SITE ASSESSMENT ANALYTICAL RESULTS REPORT
PHASE I - SEPTEMBER 2001

SNAKE RIVER TECHNICAL SUPPORT
Summit County, Colorado

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

PAGE #

FIGURES

TABLES

APPENDICES

1.0 INTRODUCTION

URS Operating Services, Inc. (UOS) has been tasked by the U.S. Environmental Protection Agency (EPA), Region VIII, under Technical Direction Document (TDD) number 0108-0005 to conduct a Site Assessment (SA) for the Snake River Technical Support Project in Summit County, Colorado. Field work for this SA is planned to be conducted in three major phases; a low flow event in September 2001, a mid-winter event in February 2002, and a high flow event in June 2002. This Phase I Analytical Results Report (ARR) is a report of the analytical results of environmental samples and other data collected during Phase I field activities conducted September 24 through 26, 2001. When additional field activities are conducted for Phase II and Phase III, additional ARRs may be prepared at the direction of the EPA Site Assessment Manager (SAM).

The Field Sampling Plan (FSP) for Phase I field activities was approved by the EPA SAM on September 17, 2001. A Sampling Activities Report (SAR) was submitted to the EPA SAM on November 1, 2001, and is included in this ARR as Appendix C. Both the SAR and this ARR were prepared in accordance with TDD number 0108-0005, the EPA "Guidance for Performing Site Inspections Under CERCLA," Interim Final September 1992, the "Region VIII Supplement to Guidance for Performing Site Inspections," and the "UOS Generic Quality Assurance Project Plan" (U.S. Environmental Protection Agency (EPA) 1992; EPA 1993; URS Operating Services, Inc. (UOS) 2001). This ARR includes the analytical results of Target Analyte List (TAL) total and dissolved metals analyses and wet chemistry analytical results of aqueous mine waste water discharge and stream water samples; the analytical results of TAL total metals analyses of stream and wetlands sediment, mine waste rock, and undisturbed soil; stream flow measurements; and measurements of field water quality parameters for each aqueous sample location and additional stream locations of potential interest. Sampling procedures adhered to the UOS Technical Standard Operating Procedures (TSOPs) for field operations at hazardous waste sites (UOS 2000).

The Phase I sampling event was conducted as a synoptic event. All water samples within the primary study area drainage (Upper Peru Creek and Cinnamon Gulch) were collected within a four-hour window on September 24, 2001. The analytical results of the Phase I sampling event as well as field data collected during the sampling event were evaluated by HRS criteria and reported in this Analytical Results Report (ARR). The data collected during Phase I was also used to perform a low-flow hydrologic evaluation of the Peru Creek and Snake River drainages and an engineering evaluation of proposed remediation options of select sources of contaminants to the Peru Creek and Snake River drainages. This dual evaluation is included in this report as Appendix B -

Hydrologic Evaluation of Metals Contamination to the Snake River and Peru Creek Drainages from the Montezuma Mining District. The Phase I Photolog is included in this report as Appendix A.

Phase I samples included one background soil sample from an undisturbed area topographically above mining activity, six mine waste rock samples, four mine waste drainage samples, fifteen surface water samples, eleven sediment samples, and two Quality Assurance/Quality Control (QA/QC) samples (in addition to the laboratory matrix spike/matrix spike duplicates (MS/MSD)) (Table 1). The QA/QC samples followed the requirements of the "Region VIII Supplement to Guidance for Performing Site Inspections under CERCLA" and included one duplicate aqueous sample and one rinsate sample (EPA 1993).

Mine waste rock, soil, and sediment samples were analyzed through the EPA's Contract Laboratory Program (CLP) Routine Analytical Services (RAS) for TAL total metals. All aqueous samples, including mine waste water and surface water samples, were analyzed through CLP RAS for TAL total metals and, on specific samples, dissolved metals. Unique Laboratory Analytical Services (ULSA) were utilized for alkalinity, chlorides, and sulfate analyses of aqueous samples. Laboratory specific information and copies of the sample Chain of Custody forms are included in the SAR (Appendix C). Copies of the analytical data laboratory reports and associated validation reports are included in Appendix D.

2.0 OBJECTIVES

The purpose of this SA is to evaluate, characterize, and document water quality conditions in Peru Creek, and the impact of the Peru Creek drainage on the water quality of the Snake River. The SA is also designed to gather information for the evaluation of this site with regard to the EPA's Hazard Ranking System (HRS) criteria. The specific objectives of this SA are:

- To evaluate, characterize, and document background conditions in the Peru Creek and Snake River drainages;

- To evaluate, characterize, and document the potential to release of metals contaminants to the environment from mine waste rock and mine waste water discharges in the upper Cinnamon Gulch mine workings (i.e., Silver Spoon Mine) and the Shoe Basin Mine, via the surface water and groundwater to surface water pathways;

- To evaluate, characterize, and document the impact of potential releases of metals from the upper Cinnamon Gulch mine workings and Shoe Basin Mine to the surface water targets of Peru Creek and the Snake River, including wetlands, fisheries, drinking water users, and recreational users;

- To evaluate whether an existing design for an engineered diversion plan in Cinnamon Gulch would improve water quality, and if so, to what extent;

- To provide a rough estimate for the proposed Cinnamon Gulch diversion operation and maintenance costs; and

- To propose, evaluate, and document other options for potential mitigation activities at Cinnamon Gulch, including the Silver Spoon Mine and the Shoe Basin Mine sites, which will decrease contamination loading on Peru Creek and the upper Snake River.

3.0 SITE DESCRIPTION

3.1 SITE LOCATION

The Peru Creek drainage is located in Summit County, Colorado, in the Montezuma Mining District east-northeast of the town of Montezuma. The headwaters of Peru Creek originate from the highly mineralized and glaciated terrain found along the Continental Divide (Figures 1 and 2).

The Peru Creek drainage is reached by traveling east from the Keystone Ski Area on U.S. Highway 6 for approximately 1.2 miles to Montezuma Road. Turn south at Montezuma Road and then turn left at the first fork in the road and proceed east, past the ski area parking lots, for 4.6 miles to where the road makes a sharp bend and crosses the Snake River. Immediately after crossing the Snake River turn left at the unpaved 4-wheel drive road and proceed first north then west up Peru Creek on a road that becomes increasingly rugged (Sudduth 1976).

3.2 SITE ACCESS

Site access to properties sampled was obtained by the EPA Region VIII prior to the collection of all samples.

3.3 SITE HISTORY AND PREVIOUS WORK

There are no records of production for the Shoe Basin Mine available from the Colorado Bureau of Mines prior to 1914 (Colorado Bureau of Mines 1914). The Shoe Basin Mine buildings burned in 1958. Production of 656 tons of ore is recorded for the years of 1964 and 1965 (Colorado Bureau of Mines 1965). There are no records of production available from the Colorado Bureau of Mines prior to 1961 for the Silver Spoon Mine (Colorado Bureau of Mines 1965).

The U.S. Forest Service conducted an inventory of abandoned mine lands in the Dillon Ranger District in 1993, which included the mines and adits of the Peru Creek drainage (U.S. Forest Service (USFS) 1994). A study of abandoned mine lands and their potential amelioration, which included the mines and adits covered by this SA, was published by the U.S. Forest Service (Munroe 2000).

Water quality data presented in the U.S. Forest Service reports indicate that the mine workings in the area are contributing significant metals contaminants to Peru Creek and farther downstream into the Snake River (USFS 1994; Munroe 2000).

3.4 SITE CHARACTERIZATION

3.4.1 Physical Geography

The Snake River Project Study Area is located in the Rocky Mountains of central Colorado in alpine terrain characterized by steep-sided glaciated valleys and unvegetated rocky upland ridges and peaks. Elevations in the study area range from 9,000 feet above mean sea level (MSL) to 14,270 feet MSL (U.S. Geological Survey (USGS) 1974; USGS 1987a; USGS 1987b).

3.4.2 Geology and Hydrogeology

The predominate rock types found in the Snake River study area are the Precambrian Swandyke Hornblende Gneiss and the Idaho Springs Formation, which have been intruded by Cretaceous age hornfels and Tertiary age porphyritic quartz monzonites and aplites. The controlling structural features of the study area are the Thurman Gulch Fault bounding the west side of the study area, the Ruby Gulch Fault bounding the north side of the study area, and the Montezuma Shear Zone running from southwest to northeast. The Shoe Basin and Silver Spoon Mines are both located along the Montezuma Shear Zone. Hydrothermal alteration controlled by veins and faulting is common throughout the study area. Common sulfide minerals that are associated with the hydrothermal alteration of the bedrock include pyrite, galena, sphalerite, chalcopyrite, molybdenite, and arsenopyrite (Munroe 2000; USGS 1972).

Groundwater is expected to be present in the alluvial material in the stream valleys and in fractures of bedrock. Direction of groundwater flow is expected to be downstream following stream valley contours. There is no specific information available concerning depth to groundwater at the site area.

3.4.3 <u>Hydrology</u>

Stream gradients in the study area are very steep and stream flow rates are rapid. There is considerable variation in flow volumes between low-flow and high-flow regimes. The Snake River is the major stream in the area and flows into Dillon Reservoir within the 15-mile downstream limit (Figure 1). Peru Creek is the surface water stream that drains the area of the Shoe Basin and Silver Spoon Mines and flows into the Snake River approximately three miles downstream of the mines (Figures 1 and 2). Results of Phase I stream gauging conducted with a Marsh McBirney flow meter are presented in Section 9.3 and Figure 3 of this report.

3.4.4 <u>Meteorology</u>

The Snake River Project study area is located in a semiarid climate zone. Most of the annual precipitation falls as snow during the winter and spring. The mean annual precipitation, as totaled from the University of Delaware database, is 11.7 inches. The net annual precipitation, as calculated from the precipitation and evapotranspiration data obtained from the UD, is 3.7 inches (University of Delaware (UD) 1986. The 2-year, 24-hour rainfall event for this area is 1.5 inches (Dunne, Thomas and Luna B. Leopold 1978).

4.0 <u>ANALYTICAL DATA</u>

4.1 DATA INTERPRETATION

The sample data collected during this SA were reviewed using the HRS guidelines for analytical interpretation (Office of the Federal Register 1990). As reported in the analytical results in Tables 2 through 5, elevated concentrations of contaminants reported as significantly above upgradient contaminant values are noted by a star (★) and are determined by sample concentrations based on the following:

- If the **<u>upgradient</u>** analyte concentration is greater than its Sample Quantitation Limit (SQL) and if the **<u>release sample</u>** analyte concentration is greater than its SQL, three times greater than the upgradient, and five times greater than the blank concentration.

- If the **<u>upgradient</u>** analyte concentration is not greater than its SQL, and if the **<u>release sample</u>** analyte concentration is greater than its SQL, greater than the upgradient SQL, and five times greater than the blank concentration.

4.2 DATA QUALITY ASSESSMENT

TAL total metals (both aqueous and soil matrix) and aqueous dissolved metals were analyzed by CLP statement of work (SOW). Detection levels for the TAL total and dissolved metals are those of the CLP SOW for inorganic analyses (EPA 1999). Alkalinity and bicarbonate analyses of aqueous samples were performed by Method for the Chemical Analyses of Water and Waste (MCAWW) number 310.1. The detection limit for the alkalinity analyses was 20 milligrams per liter (mg/L). Chloride and sulfate analyses of aqueous samples was performed by MCAWW method number 300.0. Detection limits for the chloride and sulfate analyses was 0.5 mg/L.

