



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

# Preliminary Site Investigation of the Blue Creek-Scotchman Mine Site in the Lake Pend Oreille Watershed, Montana

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## Introduction

The Blue Creek-Scotchman Mine site is an abandoned mine located on United States Forest Service (USFS) land in the watershed of Lake Pend Oreille, Sanders County, Montana. The Blue Creek-Scotchman Mine was identified by the USFS Region 1 office as an abandoned mine in the Lake Pend Oreille watershed that may be a source of contaminated sediments to Blue Creek and eventually Lake Pend Oreille, a major recreation site in Idaho. Preliminary testing by the Montana Bureau of Mines and Geology (MBMG) and the USFS identified waste rock in the watershed contaminated with elevated concentrations of arsenic, cadmium, copper, lead, and zinc. A preliminary site investigation of the mine was deemed necessary to determine the nature, extent, and magnitude of contamination in the Blue Creek drainage and to assess potential impacts to human health, Blue 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 Blue Creek-Scotchman Mine site investigation data will allow the Seattle District Corps of Engineers (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, in cooperation with the USFS, conducted a preliminary site investigation at the Blue Creek-Scotchman Mine site. The purpose of the study was to determine the spatial distribution of contaminant sources in the Blue Creek watershed near the Blue Creek-Scotchman Mine site. The major objectives of this study were:

- To determine the nature and extent of contamination at the Blue Creek-Scotchman Mine site
- To evaluate the water and sediment quality of Blue Creek upstream and downstream of the Blue Creek-Scotchman 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 five (5) background sites and seven (7) waste rock sites. Stream sediment data were collected from three (3) sites upstream of the mine and five (5) sites downstream of the mine. Surface water data were collected from six (6) sites upstream and downstream of the mine. The study was conducted from October 21 to October 29, 2008.

## Project Description

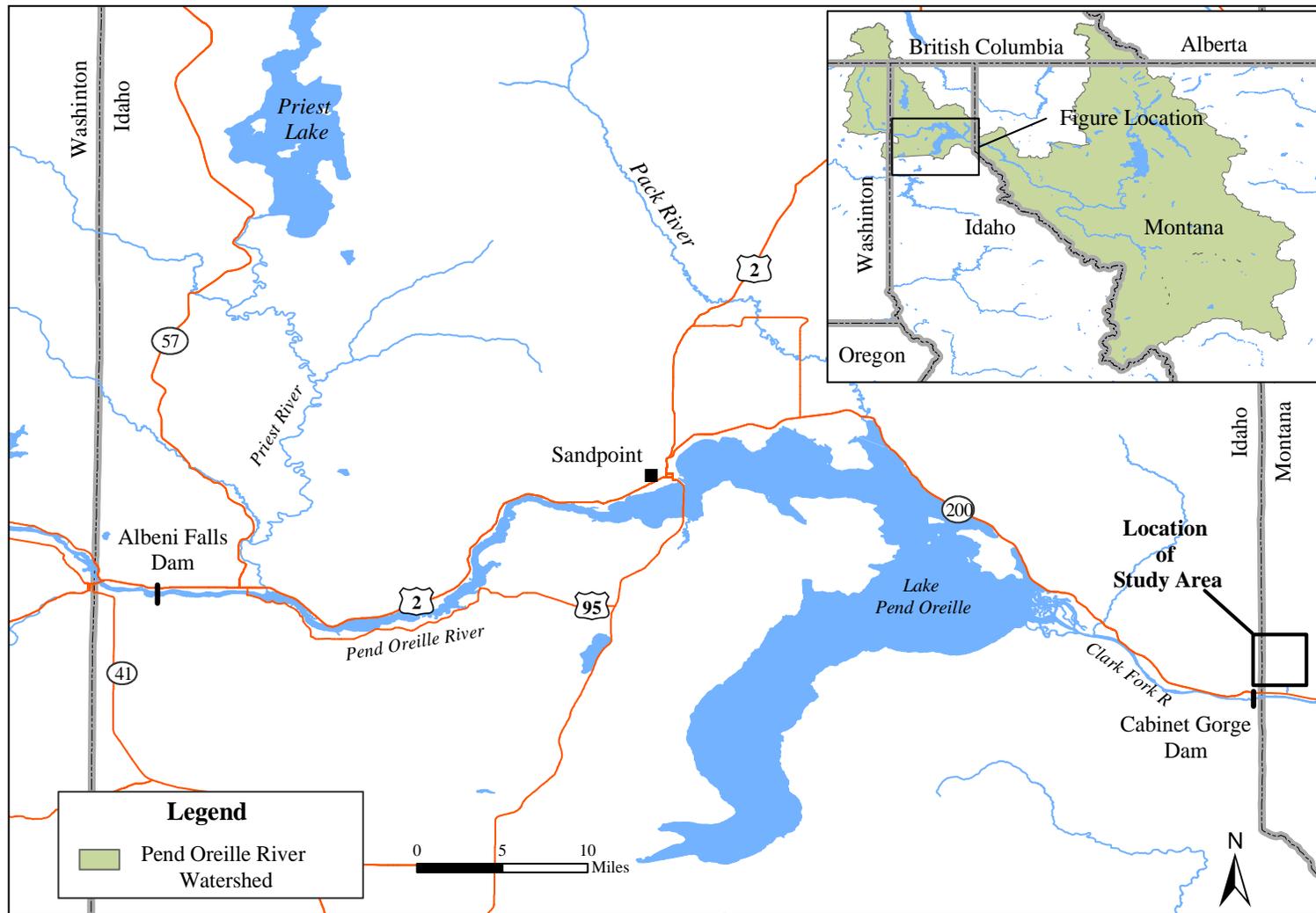
### Regional Setting and Albeni Falls Dam

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 Blue Creek-Scotchman Mine Site study area in the Clark Fork-Pend Oreille River watershed.**

## **Blue Creek-Scotchman Mine Site Description**

Blue Creek-Scotchman Mine is located on the East Fork Blue Creek in Sanders County, Montana, approximately 10 miles east of the city of Clark Fork, Idaho (Figure 2). This perennial stream is about 5 miles long and drains a watershed area approximately 6 square miles in size. The stream flows in a southwest trending direction through a steep canyon from an elevation of 6,920 feet near Sawtooth Peak and discharges into the Clark Fork River at an elevation of 2,200 feet. 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.

Blue Creek-Scotchman Mine is located in the Kootenai National Forest at an elevation of approximately 3,200 feet on the bank of the East Fork Blue Creek (Figure 2). The site is located on Forest Service administered land and private land on the east side of the valley and consists of one adit, one waste rock dump, three old concrete foundation structures and several collapsed ore chute pilings. The waste rock dump is located entirely on Forest Service administered land and extends from the main adit into the East Fork of Blue Creek. This dump is about 120 feet long by 25 to 60 feet wide by 20 to 30 feet high, with a steep face above the creek. Little vegetation is present on the waste rock dump.

Groundwater discharges from the main adit, and flows via a small drainage channel to the south of the waste rock dump before seeping into the ground near the waste rock dump. A portion of the adit discharge appears to seep through or under the waste rock dump and discharges into the creek at the base of the waste rock dump. This seepage has created two wet discharge zones near the toe of the waste rock dump.

