



**U.S. Army Corps  
of Engineers**  
Seattle District

# Preliminary Site Investigation of the Falls Creek Mine Site in the Lake Pend Oreille Watershed, Idaho

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## Contents

Introduction.....	1
Purpose and Scope.....	1
Project Description.....	2
Regional Setting and Albeni Falls Dam .....	2
Falls Creek Mine Site Description.....	4
Falls Creek Mine Site History .....	4
Geologic Characteristics.....	8
Climate.....	8
Previous Investigations.....	8
Methods and Materials.....	10
Sampling Design.....	10
Surface Soil, Waste Rock and Mine Tailings Sampling.....	17
Surface Water Sediment Sampling .....	18
Surface Water Sampling.....	18
Surface Water Discharge Measurement Procedures .....	19
Leaching Test Procedures.....	19
Quality Assurance Procedures.....	19
Applicable Standards and Criteria.....	20
Water Quality Criteria.....	20
Freshwater Sediment Standards .....	20
Mine Waste and Soil Standards .....	20
TCLP and SPLP Standards .....	22
Results and Discussion .....	23
Background Soil and Stream Sediment .....	23
Waste Rock.....	23
Tailings Pile.....	25
Waste Rock and Tailings Pile Leachate .....	27
Stream Sediment.....	27
Surface Water .....	29
Conclusions.....	32
References.....	34
Appendix A.....	36

## Figures

Figure 1. Location of the Falls Creek Mine Site Investigation study area in the Clark Fork-Pend Oreille River watershed.....	3
Figure 2. Location of the Falls Creek watershed and Lake Pend Oreille.....	5
Figure 3. Location of the Falls Creek Mine Site. ....	6
Figure 4. General locations of the main mine features at the Falls Creek Mine Site.....	7
Figure 5. Location of the Falls Creek Mine Site and background soil and sediment sampling locations.....	13
Figure 6. Falls Creek Mine site waste rock, tailings pile, stream sediment, and water quality sampling locations. ....	14
Figure 7. Box plots showing Falls Creek Mine site background soil metal concentrations compared to concentrations from waste rock and tailings pile samples. ....	26
Figure 8. Falls Creek Mine site background sediment metal concentrations compared to stream sediment concentrations. ....	30

## Tables

Table 1. Soil and sediment sampling station locations and details. ....	11
Table 2. Water quality sampling station locations and details.....	12
Table 3. Methods, detection limits, containers, preservation techniques and holding times for soil and sediment quality analyses.....	15
Table 4. Methods, detection limits, containers, preservation techniques and holding times for water quality analyses.....	16
Table 5. Soil, sediment and water quality criteria and guidelines.....	21
Table 6. Summary of soil and sediment data collected at the Falls Creek Mine Site. ....	24
Table 7. Summary of soil TCLP and SPLP data collected at the Falls Creek Mine Site. ....	28
Table 8. Summary of surface water data collected at the Falls Creek Mine Site.....	31

## Introduction

The Falls Creek Mine site is an abandoned mine located on United States Forest Service (USFS) land in the watershed of Lake Pend Oreille, Bonner County, Idaho. The Falls Creek Mine was identified by the USFS Idaho Panhandle Nation Forest office as an abandoned mine that may be a source of contaminated sediments to Falls Creek and eventually Lake Pend Oreille, a major recreation site in Idaho. Preliminary testing by the United States Forest Service (USFS) identified waste rock and mine tailings in the watershed contaminated with elevated concentrations of arsenic, copper, manganese, lead, and zinc. A preliminary site investigation of the mine was deemed necessary to determine the nature, extent, and magnitude of contamination in the Falls Creek drainage and to assess potential impacts to human health, Falls Creek, and Lake Pend Oreille.

The U.S. Army Corps of Engineers' Albeni Falls Dam regulates the level of Lake Pend Oreille for flood control, navigation, fish and wildlife conservation, recreation, and power generation. The Falls Creek Mine preliminary site investigation data allows the Seattle District to better understand the environmental impacts of abandoned mine drainage and the deposition of contaminated sediments into Lake Pend Oreille and tributaries. Additionally, the site investigation allows the Seattle District to share data and work together with the USFS to better understand sources of contamination to Lake Pend Oreille from the surrounding watershed.

## Purpose and Scope

The Seattle District Corps of Engineers (Seattle District), in cooperation with the USFS, conducted a preliminary site investigation at the Falls Creek mine site. The purpose of the study was to determine the spatial distribution of contaminant sources in the Falls Creek watershed near the Falls Creek Mine site. The major objectives of this study were:

- To determine the nature and extent of contamination at the Falls Creek Mine site
- To evaluate the water and sediment quality of Falls Creek upstream and downstream of the Falls Creek Mine site
- To assess the potential mobility of metals
- To evaluate potential contaminant migration pathways.

These objectives were addressed using data collection and analysis methods to evaluate soils quality, stream sediment quality, and surface water quality. Soil data were collected from four (4) background sites, four (4) waste rock sites, and seven (7) tailings pile sites. Stream and pond sediment data were collected from two (2) sites upstream of the mine and three (3) sites downstream of the mine. Surface water data were collected from five (5) sites upstream and downstream of the mine site. The study was conducted from October 19 to October 20, 2005.

## Project Description

### Regional Setting and Albeni Falls Dam

The Clark Fork-Pend Oreille River basin drains about 25,000 square miles in southern British Columbia, western Montana, northern Idaho, and northeastern Washington (Figure 1). The Clark Fork River originates in the Rocky Mountains of western Montana and flows northwest about 350 miles to Lake Pend Oreille. Major tributaries to the Clark Fork include the Flathead River, Blackfoot River, and Bitterroot River. The Pend Oreille River begins at the outlet of Lake Pend Oreille, flows eastward for about 29 miles to Albeni Falls Dam and then flows to the northwest for about 90 miles to the confluence with the Columbia River in British Columbia. Major tributaries to the Pend Oreille River include the Priest River (Figure 1).

Albeni Falls Dam is a United States Army Corps of Engineers (COE) project located near the Washington-Idaho border on the Pend Oreille River at river mile (RM) 90.1. The dam became operational in 1952 and is about 2.5 miles upstream and east of the city of Newport, Washington, 26 miles west of the city of Sandpoint, Idaho, and 29 miles downstream from Lake Pend Oreille (Figure 1). Lake Pend Oreille is a natural lake that is located in a glacially scoured basin in the Purcell Trench in Northern Idaho (Fields et al. 1996). The Clark Fork is the major inflow to the lake supplying about 85 percent of the surface water inflow to the lake and the outlet arm (Frenzel, 1991).

Although Lake Pend Oreille is a natural lake, Albeni Falls Dam is authorized for regulation of the lake level for flood control, navigation, fish and wildlife conservation, recreation, and power generation. Before the project became operational in 1952, the annual surface elevation of Lake Pend Oreille varied according to seasonal inflows, from an average fall/winter low of about 2,048.0 feet to an average spring runoff high of about 2,062.0 feet, with a maximum spring elevation of 2071.8 feet recorded on June 9, 1948 (COE 2000). After reaching a maximum elevation during spring runoff, the lake gradually receded to an elevation of about 2,050.0 feet by August and reached its minimum elevation of about 2,048.0 feet by October.

Current Lake Pend Oreille regulating procedures are briefly described below. After the spring runoff period is completed (usually late May to early July), Lake Pend Oreille is maintained in a 0.5-foot summer operation range between elevations 2,062.0 and 2,062.5 feet until the end of the summer recreation season. A fall drawdown generally begins after Labor Day and the lake is stabilized at a minimum control elevation of 2,051.0 feet for the winter typically by December 1. The lake is held at this minimum control elevation until April 1, after which spring runoff typically occurs and the lake is refilled during May and June.

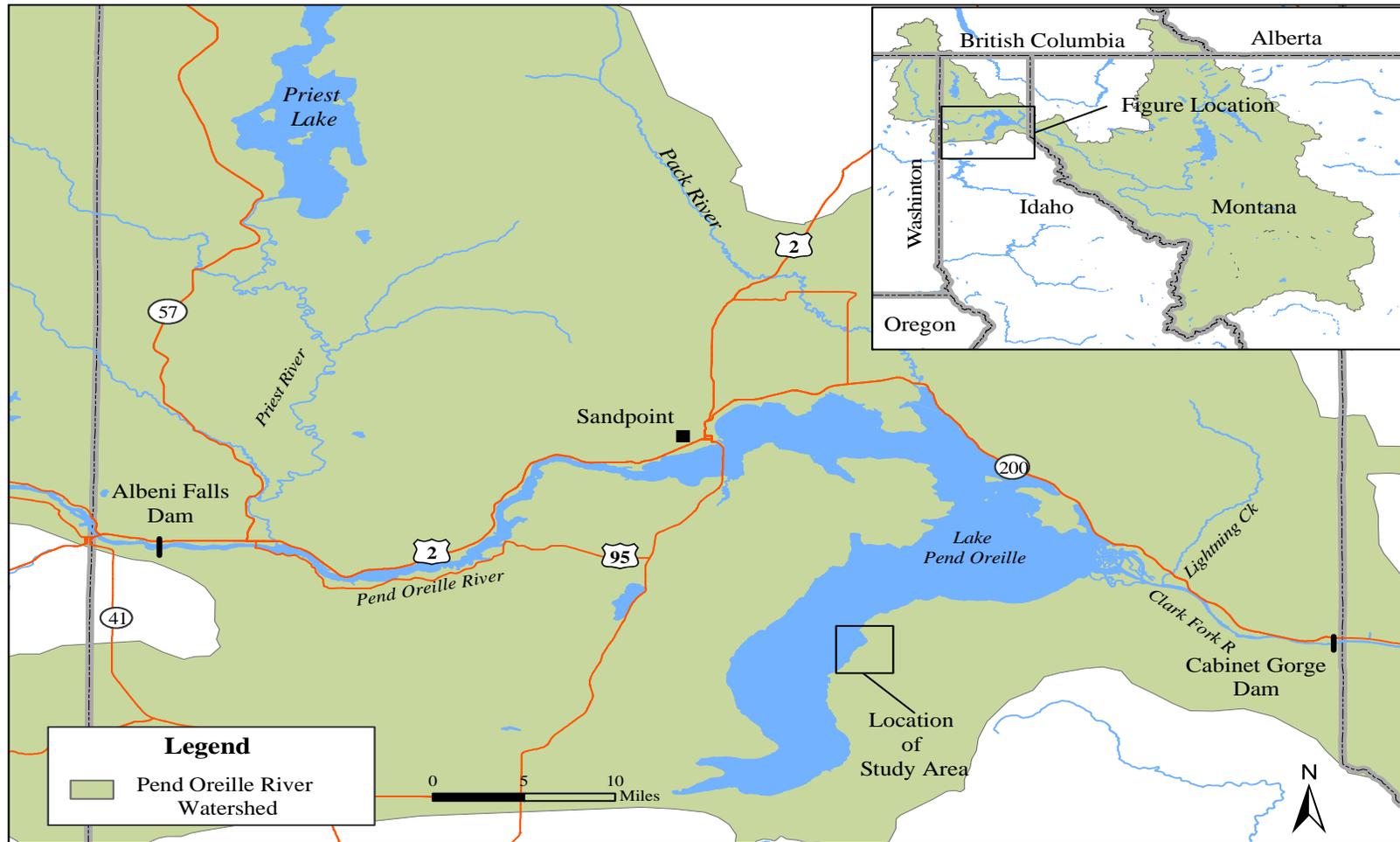


Figure 1. Location of the Falls Creek Mine Site Investigation study area in the Clark Fork-Pend Oreille River watershed.

## **Falls Creek Mine Site Description**

Falls Creek is located in Bonner County, Idaho, approximately 20 miles southeast of the city of Sandpoint (See Figure 1). This perennial stream is about 5 miles long and drains a watershed approximately 4.6 square miles in size. The stream flows in a northwest trending direction through a steep canyon from an elevation of 6,405 feet at Packsaddle Mountain and discharges into Lake Pend Oreille at an elevation of 2,062 feet (Figure 2). The mountains rise as much as 2,000 feet per mile from the valley and vegetation is dominated by Douglas-fir and Western Red Cedar.