Data validation reports for the analytical data from samples collected during Phase I are presented in Appendix D - Laboratory Data, Data Validation Reports, and SQL Calculations. Data for the 21 wet chemistry samples were not qualified by the validator (Bicarbonate Alkalinity, Carbonate Alkalinity, Total Alkalinity, Chloride, and Sulfate analyses). Overall data quality of the wet chemistry analyses is considered excellent.

Minor qualifications were placed on many of the TAL total metals analytical results for the 20 soil and sediment samples collected during Phase I. Blank contamination also caused detections for calcium, sodium, magnesium, and beryllium to be changed to undetected in many samples. Blank contamination caused detections of arsenic and thallium to be qualified as estimated in many samples. Silver and arsenic results were qualified in all samples because the duplicate Relative Percent Difference (RPD) was outside control limits. Sodium results were qualified in all samples because of problems with the serial dilution. Mercury results were qualified in all samples because the spike recovery was outside control limits. Cadmium, chromium, cobalt, and sodium were qualified in certain samples because of iron interference. Overall data quality of the TAL total metals and mercury analyses in soils and sediments samples is considered acceptable.

Minor qualifications were placed on the analytical results for the 21 aqueous samples that were analyzed for TAL total metals. Blank contamination resulted in detections being qualified as non-detections for aluminum, beryllium, potassium, iron, arsenic, cadmium, copper, barium, magnesium, manganese, chromium, and arsenic. Overall data quality of the TAL total metals and mercury analyses in aqueous samples is considered good.

Minor qualifications were placed on the analytical results for the 6 aqueous samples that were analyzed for dissolved metals. Blank contamination resulted in detections being qualified as non-detections for aluminum, beryllium, chromium, cobalt, lead, barium, magnesium, manganese, sodium, and potassium.

Overall data quality of the dissolved metals and mercury analyses in aqueous samples is considered good.

4.3 QUALITY ASSURANCE/QUALITY CONTROL SAMPLES

QA/QC samples collected during Phase I of this SA included a duplicate aqueous sample and a rinsate blank sample. Sample PC-SW-06 was collected as a duplicate of surface water sample PC-SW-01, the most upstream background sample on Peru Creek. Duplicate sample PC-SW-06 was analyzed for both TAL total metals and wet chemistry. Results for samples PC-SW-01 and PC-SW-06 are presented side-by-side in Tables 3 and 6. There is good correlation between the results of the two samples indicating that specified sampling techniques were reproducible and adhered to the TSOPs (UOS 2000). Rinsate sample SR-SW-04 was collected on September 26, 2001, to serve as a field blank and a test of decontamination procedures. The rinsate sample was analyzed for TAL total and dissolved metals and wet chemistry. Results for SR-SW-04 are presented in Tables 3, 4, and 6 and indicate that the decontamination procedures were correctly performed and that the rinsate blank was correctly collected as per the TSOPs (UOS 2000).

5.0 SOURCE CHARACTERIZATION

Two primary sources were identified in the Peru Creek Basin for sampling and evaluation in Phase I of this SA: the Silver Spoon Mine and other closely associated mine workings in Cinnamon Gulch; and the Shoe Basin Mine in the upper Peru Creek Basin (Figure 2). Both locations include mine waste rock and mine waste water discharge sources (USFS 1994; Munroe 2000). No evidence of engineered run-on and runoff control or other engineered containment of the mine waste rock piles or identifiable engineered control of mine waste water discharges was noted at either mine.

5.1 SHOE BASIN MINE WASTE ROCK AND MINE WATER DISCHARGE

The Shoe Basin Mine has a 1,030-foot adit and a 1,500-foot tunnel along the sulfide vein and one main mine waste rock dump (Colorado Bureau of Mines 1914). The entrance to the Shoe Basin Mine is located approximately 100 feet north and 50 feet above the dirt road along Peru Creek. The mine's waste rock dump is located between the mine entrance and the dirt road, covers about 6,000 square feet with a central high point of about 50 feet, and contains an estimated 7,000 cubic yards of mine waste rock. The material in the mine waste rock dump contains approximately 30 percent sulfide minerals (Munroe 2000). Most of the material exposed on the surface of the Shoe Basin Mine waste rock dump is a fine to medium to coarse, sandy, angular, limonite stained rubble. The evidence of coarser material around the base of the waste rock dump and the inability of hand augers to penetrate to a depth greater than one foot indicates that coarser material predominates at depth. Erosional gullies or rilling are evident on the un-vegetated slopes of the mine waste rock dump (Photos 15, 17, 18, and 19). A smaller quantity of mine waste rock has been disposed of on the south side of the dirt road in the wetlands area between the road and Peru Creek. (Photo 15).

Four mine waste rock samples were collected from the Shoe Basin mine waste rock dump during Phase I. The analytical results of the TAL total metals analyses of these samples are presented in Table 2. Samples SR-MWR-02 and SR-MWR-03 were collected from the south side of the waste rock dump about five feet from the gully of the mine waste discharge runoff, from the 0 to 6-inch depth and the 6- to 12-inch depth, respectively (Photo 17). Sample SR-MWR-02 from the 0 to 6-inch horizon shows high concentrations of lead, silver, and zinc, and sample SR-MWR-03 from the 6- to 12-inch horizon shows a high concentration of zinc compared to background sample SR-MWR-01. Samples SR-MWR-06 and SR-MWR-07 were collected from the east side of the dump about five feet above the dirt road, from the 0 to 6-inch depth and the 6- to 12-inch depth, respectively (Photo 19). The 0 to 6-inch sample shows high concentrations of arsenic, copper, lead, and zinc, and the 6- to 12-inch sample shows high concentrations of copper, lead, and zinc compared to the background sample (SR-MWR-01)

Two samples of the mine water discharge from the Shoe Basin Mine were collected during Phase I. Sample PC-MWD-01 was collected at the mouth of the mine and sample PC-MWD-02 was collected from the gully through which flows the mine waste water discharge on the southwest slope of the mine waste rock dump from approximately 5 feet above the road (Figure 2) (Photos 16 and 18). Flow at the mouth of the mine (PC-MWD-01) was measured by the field crew using an eight-ounce bottle and stopwatch and determined to be approximately 2.5 gallons per minute, and flow at the base of the mine waste rock dump (PC-MWD-02) was measured to be approximately 1.1 gallons per minute. It is estimated that approximately 1 to 1.5 gallons of mine water discharge either evaporates or infiltrates the Shoe Basin Mine waste rock dump every minute. A review of the water quality parameters collected during the September 24, 2001, Phase I sampling event indicate that the water quality parameters of the

Shoe Basin mine water discharge (pH, 3.1 to 2.9; conductivity 1,452 to 1,462 micro Siemens per centimeter (µS/cm); and oxidation reduction potential, 532 to 544 mV) essentially remain constant as the discharge flows over the mine waste rock (Appendix C, Table 1). The only significant change is an increase in temperature (5.1 to 13.6°C) as the discharge flows over the exposed surface of the shallow gully and is heated by the sun (Appendix C).

A review of the wet chemistry analytical results presented in Table 6 also indicates little change as the Shoe Basin mine water discharge leaves the mine and flows across the mine waste rock dump. Chloride and sulfate concentrations decrease very slightly and bicarbonate and alkalinity are below detection levels in the acidic mine water discharge. The results of the TAL total metals analyses of the Shoe Basin mine water discharge samples PC-MWD-01 and PC-MWD-02 show high concentrations of cadmium, calcium, copper, iron, magnesium, manganese, nickel, thallium, and zinc and notably low concentrations of lead in the mine discharge water in comparison to concentrations in nearby Peru Creek (Table 3). There are small increases and decreases in some metals as the mine water discharge flows across the waste rock dump. The chemistry and environmental impacts of the mine water discharge are discussed in Appendix B, *Hydrologic Evaluation of Metals Contamination to the Snake River and Peru Creek Drainages from the Montezuma Mining District.*

5.2 CINNAMON GULCH/SILVER SPOON MINE WASTE ROCK AND MINE WATER DISCHARGE

More than a dozen adits have been identified in the Upper Cinnamon Gulch area and at least six of these have been identified as sources of mine waste water drainage. The two major sources of mine water discharge are located at the former Silver Spoon Mine site and at an adit on the east side of the gulch approximately 250 feet below the Silver Spoon Mine (Photo 14) (USFS 1994). There is no historical information available from the Colorado Bureau of Mines about specific construction details of the Silver Spoon Mine and other adits in upper Cinnamon Gulch (Colorado Bureau of Mines 1914).

The mine waste rock pile at the Silver Spoon Mine site covers an area of approximately 50 feet by 50 feet and reaches a height of approximately 20 feet. It is estimated that the volume of mine waste rock at the location is approximately 1,000 cubic yards. The material sampled at the Silver Spoon Mine waste rock pile was an unsorted mixture of angular mining rubble that is in size and coloring similar to the surrounding material mantling the hillside. Coarser angular rocks cover the mine waste rock pile and the finer grained material appears to have infiltrated into the depths of the waste rock pile (Photographs 12, and 13). Two samples of the mine waste rock, sample SR-MWR-05 from the 0 to 6-inch horizon and sample SR-MWR-04 from the 6- to 12-inch horizon were collected with a hand auger from the center of the mine waste rock pile (Figure 2) (Photo 13). No evidence of chemical zoning was noted at the sample collection point. It has been reported that between 20 and 50 percent of the waste rock material in the Cinnamon Gulch mine waste rock piles are sulfide minerals (Munroe 2000). A review of the analytical data presented in Table 2 indicates that sample SR-MWR-05 collected from 0 to 6 inches, contains the highest concentration of barium of all source samples, but lower than average concentrations for all other metals than is found in other source samples collected during the study. Sample SR-MWR-04, the 6- to 12-inch sample, also exhibits lower metals concentrations than would be expected for mine waste rock. Mine waste water discharge from the Silver Spoon Mine flows along the north flank of the waste rock pile and is eroding and transporting some of the waste rock material (Photo 12).

Two samples of mine waste water discharge were collected in Cinnamon Gulch during Phase I field work, sample CG-MWD-01 from the Silver Spoon Mine and sample CG-MWD-02 from the adit approximately 250 feet downgradient of the Silver Spoon Mine (Figure 2) (Photos 10 and 14). The Silver Spoon Mine water discharge (CG-MWD-01) was flowing at an estimated 2 to 3 gallons per minute on September 24, 2001, and field water quality parameters measured at sample collection were pH of 3.33 and a conductivity of 471 µS/cm (Appendix C, Table 1). The wet chemistry data presented in Table 6 indicates that the chloride content of the water is normal, but that the sulfate content of the water is approximately twice background stream levels. A review of the analytical data for TAL total metals analyses presented in Table 3 shows that the Silver Spoon Mine waste water discharge could be a source of aluminum, cadmium, chromium, cobalt, copper, lead, manganese, nickel, and zinc contamination in Cinnamon Gulch and Peru Creek. A more complete discussion of water quality issues can be found in Appendix B.