## **Blue Creek-Scotchman Mine Site History**

The company which discovered and initially developed the Blue Creek-Scotchman Mine is uncertain. However, Crowley (1963) believes that the Blue Creek-Scotchman Mine was likely discovered and developed by the Montana Gold Mining and Mineral Company in the early 1910's, with possible workings as early as 1908. The Blue Creek-Scotchman Mine was a silver-lead-zinc mine which produced recoverable amounts of gold, silver, copper, lead, and zinc (Crowley 1963). The Blue Creek Mining Company was incorporated in 1923 and developed and intermittently worked the mine from about 1923 to 1937 (Crowley 1963). Ore from the Blue Creek-Scotchman Mine was shipped to another location to be milled. It appears that after the late 1930's no work was performed at the Blue Creek-Scotchman Mine.



Figure 2. Location of the Blue Creek-Scotchman Mine Site.

The Blue Creek-Scotchman Mine consisted of two adits, a northern and southern adit. The northern adit is currently located on private land but the associated waste rock dump is located on Kootenai National Forest land. The southern adit is located on private land.

## **Geologic Characteristics**

The Blue Creek drainage is located in the Cabinet Mountains that rise up from the northeastern shore of Lake Pend Oreille near the border of Idaho and Montana. The dominant geologic feature is the Hope fault, a northwest trending transverse fault which has experienced both large horizontal movements as well as some vertical movements (Crowley 1963; Harrison et al 1992). Blue Creek-Scotchman Mine is located to the northeast of the Hope fault. Bedrock consists of metasedimentary rocks of the Middle Proterzoic Belt Supergroup and include the Ravelli group (Harrison et al. 1992). Belt strata in the area is dominated by the Burke formation. Several distinct rock types are associated with the Burke Formation, including argillite, siltite, and quartzite (Harrison et al. 1992; Boleneus et al. 2001). Crowley (1963) characterized the Burke formation near the Blue Creek-Scotchman Mine site area as being predominately quartzitic.

## **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 (1918-2005) 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 57°F, with extremes recorded of – 34°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 Blue Creek-Scotchman Mine site was conducted on September 10, 1997 for the Kootenai National Forest by the Montana Bureau of Mines and Geology (MBMG 1999). Surface water samples were collected from the adit discharge, the East Fork Blue Creek upstream and downstream of the mine, and from a small seep at the toe of the waste rock dump. Surface water from the adit discharge and from the East Fork Blue Creek upstream and downstream of the mine did not contain elevated metals concentrations. Water from the waste rock dump seep only exceeded the chronic aquatic life standard for lead.

One soil sample was collected from the waste rock dump. The waste rock sample contained elevated concentrations of arsenic (1,000 mg/kg), cadmium (36.6 mg/kg) copper (307 mg/kg), lead (5,274 mg/kg), and zinc (10,930 mg/kg). All concentrations exceeded Clark Fork Superfund background levels and concentrations of arsenic, copper, lead, and zinc exceeded Clark Fork Superfund phytotoxic levels (MBMG 1999).

## Methods and Materials

### Sampling Design

The purpose of the surface soil 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 Blue Creek-Scotchman Mine site. Five (5) soil samples, seven (7) waste rock samples, eight (8) stream sediment samples, and six (6) surface water samples were collected from background and potentially impacted areas of the Blue Creek-Scotchman 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 3 and 4. Soil and water quality parameters monitored are presented in Tables 3 and 4.

Background soil samples (BCSM-BS-1S to 5S) were collected from upland soils representative of the site, while background stream sediment samples (BCSM-BSS-1S to 3S) were collected from upstream locations (Figure 3). All background samples were collected from locations outside of known waste areas or areas of other disturbances. Waste rock samples were collected from seven (7) sites (BCSM-WR-1S to 7S) representing the waste rock dump located below the mine adit (Figure 4). Stream sediment samples (BCSM-DSS-1S to 5S) were collected from downstream locations representative of that part of Blue Creek potentially impacted by runoff from the mine site (Figures 3 and 4). Surface water samples were collected upstream (BCSM-SW-1W) and downstream (BCSM-SW-2W and 7W) of the mine site at locations adjacent to stream sediment sampling locations (Figures 3 and 4). Additional water quality samples were collected from the mine adit runoff (BCSM-SW-5W), seeps located at the toe of the waste rock dump (BCSM-SW-3W), and from the waste rock dump runoff at Blue Creek (BCSM-SW-4W) (Figure 4).