Falls Creek Mine is located in the Idaho Panhandle National Forest at an elevation of approximately 3185 feet, about 1000 linear feet upslope from Falls Creek (Figure 3). The site is located entirely on Forest Service land on the south side of the valley and consists of a collapsed mill building, several old cabins, three adits, three waste rock dumps and a tailings pile (Figure 4). The main waste rock dump extends from the main adit and is about 190 feet long by 25 to 60 feet wide by 20 to 30 feet high, with a steep face above the old mill site. Little vegetation is present on the waste rock dump. Two smaller adits and waste rock dumps are located on the hillside several hundred vertical feet above the main adit and dump. These smaller dumps are about 100 and 150 feet in length by 25 and 50 feet in width and of an unknown depth. The tailings pile is located immediately downslope of the mill site and is about 70 feet long by 40 feet wide and of an unknown depth. Although little vegetation is present on the tailings pile, vegetation is dense in the areas surrounding the pile. Three berms are located immediately below the tailings pile and two shallow ponds are located behind these berms.

Groundwater discharges from the main adit, and flows via a small drainage channel to the west of the mill site and tailings pile, passes under the access road via a culvert and enters Falls Creek below the road. A portion of the adit discharge appears to seep through or under the tailings pile and into the tailings ponds. This seepage has created a wet zone near the tailings pile, with surface water pools and wet soils in the vicinity of the tailings ponds.

## **Falls Creek Mine Site History**

Falls Creek mine was discovered in 1908 and produced lead and silver from about 1914 to 1937 (Gammell 1943). The Falls Creek Mining Company was incorporated in 1911 and developed the Falls Creek mine as well as the Minerva mine located across the valley on the north side of Falls Creek. Ore production began around 1913 and a 50 tons-per-day flotation mill was constructed in 1918 (Nieman 2005a). Gammell (1943) reported that ore from both the Falls Creek and Minerva mines were milled at the Falls Creek mill.

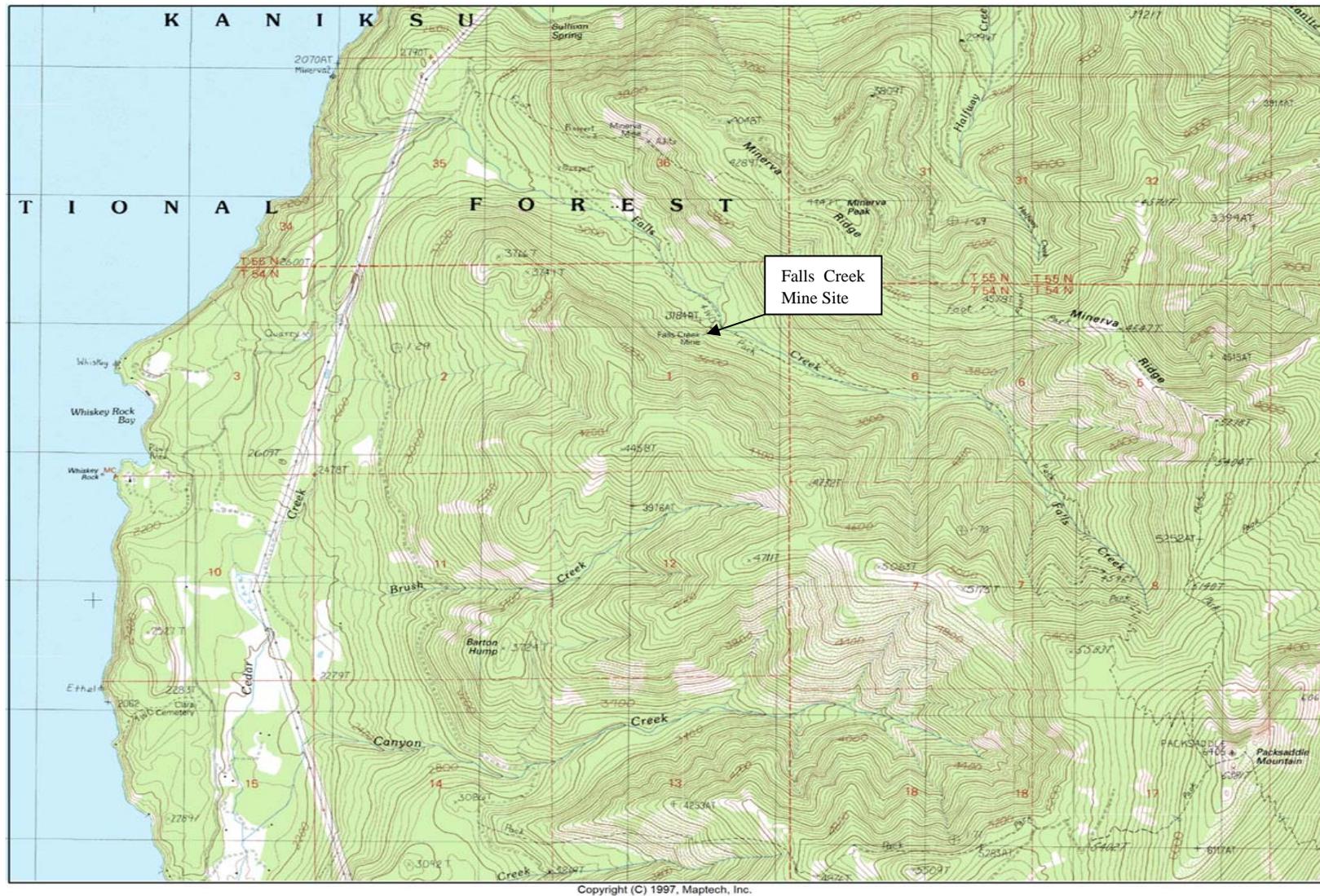
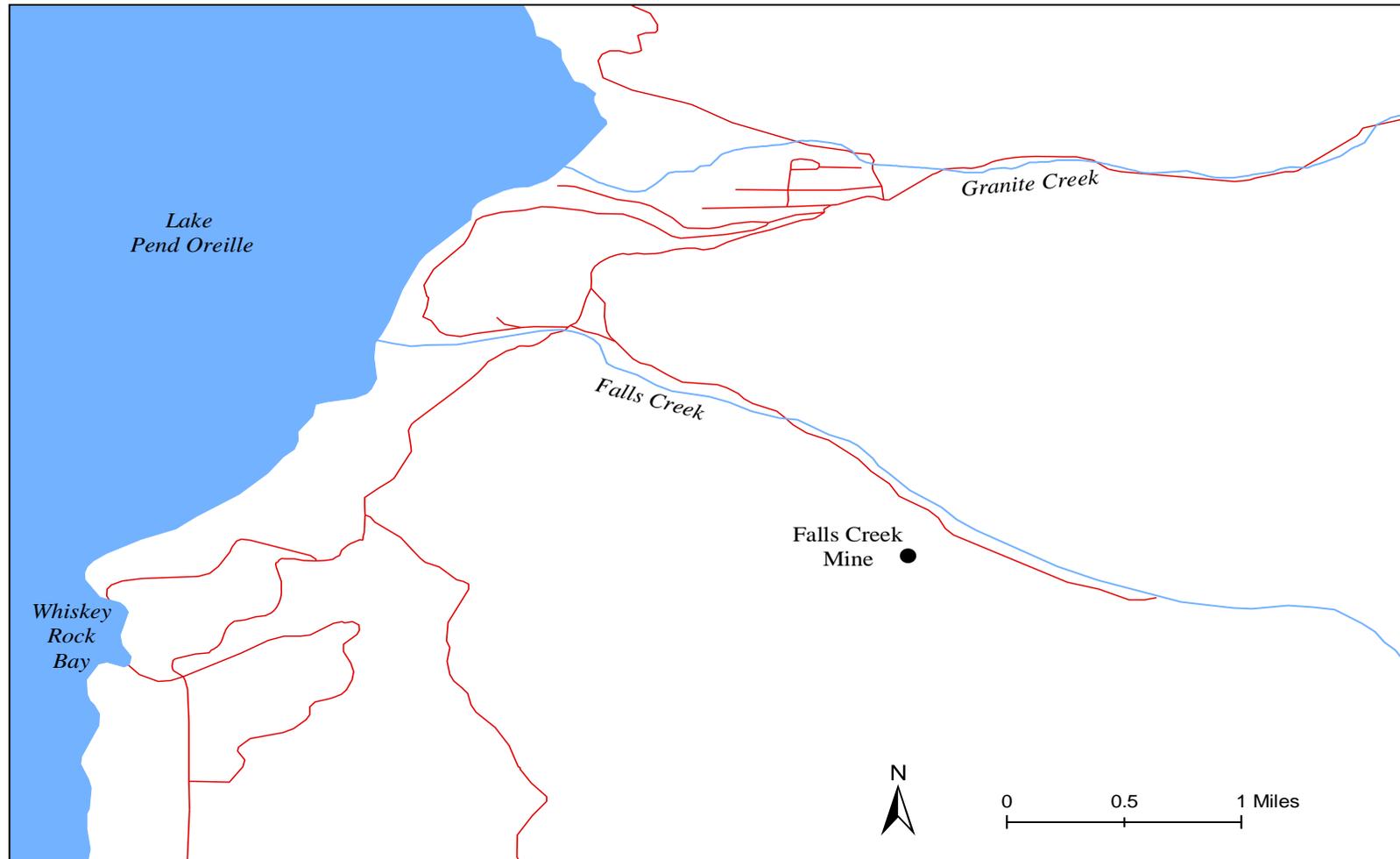
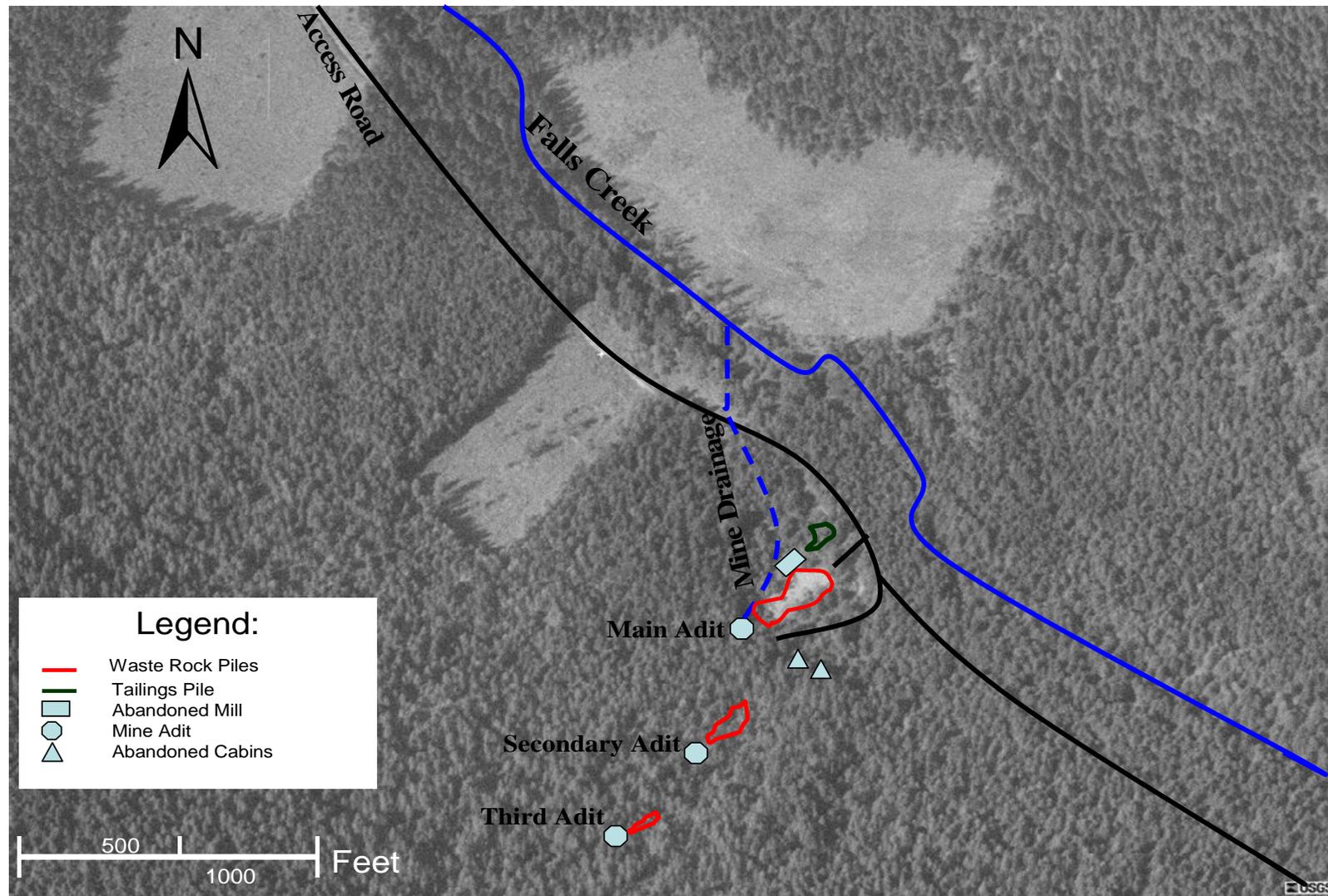


Figure 2. Location of the Falls Creek watershed and Lake Pend Oreille.