The mine water discharge from the adit below the Silver Spoon Mine at sample location CG-MWD-02 was flowing at an estimated 2 gallons per minute, and field water quality parameters measured at sample collection were a pH of 3.32 and a conductivity of 537 µS/cm (Appendix C, Table 1) (Photos 10 and 11). The wet chemistry data presented in Table 6 indicate that the chloride content of the water is normal, but that the sulfate content of the water is approximately twice background stream levels. A review of the analytical data for TAL total metals analyses presented in Table 3 shows that the lower adit could be a source of aluminum, cadmium, cobalt, lead, manganese, nickel, and zinc contamination in the waters of Cinnamon Gulch and Peru Creek. Additional discussion of water quality issues is presented in Appendix B.

6.0 AIR PATHWAY

The air pathway has not been sampled or evaluated at the Shoe Basin Mine, Silver Spoon Mine, or at any other potential source in the study area. The mine waste rock pile at the Shoe Basin Mine is composed predominately of a fine grained sand to silty material that is mixed with a secondary component of angular rock fragments that vary in size from small to large. There is almost no vegetation on the mine waste rock pile and the slope of the mine waste rock pile is very steep, which would facilitate runoff and leave the finer grained material dry most of the year and potentially available to wind transport (Photos 15, 17, 18 and 19). The mine waste rock at the Silver Spoon Mine in Cinnamon Gulch is predominately composed of a mixture of fine grained and coarse angular material. There is no vegetation growing on the mine waste rock piles. The mine waste rock piles at the Silver Spoon Mine are mantled by coarse-grained angular rock fragments that cover the finer grained material and would inhibit wind transport of the finer grained material (Photos 10, 11, 12, 13, and 14).

Approximately five acres of palustrine emergent scrub-shrub saturated wetlands are located immediately adjacent to the Shoe Basin Mine site along Peru Creek. Approximately three acres of upland wetland areas are located in upper Cinnamon Gulch near the Silver Spoon Mine and associated adits. (U.S. Department of the Interior Fish and Wildlife Service 1977).

Federally listed and candidate threatened and endangered species found in Summit County include the Canada lynx (threatened); the bald eagle, the Mexican spotted owl, and Penland alpine fen mustard (all listed threatened); the Uncompahgre fritillary butterfly, razorback sucker, humpback chub, bonytail chub, and Colorado pikeminnow (all listed endangered); and the Boreal toad (candidate for listing) (U.S. Fish and Wildlife Service 2000). State listed and candidate threatened and endangered species found in Summit County include the Boreal toad, whooping crane, wolverine, and lynx (all endangered) and the Penland alpine fen mustard (listed threatened) (Colorado Natural Heritage 2001).

7.0 GROUNDWATER PATHWAY

A review of groundwater well records maintained by the State of Colorado Division of Water Resources, State Engineers Office, indicates that there are no groundwater wells permitted in the Peru Creek Drainage. State records indicate that 79 groundwater wells have been permitted in the townsite of Montezuma, approximately 2.75 miles west, southwest of the Peru Creek Mine sites (Figure 1)(Colorado Division of Water Resources 2001). The townsite of Montezuma is located in the valley of the Snake River, upgradient of Peru Creek and there is no known mechanism to permit mixing of groundwater from the Peru Creek Valley with that from the Snake River Valley upgradient of the confluence of the two streams. Four other groundwater wells are permitted along the Snake River downstream of the confluence of Peru Creek with the Snake River within four miles of the site (Colorado Division of Water Resources 2001). Mine water discharge was sampled at the Shoe Basin Mine, the Silver Spoon Mine, and an adit below the Silver Spoon Mine. An area of iron bog seeps were noted along Peru Creek at the base of Brittle Silver Mountain (Photo 7). The groundwater pathway was not specifically sampled and investigated as a part of this SA.

8.0 SOIL EXPOSURE PATHWAY

The soil exposure pathway was not specifically evaluated as a part of the SA. A background soil sample (SR-MWR-01) was collected in Cinnamon Gulch from a grassy hillside location topographically above the mining activity associated with the Silver Spoon Mine (Figure 2). A review of the analytical data from the background sample and from samples collected from mine waste rock piles in Cinnamon Gulch and the Shoe Basin Mine indicate that metals concentrations in the mine waste rock piles is above background levels (Table 2).

The Silver Spoon Mine is located high in the rugged terrain of Cinnamon Gulch, which requires considerable effort to reach. There are no fences or signage at the Silver Spoon Mine or any of the other potential sites in Cinnamon Gulch (Photo 14). The Shoe Basin Mine is located alongside the 4-wheel drive road that parallels Peru Creek, is not fenced or signed, and is easily accessible to the public (Photo 15). Recreational use of the 4-wheel drive road along Peru Creek by tourists was observed by the Superfund Technical Assessment and Response Team 2 (START2) in September 2001 and Peru Creek is a popular winter cross country ski route (Sudduth 1976). There was no direct evidence observed by START2 that the individual mine sites are used for recreational purposes or that any terrestrial sensitive environments exist on the sites.

Federally listed and candidate threatened and endangered species found in Summit County include the Canada lynx (threatened); the bald eagle, the Mexican spotted owl, and Penland alpine fen mustard (all listed threatened); the Uncompahgre fritillary butterfly, razorback sucker, humpback chub, bonytail chub, and Colorado pikeminnow (all listed endangered); and the Boreal toad (candidate for listing) (U.S. Fish and Wildlife Service 2000). State listed and candidate threatened and endangered species found in Summit County include: the Boreal toad, whooping crane, wolverine, and lynx (all endangered) and the Penland alpine fen mustard (listed threatened) (Colorado Natural Heritage 2001).

9.0 SURFACE WATER PATHWAY

9.1 DESCRIPTION AND TARGETS

Peru Creek drains the study area and then flows into the Snake River, which flows west entering Dillon Reservoir, a municipal source of drinking water for the City of Denver (Figure 1). The intake for the Roberts Tunnel is located in Dillon Reservoir approximately ½ mile downstream of the 15-mile downstream limit from the Shoe Basin and Silver Spoon Mines (Denver Water 2001). The drainage basin of Peru Creek is enclosed by the continental divide on the north, east, and south and encompasses approximately 20 square miles (Figures 1 and 2).

There are 0.8 mile of palustrine scrub-shrub emergent wetlands located along Peru Creek immediately downstream of the Shoe Basin Mine. Multiple small isolated semipermanent palustrine open water wetlands are located along Peru Creek downstream of the site to Peru Creek's confluence with the Snake River. Approximately six acres of streamside wetlands are located along the Snake River from the confluence of Peru Creek to the inlet of Dillon Reservoir. There are small upland wetland areas located in upper Cinnamon Gulch near the Silver Spoon Mine and associated adits (U.S. Department of the Interior, Fish and Wildlife Service 1975; U.S. Department of the Interior, Fish and Wildlife Service 1976; U.S. Department of the Interior, Fish and Wildlife Service 1977).

There are no recorded surface water intakes along Peru Creek. Peru Creek and the Snake River are not stocked (Colorado Department of Fish and Wildlife 2001). The START2 field team did not observe any sport fishing or other recreational use of Peru Creek or the Snake River during field work, however trout were observed in Chihuahua Gulch during the reconnaissance of September 25, 2001.

9.2 SAMPLE LOCATIONS

Sample locations are shown in Figure 2 and are listed along with a description of each sample location and sample rationale in Table 1. All sample locations have been documented by Geographic Positioning System (GPS) coordinates. All sample locations were photographed and representative photographs are in Appendix A - Photolog.

Background surface water and sediment samples were collected on Peru Creek at PC-SW/SE-01 (Photo 21). This location is above the influence of the Shoe Basin Mine and at the entrance to Horseshoe Basin. Sample location PC-SW-02 on Peru Creek is downstream of the Shoe Basin Mine and the wetlands area below the mine, but prior to any influences of the Pennsylvania Mine (Photo 20). Sample location PC-SW-03 on Peru Creek is downstream of the confluence with Cinnamon Gulch. Sample location PC-SW-04 on Peru Creek is downstream of the confluence with Chihuahua Gulch (Photo 6). Sample location PC-SW-05 on Peru Creek is located approximately 100 feet before the confluence of Peru Creek and the Snake River (Photo 5). Two samples were collected from the wetlands along Peru Creek between the Shoe Basin Mine and the Pennsylvania Mine (PC-SE-02 and PC-SE-03) (Photo 15) (Figure 2).

Background surface water and sediment samples were not collected on Cinnamon Gulch because there was no flow detected above the mine waste water discharge of the Silver Spoon Mine. The most upstream sample on Cinnamon Gulch was collected at CG-SW-02 located between the Silver Spoon Mine and the lower adit (Photo 12). Sample CG-SW-03 was collected on Cinnamon Gulch below both the mining activity in the vicinity of the Silver Spoon Mine and the wetlands area below the mining activity (Photo 9). Sample CG-SW-04 was collected on Cinnamon Gulch just before the main stream braids into several channels and drops into the Peru Creek valley (Photo 8). Three wetlands sediment samples were collected from the grassy inundated wetlands along Cinnamon Gulch between sample locations CG-SW-03 and CG-SW-04. These wetlands sediment samples were collected from the upper section, middle section, and lower section of the wetlands (CG-SE-02U, CG-SE-02M, and CG-SE-02L) (Figure 2).

Two surface water and sediment samples were collected from Chihuahua Gulch. Samples CH-SW/SE-01 were collected as background samples from an area of wetlands approximately one mile upstream of the Chihuahua Gulch's confluence with the Snake River, and samples CH-SW/SE-02 were collected from a location approximately 1,200 feet upstream of Chihuahua Gulch's confluence with Peru Creek (Photo 24) (Figure 2).

Surface water and sediment samples (TH-SW/SE-01) were collected from Thurman Gulch approximately 200 feet upstream from the stream's confluence with the Snake River (Figure 2).

Four samples were collected along the Snake River. Background surface water sample SR-SW-01 was collected from the Snake River approximately 150 feet upstream of the confluence of the Snake River and Peru Creek (Photo 1). Sample SR-SW-02A was collected on the Snake River approximately 100 feet downstream of the confluence of Peru Creek (Photo 4). Samples SR-SW/SE-02B were collected on the Snake River downstream of the confluence of Thurman Gulch. The most downstream sample was SR-SW-03 collected from the Snake River approximately 1,000 feet upstream of Dillon Reservoir (Photo 3) (Figure 2). A sediment sample was collected from a sandbar approximately 30 feet upstream from the background location on the Snake River (SR-SE-01). This was an opportunity sample collected because the sandbar that was elevated approximately five feet above the stream bed appeared to be stream-deposited mine and mill tailings (Photo 2).

9.3 STREAM GAUGING

Stream gauging using a Marsh McBirney flow meter was conducted at five locations on Peru Creek and two locations on the Snake River. These measurements are presented in Figure 3. The flow measurement of sample location PC-SW-05 was performed twice as a QA/QC check (Photo 5). The replicate measured flow rates are recorded in Table 2 of the SAR and vary by approximately 24 percent, which is a good correlation considering the rocky stream bed and resultant very turbulent flow (Appendix B). The flow rate for the Snake River after the confluence with Peru Creek was measured at 9,326 gallons per minute, which is very close to the sum of the flow rate for the two streams immediately before their confluence (Figure 3). Flow rates at all other stream sampling locations were measured by using a calibrated container and a stopwatch to measure fill time or by visually estimating the flow rate when a container could not be used. Measured and estimated flow rates for sample locations are presented in Table 6.