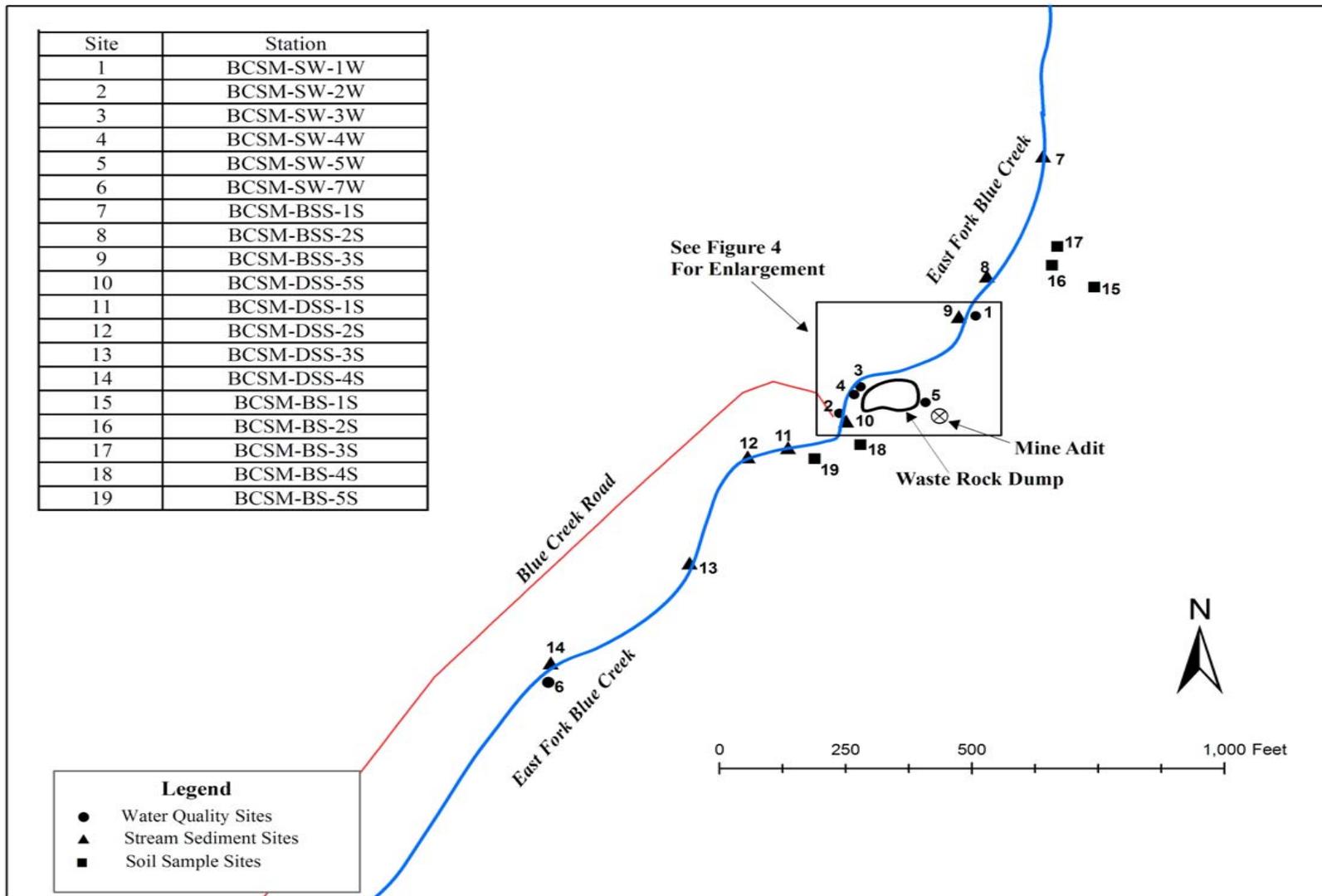
Smith et al. (2000) noted that collecting representative samples of mine waste (waste rock and tailings piles) can be difficult due to the physical, chemical and spatial heterogeneity of the waste material and that a single composite of up to thirty (30) grab samples can provide an overview of the total 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 Blue Creek-Scotchman 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>					
BCSM-BS-1S	Background Soil	10/21/2008	1100	48.12928	-115.96873
BCSM-BS-2S	Background Soil	10/21/2008	1140	48.12957	-115.96899
BCSM-BS-3S	Background Soil	10/21/2008	1250	48.12947	-115.96902
BCSM-BS-4S	Background Soil	10/29/2008	1700	48.12824	-115.97027
BCSM-BS-5S	Background Soil	10/29/2008	1730	48.12814	-115.97065
BCSM-WR-1S	Waste Rock	10/22/2008	1300	48.12847	-115.97005
BCSM-WR-2S	Waste Rock	10/22/2008	1345	48.12848	-115.96999
BCSM-WR-3S	Waste Rock	10/22/2008	1430	48.12849	-115.96999
BCSM-WR-4S	Waste Rock	10/22/2008	1515	48.12850	-115.97012
BCSM-WR-5S	Waste Rock	10/22/2008	1630	48.12851	-115.96999
BCSM-WR-6S	Waste Rock	10/22/2008	1715	48.12856	-115.97002
BCSM-WR-7S	Waste Rock	10/22/2008	1745	48.12854	-115.97018
<b>Sediment Samples</b>					
BCSM-BSS-1S	Background Stream Sediment	10/21/2008	1320	48.13020	-115.96907
BCSM-BSS-2S	Background Stream Sediment	10/21/2008	1430	48.12935	-115.96942
BCSM-BSS-3S	Background Stream Sediment	10/21/2008	1500	48.12912	-115.96957
BCSM-DSS-1S	Downstream Stream Sediment	10/21/2008	1600	48.12814	-115.97065
BCSM-DSS-2S	Downstream Stream Sediment	10/21/2008	1620	48.12807	-115.97095
BCSM-DSS-3S	Downstream Stream Sediment	10/21/2008	1700	48.12732	-115.97130
BCSM-DSS-4S	Downstream Stream Sediment	10/21/2008	1720	48.12650	-115.97223
BCSM-DSS-5S	Downstream Stream Sediment	10/21/2008	1800	48.12838	-115.97028

**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>					
BCSM-SW-1W	Blue Creek Upstream of Mine Site	10/22/2008	1020	48.12912	-115.96957
BCSM-SW-2W	Blue Creek Immediately Downstream of Mine Site	10/22/2008	1030	48.12838	-115.97028
BCSM-SW-3W	Seep at Toe of Waste Rock Dump	10/22/2008	1045	48.12854	-115.97018
BCSM-SW-4W	Waste Rock Runoff at Blue Creek	10/22/2008	1055	48.12851	-115.97020
BCSM-SW-5W	Mine Runoff at Adit	10/22/2008	1110	48.12843	-115.96984
BCSM-SW-7W	Blue Creek 1/4 Mile Downstream of Mine Site	10/22/2008	1130	48.12650	-115.97223



**Figure 3. Location of the Blue Creek-Scotchman Mine Site and background soil, sediment and water quality sampling locations.**