**Figure 3. Location of the Falls Creek Mine Site.**



**Figure 4.** General locations of the main mine features at the Falls Creek Mine Site.

Up to two tunnels were in operation by 1925, but the tonnage of ore mined during this period is unknown at this time. The Falls Creek mine was leased to Amazon Mines Inc. (which became Amazon Mining Company) from 1930 to 1933. During this time period, considerable work was completed at the mine which consisted of three tunnels, two shafts, and two raises. After a series of prospective buyers worked the property in the 1930's the mine was leased to Falls Creek Mines, Inc. in 1936 after which little to no work appears to have been performed at the mine site. By 1940 it appears that no mining work was being performed at the Falls Creek Mine. By 1954 the Falls Creek Mining Company forfeited its corporate charter (Nieman 2005a).

## **Geologic Characteristics**

The Falls Creek drainage is located in the mountains that rise up from the eastern shore of Lake Pend Oreille near the border of Idaho and Montana. Bedrock consists of relatively low-grade metasedimentary rocks of the Mesoproterozoic Belt Supergroup (IGS 2002). Poole (1935) characterized the area as being dominated by widely faulted Pre-Cambrian sediments overlying a grano-diorite batholith. Ravalli Group metasediments and Piegan Group or Middle Belt Group metasediments are found in the drainage (IGS 2002). Ravalli Group sediments are dominated by quartzite and siltite and include the Burke, Revett and St. Regis formations in Idaho. Piegan Group or Middle Belt Group sediments include the Wallace Formation in Idaho. Several distinct rock types are associated with the Wallace Formation, including argillite, siltite, and limestone (IGS 2002).

## **Climate**

The climate of the study area is influenced by easterly moving weather systems from the Pacific Ocean. Winters are generally cloudy, cool, and wet, with November through March being the wettest months. Most of the snowpack in the mountains falls between November and April. Summers are typically warm and dry, with little rainfall occurring from June through September. Sandpoint, Idaho (elevation 2,062 ft.) is the closest long-term (1910-2008) weather station to the site. The mean annual precipitation at Sandpoint is about 32 inches, with an annual snowfall of about 70 inches (WRCC 2009). The mean annual temperature is about 46°F, with extremes recorded of – 37°F and 104°F (WRCC 2009). Typically, December and January are the coldest and wettest months while July is the warmest and driest month. The first snowfall usually occurs in early November, and heavy snows can occur throughout the winter as can extended periods of melting and freezing. The snow pack generally remains in the area from December through March or April.

## **Previous Investigations**

A preliminary investigation of the Falls Creek Mine site was conducted by William Rember (USGS and University of Idaho) on September 10, 1997 (Nieman 2005a). Surface water

samples were collected from the adit water and the seep below the tailings pond. Additionally, Falls Creek was sampled several hundred feet upstream and downstream of the mine site. Surface water from Falls Creek upstream of the mine did not contain elevated metals concentrations while downstream of the mine the creek contained elevated concentrations of cadmium. Water from the adit exceeded the aquatic life chronic standard for cadmium, while water collected from the seep below the tailings pond exceeded the cadmium chronic standard and was within the range of the chronic lead standard.

Solid samples were collected from the waste rock dump and the tailings pile. The waste rock sample exceeded background and environmental levels for arsenic, cadmium, chromium, copper, iron, manganese, nickel, lead, and zinc. A toxicity characteristic leaching procedure (TCLP) metals screen identified significant amounts of cadmium, chromium, and lead leached from the waste rock. The tailings pile sample exceeded background and environmental levels for arsenic, cadmium, copper, iron, manganese, lead, and zinc. The TCLP screen identified significant amounts of cadmium and lead leached from the tailings pile.

The USFS performed a field analysis in 2005 to determine contaminant concentrations at the Falls Creek Mine site using an X-ray Fluorescence (XRF) unit (Nieman 2005b). Three samples were collected from the tailings pond and one sample from the waste rock dump. Tailings pond samples contained elevated concentrations of arsenic (6420 mg/kg), copper (483 mg/kg), lead (2690 mg/kg), manganese (2940 mg/kg), and zinc (2710 mg/kg), with the values shown representing the maximum concentration measured. Similarly, the waste rock sample contained elevated concentrations of arsenic (2610 mg/kg), copper (326 mg/kg), lead (2000 mg/kg), manganese (2695 mg/kg), and zinc (2870 mg/kg).

## Methods and Materials

### Sampling Design

The purpose of the surface soil/tailings sampling, waste rock sampling, stream sediment sampling, and surface water sampling was to determine contaminant concentrations, the lateral extent of contaminants, and the direction of migration of contaminants at the Falls Creek Mine site. Four (4) soil samples, four (4) waste rock samples, seven (7) tailings samples, five (5) stream/pond sediment samples, and five (5) surface water samples were collected from background and potentially impacted areas of the Falls Creek Mine site to evaluate the spatial distribution of contaminants. Soil and water quality sampling station locations and details are summarized in Tables 1 and 2 with general sampling locations shown in Figures 5 and 6. Soil and water quality parameters monitored are presented in Tables 3 and 4.

Background soil samples (FCM-BS-1S to 4S) were collected from upland soils representative of the site, while background sediment samples (FCM-SS-5S and 6S) were collected from upstream locations (Figure 5). All background samples were collected from locations outside of known waste areas or areas of other disturbances. Waste rock samples were collected from three (3) sites (FCM-WR-9S to 11S) representing the main waste rock dump located below the main adit, and from one (1) site (FCM-WR-12S) representing a smaller secondary waste rock dump located upslope from the main dump and below a secondary adit. Mine tailings pile samples were collected from seven (7) sites (FCM-TP-13S, 15S and 17S to 21S) representative of the tailings pile located immediately downslope of the abandoned mill site. Stream sediment samples (FCM-SS-7S and 8S) were collected from downstream locations representative of that part of Falls Creek potentially impacted by runoff from the mine site. A single tailings pond sediment sample (FCM-TP-22S) was collected from one of the two shallow ponds located behind the berms that surround the tailings pile (Figure 6).

Smith et al. (2000) noted that collecting representative samples of mine waste (waste rock and tailings piles) can be difficult due to the physical, chemical and spatial heterogeneity of the waste material and that a single composite of up to thirty (30) grab samples can provide an overview of the total contamination of mine waste. However, for this study, discrete soil and mine waste samples (waste rock and mine tailings) were collected to better determine the nature and extent of contamination at the Falls Creek Mine site understanding that some samples may be more or less contaminated than others. The sampling design targeted collecting representative samples from the upper 6 inches of soil due to the ease of collection and the fact that surficial material is the most likely material to impact runoff from storms and snowmelt (Smith et al. 2000). The target size fraction was < 2 mm because the smaller size fractions are generally more chemically reactive, contain greater concentrations of contaminants, and generally control the leaching properties of the mine waste material (Shelton and Capel 1994, Smith et al. 2000, Box et al. 2004).

**Table 1. Soil and sediment sampling station locations and details.**

Sample ID	Sample Type	Sample Date	Sample Time	Sample Location (NAD-83)	
				Latitude	Longitude
<b>Soil Samples</b>					
FCM-BS-1S	Background Soil	10/19/2005	1145	48.05988	-116.40142
FCM-BS-2S	Background Soil	10/19/2005	1245	48.05948	-116.40045
FCM-BS-3S	Background Soil	10/19/2005	1345	48.06370	-116.40751
FCM-BS-4S	Background Soil	10/19/2005	1430	48.05923	-116.40101
FCM-WR-9S	Waste Rock	10/20/2005	1030	48.06126	-116.40418
FCM-WR-10S	Waste Rock	10/20/2005	1130	48.06112	-116.40446
FCM-WR-11S	Waste Rock	10/20/2005	1315	48.06118	-116.40389
FCM-WR-12S	Waste Rock	10/20/2005	1345	48.05971	-116.40508
FCM-TP-13S	Tailings Pile	10/20/2005	1415	48.06200	-116.40440
FCM-TP-15S	Tailings Pile	10/20/2005	1500	48.06170	-116.40440
FCM-TP-17S	Tailings Pile	10/20/2005	1540	48.06169	-116.40437
FCM-TP-18S	Tailings Pile	10/20/2005	1610	48.06170	-116.40450
FCM-TP-19S	Tailings Pile	10/20/2005	1630	48.06166	-116.40444
FCM-TP-20S	Tailings Pile	10/20/2005	1640	48.06166	-116.40444
FCM-TP-21S	Tailings Pile	10/20/2005	1650	48.06158	-116.40437
<b>Sediment Samples</b>					
FCM-SS-5S	Background Stream Sediment	10/19/2005	1530	48.05995	-116.39849
FCM-SS-6S	Background Stream Sediment	10/19/2005	1645	48.05987	-116.39857
FCM-SS-7S	Stream Sediment	10/19/2005	1730	48.06345	-116.40603
FCM-SS-8S	Stream Sediment	10/19/2005	1745	48.06348	-116.40579
FCM-TP-22S	Tailings Pond Sediment	10/20/2005	1830	48.06200	-116.40430

**Table 2. Water quality sampling station locations and details.**

Sample ID	Sample Type	Sample Date	Sample Time	Location (NAD-83)	
				Latitude	Longitude
<b>Surface Water Samples</b>					
FCM-SWQ-1W	Falls Creek Downstream of Mine Runoff	10/20/2005	1720	48.06345	-116.40603
FCM-SWQ-2W	Falls Creek Upstream of Mine Runoff	10/20/2005	1730	48.06344	-116.40574
FCM-SWQ-3W	Mine Runoff at Road Crossing	10/20/2005	1740	48.06290	-116.40570
FCM-SWQ-4W	Tailings Pond	10/20/2005	1750	48.06200	-116.40425
FCM-SWQ-5W	Mine Runoff at Adit	10/20/2005	1800	48.06082	-116.40462