A more in-depth discussion of flow and loading calculations is presented in Appendix B.

9.4 WATER QUALITY PARAMETERS

Water quality parameters were collected at all surface water sample locations and are presented in Table 1 of the SAR (Appendix C). The water quality parameters that were recorded included water temperature, pH, conductivity, and oxidation/reduction potential.

The pH of Peru Creek at the background sample location, PC-SW-01, is 5.5 and increases slightly to a stream high of 5.6 at sample station PC-SW-02 below the Shoe Basin Mine and associated wetlands. The lowest pH recorded on Peru Creek is 4.2 at sample station PC-SW-03 after drainage from the Cinnamon Gulch area has entered Peru Creek. Conductivity in Peru Creek increased after the Cinnamon Gulch area, but dropped back to less than background levels before its confluence with the Snake River. Oxidation/reduction potential in Peru Creek increased after the Cinnamon Gulch area and remained slightly above background levels to the confluence with the Snake River (Appendix C, Table 1). The drainage from the Cinnamon Gulch area, which includes the Cinnamon Gulch stream and potential iron bog seeps along the base of Brittle Silver Mountain, appears to be the major influence on field water quality parameters in Peru Creek (Photo 7).

The pH of the Snake River drops from 6.35 before the confluence with Peru Creek to 5.2 after the confluence with Peru Creek. All other field measured water quality parameters on the Snake River remain essentially unchanged after the confluence. The Snake River returns to a pH of 6.74 just before it enters Dillon Reservoir (Appendix C, Table 1).

9.5 ANALYTICAL RESULTS AND ATTRIBUTION

9.5.1 Surface Water - TAL Total and Dissolved Metals

Surface water samples were collected from five different streams in the Snake River Technical Support Site Assessment study area: Thurman Gulch, Chihuahua Gulch, Cinnamon Gulch, Peru Creek, and the Snake River (Figure 2). Samples for analysis of TAL total metals were collected from all five streams (Table 3). Samples for dissolved metals were collected from Peru Creek and the Snake River (Table 4).

Analytical results of the TAL total metals sample from Thurman Gulch (TH-SW-01) show non-detects for all metals except barium, magnesium, potassium, and sodium, which were all detected at concentrations below the CLP reporting limit (Table 3). Thurman Gulch is not a source or contributor to levels of surface water contamination from metals in the Snake River.

Two samples for TAL total metals analysis were collected in Chihuahua Gulch (CH-SW-01 and CH-SW-02) (Figure 2). The analytical results of these two analyses show non-detects for all metals except barium, calcium, chromium, iron, magnesium, manganese, potassium, and sodium (Table 3). Chihuahua Gulch is not a source or contributor to levels of surface water contamination from metals in Peru Creek or the Snake River.

Three surface water samples were collected in Cinnamon Gulch for TAL total metals analysis. The identification of elevated concentrations of metals in surface water from Cinnamon Gulch was not made because a background sample could not be collected. The three Cinnamon Gulch surface water samples (CG-SW-02, CG-SW-03, and CG-SW-04) all contain concentrations of aluminum, cadmium, cobalt, copper, iron, lead, manganese, nickel, and zinc that are greater than concentrations found in Peru Creek prior to its confluence with Cinnamon Gulch (Table 3) (Figure 2). The surface water entering Peru Creek from Cinnamon Gulch can be considered a source of metals contamination to the surface water of Peru Creek. Two other potential sources that were not sampled during Phase I are the Pennsylvania Mine and a series of iron bog seeps that were identified at the base of Brittle Silver Mountain (Figure 2) (Photo 7). It is possible that the groundwater to surface water pathway in the lower Cinnamon Gulch area is a significant component of the total contamination present in Peru Creek downstream of the area.

Five surface water samples were collected from Peru Creek for TAL total metals analysis. A background sample was collected at PC-SW-01 (Table 3) (Figure 2). Elevated concentrations of aluminum, cadmium, copper, iron and zinc are recorded in surface water sample PC-SW-03 collected on Peru Creek after the confluence of Cinnamon Gulch (Table 3). Elevated concentrations of aluminum, copper, iron, and zinc are found in all samples from Peru Creek downstream of Cinnamon Gulch (Table 3).

Four surface water samples were collected from the Snake River for TAL total metals analysis. A background sample was collected at SR-SW-01 (Table 3) (Figure 2). Elevated concentrations of copper were detected in the first two surface water samples (SR-SW-02A and SR-SW-02B) located downstream of the confluence of Peru Creek with the Snake River. The elevated concentrations of copper extend along the surface water pathway from below Cinnamon Gulch (PC-SW-03) to below Thurman Gulch (SR-SW-02B) (Figure 2). Concentrations of total copper decrease at the most downgradient sample (SR-SW-03).

The analytical results for dissolved metals indicates that elevated concentrations of copper are found in samples for dissolved metals from the Snake River (SR-SW-02A and SR-SW-02B). Concentrations of dissolved copper decrease at the most downgradient sample (SR-SW-03).

The source of elevated concentrations of metals in the surface water of lower Peru Creek and the Snake River after its confluence with Peru Creek appears to be Cinnamon Gulch.

9.5.2 Surface Water - Chemistry

Results of the wet chemistry analysis of surface water samples are presented in Table 6. A detailed discussion of these results and their applicability to the project are included in Section 4 of Appendix B.

Chloride values remain low through all sample locations showing little variation. Alkalinity values decrease through the course of Peru Creek and then rebound as the course of the Snake River is followed through the 15-mile limit. A review of the data in Table 6 indicates that levels of sulfate are highest in mine waste water discharge from the Shoe Basin Mine (PC-MWD-01 and PC-MWD-02) however flow from the mine was observed not to cross the road and enter Peru Creek. Peru Creek has lower sulfate concentrations after the Shoe Basin Mine (PC-SW-02) than at the background location (PC-SW-01). The water from Cinnamon Gulch contains moderately elevated concentrations of sulfate at CG-SW-04 that moderately elevate sulfate in Peru Creek; however, sulfate levels in Peru Creek return to background levels before the creek's confluence with the Snake River at PC-SW-05 (Table 6).

9.5.3 Sediments - TAL Total Metals

Sediment samples were collected from stream beds and from wetlands bordering streams. The results of the analyses of these samples are presented in Table 5. Wetlands sediment samples tended to have higher concentrations of TAL metals than stream sediment samples. Background sediment samples were collected on Peru Creek (PC-SE-01) and the Snake River (SR-SE-01). The downstream sediment sample (SR-SE-02B) collected after the confluence of Peru Creek with the Snake River indicates that in general TAL total metals concentrations in the sediment of the Snake River are not increased by the addition of sediment from Peru Creek. Many TAL total metals concentrations in the Snake River below the confluence with Peru Creek (SR-SE-02B) are actually lower than the background concentrations from the sample collected at SR-SE-01, with the notable exceptions of aluminum, sodium, and zinc (Table 5). Sediment sample SR-SE-01 was collected from what appeared to be the erosional remnant of a sandbar approximately two and one half feet above the stream bed. The sandbar remnant appeared to be composed of mineralized mine waste rock and mill tailings (Photo 2). The location and composition of the sandbar remnant could indicate that much of the Snake River stream bed was once filled with similar material. The sediment from the sandbar remnant recorded the highest concentrations of antimony, arsenic, barium, copper, lead, manganese, selenium, silver, and thallium. Reconnainance activity was not conducted further upstream on the Snake River and no similar material was noted on Peru Creek. Concentrations of TAL total metals in the sediment of Chihuahua Gulch and Thurman Gulch are less than in samples from Peru Creek and the Snake River (Table 5).

Samples of wetlands sediments were collected from wetlands along Peru Creek downgradient of the Shoe Basin Mine and from wetlands along Cinnamon Gulch downgradient of the mine workings associated with the Silver Spoon Mine (Figure 2). These samples contained concentrations of many metals that were above background levels.

10.0 OTHER DATA COLLECTION ACTIVITIES

10.1 RECONNAISSANCE OF HORSESHOE BASIN AND UPPER PERU CREEK

A field reconnaissance of the Horseshoe Basin and Upper Peru Creek was conducted by START2 Team members B. Hayhurst, B. Halwa, M. Mejia, and L. Durbin on September 26, 2001. The team reconnoitered the complete drainages of Peru Creek and Falls Gulch and collected field water quality parameters of temperature, pH, conductivity, and oxidation/redox potential at 18 stream and lake locations.

The East Branch of Peru Creek is shown on topographic maps of the area as extending to the north of Horseshoe Basin (Figures 1 and 2). The field reconnaissance determined that the East Branch of Peru Creek begins at location PC-F as a spring (Figure 2). A berm has been constructed across the floor of Horseshoe Basin at this point for what appears to be an abandoned water diversion project, and the initial flow of the East Branch of Peru Creek passes through a breach in the berm at this point. No clearly defined stream channel was observed above location PC-F. There appears to be only minor evidence of mining activity on the east side of Horseshoe Basin, and streams flowing into the East Branch of Peru Creek from the east side, such as at location PC-G, were choked with a luxuriant growth of moss and were home to a variety of aquatic insect life (Table 7).

The Peruvian Mine, National Treasure Mine, Paymaster Mine, and an unidentified mine above location PC-L, all located on the west side of Horseshoe Basin were reconnoitered during the investigation (Figures 2, 4, and 5). All of these mines had mine waste rock piles, but mine waste water discharge was not noted at any of these mines.

The stream that has the most impact on water quality in the Horseshoe Basin appears to be Falls Gulch, which flows into the West Branch of Peru Creek (Figures 2, 4, and 5). A distinct white deposit appears on the rocks in the stream bed of Falls Gulch Creek within one hundred yards of leaving the source lake. This distinctive white deposit continues down Falls Gulch Creek, over the waterfalls and then down Peru Creek past surface water sample station PC-SW/SE-01 (Photos 21, 22, and 23). Aquatic plant or insect life was not observed at any of the water quality stations where the streambed rocks were coated by the white deposit (Table 7).

10.1.1 <u>Water Quality Parameters of Upper Peru Creek in Horseshoe Basin</u>

Field pH, conductivity, and oxidation/reduction readings were taken at 18 locations in the Upper Peru Creek drainage in Horseshoe Basin. The results are presented in Table 7. A map representation of the pH field data is presented in Figure 4. These data show that stream waters from the northern and eastern sides of the Horseshoe Basin have a higher pH than surface waters entering Peru Creek from the west. The two lowest pH readings in the Upper Peru Creek drainage were recorded from Falls Gulch Creek. No mine workings were located around the lake that is the source of Falls Gulch Creek thus indicating that the low pH of the stream's water is potentially the result of natural conditions.

Field conductivity readings, which are presented in Table 7 and displayed on the map representation of Figure 5, indicate that surface waters originating in the northern part of the Horseshoe Basin are characterized by low conductivity, but waters entering from Falls Gulch Creek and the west side of the Horseshoe Basin are characterized by higher conductivity.

The three highest values for oxidation/reduction potential were recorded at the three locations along Falls Gulch Creek (PC-Lake, PC-Falls, and PC-N) (Table 7) (Figure 2).