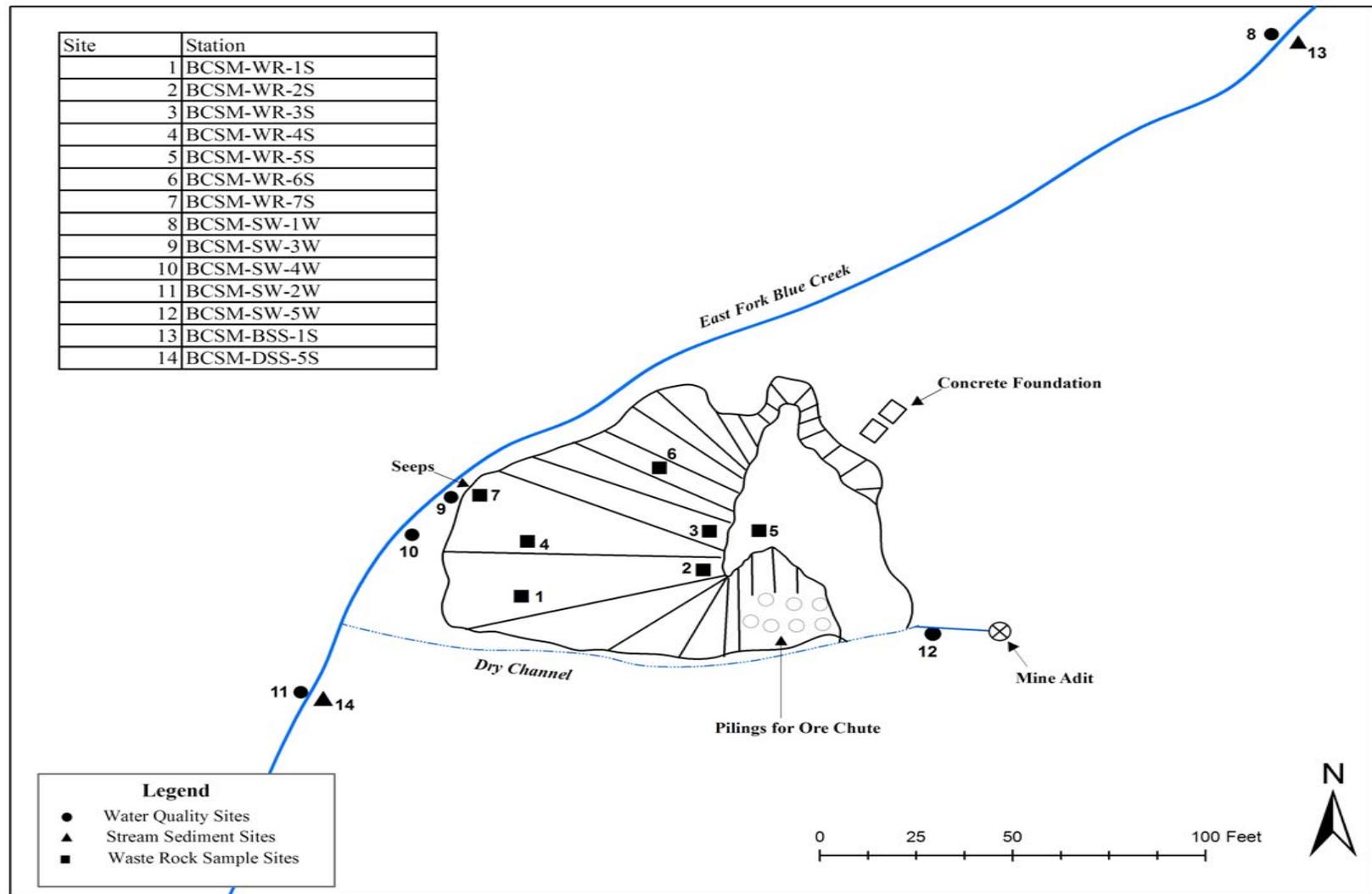


Figure 4. Blue Creek-Scotchman Mine site waste rock, stream sediment, and water quality sampling locations.

**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 1990).

<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 and Waste Rock Sampling

Soil and waste rock samples were collected from twelve (12) sites in the Blue Creek-Scotchman 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
- 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/waste rock 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 four waste rock 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, prelabelled 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.

## Leaching Test Procedures

The four (4) waste rock 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 Blue Creek-Scotchman Mine Site in the Lake Pend Oreille Watershed, Montana* (USCOE 2008). 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 Montana Department of Environmental Quality (MDEQ) determines surface water quality criteria for Blue Creek. The MDEQ has classified Blue Creek as an undesignated surface water in the Clark Fork drainage that must meet the B-1 classification (MDEQ 2008). Waters classified as B-1 shall be suitable for drinking, culinary and food processing after conventional treatment; bathing, swimming and recreation; growth and propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply. General water quality standards for B-1 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 Montana 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 Blue Creek-Scotchman 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 Regional Screening Levels (RSLs) (EPA 1996 and 2008). The SSLs were developed in 1996 and are generic risk based concentrations derived from equations combining exposure information assumptions with EPA toxicity data. The RSLs developed by EPA Region 9 in 2008 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. RSL concentrations are sub-classified into cancer risk and chronic exposure concentrations for residential and industrial land uses. For the purpose of the Blue Creek-Scotchman 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)	MDEQ Risk Based Cleanup Guidelines for Abandoned Mines <sup>2</sup> (mg/kg)	EPA Soil Screening Levels <sup>3</sup> (mg/kg)	EPA Region 9 Regional Screening Level (RSLs) for Residential Soils <sup>4</sup> (mg/kg)	EPA Region 9 Regional Screening Level (RSLs) for Industrial Soils <sup>5</sup> (mg/kg)	Freshwater Sediment Quality Standard (SQS) <sup>6</sup> (mg/kg)	Freshwater Sediment Cleanup Screening Level (CSL) <sup>6</sup> (mg/kg)	EPA TCLP Criteria <sup>7</sup> (mg/L)	MDEQ Surface Water Quality Chronic Criteria*20DAF <sup>8</sup> (mg/L)
Arsenic	340	150	700**	40 <sup>#</sup>	40 <sup>#</sup>	40 <sup>#</sup>	20	51	5	3
Cadmium	0.52*	0.097*	19,500**	78	70	810	0.6	1	1	0.002
Chromium	579*	27.7*	2,920**	390	280	1,400	95	100	5	0.554
Copper	3.79*	2.85*	27,100	—	3,100	41,000	80	830	—	0.057
Iron	—	—	—	—	55,000	720,000	—	—	—	—
Lead	13.98*	0.545*	1,100	400	400	800	335	430	5	0.011
Manganese	—	—	665	—	1,800	23,000	—	—	—	—
Nickel	145*	16.1*	14,650	1,600	1,600	20,000	60	70	—	0.322
Zinc	37*	37*	220,000	23,000	23,000	310,000	140	160	—	0.74

Notes:

1. MDEQ (2008).
  2. MDEQ (1996). Risk based cleanup guidelines for abandoned mine sites.
  3. EPA (1996).
  4. EPA (2008). Regional Screening Levels (RSL) for Chemical Contaminants at Superfund Sites-Residential Soils.
  5. EPA (2008). Regional Screening Levels (RSL) for Chemical Contaminants at Superfund Sites-Residential Soils.
  6. Michelson (2003).
  7. EPA 40 CFR 261.24.
  8. Represents the MDEQ 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 Blue Creek of 25 mg/L as CaCO<sub>3</sub>.
- # Arsenic value of 40 mg/kg based on MDEQ (2005) *Montana Department of Environmental Quality Remediation Division Action Level for Arsenic in Surface Soil*.
- \*\* Concentrations shown for arsenic, cadmium, and chromium VI are for a carcinogenic risk of 5E-04.
- Not Available.

The Montana Department of Environmental Quality has developed generic action levels for arsenic in residential surface soils (MDEQ 2005). Because arsenic occurs naturally in Montana soils at concentrations greater than the EPA SSLs and the EPA Region 9 RSLs, MDEQ determined that the SSL and RSL for arsenic was not appropriate for Montana. MDEQ (2005) determined Montana specific arsenic action levels as shown in Table 5.

In addition, the Montana Department of Environmental Quality sponsored a study that developed risk based cleanup guidelines for abandoned mine sites that focus on a recreation population. This included four (4) groups including hunters, fishermen, gold panners/rock collectors, and ATV riders (MDEQ 1996). These guidelines set soil, sediment, and waste cleanup levels for lead at 1,100 mg/kg and cleanup levels for arsenic at 700 mg/kg (based on a risk factor of  $5 \times 10^{-4}$ ), and are presented in Table 5.

The EPA SSLs and RSLs 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 Blue Creek-Scotchman Mine site and are provided to allow for a general assessment of the relative levels of contamination at the Blue Creek-Scotchman Mine site. Concentrations of metals above the SSLs and RSLs 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 set forth in the Code of Federal Regulations (EPA 40 CFR 261.24) and 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 MDEQ surface water chronic criteria in Table 5.

## Results and Discussion

### Background Soil and Stream Sediment

Background soil sample (BCSM-BS-1S to 5S) 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 elevated concentrations of manganese in sample BCSM-BS-1S (2,899.2 mg/kg). Manganese concentrations in BCSM-BS-1S exceeded the MDEQ (1996) cleanup guidelines for abandoned mine sites (665 mg/kg) and the EPA residential soil RSL value (1,800 mg/kg) but were well below the EPA industrial RSL value (23,000 mg/kg). This elevated manganese concentration in native background soils is not unusual in areas with similar geologic characteristics as the Blue Creek-Scotchman Mine Site. Table 6 shows results of the grain size analysis and percent solids for background soils. Results varied between the five background samples, with percent solids ranging from about 62 to 88 percent. Grain size data indicates that the background samples were slightly different, with sample BCSM-BS-1S dominated by the clay/silt fraction (53 percent) while samples BCSM-BS-2S to 5S were dominated by the sand fraction (66 to 88 percent).

