28	RY616			A 867		A 332	

ppm = parts per million (mg/kg)
"A" Letter designates individual sampling location at the property

8.2.2 Non-Residential Properties

The same analysis can be performed for non-residential properties (Exhibit 8-1). The HHRA looked only at current risk. However, the lack of zoning regulations in Superior allows for many of the non-residential properties to be used for residential purposes in the future, which could present a potential for unacceptable risk. Including these non-residential properties adds 17 properties to the list of potential properties to be remediated:

- **Sampling locations vs. yards.** Using individual samplings location, rather than yard-wide averages adds 11 non-residential properties.

- **Below surface depths.** Including subsurface results adds 13 non-residential properties.

Exhibit 8-2. Potential Additional Non-Residential Properties to be Remediated.

Index	Property ID	Sampling Area > 400 ppm Lead			Sampling Area > 100 ppm Arsenic		
		Depth Interval (inches)			Depth Interval (inches)		
		0-2	2-6	6-12	0-2	2-6	6-12
1	RY097	C 477					
2	RY098	A 1,160 B 475	A 1,260 C1,040	A 1,350 C 811	A 125	A 151 C 139	A 131
3	RY099	B 495					
4	RY100	A 530	A 437	A 470 B 715			
5	RY111			B 1,330			B 439
6	RY115*	E 706	E 2,930	E 873	E 129	E 465	E 287
7	RY136		B 434	B 608			
8	RY146						B 425
9	RY213	B 717	B 1,190	B1,960	B119	B 144	B169
10	RY289		F 763 G 7,080				
11	RY332	A 406	A 578	D 755			B 350
12	RY366			A 592 D 495			D 167
13	RY369		B 1,160				
14	RY386	D 452	A 705 B 564	A 475	B 191		A 111
15	RY398	A 932 B 451	A 1,250 B 2,480	A 1,310 B 1,150		B 462	B 201
16	RY402	A 13,900					
17	RY627	B 6,700 C 1,270	B 3,690 C 5,810 D 6,000	B 1460 C2790 D 1980	B2,620 C 269	B 985 C 1240 D 933	B 311 C555 D 376

Remediation of RY115E cannot be confirmed until removal report is obtained.
ppm = parts per million
"A" Letter designates individual sampling location at the property
All concentrations are CLP laboratory results

8.3 Conclusions

The conclusions of this RI are:

- The nature and extent of contamination in the surface and near surface soils in OU1 has been adequately characterized in the 2009 and 2010 sampling events.
- Any additional properties that were not characterized during the RI can be addressed in the remedial design.
- The majority of the properties (88 percent) in Superior have no unacceptable risks associated with mine waste in soils. Of the remaining 12 percent of properties, most concentrations of lead or arsenic are not an immediate threat to human health.
- EPA's emergency removals in 2010 addressed the majority of the most contaminated properties at the OU.
- The HHRA identified 7 properties for potential remediation based on a yard-wide average concentration in surface soils at residential properties of 400 ppm of lead, 100 ppm of arsenic, or 130 ppm of antimony.
- The RI identifies additional yards that EPA and DEQ may potentially include for remediation based on risk management decisions. These properties include those that exceed 400 ppm of lead or 100 ppm of arsenic for individual sampling locations, all depths, and both residential and non-residential properties. This list is the most conservative estimate of properties for possible remediation. It includes 28 additional residential properties and 17 additional non-residential properties, in addition to the 7 properties identified by the HHRA.

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