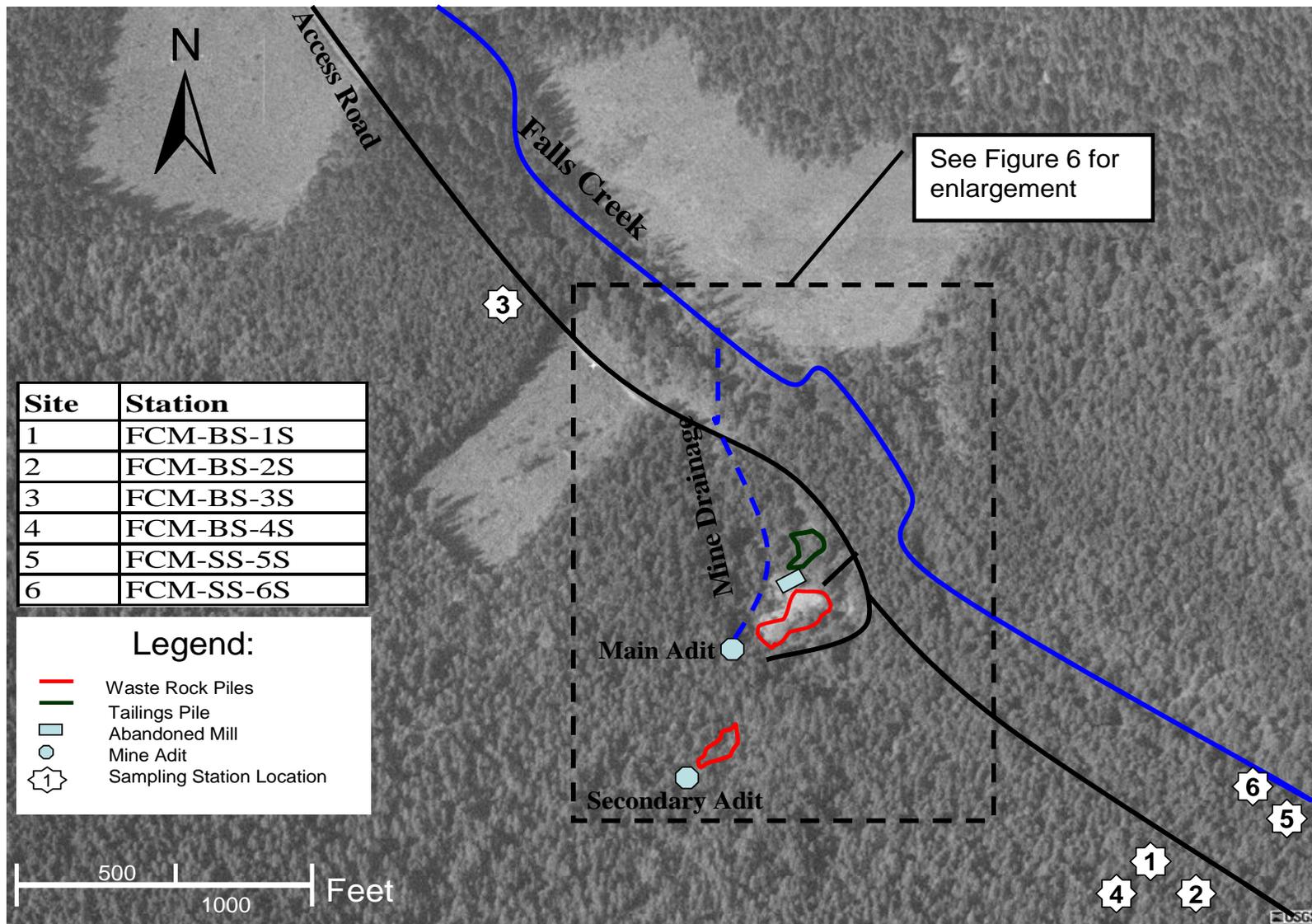


Figure 5. Location of the Falls Creek Mine Site and background soil and sediment sampling locations.

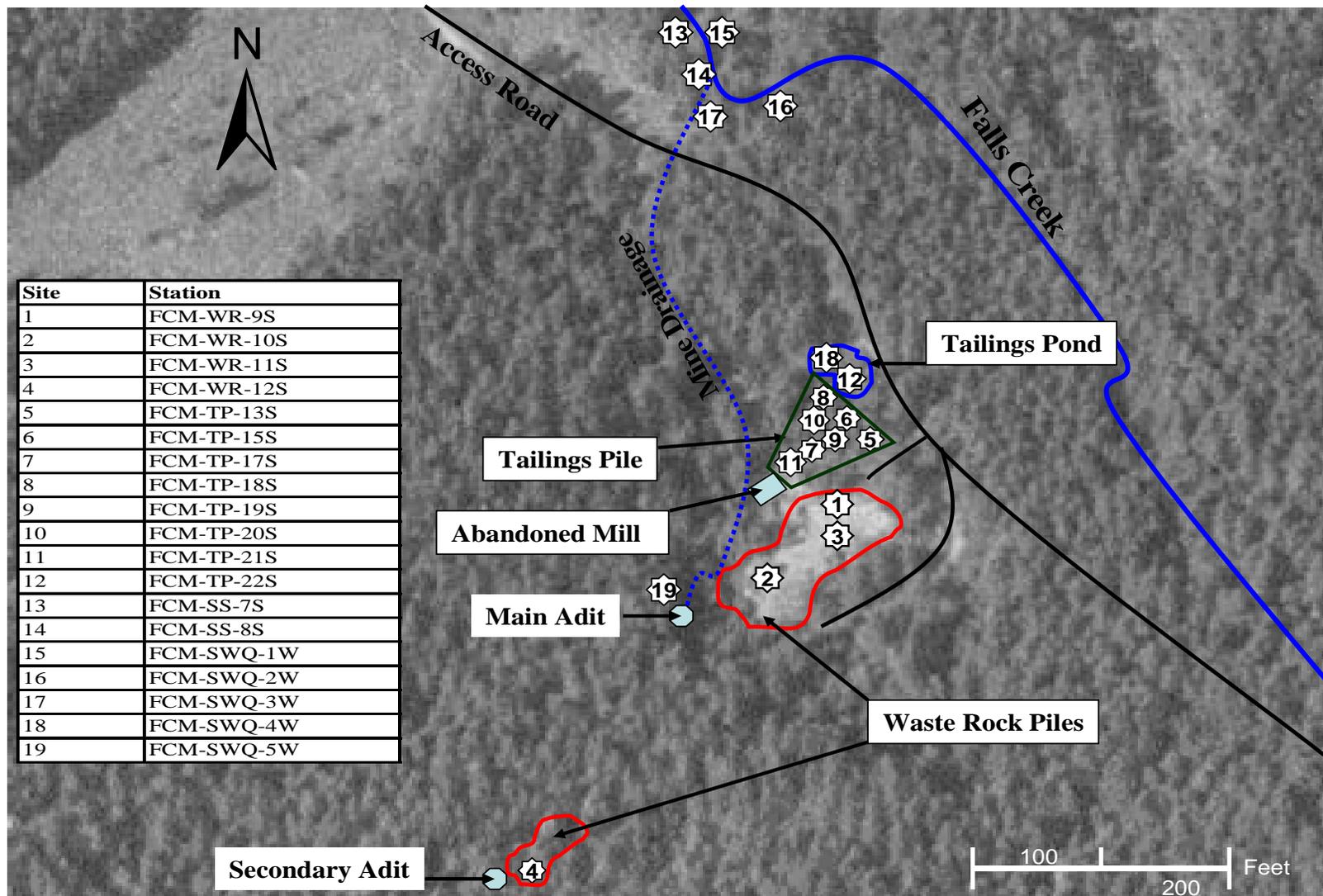


Figure 6. Falls Creek Mine site waste rock, tailings pile, stream sediment, and water quality sampling locations.

**Table 3. Methods, detection limits, containers, preservation techniques and holding times for soil and sediment quality analyses.**

	Matrix	Method Number <sup>a</sup>	Detection Limit/Unit	Container and Preservation	Holding Time
<b>Laboratory Chemical Parameters</b>					
Arsenic	Soil/Sediment	EPA 7060	1.5 mg/kg	P/G, 4° C	6 Months
Cadmium	Soil/Sediment	EPA 6010	0.2 mg/kg	P/G, 4° C	6 Months
Chromium	Soil/Sediment	EPA 6010	0.5 mg/kg	P/G, 4° C	6 Months
Copper	Soil/Sediment	EPA 6010	0.5 mg/kg	P/G, 4° C	6 Months
Lead	Soil/Sediment	EPA 7421	0.1 mg/kg	P/G, 4° C	6 Months
Manganese	Soil/Sediment	EPA 7461	0.2 mg/kg	P/G, 4° C	6 Months
Nickel	Soil/Sediment	EPA 6010	0.25 mg/kg	P/G, 4° C	6 Months
Zinc	Soil/Sediment	EPA 6010	0.25 mg/kg	P/G, 4° C	6 Months
Toxicity Characteristics Leaching Procedure (TCLP)	Soil/Sediment	EPA 1311	—	P/G, 4° C	6 Months
Synthetic Precipitation Leaching Procedure (SPLP)	Soil/Sediment	EPA 1312	—	P/G, 4° C	6 Months
Particle Size	Soil/Sediment	—	—	P/G, 4° C	6 Months

<sup>a</sup> EPA method numbers are from U.S. EPA (1986).  
 mg/kg Milligrams per kilogram  
 P, G Polyethylene, Glass

**Table 4. Methods, detection limits, containers, preservation techniques and holding times for water quality analyses.**

	Matrix	Method Number <sup>a</sup>	Detection Limit/Unit	Container and Preservation	Holding Time
<b>Field Parameters</b>					
Temperature	Water	SM 2550-B	0.1°C	—	Analyze
pH	Water	SM 4500-H	–	P/G, 4° C	3 hours
Conductivity	Water	SM 2510-B	1 µS/cm	P/G, 4° C	28 days
Turbidity	Water	SM 2130-B	0.1 NTU	P/G, 4° C	48 hours
Dissolved Oxygen	Water	SM 4500-O-G	0.1 mg/L	G, Dark	8 hours
<b>Laboratory Chemical Parameters</b>					
Nitrate+Nitrite	Water	EPA 353.2	0.010 mg/L	P/G, 4° C, H <sub>2</sub> SO <sub>4</sub> to pH<2	48 hours
Alkalinity	Water	EPA 310.1	1.00 mg/L	P/G, 4° C	14 days
Hardness	Water	SM182340B	1.00 mg/L	P/G, 4° C, HNO <sub>3</sub> to pH<2	6 months
Calcium	Water	EPA 200.7	0.100 mg/L	P/G, 4° C, HNO <sub>3</sub> to pH<2	6 months
Magnesium	Water	EPA 200.7	0.100 mg/L	P/G, 4° C, HNO <sub>3</sub> to pH<2	6 months
Potassium	Water	EPA 200.7	0.700 mg/L	P/G, 4° C, HNO <sub>3</sub> to pH<2	6 months
Sodium	Water	EPA 200.7	0.500 mg/L	P/G, 4° C, HNO <sub>3</sub> to pH<2	6 months
Sulfate	Water	EPA 375.4	1.00 mg/L	P/G, 4° C	28 days
Chloride	Water	EPA 325.3	0.50 mg/L	P/G, 4° C	28 days
<b>Total and Dissolved Trace Metals</b>					
Arsenic	Water	EPA 206.2	0.003 mg/L	P/G, 4° C <sup>b</sup>	6 months
Cadmium	Water	EPA 213.2	0.0002 mg/L	P/G, 4° C <sup>b</sup>	6 months
Chromium	Water	EPA 218.2	0.0020 mg/L	P/G, 4° C <sup>b</sup>	6 months
Copper	Water	EPA 220.2	0.0010 mg/L	P/G, 4° C <sup>b</sup>	6 months
Iron	Water	EPA 200.7	0.010 mg/L	P/G, 4° C <sup>b</sup>	6 months
Lead	Water	EPA 239.2	0.0010 mg/L	P/G, 4° C <sup>b</sup>	6 months
Manganese	Water	EPA 243.2	0.0010 mg/L	P/G, 4° C <sup>b</sup>	6 months
Nickel	Water	EPA 249.2	0.0020 mg/L	P/G, 4° C <sup>b</sup>	6 months
Zinc	Water	EPA 200.7	0.005 mg/L	P/G, 4° C <sup>b</sup>	6 months

<sup>a</sup> SM method numbers are from APHA et al. (2000); EPA method numbers are from U.S. EPA (1983, 1984, and 1992).