Background stream sediment sample (BCSM-BSS-1S to 3S) results are presented in Table 6. Concentrations of all metals except arsenic were low in the background stream sediment samples. Concentrations of arsenic in BCSM-BSS-2S (21.6 mg/kg) exceeded the freshwater sediment SQS standard (20 mg/kg). Arsenic 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, chromium, copper, lead, manganese, nickel and zinc were elevated in the seven waste rock samples (BCSM-WR-1S to 7S) (Table 6). Arsenic and lead concentrations at all waste rock sample locations exceeded the industrial RSL value, while manganese concentrations at BCSM-WR-1S, 2S, 4S, and 6S exceeded the residential RSL value. In addition, arsenic, lead, and manganese concentrations at all waste rock sample locations exceeded the MDEQ (1996) cleanup guidelines for abandoned mine sites. Maximum concentrations of arsenic (6,246.3 mg/kg), copper (648.2 mg/kg) and lead (38,089.8 mg/kg) were measured in sample BCSM-WR-3S. Maximum concentrations of cadmium (40.5 mg/kg), manganese (3,475.8 mg/kg) and zinc (12,735.1 mg/kg) were measured in sample BCSM-WR-6S. Maximum concentrations of chromium (47.5 mg/kg) and Nickel (54.0 mg/kg) were measured in sample BCSM-WR-1S. See Figure 4 for the locations of these sampling sites.

Figure 5 shows background soil metal concentrations versus waste rock metal concentrations. Arsenic, lead and zinc concentrations showed the greatest increase over background with arsenic concentrations approximately 100 to 500 times background concentrations, lead concentrations

**Table 6. Summary of soil and sediment data collected at the Blue Creek-Scotchman 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>																
BCSM-BS-1S	Background Soil	10/21/2008	1100	17.6	1.5	9.6	10.4	22.2	<b><u>2899.2</u></b>	11.5	134.5	61.87	0.00	46.99	53.01	0.1648
BCSM-BS-2S	Background Soil	10/21/2008	1140	6.9	0.3	4.9	3.9	14.7	552.8	3.4	45.8	85.67	0.00	66.26	33.74	0.2770
BCSM-BS-3S	Background Soil	10/21/2008	1250	20.8	0.8	6.2	13.3	21.6	<u>956.9</u>	10.8	88.3	75.73	0.00	63.59	36.41	0.2668
BCSM-BS-4S	Background Soil	10/29/2008	1700	16.2	1.0	3.1	10.9	25.4	579.0	6.6	53.2	88.30	0.34	88.13	11.53	0.5026
BCSM-BS-5S	Background Soil	10/29/2008	1730	12.7	1.0	4.0	15.0	44.7	581.0	7.1	63.7	87.80	0.35	88.52	11.14	0.5184
BCSM-WR-1S	Waste Rock	10/22/2008	1300	<b>1462.5</b>	12.8	47.5	180.0	<b>2974.7</b>	<b>1847.3</b>	54.0	2444.3	91.59	0.15	92.35	7.50	0.5974
BCSM-WR-2S	Waste Rock	10/22/2008	1345	<b>2051.5</b>	16.7	45.3	219.9	<b>3591.4</b>	<b>2098.4</b>	38.0	3510.5	91.74	0.14	90.77	9.09	0.5136
BCSM-WR-3S	Waste Rock	10/22/2008	1430	<b>6246.3</b>	15.4	11.1	648.2	<b>38089.8</b>	<u>1061.9</u>	7.1	3772.9	86.94	0.00	89.13	10.87	0.4510
BCSM-WR-4S	Waste Rock	10/22/2008	1515	<b>2164.9</b>	8.8	10.0	647.3	<b>20103.2</b>	<b>2020.2</b>	12.2	3170.0	89.59	0.10	85.73	14.17	0.4492
BCSM-WR-5S	Waste Rock	10/22/2008	1630	<b>938.7</b>	4.4	33.8	293.0	<b>4406.4</b>	<u>1355.5</u>	15.0	1202.3	91.27	0.05	90.60	9.35	0.5109
BCSM-WR-6S	Waste Rock	10/22/2008	1715	<b>3266.1</b>	40.5	30.8	543.7	<b>26086.4</b>	<b>3475.8</b>	50.0	12735.1	87.41	0.15	91.66	8.18	0.5465
BCSM-WR-7S	Waste Rock	10/22/2008	1745	<b>1234.4</b>	10.9	19.1	299.9	<b>4443.4</b>	<u>1162.5</u>	18.4	2385.0	88.41	1.46	88.90	9.64	0.5777
<b>Sediment Samples</b>																
BCSM-BSS-1S	Background Stream Sediment	10/21/2008	1320	17.7	0.3	3.3	3.9	13.6	316.9	5.1	32.7	69.83	0.17	93.46	6.36	0.5335
BCSM-BSS-2S	Background Stream Sediment	10/21/2008	1430	<b>21.6</b>	0.4	4.1	4.2	12.8	391.7	5.0	34.3	71.74	0.66	95.35	4.00	0.6010
BCSM-BSS-3S	Background Stream Sediment	10/21/2008	1500	17.1	0.3	3.1	6.1	10.1	306.8	5.9	31.0	68.85	0.03	92.53	7.44	0.4473
BCSM-DSS-1S	Downstream Stream Sediment	10/21/2008	1600	<b>34.4</b>	<b>0.7</b>	3.7	10.9	147.6	287.2	5.1	114.2	64.52	0.00	95.26	4.74	0.3907
BCSM-DSS-2S	Downstream Stream Sediment	10/21/2008	1620	<b>30.3</b>	<b>0.8</b>	4.2	9.3	227.6	419.3	5.3	<b>154.9</b>	67.13	0.09	87.40	12.51	0.4558
BCSM-DSS-3S	Downstream Stream Sediment	10/21/2008	1700	<b>34.9</b>	0.5	3.6	7.9	99.8	397.7	4.4	74.7	62.04	0.14	92.42	7.45	0.4848
BCSM-DSS-4S	Downstream Stream Sediment	10/21/2008	1720	<b>112.6</b>	<b>0.6</b>	3.5	47.2	144.2	335.1	4.7	103.2	72.97	0.08	95.53	4.39	0.5641
BCSM-DSS-5S	Downstream Stream Sediment	10/21/2008	1800	<b>25.8</b>	<b>0.8</b>	2.3	4.7	62.4	246.5	3.6	103.3	71.67	0.21	95.60	4.19	0.5680

Notes:

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

Soil sample values underlined are in excess of the MDEQ (1996) risk based cleanup guidelines for abandoned mine sites.