10.2 RECONNAISSANCE OF CHIHUAHUA GULCH

Two surface water and sediment samples (CH-SW/SE-01 and CH-SW/SE-01) were collected from Chihuahua Gulch on September 25, 2001. Samples CH-SW/SE-01 were collected as background samples from an area of wetlands approximately one mile upstream of the Chihuahua Gulch's confluence with the Peru Creek, and samples CH-SW/SE-02 were collected from a location approximately 1,200 feet upstream of Chihuahua Gulch's confluence with the Peru Creek (Figures 1 and 2).

A review of the water quality data of the two samples (CH-SW-01 and CH-SW-02) collected along Chihuahua Gulch, and shown in Table 6, indicates that chloride was near background levels established for Peru Creek and that sulfate was less than background levels. Bicarbonate and total alkalinity were both above the background levels measured for Peru Creek (Table 6). The analytical results for the aqueous TAL total metals samples collected along Chihuahua Gulch indicate that all TAL total metals in the water are less than background except for iron and sodium. Zinc concentrations in the water samples, in particular, are much lower than average for the area (Table 3). The results of the TAL total metals analysis of the two sediment samples collected from Chihuahua Gulch (CH-SE-01 and CH-SE-02) are shown in Table 5. All levels of metals in the sediments are less than background levels detected in samples from Peru Creek (Table 5).

In addition a field reconnaissance of the gulch was conducted by START2 Team members G. Miller, A. Hellie, and B. Barrett on September 25, 2001. The START2 reconnaissance team did not locate any evidence of mining activity, mine water discharges, or mine waste rock piles. The START2 team did note that there were fish and aquatic insect life in Chihuahua Gulch and that there was no evidence of staining of streambed rocks (Photo 24).

10.3 RECONNAISSANCE OF THURMAN GULCH

Surface water and sediment samples TH-SW/SE-01 were collected from Thurman Gulch approximately 200 feet upstream from the stream's confluence with the Snake River on September 25, 2001 (Figures 1 and 2). Flow at the sample location TH-SW/SE-01 on Thurman Gulch was estimated to be approximately 50 gallons per minute (Table 6). Invertebrate water life was observed to be abundant however no vertebrates were observed by the START2 field crew. A review of the wet chemistry results for sample TH-SW-01 presented in Table 6 indicate that chloride and sulfate were lower than background determined for Peru Creek, and the result for sulfate in particular was the lowest detected in the study area. The levels of bicarbonate and total alkalinity were the highest recorded in the study area (Table 6). A review of the analytical results for TAL total metals analysis of the aqueous sample from Thurman Gulch (TH-SW-01) indicates that only potassium exceeded background levels established for Peru Creek (Table 3). The sediment sample for Thurman Gulch (TH-SE-01) also revealed lower than average levels of all metals (Table 5). These results indicate that Thurman Gulch is not a source of contamination to the Snake River.

In addition to environmental sampling a field reconnaissance of the gulch was conducted by START2 members J. Miller and P. Sowell on September 25, 2001. The field reconnaissance conducted by START2 noted the presence of the abandoned workings of the American Eagle Mine high up in the gulch (Photo 25). START2 did not detect any mine water discharge from the American Eagle Mine nor did they note any significant source of waste rock material associated with the American Eagle Mine or any other abandoned mine site in Thurman Gulch (Photo 26).

11.0 SUMMARY

The Peru Creek drainage is located in Summit County, Colorado, in the Montezuma Mining District. The headwaters of Peru Creek originate along the Continental Divide and the stream experiences wide variations in flow between high flow spring runoff and low flow conditions in fall and winter. Mining activity along Peru Creek dates back almost 150 years.

The National Forest Service Abandoned Mine Lands program and the Colorado Geological Survey have extensively studied or sponsored studies of the mining sites of the Peru Creek drainage. During sampling for this site assessment conducted during low flow conditions in September 2001 two specific potential sources were examined. These potential sources are the Shoe Basin Mine including a mine waste water discharge and a mine waste rock pile, and mine workings in Upper Cinnamon Gulch that include mine waste water discharges both from the Silver Spoon Mine and from an unnamed adit plus mine waste rock piles in the area of the Silver Spoon Mine and the unnamed adit.

Flow of mine waste water from the Shoe Basin Mine in September 2001 was measured to be 2.5 gallons per minute. The flow was measured to be 1.1 gallon per minute after crossing the mine's waste rock pile. Flow observed from the mine in September 2001 was not crossing the road and reaching Peru Creek, but appeared to evaporate from or infiltrate into the soil of the ditch along the northwest side of the road within approximately 150 feet of the waste rock pile. The mine waste water discharge contained elevated concentrations of metals that did not significantly change as the discharge flowed across the mine waste rock pile. Water quality in Peru Creek was noticeable better below the Shoe Basin Mine and associated wetlands than it was above the mine. Samples collected during the September 2001 event indicate that the low volume of mine water discharge from the Shoe Basin Mine is not significantly affecting water quality in Peru Creek.

Flow of mine waste water from the Silver Spoon Mine in September 2001 was estimated to be two to three gallons per minute and flow from the unnamed adit was estimated to be approximately two gallons per minute. The discharges flow over mine waste rock at both locations. The mine waste water discharges contain elevated concentration of metals. Elevated concentrations of aluminum, copper, iron, and zinc are recorded in all surface water samples collected from Peru Creek downstream of the confluence with Cinnamon Gulch. Other sources of contamination in the immediate area of Cinnamon Gulch that could be contributing to levels of contamination below Cinnamon Gulch are the Pennsylvania Mine and iron bog seeps at the base of Brittle Silver Mountain. These potential sources were not sampled during Phase I. It is possible that the groundwater to surface water pathway plays a significant role in elevating contaminant levels in Peru Creek downstream of the Cinnamon Gulch area.

Elevated concentrations of copper were detected in the Snake River downstream of its confluence with Peru Creek, in aqueous TAL total and dissolved metals analyses. Elevated concentrations of aqueous TAL total and dissolved metals were not detected in the most downstream sample collected on the Snake River prior to Dillon Reservoir.

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Figure 1 15 Miles Downstream from Silver Spoon Mine and Shoe Basin Mine

Figure 2 Sample Location Map

Figure 3 Flow at Stream Gauging Stations

Figure 4 Upper Peru Creek - Water Quality Stations - Field pH Readings

Figure 5 Upper Peru Creek - Water Quality Stations - Field Conductivity Readings

TABLE 1
Sample Locations and Rationale

(continued)

Matrix	Sample ID	Location	Rationale
Source-Waste Rock and Soil	SR-MWR-01	Background from upper Cinnamon Gulch field located on National Forest land.	To establish background conditions.
	SR-MWR-02	Mine waste rock from the south side of the Shoe Basin Mine dump, 0 to 6-inch horizon.	To characterize potential source.
	SR-MWR-03	Mine waste rock from the south side of the Shoe Basin Mine dump, 6- to 12-inch horizon.	To characterize potential source.
	SR--MWR-04	Mine waste rock from the Silver Spoon Mine dump, 6- to 12-inch horizon.	To characterize potential source.
	SR--MWR-05	Mine waste rock from the Silver Spoon Mine dump, 0 to 6-inch horizon.	To characterize potential source.
	SR-MWR-06	Mine waste rock from the east side of the Shoe Basin Mine dump, 0 to 6-inch horizon.	To characterize potential source.
	SR-MWR-07	Mine waste rock from the east side of the Shoe Basin Mine dump, 6- to 12-inch horizon.	To characterize potential source.
Source-Mine Water Discharge	PC-MWD-01	Mine water discharge from the mouth of the Shoe Basin Mine.	To characterize potential source.
	PC-MWD-02	Mine water discharge from the base of the base of the Shoe Basin Mine waste rock dump.	To characterize potential source.
	CG-MWD-01	Mine water discharge from the Silver Spoon Mine in Cinnamon Gulch.	To characterize potential source.
	CG-MWD-02	Mine water discharge from the adit downstream of the Silver Spoon Mine in Cinnamon Gulch.	To characterize potential source.
Surface Water	PC-SW-01	Background, located on Peru Creek upstream of Shoe Basin Mine.	To establish background conditions.
Surface Water (continued)	PC-SW-02	Surface water sample from Peru Creek 0.7 mile downstream of Shoe	To assess impacts to environmental targets on Peru

TABLE 1
Sample Locations and Rationale

Matrix	Sample ID	Location	Rationale
		Basin Mine prior to influence of Pennsylvania Mine.	Creek.
	PC-SW-03	Surface water sample from Peru Creek 0.75 mile downstream of Cinnamon Gulch.	To assess impacts to environmental targets on Peru Creek.
	PC-SW-04	Surface water sample from Peru Creek below confluences with Warden Gulch and Chihuahua Gulch.	To assess impacts to environmental targets on Peru Creek.
	PC-SW-05	Surface water sample from Peru Creek approximately 0.1 mile upstream of the confluence with the Snake River.	To assess impacts to environmental targets on Peru Creek.
	CG-SW-02	Surface water sample from Cinnamon Gulch topographically below the Silver Spoon Mine.	To assess impacts to environmental targets in Cinnamon Gulch.
	CG-SW-03	Surface water sample from Cinnamon Gulch topographically below the flowing adit.	To assess impacts to environmental targets in Cinnamon Gulch.
	CG-SW-04	Surface water sample from Cinnamon Gulch 0.2 mile before confluence with Peru Creek.	To assess impacts to environmental targets in Cinnamon Gulch.
	CH-SW-01	Surface water sample from Chihuahua Gulch. Background in upper wetlands area.	To establish background conditions.
	CH-SW-02	Surface water sample from Chihuahua Gulch before confluence with Peru Creek.	To assess impacts to environmental targets on Chihuahua Gulch and Peru Creek.
	TH-SW-01	Surface water sample from Thurman Gulch near the confluence with the Snake River.	To assess impacts to environmental targets on the Snake River.
Surface Water (continued)	SR-SW-01	Surface water sample from the Snake River approximately 0.1 mile upstream of the confluence of Peru Creek with the Snake River.	To assess impacts to environmental targets on the Snake River.