<sup>b</sup> Samples for analysis of total trace metals should be preserved within 24 hours with HNO<sub>3</sub> to pH<2. Samples for dissolved trace metals should be preserved within 24 hours with HNO<sub>3</sub> to pH<2 after filtration

mg/L Milligrams per liter

µS/cm Microsiemens per centimeter

NTU Nephelometric turbidity unit

P, G Polyethylene, Glass

All soil, rock, sediment, and surface water sampling locations were marked directly onto a 1:24,000-scale USGS topographic map as well as a smaller-scale field drawn site map, and the latitude and longitude was obtained using a Garmin GPS-V global positioning satellite (GPS) receiver system, typically with an accuracy less than  $\pm 10$  meters. Where the GPS instrument would not give a location due to a lack of available satellites or instrument error due to canopy cover, an estimated sampling position was recorded in the field notebook and on the site map. This estimated location was transferred to a digitized orthophoto using Arcview software where a latitude and longitude were obtained with an estimated accuracy of less than  $\pm 30$  meters.

## **Surface Soil, Waste Rock and Mine Tailings Sampling**

Soil, waste rock, and mine tailings samples were collected from eleven (11) sites in the Falls Creek Mine site by two field technicians wearing new powderless vinyl gloves and practicing clean hands-dirty hands field techniques as follows according to the following procedures.

- All sampling equipment was dedicated to each sampling site and kept in a plastic bag (e.g. Ziploc) until used
- A clean plastic sheet was placed near the sampling area and all decontaminated equipment and sampling containers were placed on the plastic sheet and covered with clean plastic when not in use
- If necessary, prior to sampling, any vegetation overlying the soil was loosened and peeled back with a decontaminated high density polyethylene (HDPE) spoon
- Samples were collected from the upper 6-inches using a decontaminated HDPE spoon and sieved through a decontaminated 2 mm mesh nylon sieve into a decontaminated HDPE bowl, thoroughly mixed, and placed into precleaned containers using a decontaminated HDPE spoon
- All surface soil/tailings samples were discrete and no composite samples were collected
- Two (2) duplicate samples were collected. Duplicate samples were labeled similar to the other samples and submitted blind to the laboratory. The locations for a duplicate sample collection were determined in the field
- All sampling containers were appropriately labeled, immediately placed on ice in a cooler, and delivered to the laboratory following proper chain of custody procedures

- Each sample was analyzed for the parameters shown in Table 3 with the following exceptions. The three waste rock samples and tailings pile samples with the highest metals concentrations were further analyzed for leachable metals according to Toxicity Characteristics Leaching Procedure (TCLP) and Synthetic Characteristics Leaching Procedure (SPLP) methods described in detail below.

## Surface Water Sediment Sampling

Trace metals occur naturally in creek sediments from the weathering of rocks and mineral soils in the watershed. However, metals can also be introduced by past mining activities which result in mine wastes being transported down gradient to receiving water bodies. The target locations for surface water sediment sampling was from natural depositional zones within designated creek reaches upstream and downstream of contaminant sources. Surface water sediment sampling locations were as near to surface water sampling locations as field conditions allowed.

All surface water sediment sampling was performed by two field technicians wearing new powderless vinyl gloves and practicing clean hands-dirty hands field techniques as follows:

- All sampling equipment was dedicated to each sampling location and kept in a plastic bag (e.g. Ziploc) until used
- Sediment samples were collected using a decontaminated HDPE spoon from between two (2) to five (5) depositional zones located in shallow pools, back eddies, behind boulders, and along the banks of an approximately 100 foot reach of the creek at each station
- Sediment samples were sieved through a decontaminated 2 mm mesh nylon sieve into a decontaminated HDPE bowl. When needed, samples were wet-sieved using ambient creek water to pass through the sieve
- Samples were composited in a decontaminated HDPE bowl, transferred to laboratory cleaned sample containers, appropriately labeled, immediately placed on ice in a cooler and delivered to the laboratory following proper chain of custody procedures
- Each sample was analyzed for the parameters shown in Table 3 with the exception of no sample was submitted for TCLP or SPLP analysis.

## Surface Water Sampling

Surface water sampling was performed by two field technicians wearing new powderless vinyl gloves and practicing clean hands-dirty hands field techniques. Grab samples were collected

from the center of the stream/drainage channel by submerging laboratory-cleaned, prelabeled sample containers below the water surface at mid-depth. For smaller drainage channels, samples were collected as practical from pools or falls. When appropriate (i.e., when the sample bottle contains no preservative), the sample bottle and cap was rinsed three times with sample water prior to filling. Sample containers were immediately capped and placed on ice in a cooler. Measurements of field parameters (See Table 4) were performed by submerging a Hydrolab MiniSonde 4A multiprobe directly into the water or from a sample withdrawn from the creek/drainage. Equipment used for field measurements was calibrated prior to the sampling event following manufacturer's specifications. One set of field duplicates was collected to assess both environmental and analytical variability. Each sample was analyzed for the parameters presented in Table 4.

### **Surface Water Discharge Measurement Procedures**

Discharge measurements were taken at each surface water sampling station in accordance with Puget Sound Estuary Program (PSEP) protocols (U.S. EPA 1997). Water depth and velocity was measured at an appropriate number of width segments using a USGS Pigmy style current meter. For small seeps and shallow drainages, flows were estimated by either filling a 2-gallon bucket over a measured time period or by recording the travel time of a floating object (e.g. stick) from upstream to downstream over a known distance.

### **Leaching Test Procedures**

Three (3) waste rock and three (3) tailings pile samples with the greatest metals concentrations were submitted for the Toxicity Characterization Leaching Procedure (TCLP) and the Synthetic Precipitation Characteristic Leaching Procedure (SPLP) using EPA (1986) methods outlined in Table 3. The purpose of leaching tests is to evaluate the potential for metals to mobilize and move through soils in fluid form. The TCLP test was designed to simulate leaching at hazardous waste sites, such as a municipal landfill location, by organic acids generated from the biological breakdown of waste in a municipal landfill. One assumption with the TCLP test is that the waste is contained and not exposed to atmospheric deposition. The SPLP test was designed to model an acid rain leaching environment on wastes that are exposed to atmospheric deposition. The EPA (1996) recommends using the SPLP test for contaminated soils that are not being disposed of in a municipal landfill.

### **Quality Assurance Procedures**

Quality assurance of water quality samples followed procedures set forth in the *Sampling and Analysis Plan: Preliminary Site Investigation of the Falls Creek Mine Site in the Lake Pend Oreille Watershed, Idaho* (USCOE 2005). Data were validated according to the sampling and analysis plan, and quality control data provided by the laboratory were combined with results of field duplicates to check the precision and accuracy of the data. Data validation results are

presented in **Appendix A** at the end of this report. Values qualified as estimates were used in the evaluation.

## **Applicable Standards and Criteria**

### **Water Quality Criteria**

The Idaho Department of Environmental Quality (IDEQ) determines surface water quality criteria for Falls Creek. The IDEQ has classified Falls Creek as an undesignated surface water of the state that is a cold water aquatic life use water body that supports primary or secondary contact recreation beneficial uses. General water quality standards for cold water aquatic life use water bodies are presented in Table 5. Criterion maximum concentrations (acute 1-hour average) and criterion chronic concentrations (chronic 4-day average) for metals are presented in Table 5.

### **Freshwater Sediment Standards**

There are currently no Idaho State criteria or EPA national criteria for contaminants in freshwater sediments. Therefore, freshwater sediment guidelines developed by other states were used to assess the relative levels of contamination and potential effects on benthic organisms by sediments collected at the Falls Creek Mine site.

The Washington State Department of Ecology (WDOE) is currently developing a set of freshwater sediment quality values (SQVs) to be used in WDOE's sediment management programs (Michelsen 2003). The proposed SQVs are separated into sediment quality standards (SQS) and cleaning screening levels (CSL). Sediments with contaminant concentrations less than the SQS values should have little to no effect on biological organisms, while sediments with concentrations greater than the CSL require further study and may warrant cleanup. The proposed WDOE freshwater sediment standards are presented in Table 5.

### **Mine Waste and Soil Standards**

Generic, non site-specific soil screening guidelines and cleanup levels have been developed by the EPA and are presented in Table 5. Two different EPA guidelines are presented, the EPA Soil Screening Levels (SSLs) and the EPA Region 9 Preliminary Remediation Goals (PRGs) (EPA 1996 and 2004). The SSLs were developed in 1996 and are generic risk based concentrations derived from equations combining exposure information assumptions with EPA toxicity data. The PRGs developed by EPA Region 9 in 2004 represent the most current EPA guidelines available and were derived using the most recent EPA toxicity values and standard exposure factors to estimate contaminant concentrations that are protective of humans over a lifetime. PRG concentrations are sub-classified into cancer risk and chronic exposure concentrations for residential and industrial land uses. For the purpose of the Falls Creek Mine site chronic exposure concentrations for residential and industrial land uses are presented in Table 5.

**Table 5. Soil, sediment and water quality criteria and guidelines.**

Parameters	Applicable Criteria and Guidelines									
	Surface Water		Soil			Freshwater Sediment		TCLP and SPLP		
	Acute Water Quality Criteria <sup>1</sup> (µg/L)	Chronic Water Quality Criteria <sup>1</sup> (µg/L)	EPA Soil Screening Levels <sup>2</sup> (mg/kg)	EPA Region 9 Preliminary Remediation Goals (PRGs) for Residential Soils <sup>3</sup> (mg/kg)	EPA Region 9 Preliminary Remediation Goals (PRGs) for Industrial Soils <sup>4</sup> (mg/kg)	Freshwater Sediment Quality Standard (SQS) <sup>5</sup> (mg/kg)	Freshwater Sediment Cleanup Screening Level (CSL) <sup>5</sup> (mg/kg)	EPA TCLP Criteria <sup>6</sup> (mg/L)	IDEQ Surface Water Quality Chronic Criteria*20DAF <sup>7</sup> (mg/L)	
Arsenic	340	150	0.4	22	260	20	51	5	3	
Cadmium	1.06*	0.50*	78	37	450	0.6	1	1	0.02	
Chromium	475*	62*	390	210	450	95	100	5	1.28	
Copper	13.8*	9.4*	—	3,100	41,000	80	830	—	0.188	
Iron	—	—	—	23,000	100,000	—	—	—	—	
Lead	51*	1.97*	400	400	800	335	430	5	0.038	
Manganese	—	—	—	1,800	19,000	—	—	—	—	
Nickel	388*	43*	1,600	1,600	20,000	60	70	—	0.9	
Zinc	98*	97*	23,000	23,000	100,000	140	160	—	1.9	

Notes:

1. Idaho Department of Environmental Quality.
  2. EPA (1996).
  3. EPA (2004). PRG for non-cancer endpoint for direct contact with residential soils.
  4. EPA (2004). PRG for non-cancer endpoint for direct contact with industrial soils.
  5. Washington Department of Ecology (2004).
  6. EPA (1996).
  7. Represents the IDEQ criteria multiplied by a dilution attenuation factor (DAF) of 20 (EPA 1996. Soil Screening Guidance: User's Guide).
- \* Hardness dependant. Value based on an average hardness in Falls Creek of 80 mg/L as CaCO<sub>3</sub>.
- Not Available.

The SSLs and PRGs are not legally enforceable standards but are designed to assist in the evaluation of contaminants in soil for initial screening level studies. These soil standards are not site specific criteria for the Falls Creek Mine site and are provided to allow for a general assessment of the relative levels of contamination at the Falls Creek Mine site. Concentrations of metals above the SSLs and PRGs do not designate the site as contaminated, but suggest that further evaluation of the site and the potential risk is warranted.

### **TCLP and SPLP Standards**

The EPA metals criteria for TCLP concentrations are presented in Table 5. There are currently no EPA regulatory criteria for SPLP concentrations. However, The EPA (1996) suggests that the dilution attenuation factor (DAF) method can be used to compare SPLP results to water quality criteria. A generic DAF of 20 (EPA 1996) was applied to the IDEQ surface water chronic criteria in Table 5.