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

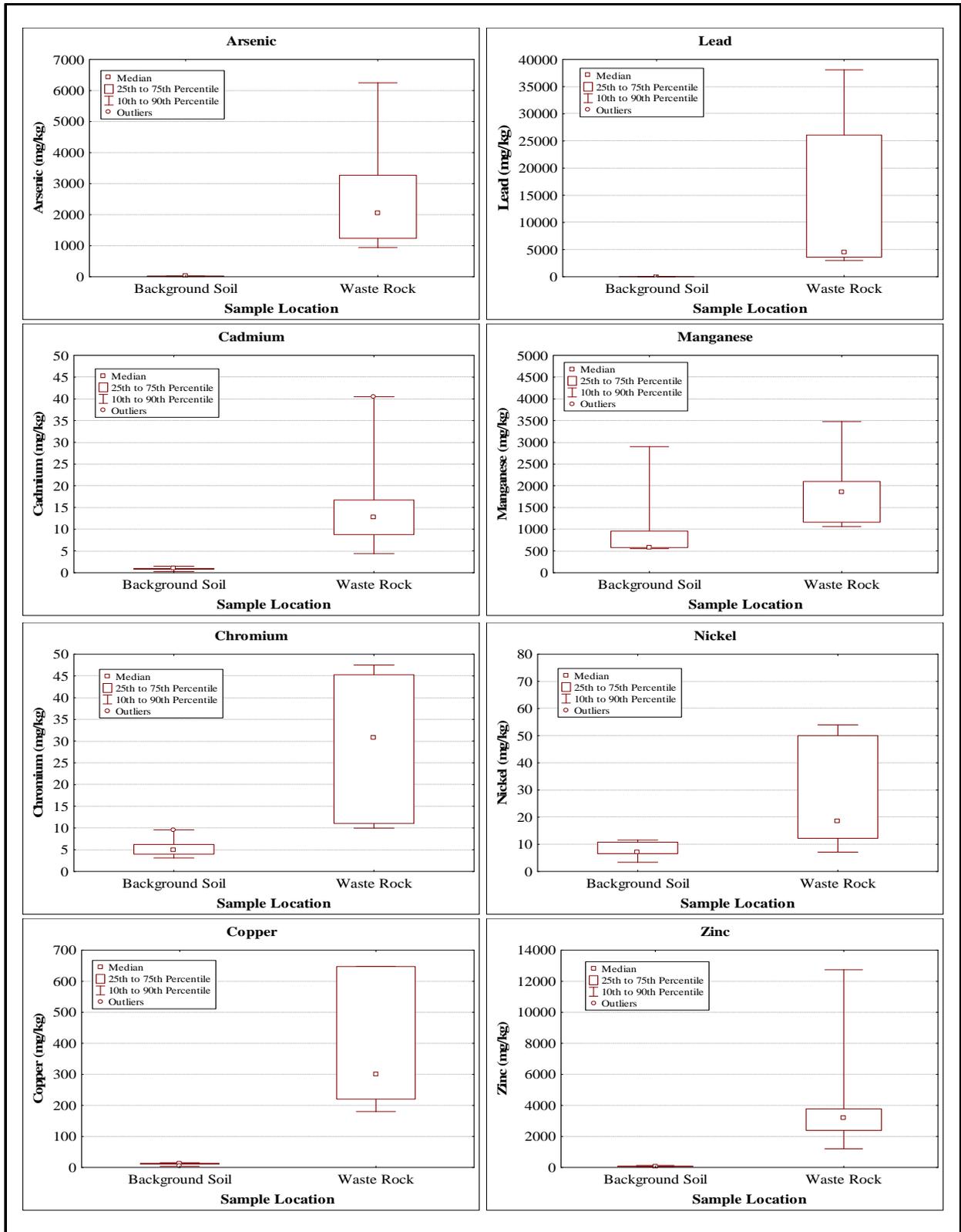


Figure 5. Box plots showing Blue Creek-Scotchman Mine site background soil metal concentrations compared to concentrations from waste rock samples.

approximately 100 to 2,500 times background concentrations, and zinc concentrations approximately 100 to 500 times background concentrations. Cadmium and copper concentrations were about 10 to 50 times background, while chromium, manganese and nickel concentrations were about 2 to 10 times background. Table 6 shows results of the grain size analysis and percent solids for waste rock soils. Results were similar between the seven samples, with percent solids near 90 percent. Grain size data indicates that the waste rock samples were similar and consisted mostly of sand (> 85 percent).

Two distinct types of waste rock were noted during the study but a formal classification of the waste rock types was not performed. In general, waste rock from sites BCSM-WR-1S, 2S, 5S, and 7S were dominated by a moderate bluish-grey rock, while waste rock from sites BCSM-WR-3S, 4S, and 6S were dominated by a moderate reddish-brown rock mixed together with smaller amounts of the moderate bluish-grey rock. Table 6 shows that the samples with the greatest lead concentrations were collected from sites BCSM-WR-3S, 4S, and 6S which represent sites dominated by moderate reddish-brown rock.

## **Waste Rock Leachate**

Leaching tests (TCLP and SPLP) conducted on four waste rock samples (BCSM-WR-2S, 3S, 4S and 6S) indicate that some metals may be released from the mine waste (Table 7). Results of the TCLP analysis showed that concentrations of lead from BCSM-WR-3S and 4S exceeded the EPA TCLP criteria of 5 mg/L. Concentrations of cadmium were slightly elevated (range from <0.002 mg/L to 0.166 mg/L) but did not exceed the EPA TCLP criteria of 1 mg/L, while concentrations of zinc (range of 0.023 mg/L to 32.9 mg/L) were elevated; however, no EPA criteria exist for zinc. Leachate concentrations of arsenic, copper, manganese, and nickel indicate that these metals were mobilized from some waste rock samples. Leachate concentrations of arsenic were below EPA criteria, while no EPA criteria exist for copper, 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 MDEQ surface water quality chronic standards multiplied by a dilution attenuation factor (DAF) of 20 (Table 7). Concentrations of cadmium, lead, and zinc exceeded the MDEQ surface water chronic criteria multiplied by a DAF of 20 for samples BCSM-WR-3S, 4S and 5S, while concentrations of copper exceeded the MDEQ surface water chronic criteria multiplied by a DAF of 20 for samples BCSM-WR-3S and 4S. SPLP

**Table 7. Summary of soil TCLP and SPLP data collected at the Blue Creek-Scotchman 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>									
BCSM-WR-2S	Waste Rock	0.393	<0.002	<0.010	<0.010	<0.025	<0.005	<0.010	0.023
BCSM-WR-3S	Waste Rock	<0.025	0.166	<0.010	0.436	<b>6.96</b>	2.10	0.010	32.9
BCSM-WR-4S	Waste Rock	<0.025	0.031	<0.010	0.103	<b>7.81</b>	1.31	0.017	16.3
BCSM-WR-6S	Waste Rock	<0.025	0.042	<0.010	<0.010	0.125	0.124	<0.010	3.72
<b>SPLP</b>									
BCSM-WR-2S	Waste Rock	0.407	<0.002	<0.010	<0.010	<0.025	0.005	<0.010	0.019
BCSM-WR-3S	Waste Rock	<0.025	<b>0.163</b>	<0.010	<b>0.450</b>	<b>6.94</b>	1.70	0.010	<b>33.2</b>
BCSM-WR-4S	Waste Rock	<0.025	<b>0.032</b>	<0.010	<b>0.1</b>	<b>8.14</b>	1.28	0.017	<b>17.7</b>
BCSM-WR-6S	Waste Rock	<0.025	<b>0.044</b>	<0.010	<0.010	<b>0.119</b>	0.121	<0.010	<b>3.77</b>
<b>Applicable Criteria</b>									
EPA TCLP Criteria		5	1	5	—	5	—	—	—
MDEQ Surface Water Chronic Criteria*20DAF		3	0.002	0.554	0.057	0.011	—	0.322	0.74

Notes:

- 1 Values that are shaded and in bold are in excess of either the TCLP Criteria or the MDEQ surface water chronic criteria multiplied by a dilution attenuation factor (DAF) of 20.