TABLE 1
Sample Locations and Rationale

(continued)

Matrix	Sample ID	Location	Rationale
	SR-SW-02A	Surface water sample from the Snake River approximately 0.1 mile downstream of the confluence of Peru Creek with the Snake River.	To assess impacts to environmental targets on the Snake River.
	SR-SW-02B	Surface water sample from the Snake River approximately 0.5 mile downstream of the confluence of Thurman Gulch with the Snake River.	To assess impacts to environmental targets on the Snake River.
	SR-SW-03	Surface water sample from the Snake River immediately prior to entering Dillon Reservoir.	To assess impacts to environmental targets on the Snake River.
Sediment	PC-SE-01	Streambed of Peru Creek upstream of Shoe Basin Mine.	To establish background conditions.
	PC-SE-02	Wetlands in Peru Creek at PPE of mine waste water discharge into Peru Creek from Shoe Basin Mine.	To assess impacts to environmental targets, including wetlands on Peru Creek at Shoe Basin Mine PPE.
	PC-SE-03	Wetlands in Peru Creek approximately 0.1 mile downstream of Shoe Basin Mine PPE.	To assess impacts to environmental targets, including wetlands on Peru Creek at 0.1 mile downstream of Shoe Basin Mine PPE.
	CG-SE-02U	Wetlands below the Silver Spoon Mine–upper.	To assess impacts to wetlands and other environmental targets below the Silver Spoon Mine.
	CG-SE-02M	Wetlands below the Silver Spoon Mine–middle.	To assess impacts to wetlands and other environmental targets below the Silver Spoon Mine.
Sediment (continued)	CG-SE-02L	Wetlands below the Silver Spoon Mine–lower.	To assess impacts to wetlands and other environmental targets below the Silver Spoon Mine.
	CG-SE-04	Streambed of Cinnamon Gulch approximately 0.2 mile before confluence with Peru Creek.	To assess impacts to environmental targets in Cinnamon Gulch and Peru Creek.
	CH-SE-01	Streambed of Chihuahua Gulch in a	To establish background

TABLE 1
Sample Locations and Rationale

Matrix	Sample ID	Location	Rationale
		wetlands area.	conditions.
	CH-SE-02	Streambed of Chihuahua Gulch before confluence with Peru Creek.	To assess impacts to environmental targets in Chihuahua Gulch and Peru Creek.
	TH-SE-01	Streambed of Thurman Gulch before confluence with the Snake River.	To assess impacts to environmental targets in Thurman Gulch and the Snake River.
	SR-SE-02B	Streambed of the Snake River downstream of Peru Creek and Thurman Gulch.	To assess impacts to environmental targets on the Snake River.
QA/QC	SR-SW-04	Rinsate Sample.	Document thoroughness of field decontamination procedures.
	PC-SW-06	Duplicate aqueous sample.	Document reproducibility of field sample collection methodology.

TABLE 2
Target Analyte List-Total Metals in Mine Waste Rock Samples, Stream Sediment Samples, and Wetlands Soil Samples (mg/kg)
Phase I - September 2001

Sample Station CLP Sample No. Sample Location and Description Analyte	SR-MWR-02 MHFA55 Shoe Basin Mine-mine waste rock from south side of dump 0-6 inches	SR-MWR-03 MHFA56 Shoe Basin Mine-mine waste rock from south side of dump 6-12 inches	SR-MWR-06 MHFA57 Shoe Basin Mine-mine waste rock from east side of dump 0-6 inches	SR-MWR-07 MHFA59 Shoe Basin Mine-mine waste rock from east side of dump 6-12 inches	PC-SE-02 MHEZ58 Wetland sediment on Peru Creek below Shoe Basin Mine	PC-SE-03 MHEZ59 Wetland sediment on Peru Creek below Shoe Basin Mine	SR-MWR-01 MHFA54 Cinnamon Basin from area above mining activity Background	SR-MWR-05 MHFA60 Silver Spoon Mine-mine waste rock 0-6 inches	SR-MWR-04 MHFA58 Silver Spoon Mine-mine waste rock 6-12 inches	CG-SE-02U MHEN16 Cinnamon Gulch-wetlands below mining activity upper area	CG-SE-02M MHEN15 Cinnamon Gulch-wetlands below mining activity middle area	CG-SE-02L MHEN14 Cinnamon Gulch-wetlands below mining activity lower area	CG-SE-04 MHEN13 Cinnamon Gulch downstream sediment
Aluminum (Al)	651	438	1,690	849	990	4,400	10,600	1,390	945	20,000	11,100	18,400	5,660
Antimony (Sb)	75.1	40.5	25.1	17.5	[9.7]	[29.6]	0.70 U	[1.5]	[3.7]	[2.8]	[2.8]	[1.3]	[1.6]
Arsenic (As)	49.0 J	62.3 J	186 J	111 J	42.7 J	178 J	6.3 J	7.0 J	9.2 J	7.2 J	19.1 J	18.3 J	16.4 J
Barium (Ba)	230	399	271	229	262	300	301	574	126	209	395	268	150
Beryllium (Be)	0.074 U	0.064 U	0.16 U	0.11 U	0.083 U	0.30 U	0.33 U	0.23 U	0.20 U	[1.9]	0.49 U	[1.1]	0.30 U
Cadmium (Cd)	5.9	5.9	4.6	2.0	1.7	0.26 U	0.11 U	[1.1] J	3.5	5.9	0.13 U	0.14 UJ	[0.21]
Calcium (Ca)	62.8 U	49.6 U	[1,000]	1,710	[143]	[430]	[1,330]	[188]	93.2 U	[4,710]	2,010	[891]	[678]
Chromium (Cr)	[1.2]	[0.46]	3.8 J	3.5	2.1	11.7	39.3	3.5 J	[2.0]	25.1	32.0	37.8	16.6
Cobalt (Co)	0.13 U	0.13 U	[0.94] J	0.13 U	[0.24]	0.40 U	[2.4]	0.14 UJ	0.13 U	[3.4]	[3.3]	3.7 J	100
Copper (Cu)	119	85.8	178	182	39.6	147	131	39.6	51.4	960	170	168	169
Iron (Fe)	15,800	23,900	47,900	40,800	15,300	128,000	30,200	53,400	36,500	7,060	33,400	88,400	42,200
Lead (Pb)	37,600	5,740	6,740	8,360	1,050	2,020	272	2,050	2,580	454	541	519	624
Magnesium (Mg)	139 U	66.7 U	[706]	[228]	[319]	[1,170]	4,330	33.4 U	30.8 U	[2,300]	5,280	4,010	2,400
Manganese (Mn)	42.1	43.1	394	331	90.5	214	268	5.8	5.1	344	346	582	9,950
Mercury (Hg)	0.36 J	0.90 J	1.5 J	3.2 J	0.63 J	1.0 J	0.061 UJ	0.33 J	0.60 J	0.22 UJ	0.082 UJ	0.077 J	0.058 J
Nickel (Ni)	[0.74]	0.71 U	[3.9]	[1.4]	[1.4]	[3.9]	19.9	[1.0]	[1.6]	[34.0]	18.5	14.1	[8.8]
Potassium (K)	1,390	1,140	3,610	3,080	1,130	[2,180]	3,080	6,940	1,450	[1,240]	3,760	[1,360]	2,070
Selenium (Se)	[0.86]	[1.1]	1.6	1.6	0.76 U	4.8	[1.1]	2.6	1.9	3.7 U	[1.3]	3.7	5.8
Silver (Ag)	135 J	33.7 J	33.2 J	36.6 J	8.5 J	22.6 J	2.8 J	35.6 J	28.5 J	9.0 J	7.7 J	5.5 J	3.3 J
Sodium (Na)	1,410 J	2,020 J	2,440 J	1,390 J	738 J	544 UJ	166 UJ	[944] J	1,570 J	2,190 J	458 UJ	301 UJ	236 UJ
Thallium (Tl)	0.74 UJ	0.75 UJ	0.75 UJ	0.75 UJ	0.72 UJ	2.32.3	0.98 UJ	0.80 UJ	0.74 UJ	3.5 UJ	1.2 UJ	1.2 UJ	4.2 J
Vanadium (V)	[2.4]	[1.8]	[7.4]	[3.8]	[3.2]	[16.9]	25.0	[6.4]	[1.2]	[26.2]	26.0	30.8	13.2
Zinc (Zn)	1,120	1,680	2,020	1,050	546	351	61.3	557	1,300	1,520	274	175	113

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UJ The reported amount is estimated because quality control criteria were not met. The analyte was not detected.
J The associated numerical value is an estimated quantity because quality control criteria were not met. Presence of the analyte is reliable.

[ ] The associated numerical value was detected below the CRDL, but was detected at a level greater than the method detection limit and is therefore an estimate qualified by the laboratory.

TABLE 3
Target Analyte List-Total Metals in Surface Water Samples (µg/L)
Phase I - September 2001

Sample Station CLP Sample No. Sample Location Analyte (Abbrev.)	PC-SW-01 MHFA62 Peru Creek above Shoe Basin Mine Background [1]	PC-SW-06 MHFA63 Peru Creek duplicate of PC-SW-01	PC-MWD-01 MHEC74 Shoe Basin Mine discharge at mine entrance	PC-MWD-02 MHEC75 Shoe Basin Mine discharge at toe of waste rock pile	PC-SW-02 MHEC83 Peru Creek prior to influence of the Pennsylvania Mine	CG-MWD-01 MHEC76 Silver Spoon Mine discharge at mine entrance	CG-SW-02 MHEZ63 Cinnamon Gulch at toe of waste rock pile	CG-MWD-02 MHEC77 Adit discharge from below Silver Spoon Mine	CG-SW-03 MHEZ64 Cinnamon Gulch below mines and before wetlands	CG-SW-04 MHEZ65 Cinnamon Gulch before confluence with Peru Creek	PC-SW-03 MHEC84 Peru Creek at gravesite below the confluence with Cinnamon Gulch
Aluminum (Al)	460	444	1,880	1,900	141 U	7,550	7,660	4,380	9,180	5,130	★ **3440** (200.0)
Antimony (Sb)	2.5 U	2.5 U	1.7 U	1.7 U	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U
Arsenic (As)	2.8 UJ	2.8 UJ	4.2 U	2.5 U	2.8 UJ	[3.4]	2.8 UJ	2.8 U	2.8 UJ	2.8 UJ	2.8 UJ
Barium (Ba)	[62.4]	[60.9]	[9.7]	[12.4]	[46.6]	[14.3]	[14.5]	[16.3]	[31.0]	[32.5]	[36.2]
Beryllium (Be)	0.23 U	0.20 U	[2.2]	[2.2]	0.24 U	0.94 U	0.92 U	1.8 U	1.1 U	0.86 U	0.48 U
Cadmium (Cd)	[1.3]	[1.1]	75.4	74.6	0.40 U	19.8	20.5	24.7	11.4	8.2	★ **6.2** (5.0)
Calcium (Ca)	23,900	23,200	118,000	118,000	16,900	6,690	6,810	19,500	9,270	18,900	18,700
Chromium (Cr)	0.50 U	0.50 U	1.0 UJ	1.0 UJ	0.50 U	[3.3]	[3.3]	[1.1]	[0.94]	[0.50]	0.50 U
Cobalt (Co)	0.60 U	0.60 U	[31.2]	[31.3]	0.60 U	[24.3]	[25.2]	[31.1]	[20.0]	[9.9]	[5.6]
Copper (Cu)	3.8 U	5.7 U	785	776	0.80 U	499	507	[15.1]	470	233	★ **154** (25.0)
Iron (Fe)	12.4 U	12.4 U	28,400	23,400	[36.3]	22,000	18,600	18,800	481	249	★ **1050** (100.0)
Lead (Pb)	3.8	4.1	167	191	[2.1]	316	326	542	21.4	14.3	9.2
Magnesium (Mg)	5,240	5,070	16,300	16,300	[4,060]	[4,590]	[4,700]	8,950	5,300	5,780	5,130
Manganese (Mn)	199	193	84,600	84,400	96.8	6910	7,080	8,230	4,260	3,040	1,530
Mercury (Hg)	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U
Nickel (Ni)	[7.3]	[8.6]	77.7	77.7	3.3 U	42.4	43.1	55.7	[34.2]	[24.1]	[11.4]
Potassium (K)	[817]	[800]	[932]	[974]	[813]	[1,330]	[1,360]	[1,590]	[1,190]	[1,170]	[957]
Selenium (Se)	3.7 U	3.7 U	17.7	16.8	3.7 U	3.7 U	3.7 U	3.7 U	3.7 U	3.7 U	3.7 U
Silver (Ag)	0.70 U	0.70 U	[2.8]	[3.3]	0.70 U	0.70 U	0.70 U	[1.2]	0.70 U	0.70 U	0.70 U
Sodium (Na)	[1,130]	[1,180]	[4,940]	[4,680]	[1,170]	6,670	6,920	9,000	[4,740]	[3,930]	[3,300]
Thallium (Tl)	3.5 U	3.5 U	77.6	76.8	3.5 U	3.5 U	3.5 U	[3.6]	3.5 U	3.5 U	3.5 U
Vanadium (V)	0.50 U	0.50 U	0.60 U	0.60 U	0.50 U	[0.78]	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U
Zinc (Zn)	158	156	27,400	27,300	106	4,430	4,570	5,560	2,510	1,670	★ **1,530** (20)