## Results and Discussion

### Background Soil and Stream Sediment

Background soil sample (FCM-BS-1S to 4S) results are presented in Table 6. Concentrations of arsenic, cadmium, chromium, copper, lead, manganese, nickel, and zinc were low in the background soils with the exception of slightly elevated concentrations of arsenic in sample FCM-BS-3S (33.6 mg/kg) and manganese in samples FCM-BS-1S and 4S (2,310.1 mg/kg and 1971 mg/kg, respectively). Arsenic concentrations in FCM-BS-3S exceeded the residential soil PRG value (22 mg/kg) but were well below the industrial PRG value (210 mg/kg). This slightly elevated arsenic concentration in native background soils is not unusual in areas with similar geologic characteristics as the Falls Creek Mine Site. The State of Montana recognized that arsenic concentrations in native soils in Montana naturally exceed the residential PRG of 22 mg/kg and has subsequently increased the generic action level to 40 mg/kg (MDEQ 2005). Concentrations of manganese in background samples FCM-BS-1S and 4S slightly exceeded the residential PRG value (1,800 mg/kg) but were far below the industrial PRG value (19,000 mg/kg). It is likely that the same geologic characteristics that resulted in elevated arsenic concentrations in the native soil would also result in elevated manganese concentrations.

Table 6 shows results of the grain size analysis and percent solids for background soils. Results were similar between the four background samples, with percent solids ranging from about 70 to 76 percent. Grain size data indicates that the background samples were similar and consisted of a relatively even mix of sand (36 to 47 percent) and clay/silt (53 to 64 percent).

Background stream sediment sample (FCM-SS-5S and 6S) results are presented in Table 6. Concentrations of all metals except cadmium were low in the background stream sediment samples. Concentrations of cadmium in the background sediment samples exceeded the freshwater sediment CSL value (1 mg/kg). Cadmium concentrations in the background stream sediments were similar to background soil concentrations and likely reflect a geologic source of the metal rather than contamination of the background location.

### Waste Rock

Concentrations of arsenic, cadmium, copper, lead, manganese, and zinc were elevated in the four waste rock samples (FCM-WR-9S to 12S) (Table 6). Arsenic and lead concentrations at all waste rock sample locations exceeded the industrial PRG value, manganese concentrations at all sample locations exceeded the residential PRG value, while cadmium concentrations at stations FCM-WR-11S and 12S exceeded the residential PRG value. Maximum concentrations of arsenic (7,594.8 mg/kg), cadmium (112.8 mg/kg), copper (1,176 mg/kg), lead (20,818.4 mg/kg),

**Table 6. Summary of soil and sediment data collected at the Falls Creek Mine Site.**

Sample ID	Location	Sample Date	Sample Time	Arsenic (mg/kg)	Cadmium (mg/kg)	Chromium (mg/kg)	Copper (mg/kg)	Lead (mg/kg)	Manganese (mg/kg)	Nickel (mg/kg)	Zinc (mg/kg)	Solids (%)	Gravel (> 2 mm) (%)	Sand (2 - 0.075 mm) (%)	Clay/Silt (< 0.075 mm) (%)	Mean Particle Size (mm)
<b>Soil Samples</b>																
FCM-BS-1S	Background Soil	10/19/2005	1145	13.9	2.5	8.4	11.5	29.0	<b>2310.1</b>	11.9	219.1	69.08	0.03	44.19	55.78	0.1895
FCM-BS-2S	Background Soil	10/19/2005	1245	14.0	2.1	7.7	15.1	25.7	1394.7	10.1	136.0	76.33	0.00	36.53	63.47	0.1350
FCM-BS-3S	Background Soil	10/19/2005	1345	<b>33.6</b>	2.3	10.7	14.5	40.4	657.4	11.3	189.2	70.52	0.00	47.27	52.73	0.1806
FCM-BS-4S	Background Soil	10/19/2005	1430	12.9	2.2	8.5	14.8	27.2	<b>1971.0</b>	10.6	141.9	70.00	0.00	46.38	53.62	0.2146
FCM-WR-9S	Waste Rock	10/20/2005	1030	<b>4384.2</b>	24.0	4.2	152.9	<b>4816.5</b>	<b>4413.4</b>	11.4	3708.6	89.50	1.12	89.22	9.67	0.5923
FCM-WR-10S	Waste Rock	10/20/2005	1130	<b>5914.8</b>	23.7	1.9	261.7	<b>9649.7</b>	<b>2951.6</b>	6.0	3846.1	87.65	0.06	90.44	9.49	0.5487
FCM-WR-11S	Waste Rock	10/20/2005	1315	<b>2941.5</b>	<b>38.7</b>	4.1	191.3	<b>5069.9</b>	<b>6075.9</b>	14.9	5874.5	89.15	0.08	92.29	7.63	0.6341
FCM-WR-12S	Waste Rock	10/20/2005	1345	<b>7594.8</b>	<b>112.8</b>	5.8	1176.3	<b>20818.4</b>	<b>12622.5</b>	12.6	11196.8	84.88	0.24	88.67	11.09	0.5376
FCM-TP-13S	Tailings Pile	10/20/2005	1415	<b>5180.6</b>	<b>59.7</b>	2.5	305.4	<b>3728.4</b>	<b>4596.9</b>	3.1	7681.5	76.24	3.81	75.04	21.15	0.2698
FCM-TP-15S	Tailings Pile	10/20/2005	1500	<b>5726.4</b>	<b>70.9</b>	2.4	349.8	<b>3279.6</b>	<b>6334.9</b>	3.7	9854.8	78.46	0.24	74.82	24.94	0.1029
FCM-TP-17S	Tailings Pile	10/20/2005	1540	<b>5368.9</b>	<b>41.8</b>	1.2	147.3	<b>3120.4</b>	<b>2801.2</b>	1.6	6240.3	77.81	2.04	67.05	30.91	0.1746
FCM-TP-18S	Tailings Pile	10/20/2005	1610	<b>5538.8</b>	<b>55.9</b>	2.6	291.3	<b>4433.7</b>	<b>3569.6</b>	4.1	6977.2	76.87	1.16	67.09	31.74	0.1307
FCM-TP-19S	Tailings Pile	10/20/2005	1630	<b>5178.7</b>	<b>63.3</b>	2.0	683.6	<b>3353.0</b>	<b>3021.3</b>	4.9	7600.5	79.36	1.21	75.74	23.05	0.1342
FCM-TP-20S	Tailings Pile	10/20/2005	1640	<b>4431.3</b>	<b>56.8</b>	2.5	291.5	<b>3593.2</b>	<b>5587.5</b>	7.4	7799.6	78.72	0.06	82.95	16.99	0.1016
FCM-TP-21S	Tailings Pile	10/20/2005	1650	<b>2540.0</b>	13.0	2.4	109.7	<b>2337.3</b>	138.2	4.0	701.1	72.30	0.24	48.03	51.73	0.0707
<b>Sediment Samples</b>																
FCM-SS-5S	Background Stream Sediment	10/19/2005	1530	15.1	<b>2.0</b>	13.7	13.2	16.3	398.8	13.7	50.7	85.63	0.51	97.70	1.79	0.6099
FCM-SS-6S	Background Stream Sediment	10/19/2005	1645	11.1	<b>1.7</b>	12.0	11.3	11.8	327.1	11.7	40.0	75.44	1.12	95.07	3.82	0.6771
FCM-SS-7S	Stream Sediment	10/19/2005	1730	<b>23.2</b>	<b>1.6</b>	10.2	10.9	26.7	478.0	9.1	64.0	72.19	0.35	96.75	2.90	0.6089
FCM-SS-8S	Stream Sediment	10/19/2005	1745	<b>134.3</b>	<b>2.9</b>	10.4	21.8	162.7	817.0	9.7	<b>230.2</b>	64.98	0.12	93.69	6.19	0.5749
FCM-TP-22S	Tailings Pond Sediment	10/20/2005	1830	<b>326.6</b>	<b>31.9</b>	10.1	<b>500.9</b>	<b>937.2</b>	516.1	8.2	<b>902.1</b>	31.63	0.31	32.11	67.58	0.0729

Notes:

Soil sample values in bold are in excess of the residential PRG while values in bold and shaded are in excess of the industrial PRG.

Sediment sample values in bold are in excess of the Freshwater Sediment SQL while values in bold and shaded are in excess of the Freshwater Sediment CSL.

manganese (12,622.5 mg/kg), and zinc (11,196.8 mg/kg) were measured in sample FCM-WR-12S. As shown in Figure 7, sample FCM-WR-12S was collected from the smaller secondary waste rock dump located upslope from the main dump and below the secondary adit.

Figure 7 shows background metal concentrations versus waste rock metal concentrations. Arsenic and lead concentrations showed the greatest increase over background with arsenic concentrations approximately 100 to 500 times background concentrations and lead concentrations approximately 100 to 1000 times background concentrations. Cadmium, copper, and zinc concentrations were about 10 to 50 times background, while manganese concentrations were about 2 to 10 times background. Little to no increase in nickel concentrations over background were measured, while chromium concentrations were slightly lower in waste rock samples versus background samples.

Table 6 shows results of the grain size analysis and percent solids for waste rock soils. Results were similar between the four samples, with percent solids near 90 percent. Grain size data indicates that the waste rock samples were similar and consisted mostly of sand (> 88 percent).

## **Tailings Pile**

Concentrations of arsenic, cadmium, copper, lead, manganese, and zinc were elevated in the seven tailings pile samples (FCM-TP-13S, 15S, and 17S to 21S) (Table 6). Arsenic and lead concentrations at all tailings pile sample locations exceeded the industrial PRG value, while cadmium and manganese concentrations at all sample locations except FCM-TP-21S exceeded the residential PRG value. Concentrations of arsenic and lead were relatively uniform throughout the tailings pile ranging from 2,540.0 mg/kg to 5726.4 mg/kg and 2,337.3 mg/kg to 4,433.7 mg/kg, respectively. Maximum concentrations of arsenic (5,726.4 mg/kg), cadmium (70.9 mg/kg), manganese (6,334.9 mg/kg), and zinc (9,854.8 mg/kg) were measured in sample FCM-TP-15S. The maximum concentration of lead (4,433.7 mg/kg) was measured in sample FCM-TP-18S, while the maximum concentration of copper (683.6 mg/kg) was measured in sample FCM-TP-19S.

Figure 7 shows background metal concentrations versus tailings pile metal concentrations. Arsenic and lead concentrations showed the greatest increase over background with arsenic concentrations approximately 100 to 500 times background concentrations and lead concentrations approximately 100 to 200 times background concentrations. Cadmium, copper, and zinc concentrations were about 10 to 50 times background, while manganese concentrations were about 2 to 5 times background. Chromium and nickel concentrations were slightly lower in tailings pile samples versus background samples.

Table 6 shows results of the grain size analysis and percent solids for tailings pile soils. Results were similar between the seven samples, with percent solids ranging from about 70 to 80 percent. Grain size data indicates that the tailings pile samples were similar except for FCM-TP-21S. The majority of tailings pile samples consisted mostly of sand (range of 67 to 83 percent),