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 (BCSM-WR-2S) or below the detection limit while chromium concentrations were below the detection limit for all samples.

## Stream Sediment

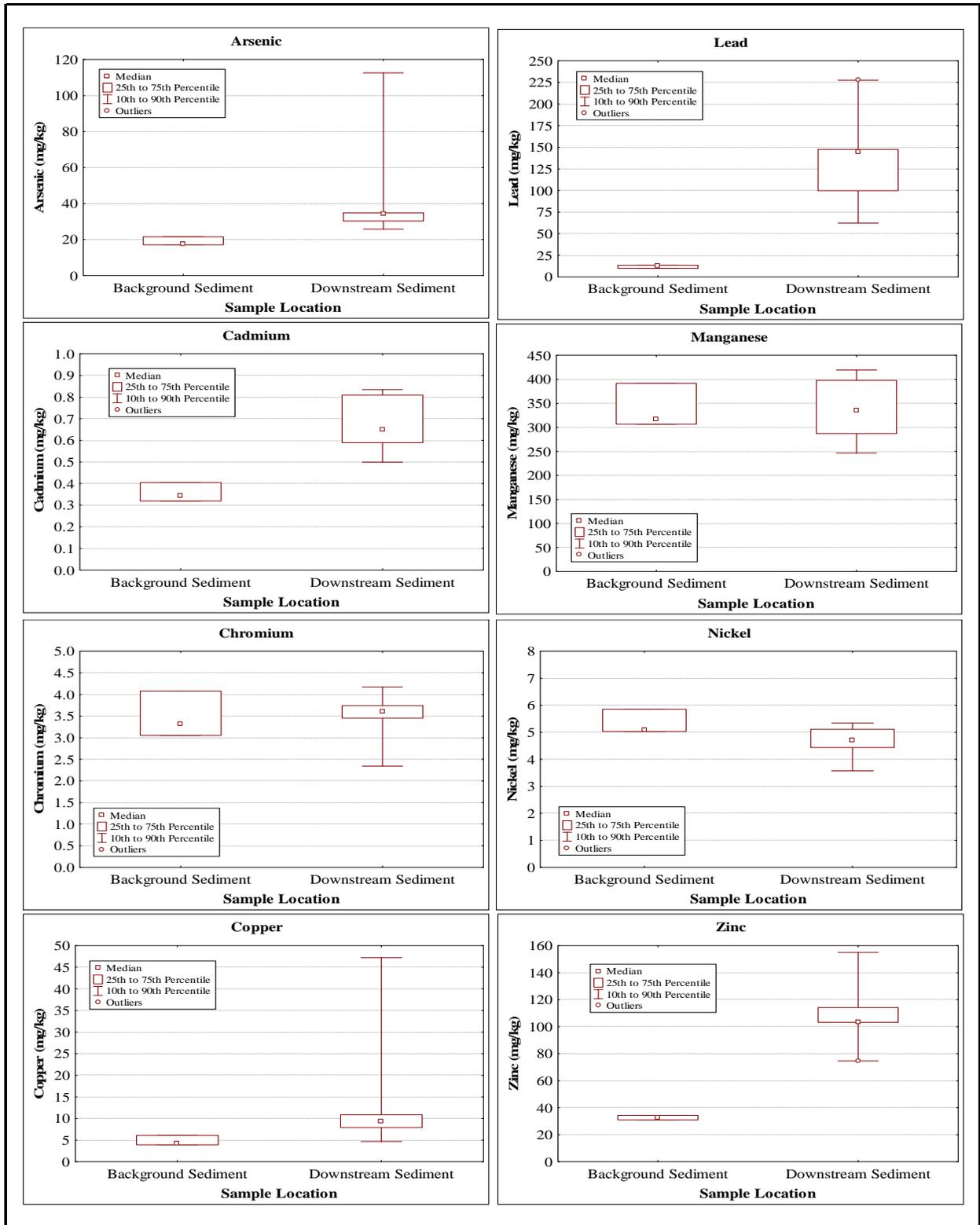
Concentrations of arsenic, copper, lead, manganese, and zinc were elevated in the five downstream stream sediment samples (BCSM-DSS-1S to 5S) when compared to the three background samples (BCSM-BSS-1S to 3S) (Table 6). For stream sediments, arsenic concentrations exceeded the freshwater SQS value for all samples and the freshwater CSL value for sample BCSM-DSS-4S. Cadmium exceeded the freshwater SQS value for BCSM-DSS-1S, 2S, 4S and 5S, while zinc concentrations exceeded the freshwater SQS value for sample BCSM-DSS-2S.

Figure 6 shows background stream sediment metal concentrations versus downstream sediment metal concentrations. Downstream arsenic, copper, lead and zinc concentrations showed the greatest increase over background with arsenic concentrations approximately 2 to 5 times background concentrations, copper concentrations approximately 2 to 5 times background concentrations, lead concentrations approximately 2 to 10 times background concentrations and zinc concentrations 2 to 5 times background concentrations. Little to no increase in cadmium, chromium and manganese concentrations were observed, while nickel concentrations were slightly lower in downstream sediment samples versus background samples.

## Surface Water

Surface water quality results are presented in Table 8. In general, mine runoff sampled at the main adit (BCSM-SW-5W), the seep at the toe of the waste rock dump (BCSM-SW-3W) and the waste rock runoff (BCSM-SW-4W) had similar concentrations of field parameters (temperature, pH, conductivity, turbidity, and dissolved oxygen). However, runoff from the mine adit was more dilute than seepage from the waste rock with slightly lower cation (calcium, magnesium, potassium, sodium) concentrations, resulting in lower alkalinity and hardness concentrations. The pH levels measured from the mine runoff ranged from 7.24 to 7.44, generally in the near neutral to slightly basic range. Surface water quality in Blue Creek measured upstream (BCSM-SW-1W) and downstream (BCSM-SW-2W and BCSM-SW-7W) of the waste rock dump had similar concentrations of field parameters and conventional parameters. The pH levels measured in Blue Creek ranged from 7.41 to 7.72, slightly more basic than the mine runoff samples. Concentrations of conventional parameters were greatest in Blue Creek samples and lowest in mine runoff and waste rock seep samples.

Background surface water total and dissolved metal concentrations in Blue Creek upstream of mine runoff (BCSM-SW-1W) were below the detection limit for all metals (Table 8).