1. Sample PC-SW-01 is used as a background only for Peru Creek Samples PC-SW-02, PC-SW-03, PC-SW-04, and PC-SW-05. A background sample could not be collected in Cinnamon Gulch and background conditions are different between Horseshoe Basin and Cinnamon Gulch i.e., levels of background mineralization

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★ Significance above background established according to HRS guidelines
( ) Calculated Sample Quantitation Limit (SQL)

TABLE 3
Target Analyte List-Total Metals in from Surface Water Sample (µg/L)
Phase I - September 2001
(continued)

Sample Station CLP Sample No. Sample Location Analyte µg/L	CH-SW-01 MHEC82 Chihuahua Gulch upstream in wetlands	CH-SW-02 MHEC86 Chihuahua Gulch downstream before Peru Creek	PC-SW-04 MHEC88 Peru Creek downstream of Chihuahua Gulch at bridge	PC-SW-05 MHFA64 Peru Creek just above confluence with Snake River	SR-SW-01 MHEC78 Snake River just before confluence with Peru Creek Background	SR-SW-02A MHEC80 Snake River just below confluence with Peru Creek	TH-SW-01 MHEC87 Thurman Gulch just before confluence with Snake River	SR-SW-02B MHEZ60 Snake River just below confluence with Thurman Gulch	SR-SW-03 MHEZ62 Snake River downstream sample-just before Dillon Reservoir	SR-SW-04 MHEZ68 Rinsate 09/26/01
Aluminum (Al)	71.3 U	49.2 U	★ **1,890** (200.0)	★ **1,790** (200.0)	1,320	2,210	24.6 U	1540	441	31.2 U
Antimony (Sb)	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U
Arsenic (As)	2.8 UJ	2.8 UJ	2.8 UJ	2.8 U	2.8 U	2.8 UJ	2.8 UJ	2.8 UJ	2.8 U	2.8 UJ
Barium (Ba)	[28.8]	[26.9]	[32.8]	[33.5]	[27.8]	[32.2]	[11.5]	[31.2]	[34.9]	0.90 U
Beryllium (Be)	0.28 U	0.18 U	[0.35]	0.32 U	0.30 U	0.85 U	0.13 U	[0.34]	0.33 U	0.12 U
Cadmium (Cd)	0.40 U	0.40 U	[4.2]	[4.3]	1.8 U	[3.7]	0.40 U	[3.2]	[1.4]	0.40 U
Calcium (Ca)	17,700	15,700	17,600	18,000	19,500	18,800	14,200	18,700	17,200	42.1 U
Chromium (Cr)	0.50 U	[0.63]	[0.56]	0.50 UJ	[0.63]	[0.77]	0.50 U	0.50 U	[5.1]	[0.51]
Cobalt (Co)	0.60 U	0.60 U	[2.7]	2.8 U	[4.0]	[3.4]	0.60 U	[3.0]	[2.2]	0.60 U
Copper (Cu)	0.80 U	0.80 U	★ **80.0** (25.0)	★ **79.7** (25.0)	5.8 U	★ **57.2** (25.0)	0.80 U	★ **47.1** (25.0)	[12.6]	0.80 U
Iron (Fe)	86.8 U	338	★ **202** (100.0)	★ **227** (100.0)	291	438	12.4 U	251	117	12.4 U
Lead (Pb)	1.6 U	1.6 U	6.6	7.2	6.5	8.0	1.6 U	4.1	[2.6]	1.6 U
Magnesium (Mg)	[3,210]	[2,590]	[4,080]	[4,160]	[4,610]	[4,460]	[2,560]	[4,340]	[3,560]	70.7 U
Manganese (Mn)	[10.7]	18.3	934	892	631	814	0.68 U	783	343	[0.73]
Mercury (Hg)	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	[0.11]	0.10 U	0.10 U
Nickel (Ni)	3.3 U	3.3 U	[7.2]	[7.4]	[9.1]	[8.4]	3.3 U	[8.0]	[6.7]	3.3 U
Potassium (K)	[670]	[806]	[924]	968 U	[1,110]	[971]	[992]	[1,010]	[1,170]	78.2 U
Selenium (Se)	3.7 U	3.7 U	3.7 U	3.7 U	3.7 U	3.7 U	3.7 U	3.7 U	3.7 U	3.7 U
Silver (Ag)	0.70 U	0.70 U	0.70 U	0.70 U	0.70 U	0.70 U	0.70 U	0.70 U	0.70 U	0.70 U
Sodium (Na)	[1,130]	[1,260]	[2,680]	[2,970]	[2,510]	[2,750]	[1,330]	[2,730]	[2,820]	138 U
Thallium (Tl)	3.5 U	3.5 U	3.5 U	3.5 U	3.5 U	3.5 U	3.5 U	3.5 U	3.5 U	3.5 U
Vanadium (V)	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	[1.4]	0.50 U
Zinc (Zn)	5.8 U	5.8 U	★ **1040** (20)	★ **1,060** (20)	545	868	5.8 U	842	337	[14.9]

1. Sample PC-SW-01 is used as a background only for Peru Creek Samples PC-SW-02, PC-SW-03, PC-SW-04, and PC-SW-05. A background sample could not be collected in Cinnamon Gulch and background conditions are different between Horseshoe Basin and Cinnamon Gulch i.e., levels of background mineralization

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★ Significance above background established according to HRS guidelines
( ) Calculated Sample Quantitation Limit (SQL)

TABLE 4
Target Analyte List-Dissolved Metals in Surface Water Samples (µg/L)
Phase I - September 2001

Sample Station CLP Sample No. Sample Location Analyte µg/L		MCLs[1]	SCDMs[2] Freshwater/ Environmental	PC-SW-05 MHEC85 Peru Creek just above confluence with Snake River	SR-SW-01 MHEC79 Snake River just before confluence with Peru Creek Background	SR-SW-02A MHEC81 Snake River just after confluence with Peru Creek	SR-SW-02B MHEZ61 Snake River just after confluence with Thurman Gulch	SR-SW-03 MHEZ67 Snake River downstream sample-just before Dillon Reservoir	SR-SW-04 MHEZ66 Rinsate 09/26/01
Aluminum	(Al)	-	-	596	24.6 U	144 U	116 U	56.7 U	24.6 U
Antimony	(Sb)	0.6	-	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U
Arsenic	(As)	5.0	190	2.8 U	2.8 U	2.8 U	2.8 U	2.8 U	2.8 U
Barium	(Ba)	200	-	[30.2]	[28.3]	[30.2]	[29.4]	[29.4]	0.5 U
Beryllium	(Be)	0.4	-	0.23 U	0.10 U	0.19 U	0.24 U	0.10 U	0.1 U
Cadmium	(Cd)	0.5	1.1	[3.9]	[1.8]	[3.3]	[3.1]	[1.3]	0.4 U
Calcium	(Ca)	-	-	16,600	20,000	18,300	17,400	17,600	42.1 U
Chromium	(Cr)	100.	11	0.50 UJ	0.50 UJ	[0.70] J	0.50 U	0.50 UJ	0.5 U
Cobalt	(Co)	-	-	2.7 U	[4.0]	[3.4]	[3.9]	1.6 U	0.6 U
Copper	(Cu)	130.0	12	70.0	[0.90]	★ **43.9** (25.0)	★ **32.4** (25.0)	[5.4]	0.8 U
Iron	(Fe)	-	1,000	112	12.4 U	[87.1]	[98.1]	12.4 U	[12.5]
Lead	(Pb)	1.5	320	5.9	1.6 U	[2.8]	1.9 U	1.6 U	1.6 U
Magnesium	(Mg)	-	-	[3,850]	[4,730]	[4,260]	[4,060]	[3,650]	80.0 U
Manganese	(Mn)	-	-	820	619	781	716	345	0.35 U
Mercury	(Hg)	2.0	0.012	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U
Nickel	(Ni)	10.0	160	[6.9]	[9.2]	[7.9]	[7.7]	[3.4]	3.3 U
Potassium	(K)	-	-	948 U	[1,210]	[1,070]	[970]	[1,240]	124 U
Selenium	(Se)	5.0	5	3.7 U	3.7 U	3.7 U	3.7 U	3.7 U	3.7 U
Silver	(Ag)	-	4.1	0.70 U	0.70 U	0.70 U	0.70 U	0.70 U	0.70 U
Sodium	(Na)	-	-	[2,810]	[2,630]	[2,790]	[2,640]	[3,000]	161 U
Thallium	(Tl)	0.2	-	3.5 U	3.5 U	3.5 U	3.5 U	3.5 U	3.5 U
Vanadium	(V)	-	-	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U
Zinc	(Zn)	-	110	983	525	861	790	305	5.8 U

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★ Significance above background established according to HRS guidelines
( ) Calculated Sample Quantitation Limit (SQL)
1 Maximum Contaminant Levels (MCLs), Colorado State Drinking Water Standards. Colorado Department of Public Health and the Environment (CDPHE) 1995

2 Superfund Chemical Data Matrix, EPA 1996

TABLE 5
Target Analyte List-Total Metals in Stream and Wetlands Sediment Samples (mg/kg)
Phase I - September 2001