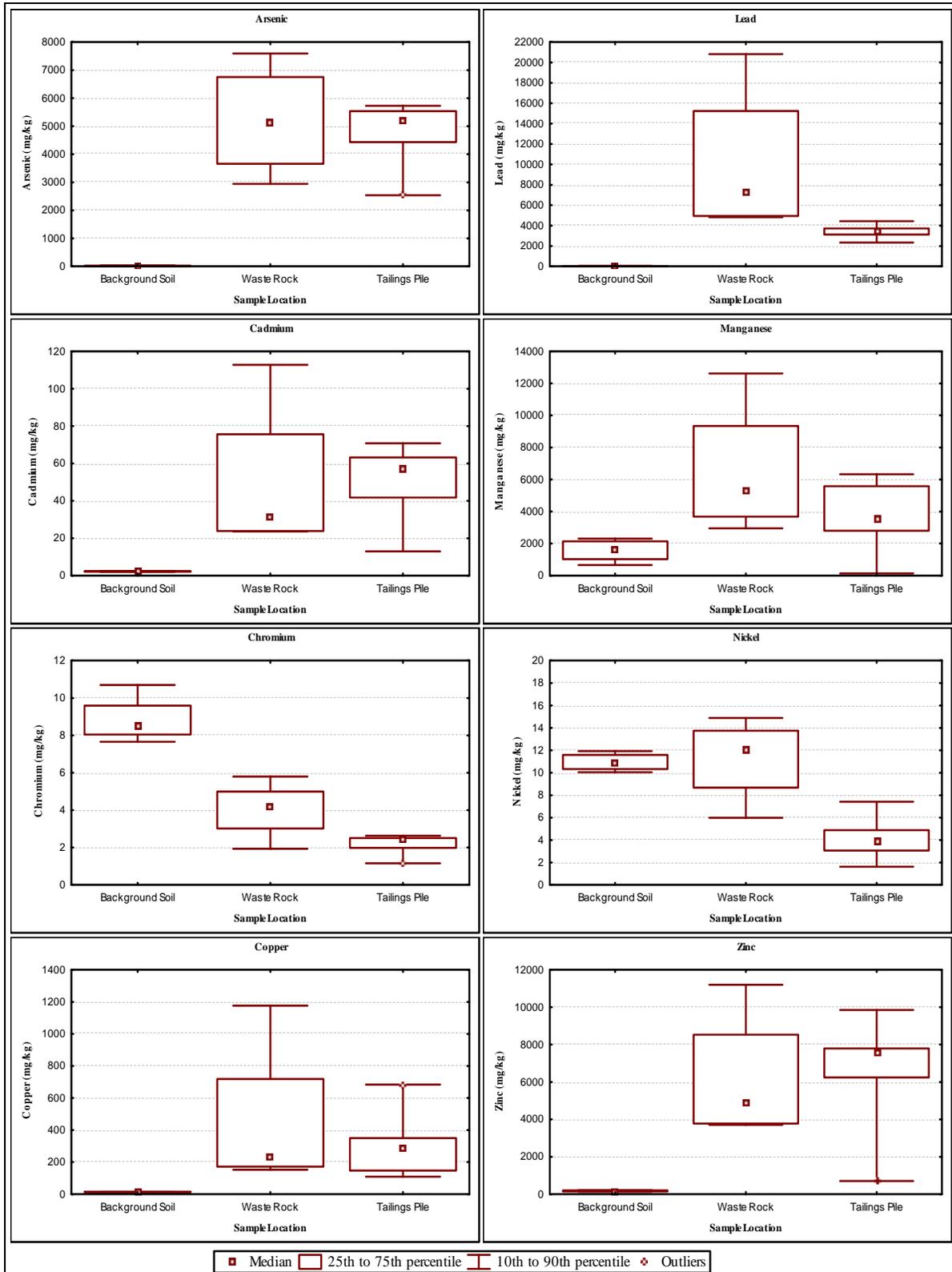


Figure 7. Box plots showing Falls Creek Mine site background soil metal concentrations compared to concentrations from waste rock and tailings pile samples.

while sample FCM-TP-21S consisted of an even mix of sand (48 percent) and clay/silt (52 percent).

## **Waste Rock and Tailings Pile Leachate**

Leaching tests (TCLP and SPLP) conducted on three waste rock samples (FCM-WR-9S, 10S, and 12S) and three tailings pile samples (FCM-TP-13S, 15S, and 19S) indicate that significant concentrations of metals may be released from the mine waste (Table 7). Results of the TCLP analysis showed that concentrations of lead from all samples except FCM-WR-9S exceeded the EPA TCLP criteria of 5 mg/L. Concentrations of cadmium were elevated (range from 0.131 mg/L to 0.7 mg/L) but did not exceed the EPA TCLP criteria of 1 mg/L. Concentrations of zinc (range of 5.81 mg/L to 74.8 mg/L) and copper (range of 0.135 mg/L to 11.6 mg/L) were elevated; however, no EPA criteria exist for these metals. Leachate concentrations of arsenic, manganese, and nickel indicate that these metals were mobilized from the waste rock and tailings pile samples. Leachate concentrations of arsenic were below EPA criteria, while no EPA criteria exist for manganese and nickel. Chromium concentrations were below the detection limit suggesting that this metal was not mobilized from the mine waste samples.

The purpose of conducting the SPLP test was to better simulate the weathering of the mine waste and to approximate the composition of runoff from the mine wastes exposed to atmospheric deposition. As soil leachate moves through the soil and ground water towards surface waters, metals concentrations are reduced due to adsorption, degradation, and dilution. This reduction in concentration is referred to as the dilution attenuation factor (DAF) and can range from 1 (where there is no dilution or attenuation) to a large number representing considerable dilution and attenuation. Although no specific DAF are used to create national SPLP standards, the EPA (1996) suggests using a generic DAF of 20 to be protective of water bodies. Results from the SPLP tests were compared with the IDEQ surface water quality chronic standards multiplied by a dilution attenuation factor (DAF) of 20 (Table 7). Concentrations of cadmium, lead, and zinc exceeded the IDEQ surface water chronic criteria multiplied by a DAF of 20 for all samples except FCM-WR-9S, while concentrations of copper exceeded the chronic criteria multiplied by a DAF of 20 for samples FCM-TP-13S and 19S. SPLP concentrations for manganese and nickel suggest that these two metals are likely mobilized in the mine waste samples under existing atmospheric conditions. Leachate concentrations of arsenic were either low (FCM-WR-9S and FCM-TP-19S) or below the detection limit while chromium concentrations were below the detection limit for all samples.

## **Stream Sediment**

Concentrations of arsenic, copper, lead, manganese, and zinc were elevated in the two stream sediment samples (FCM-SS-7S and 8S) and the one tailings pond sample (FCM-TP-22S) (Table 6). For stream sediments, arsenic concentrations exceeded the freshwater SQL value for sample

**Table 7. Summary of soil TCLP and SPLP data collected at the Falls Creek Mine Site.**

Sample ID	Sample Type	Arsenic (mg/L)	Cadmium (mg/L)	Chromium (mg/L)	Copper (mg/L)	Lead (mg/L)	Manganese (mg/L)	Nickel (mg/L)	Zinc (mg/L)
<b>TCLP</b>									
FCM-WR-9S	Waste Rock	0.221	0.238	<0.010	0.237	0.204	2.47	0.042	33.2
FCM-WR-10S	Waste Rock	<0.025	0.131	<0.010	0.135	<b>5.11</b>	0.284	0.029	14.7
FCM-WR-12S	Waste Rock	0.112	0.700	<0.010	5.16	<b>26.3</b>	0.673	0.035	74.8
FCM-TP-13S	Tailings Pile	0.032	0.515	<0.010	2.60	<b>13.0</b>	9.67	0.065	17.7
FCM-TP-15S	Tailings Pile	0.348	0.508	<0.010	1.82	<b>25.3</b>	3.01	0.032	5.81
FCM-TP-19S	Tailings Pile	0.099	0.537	<0.010	11.6	<b>23.3</b>	4.24	0.053	14.2
<b>SPLP</b>									
FCM-WR-9S	Waste Rock	0.143	<0.002	<0.010	<0.010	<0.025	<0.010	0.018	0.051
FCM-WR-10S	Waste Rock	<0.025	<b>0.130</b>	<0.010	0.073	<b>0.341</b>	0.523	0.013	<b>13.3</b>
FCM-WR-12S	Waste Rock	<0.025	<b>0.030</b>	<0.010	<0.010	<0.025	0.018	0.012	<b>7.46</b>
FCM-TP-13S	Tailings Pile	<0.025	<b>0.611</b>	<0.010	<b>4.14</b>	<b>2.69</b>	11.4	0.077	<b>19.1</b>
FCM-TP-15S	Tailings Pile	<0.025	<b>0.305</b>	<0.010	0.089	<b>0.255</b>	2.40	0.022	<b>3.63</b>
FCM-TP-19S	Tailings Pile	0.116	<b>0.482</b>	<0.010	<b>15.9</b>	<b>3.43</b>	5.66	0.063	<b>11.3</b>
<b>Applicable Criteria</b>									
EPA TCLP Criteria		5	1	5	—	5	—	—	—
IDEQ Surface Water Chronic Criteria*20DAF		3	0.02	1.28	0.188	0.038	—	0.9	1.9

Notes:

1 Values that are shaded and in bold are in excess of either the TCLP Criteria or the IDEQ surface water chronic criteria multiplied by a DAF of 20.

FCM-SS-7S and exceeded the freshwater CSL value for sample FCM-SS-8S, while zinc concentrations exceeded the freshwater CSL value for sample FCM-SS-8S. In general, sediment sample FCM-SS-8S had substantially higher concentrations of all metals compared to FCM-SS-7S. The tailings pond sample exceeded the freshwater CSL value for arsenic, cadmium, lead, and zinc and exceeded the freshwater SQL value for copper.

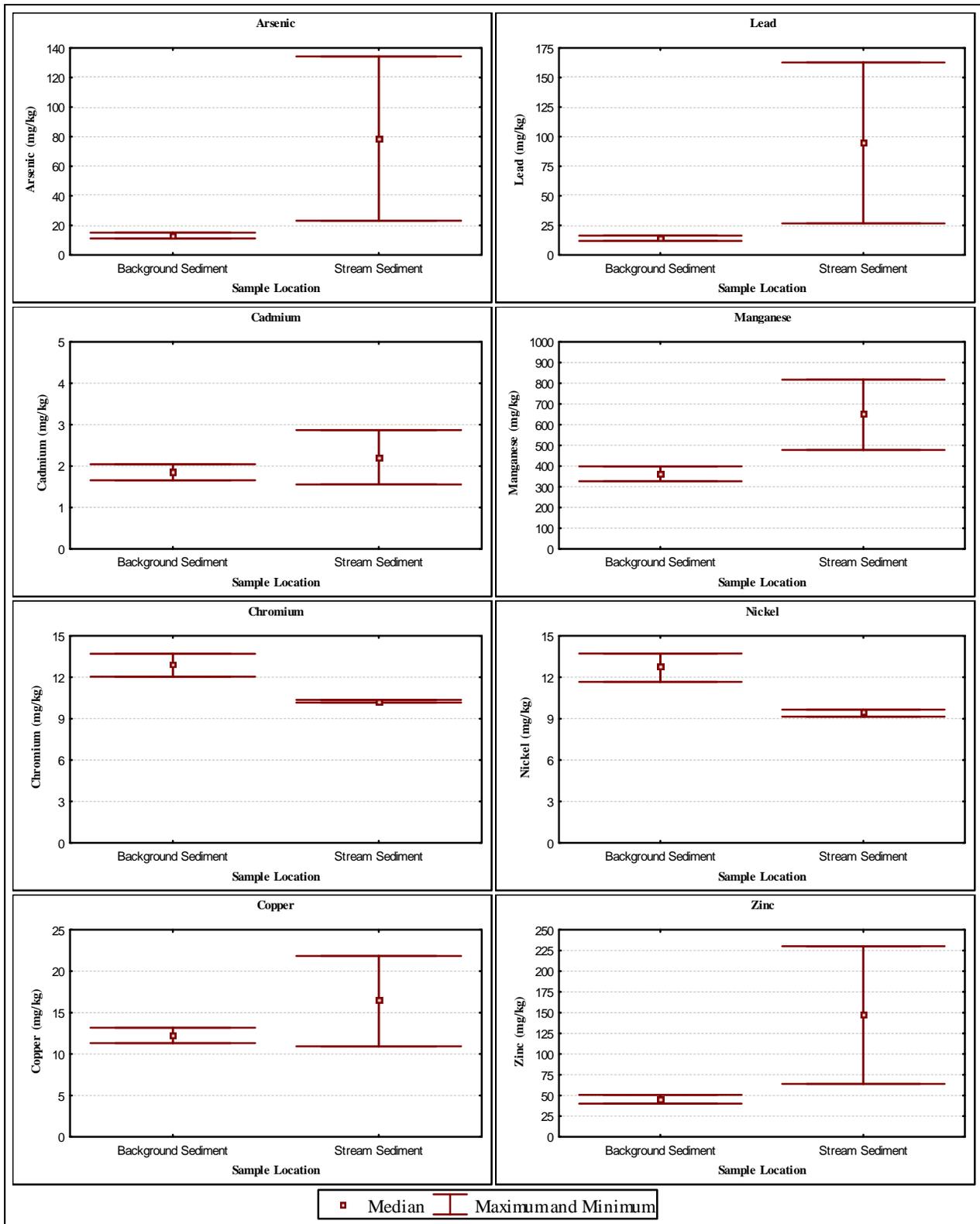
Figure 8 shows background metal concentrations versus stream sediment metal concentrations. Arsenic, lead and zinc concentrations showed the greatest increase over background with arsenic concentrations approximately 2 to 10 times background concentrations, lead concentrations approximately 2 to 10 times background concentrations and zinc concentrations up to 5 times background concentrations. Little to no increase in cadmium, copper, and manganese concentrations were measured, while chromium and nickel concentrations were slightly lower in sediment samples versus background samples.