**Figure 6. Box plots showing Blue Creek-Scotchman Mine site background stream sediment metal concentrations compared to downstream sediment concentrations.**

Samples collected in Blue Creek downstream of the mine runoff (BCSM-SW-2W and 5W) were below the detection limit for all metals except for iron and zinc (Table 8). Total zinc concentrations were low immediately downstream of the mine at station BCSM-SW-2W (8 µg/L) but were above the MDEQ acute criteria of 37 µg/L at station BCSM-SW-7W (92 µg/L) located about one-quarter mile downstream of the mine. Dissolved zinc concentrations were low at both station BCSM-SW-2W (8 µg/L) and BCSM-SW-7W (6 µg/L). Total iron was detected only at station BCSM-SW-7W (249 µg/L).

Surface water total and dissolved metal concentrations collected from mine runoff at the adit (BCSM-SW-5W) were below the detection limit for all metals (Table 8). Samples collected from waste rock seeps and runoff (BCSM-SW-3W and 4W) were below the detection limit for all metals except for iron and zinc (Table 8). Total and dissolved zinc concentrations were low from the seep (BCSM-SW-3W, 9 µg/L and 7 µg/L respectively) and slightly greater from the waste rock runoff (BCSM-SW-4W, 16 µg/L and 14 µg/L respectively) but still below the MDEQ chronic criteria of 37 µg/L. Total and dissolved iron was detected only at station BCSM-SW-3W (10 µg/L and 10 µg/L, respectively).

**Table 8. Summary of surface water data collected at the Blue Creek-Scotchman Mine Site.**

Parameters	BCSM-SW-1W Blue Creek Upstream of Mine Site	BCSM-SW-2W Blue Creek Immediately Downstream of Mine Site	BCSM-SW-3W Seep at Toe of Waste Rock Dump	BCSM-SW-4W Waste Rock Runoff at Blue Creek	BCSM-SW-5W Mine Runoff at Adit	BCSM-SW-7W Blue Creek 1/4 Mile Downstream of Mine Site
<b>Field Parameters</b>						
Date	10/22/2008	10/22/2008	10/22/2008	10/22/2008	10/22/2008	10/22/2008
Time	1020	1030	1045	1055	1110	1130
Temperature (°C)	3.82	4.09	7.19	6.98	7.03	4.18
pH (units)	7.41	7.62	7.36	7.24	7.44	7.72
Conductivity (µS/cm)	58	55.8	26.9	28.4	16.2	55.9
Turbidity (NTU)	0.18	0.19	0.31	0.27	0.29	0.13
Dissolved Oxygen (mg/L)	12.43	12.29	10.89	11.14	11.31	12.4
<b>Conventionals</b>						
Alkalinity (mg/L)	37.1	36.0	14	14.9	7.2	35.6
Nitrate+Nitrite (mg/L)	0.039	0.038	0.063	0.063	0.087	0.03
Sulfate (mg/L)	1.31	1.12	1.42	1.31	1.08	1.49
Chloride (mg/L)	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Calcium (mg/L)	8.5	6.2	3.6	2.9	2.1	6.34
Magnesium (mg/L)	1.88	1.81	0.67	0.7	0.3	1.76
Sodium (mg/L)	0.54	0.55	0.58	0.57	0.58	0.55
Potassium (mg/L)	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Hardness (mg/L)	28.9	22.9	11.8	10.3	6.2	23.10
<b>Total Metals</b>						
Arsenic (mg/L)	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030
Cadmium (mg/L)	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Chromium (mg/L)	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Copper (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Iron (mg/L)	<0.010	<0.010	0.010	<0.010	<0.010	0.249
Lead (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Manganese (mg/L)	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Nickel (mg/L)	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Zinc (mg/L)	<0.005	0.008	0.009	0.016	<0.005	<b>0.092</b>
<b>Dissolved Metals</b>						
Arsenic (mg/L)	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030
Cadmium (mg/L)	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Chromium (mg/L)	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Copper (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Iron (mg/L)	<0.010	<0.010	0.010	<0.010	<0.010	<0.010
Lead (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Manganese (mg/L)	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Nickel (mg/L)	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Zinc (mg/L)	<0.005	0.008	0.007	0.014	<0.005	0.006

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

**0.092** Dissolved metals concentrations in bold exceed MDEQ chronic criteria while values in bold and shaded exceed acute criteria.

## Conclusions

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

- Concentrations of arsenic and lead in all waste rock samples exceeded the EPA Region 9 RSLs for industrial soils.
- Concentrations of arsenic and lead in all waste rock samples exceeded the human health risk based cleanup levels for recreation population outlined by the Montana Department of Environmental Quality.
- Maximum concentrations of arsenic (6,246.3 mg/kg), copper (648.2 mg/kg), and lead (38,089.8 mg/kg) were measured in waste rock sample BCSM-WR-3S. Maximum concentrations of cadmium (40.5 mg/kg), manganese (3,475.8 mg/kg), and zinc (12,735.1 mg/kg) were measured in waste rock sample BCSM-WR-6S. Maximum concentrations of chromium (47.5 mg/kg) and nickel (54.0 mg/kg) were measured in waste rock sample BCSM-WR-1S.
- Arsenic, lead and zinc concentrations in waste rock samples showed the greatest increase over background soil samples with arsenic concentrations ranging from 100 to 500 times background concentrations, lead concentrations ranging from 100 to 2,500 times background concentrations, and zinc concentrations ranging from 100 to 500 times background concentrations.
- Leaching tests conducted on waste rock samples indicate that metals may be released from the mine waste. Lead, cadmium, copper, and zinc were released in the greatest concentrations during leaching tests.
- Downstream stream sediment concentrations of arsenic, copper, lead and zinc showed the greatest increase over background stream sediment with arsenic concentrations approximately 2 to 5 times background concentrations, copper concentrations approximately 2 to 5 times background concentrations, lead concentrations approximately 2 to 10 times background concentrations and zinc concentrations approximately 2 to 5 times background concentrations.
- Downstream stream sediment concentrations of arsenic exceeded the Washington State Department of Ecology Freshwater Sediment SQS value for all samples and exceeded the CSL value at BCSM-DSS-4S. Downstream stream sediment concentrations of cadmium exceeded the SQS value for 4 of 5 samples, while zinc concentrations exceeded the SQS value for 1 of 5 samples.

- Total and dissolved metal concentrations collected in Blue Creek upstream of mine runoff were below the detection limit for all metals, while total and dissolved metal concentrations collected in Blue Creek downstream of the mine runoff were below the detection limit for all metals except for iron and zinc. Total zinc concentrations measured one-quarter mile downstream of the mine at station BCSM-SW-7W (92 µg/L) exceeded the MDEQ acute criteria.
  
- Surface water total and dissolved metal concentrations collected from mine runoff at the adit (BCSM-SW-5W) were below the detection limit for all metals. Samples collected from waste rock seeps and runoff (BCSM-SW-3W and 4W) were below the detection limit for all metals except for iron and zinc. Total and dissolved zinc concentrations were low from the seep (BCSM-SW-3W, 9µg/L and 7 µg/L respectively) and slightly greater from the waste rock runoff (BCSM-SW-4W, 16 µg/L and 14 µg/L respectively).

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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 Blue Creek-Scotchman 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.