Sample Station CLP Sample No. Sample Location and Description Analyte mg/kg	PC-SE-01 MHEZ57 Peru Creek-sediment before Shoe Basin Mine Background	PC-SE-02 MHEN58 Peru Creek-wetland sediment below Shoe Basin Mine	PC-SE-03 MHEZ59 Peru Creek-wetland sediment below Shoe Basin Mine	SR-MWR-01 MHFA54 Cinnamon Gulch-soil above mining activity Background	CG-SE-02U MHEN16 Cinnamon Gulch-wetland sediment below mining activity-upper area	CG-SE-02M MHEN15 Cinnamon Gulch-wetland sediment below mining activity-middle area	CG-SE-02L MHEN14 Cinnamon Gulch-wetland sediment below mining activity-lower area	CG-SE-04 MHEN13 Cinnamon Gulch-sediment before Peru Creek	CH-SE-01 MHEN11 Chihuahua Gulch-sediment Background	CH-SE-02 MHEN12 Chihuahua Gulch-sediment before Peru Creek	TH-SE-01 MHEN18 Thurman Gulch-sediment before Snake River	SR-SE-01 MHEN19 Snake River-sediment from sandbar at background location	SR-SE-02B MHEZ55 Snake River-sediment from downstream of Peru Creek and Thurman Gulch confluences
Aluminum (Al)	6,740	990	4440	10,600	20,000	11,100	18,400	5,660	2,890	3,970	2,520	3,410	3,450
Antimony (Sb)	0.67 U	[9.7]	[29.6]	0.70 U	[2.8]	[2.8]	[1.3]	[1.6]	0.51 U	0.65 U	0.58 U	38.2	17.5
Arsenic (As)	1.9 J	42.7 J	178 J	6.3 J	7.2 J	19.1 J	18.3 J	16.4 J	[0.90] J	[1.8] J	[1.4] J	45.7 J	21.8 J
Barium (Ba)	109	262	300	301	209	395	268	150	[35.5]	56.2	48.8	658	81.2
Beryllium (Be)	[0.79]	0.083 U	0.30 U	0.33 U	[1.9]	0.49 U	[1.1]	0.30 U	0.26 U	[0.40]	0.15 U	[0.79]	[0.53]
Cadmium (Cd)	5.6	1.7	0.26 U	0.11 U	5.9	0.13 U	0.14 UJ	[0.21]	[0.22]	[0.26]	0.093 U	27.1	28.0
Calcium (Ca)	1,940	[143]	430 U	[1,330]	[4,710]	2,010	[891]	[678]	[977]	2050	1570	[1,020]	[466]
Chromium (Cr)	8.2	2.1	11.7	39.3	25.1	32.0	37.8	16.6	3.7	4.4	[0.82]	5.4	6.2
Cobalt (Co)	13.9	[0.24]	0.40 U	[2.4]	[3.4]	[3.3]	3.7 J	100	[3.9]	[4.8]	[2.7]	[6.8]	[9.9]
Copper (Cu)	55.1	39.6	147	131	960	170	168	169	7.5	9.7	8.2	1470	1180
Iron (Fe)	13,000	15,300	128,000	30,200	7,060	33,400	88,400	42,200	8,600	10,700	6,880	26,700	20,200
Lead (Pb)	312	1,050	2,020	272	454	541	519	624	10.5	24.1	37.2	5,800	596
Magnesium (Mg)	2,980	[319]	[1,170]	5,330	[2,300]	5,280	4,010	2,400	1,660	2440	1760	[838]	[937]
Manganese (Mn)	3,540	90.5	214	268	344	346	582	9,950	447	598	415	31,000	4,580
Mercury (Hg)	0.046 UJ	0.63 J	1.0 J	[0.061]	0.22 UJ	0.082 UJ	[0.077] J	0.058 J	0.053 UJ	.064 UJ	0.059 UJ	0.14 J	0.054 J
Nickel (Ni)	29.0	[1.4]	[3.9]	19.9	[34.0]	18.5	14.1	[8.8]	[4.1]	[4.8]	[0.91]	[5.0]	[8.2]
Potassium (K)	1,510	1,130	[2,180]	3,080	[1,240]	3,760	[1,360]	2,070	[644]	[980]	[883]	1300	[839]
Selenium (Se)	2.0	0.76 U	4.8	[1.1]	3.7 U	[1.3]	3.7	5.8	0.75 U	0.96 U	0.86 U	13.4	2.6
Silver (Ag)	3.5 J	8.5 J	22.6 J	[2.8] J	9.0 J	7.7 J	5.5 J	3.3 J	0.14 UJ	0.18 UJ	0.16 UJ	80.8 J	17.9 J
Sodium (Na)	776 J	738 J	544 UJ	166 UJ	2,190 J	458 UJ	301 UJ	236 UJ	125 UJ	175 UJ	99.3 UJ	6,230 J	8,400 J
Thallium (Tl)	1.6 J	0.72 UJ	2.3 UJ	0.98 UJ	3.5 UJ	1.2 UJ	1.2 UJ	4.2 J	0.71 UJ	0.91 UJ	0.82 UJ	14.5	0.83 UJ
Vanadium (V)	13.7	[3.2]	[16.9]	25.0	[26.2]	26.0	30.8	13.2	[8.9]	[10.9]	[10.5]	[5.8]	[6.7]
Zinc (Zn)	624	546	351	61.3	1520	274	175	113	52.2	96.4	64.9	6,190	8240

U The analyte was not detected at or above the Contract Required Detection Limit (CRDL)
J The associated numerical value is an estimated quantity because quality control criteria were not met. Presence of the analyte is reliable.
UJ The reported amount is estimated because quality control criteria were not met. The analyte was not detected.
[ ] The associated numerical value was detected below the CRDL, but was detected at a level greater than the method detection limit and is therefore an estimate qualified by the laboratory

TABLE 6
Wet Chemistry for Surface Water Samples (mg/L)
Phase I - September 2001

Sample Station. Sample Location / Analyte	PC-SW-01 Peru Creek above Shoe Basin Mine Background	PC-SW-06 Peru Creek duplicate of PC-SW-01	PC-MWD-01 Shoe Basin Mine discharge at mine entrance	PC-MWD-02 Shoe Basin Mine discharge at toe of waste rock pile	PC-SW-02 Peru Creek downstream of the Pennsylvania Mine	CG-MWD-01 Silver Spoon Mine discharge at mine entrance	CG-SW-02 Cinnamon Gulch at toe of waste rock pile	CG-MWD-02 Adit discharge from below Silver Spoon Mine	CG-SW-03 Cinnamon Gulch below mines and before wetlands	CG-SW-04 Cinnamon Gulch before confluence with Peru Creek	PC-SW-03 Peru Creek at grave site below the confluence with Cinnamon Gulch
Chloride	[0.98]	[0.98]	[1.3]	[1.2]	[0.97]	[1.0]	[1.1]	[1.0]	[0.98]	[0.99]	[0.99]
Sulfate dilution factor	64.7 X2	65.7 X2	631 X20	626 X20	46.9 X2	147 X5	150 X5	181 X5	111 X5	108 X5	90.8 X2
Bicarbonate Alkalinity	10.4	10.1	5.0 U	5.0 U	6.9	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U
Total Alkalinity	10.4	10.1	5.0 U	5.0 U	6.9	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U
Flow-gallons per minute	808	NA	2.5 (est)	1.1 (est)	2020	2.5 (est)	3.5 (est)	2 (est)	90 (est)	1000 (est)	3635

Sample Station Sample Location / Analyte	CH-SW-01 Chihuahua Gulch upstream in wetlands	CH-SW-02 Chihuahua Gulch downstream before Peru Creek	PC-SW-04 Peru Creek downstream of Chihuahua Gulch at bridge	PC-SW-05 Peru Creek just above confluence with Snake River	SR-SW-01 Snake River just before confluence with Peru Creek Background	SR-SW-02A Snake River just below confluence with Peru Creek	TH-SW-01 Thurman Gulch just before confluence with Snake River	SR-SW-02B Snake River just below confluence with Thurman Gulch	SR-SW-03 Snake River downstream sample-just before Dillon Reservoir	SR-SW-04 Rinsate 09/26/01
Chloride	[1.0]	[1.0]	[0.99]	[1.0]	[1.2]	[1.1]	[0.97]	[1.1]	[2.7]	[0.89]
Sulfate dilution factor	43.3 X1	34.6 X1	67.4 X2	66.5 X2	60.5 X2	64.8 X2	11.9 X1	62.6 X2	41.7 X1	5.0 U X1
Bicarbonate Alkalinity	13.0	13.6	5.0 U	5.0 U	7.0	[2.8]	35.2	[4.4]	20.7	[3.2]
Total Alkalinity	13.0	13.6	5.0 U	5.0 U	7.0	[2.8]	35.2	[4.4]	20.7	[3.2]
Flow-gallons per minute	not estimated	50 (est)	5116	5547	3590	9326	55 (est)	not estimated	> 12,000 (est.)	NA

U The analyte was not detected at or above the reporting limit
[ ] The reported amount was detected below the reporting limit and is therefore an estimate qualified by the laboratory
(est) Estimated using a bucket and stopwatch
NA Not applicable

TABLE 7
Water Quality Parameters from Surface Water Locations in Upper Peru Creek Drainage
Phase I - September 2001

Location	PC-A Main Peru Creek, most downstream, upstream of PC-SW/SE-01	PC-B Main Peru Creek immediately after confluence with east and west branches	PC-C East Branch of Peru Creek upstream of confluence with West Branch of Peru Creek	PC-D East Branch of Peru Creek after confluence with tributary from east	PC-E East Branch of Peru Creek before confluence with tributary from east	PC-F East Branch of Peru Creek at source in upper Horseshoe Basin	PC-G Tributary from east before confluence with the East Branch of Peru Creek	PC-H West Branch of Peru Creek before confluence with East Branch of Peru Creek
Time	1,020	1,035	1,040	1,052	1,101	1,435	1,058	1,132
Sun exposure	full	full	full	full	full	full	full	full
Temperature °C	5.1	6.4	5.8	5.7	5.7	4.7	6.5	8.9
pH	6.5	6.42	6.40	6.60	6.75	6.45	6.72	6.10
Conductivity µS/cm	181	180	260	264	261	96	274	141
Oxidation/reduction potential mV	215	208	188	190	170	236	198	198
Flow	not estimated	not estimated	not estimated	5-7 gal/min (est)	3-4 gal/min (est)	1-2 gal/min (est)	1-2 gal/min (est)	4-5 gal/min (est)
Observations	Aluminum oxide coating rocks	Aluminum oxide coating rocks	Stream flowing through wetland area with abundant moss and bugs Iron oxides coating rocks	Iron oxides on rocks, moss and bugs Steep gradient	No moss on rocks or water Bugs observed	Spring at man-made structure is source of Peru Creek. No bugs observed	Black moss covered rocks Some bugs present	Below National Treasure Mine Aluminum oxides on rocks no bugs observed

Location	PC-I West Branch of Peru Creek below confluence with Falls Gulch Creek	PC-N Falls Gulch Creek before confluence with West Branch of Peru Creek	PC-J West Branch of Peru Creek before confluence with Falls Gulch Creek	PC-K West Branch of Peru Creek above the Paymaster Mine	PC-L West Branch of Peru Creek, most upstream	PC-M Tributary from Ruby Mountain from the east to Falls Gulch Creek	PC-CLIFF At the waterfalls of Falls Gulch Creek	PC-LAKE Lake that is origin of Falls Gulch Creek, no streams identified entering lake
Time	1,145	1,203	1,156	1,245	1,310	1,140	1,331	1,355
Sun exposure	full	full	full	full	full	full	full	full
Temperature °C	9.4	10.4	10.2	12.1	11.4	8.0	11.4	11.4
pH	6.38	5.78	6.52	6.84	6.14	5.88	4.66	5.99
Conductivity µS/cm	143	153	93	95	81	147	270	155
Oxidation/reduction potential mV	208	256	188	230	162	218	330	268
Flow	3-5 gal/min (est)	1 gal/min (est)	3 gal/min (est)	1-2 gal/min (est)	1.5 gal/min (est)	0.5 gal/min (est)	1 gal/min (est)	no flow observed
Observations	Aluminum oxides on rocks	Various staining colors; red, white, orange, and yellow on rocks	Water bugs observed	No staining observed	No staining observed	Moss on rocks and water bugs observed	Waterfalls Aluminum oxide coating rocks at falls	4-5 acre lake Rocks in lake have a light rusty colored stain

(est) estimated in gallons per minute (gal/min) using either a calibrated 5-gallon bucket or a visual estimate
µS/cm micro Siemens per centimeter
mV millivolts