## Surface Water

Surface water quality results are presented in Table 8. The mine runoff sampled at the main adit (FCM-SWQ-5W) and at Falls Creek (FCM-SWQ-3W) had similar temperature, pH, conductivity, turbidity, and dissolved oxygen concentrations as Falls Creek samples collected upstream (FCM-SWQ-2W) and downstream (FCM-SWQ-1W) of the mine. Tailings pond water (FCM-SWQ-4W) had similar temperature, pH, and conductivity values but substantially lower dissolved oxygen concentrations. The pH levels measured at all surface water sites ranged from 6.94 to 7.73, generally in the near neutral to slightly basic range. In general, concentrations of conventional parameters were greatest for mine runoff and tailings pond samples and lowest in Falls Creek.

Surface water quality results indicate little difference between total and dissolved metal concentrations (Table 8). Background surface water dissolved metal concentrations collected in Falls Creek upstream of mine runoff (FCM-SWQ-2W) were below the detection limit for all metals. Samples collected in Falls Creek downstream of the mine runoff (FCM-SWQ-1W) were below the detection limit for all metals except for arsenic and zinc which were detected at very low concentrations (3.5 µg/L and 7.0 µg/L, respectively).

Low to moderate concentrations of arsenic and zinc were detected in mine runoff at the main adit (FCM-SWQ-5W) and at Falls Creek (FCM-SWQ-3W) as well as from the tailings pond (FCM-SWQ-4W). Arsenic concentrations ranged from 11.2 to 18.5 µg/L, below the IDEQ chronic criteria of 150 µg/L, while zinc concentrations ranged from 26 to 50 µg/L, below the IDEQ chronic criteria of 97 µg/L. Additionally, copper and lead were detected in low to moderate concentrations in the tailings pond sample (FCM-SWQ-4W). The copper concentration of 1 µg/L was below the IDEQ chronic criteria of 9.4 µg/L. However, the lead concentration of 3 µg/L measured in the tailings pond sample was greater than the IDEQ chronic criteria of 1.97 µg/L. Lead was not detected in any other surface water sample collected from the Falls Creek mine site.



**Figure 8. Box plot showing Falls Creek Mine site background sediment metal concentrations compared to stream sediment concentrations.**

**Table 8. Summary of surface water data collected at the Falls Creek Mine Site.**

	FCM-SWQ-1W Falls Creek Downstream of Mine Runoff	FCM-SWQ-2W Falls Creek Upstream of Mine Runoff	FCM-SWQ-3W Mine Runoff at Falls Creek	FCM-SWQ-4W Tailings Pond	FCM-SWQ-5W Mine Runoff at Main Adit
<b>Field Parameters</b>					
Date	10/20/2005	10/20/2005	10/20/2005	10/20/2005	10/20/2005
Time	1720	1730	1740	1750	1800
Flow (cfs)	0.18E	0.11E	0.07E	—	0.04E
Temperature (°C)	6.91	6.88	7.65	8.07	6.42
pH (units)	7.31	6.94	7.73	7.18	7.54
Conductivity (µS/cm)	95.6	102.4	107.9	116.6	120.4
Turbidity (NTU)	0.17	0.14	0.68	0.94	0.30
Dissolved Oxygen (mg/L)	9.45	8.33	10.1	3.05	8.98
<b>Conventionals</b>					
Alkalinity (mg/L)	73.2	80.8	81	85.2	88.4
Nitrate+Nitrite (mg/L)	<0.010	<0.010	<0.010	<0.010	0.042
Sulfate (mg/L)	<0.50	<0.50	<0.50	<0.50	<0.50
Chloride (mg/L)	2.68	1.66	5.10	7.25	5.95
Calcium (mg/L)	17.0	19.3	17.6	18.4	18.6
Magnesium (mg/L)	6.84	6.81	9.21	10.3	10.4
Sodium (mg/L)	1.65	1.61	1.74	1.66	1.69
Potassium (mg/L)	0.99	0.86	0.83	1.19	0.72
Hardness (mg/L)	70.5	76.1	81.8	88.2	89.5
<b>Total Metals</b>					
Arsenic (mg/L)	0.0049	<0.0030	0.0164	0.0192	0.0139
Cadmium (mg/L)	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Chromium (mg/L)	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Copper (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Iron (mg/L)	0.011	<0.010	0.034	0.041	<0.010
Lead (mg/L)	<0.0010	<0.0010	<0.0010	0.0035	<0.0010
Manganese (mg/L)	<0.005	<0.005	<0.005	0.01	<0.005
Nickel (mg/L)	<0.010	<0.010	<0.010	<0.010	<0.010
Zinc (mg/L)	0.007	<0.005	0.030	0.052	0.045
<b>Dissolved Metals</b>					
Arsenic (mg/L)	0.0035	<0.0030	0.0112	0.0185	0.0128
Cadmium (mg/L)	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Chromium (mg/L)	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Copper (mg/L)	<0.0010	<0.0010	<0.0010	0.001	<0.0010
Iron (mg/L)	<0.010	<0.010	<0.010	<0.010	<0.010
Lead (mg/L)	<0.0010	<0.0010	<0.0010	<b>0.003</b>	<0.0010
Manganese (mg/L)	<0.005	<0.005	<0.005	<0.005	<0.005
Nickel (mg/L)	<0.010	<0.010	<0.010	<0.010	<0.010
Zinc (mg/L)	0.007	<0.005	0.026	0.050	0.046

Notes:

mg/L Milligrams per liter

µS/cm Microsiemens per centimeter

NTU Nephelometric turbidity unit

E Estimated value

< Analyte not detected at specified detection limit

NA Not analyzed/not available

Dissolved metals concentrations in bold exceed IDEQ chronic criteria while values in bold and shaded exceed acute criteria.

## Conclusions

The evaluation and analysis of data gathered and presented during the Falls Creek Mine Site preliminary investigation are summarized as follows:

- Concentrations of arsenic and lead in all waste rock samples exceeded the industrial PRG values, manganese concentrations in all samples exceeded the residential PRG value, and cadmium concentrations in two of four waste rock samples exceeded the residential PRG value.
- Maximum concentrations of arsenic (7,594.8 mg/kg), cadmium (112.8 mg/kg), copper (1,176 mg/kg), lead (20,818.4 mg/kg), manganese (12,622.5 mg/kg), and zinc (11,196.8 mg/kg) were measured in waste rock sample FCM-WR-12S.
- Concentrations of arsenic and lead in waste rock samples showed the greatest increase over background soil, with arsenic concentrations approximately 100 to 500 times background concentrations and lead concentrations approximately 100 to 1000 times background concentrations. Cadmium, copper, and zinc concentrations were about 10 to 50 times background, while manganese concentrations were about 2 to 10 times background.
- Arsenic and lead concentrations at all seven tailings pile sample locations exceeded the industrial PRG value, while cadmium and manganese concentrations at six of seven sample locations exceeded the residential PRG value. Concentrations of arsenic and lead were relatively uniform throughout the tailings pile ranging from 2,540.0 mg/kg to 5726.4 mg/kg and 2,337.3 mg/kg to 4,433.7 mg/kg, respectively.
- Arsenic and lead concentrations in tailings pile samples showed the greatest increase over background with arsenic concentrations approximately 100 to 500 times background concentrations and lead concentrations approximately 100 to 200 times background concentrations. Cadmium, copper, and zinc concentrations were about 10 to 50 times background, while manganese concentrations were about 2 to 5 times background. Chromium and nickel concentrations were slightly lower in tailings pile samples versus background samples.
- Leaching tests conducted on waste rock and tailings pile samples indicate that significant concentrations of metals may be released from the mine waste. Lead, cadmium, copper, and zinc were released in the greatest concentrations.

- Stream sediment arsenic, lead and zinc concentrations showed the greatest increase over background sediment, with arsenic concentrations approximately 2 to 10 times background concentrations, lead concentrations approximately 2 to 10 times background concentrations and zinc concentrations up to 5 times background concentrations. Little to no increase in cadmium, copper, and manganese concentrations were measured, while chromium and nickel concentrations were slightly lower in stream sediment samples versus background samples.
- Surface water quality results indicate little difference between total and dissolved metal concentrations. Background surface water dissolved metal concentrations collected in Falls Creek upstream of mine runoff were below the detection limit for all metals, while samples collected downstream of the mine runoff were below the detection limit for all metals except for arsenic and zinc which were detected at very low concentrations (3.5 µg/L and 7.0 µg/L, respectively).
- Low to moderate concentrations of arsenic and zinc were detected in mine runoff and from the tailings pond. Arsenic concentrations ranged from 11.2 to 18.5 µg/L, below the IDEQ chronic criteria of 150 µg/L, while zinc concentrations ranged from 26 to 50 µg/L, below the IDEQ chronic criteria of 97 µg/L. Additionally, copper and lead were detected in low to moderate concentrations in the tailings pond sample. The copper concentration of 1 µg/L was below the IDEQ chronic criteria of 9.4 µg/L. However, the lead concentration of 3 µg/L measured in the tailings pond sample was greater than the IDEQ chronic criteria of 1.97 µg/L.

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# **Appendix A**

## **Quality Assurance Report**

This report presents results from the quality assurance review of soil, sediment, and water quality data collected for the Falls Creek Mine Preliminary Site Investigation. Data assessment procedures used in this quality assurance review are based on the following eight control elements:

- Completeness
- Methodology
- Holding times
- Detection limit
- Blanks
- Duplicates
- Matrix spikes
- Control samples.

No problems were associated with the data collected in connection with this project. The following sections provide specific details for each of the quality control elements reviewed and any resultant corrective action required.

### **Completeness**

Completeness was assessed by comparing valid sample data values with total number of sample values. Because the number of valid sample data divided by the total number of samples was greater than the quality assurance objective of 95 percent, no corrective actions were required to address problems related to completeness.

### **Methodology**

Methodology was assessed by examining field notebooks, sampling data sheets, and laboratory reports for deviations from the monitoring plan and quality assurance plan. Subsequent to this review, it was concluded that there were no significant deviations in methodology that required corrective action.

### **Holding Times**

Holding times were assessed by comparing analytical dates to sample collection dates. Corrective action was implemented for all values that exceeded the maximum holding times

required by U.S. EPA. Subsequent to this review, it was concluded that there were no holding time problems that required corrective action.

## **Blanks**

Preparation blanks, which are composed of reagent water that is prepared as a sample, were analyzed with collected samples, and the results were reported in each laboratory report. If a blank value exceeded the detection limit, corrective actions were to be implemented for the associated samples. Because all blanks were below the method detection limit for their respective analytes, no corrective actions were required for this quality control element.

## **Detection Limits**

Laboratory data were reported with a method detection limit (MDL) and a reporting detection limit (RDL). The laboratory MDL represents the minimum concentration of a constituent that can be detected. All data values that were below the MDL were qualified as below detection with a < symbol next to the reported detection limit.

## **Duplicates**

Laboratory duplicates are two aliquots of a sample processed concurrently and identically. Corrective action was implemented for all laboratory duplicates with a relative percent difference (RPD) greater than 25 percent. No duplicate problems were encountered.

## **Matrix Spikes**

Matrix spikes are used as an indicator of matrix effects on sample recovery and precision. If a percent recovery from a matrix spike was not within 75 to 125 percent for metals or a pre-determined laboratory range for organics, corrective actions were implemented where necessary. No matrix spike problems were encountered.

## **Control Samples**

Control samples refer to check standards, blank spikes, or standard reference materials. If the percent recovery for a control standard was not within 80 to 120 percent for metals and a pre-determined laboratory range for organics, corrective actions were implemented, where necessary. All control sample recoveries were within acceptable limits.