

**Site Inspection
Granite Creek Mines
Wallowa-Whitman National Forest, Oregon**

Prepared for

U.S. Department of Agriculture–Forest Service
Wallowa-Whitman National Forest
Baker City, Oregon 97814

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LIST OF ACRONYMS

ABA	Acid Base Accounting
AMD	Acid mine drainage
APA	Abbreviated Preliminary Assessment
bgs	Below ground surface
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
EA	EA Engineering, Science, and Technology, Inc.
EE/CA	Engineering Evaluation/Cost Analysis
EIS	Environmental Impact Statement
ER-L	Effects Range-Low
ER-M	Effects Range-Medium
ft/s	Feet per second
NF	National Forest
NOAA	National Oceanic and Atmospheric Administration
NVCS	National Vegetation Classification Standards
NWI	National Wetlands Inventory
OAR	Oregon Administrative Rules
ODEQ	Oregon Department of Environmental Quality
ODFW	Oregon Department of Fish and Wildlife
ONHIC	Oregon Natural Heritage Information Center
OSC	On-Scene Coordinator
OWRD	Oregon Water Resources Department database
PEL	Probable Effects Level
PRG	Preliminary Remediation Goal
SARA	Superfund Amendments and Reauthorization Act
SI	Site Inspection
SOC	Species of Concern
SPLP	Synthetic Precipitation Leaching Procedure
T&E	Threatened and Endangered
TAL	Target Analyte List
TDL	Target distance limit
TDS	Total dissolved solids
TEL	Threshold Effects Level
TMS	Timed Meander Search
TOC	Total Organic Carbon
TSS	Total suspended solids

USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
XRF	X-Ray Fluorescence
Yds ³	cubic yards

EXECUTIVE SUMMARY

A Site Inspection (SI) was performed at 5 mine sites located in the Wallowa-Whitman National Forest (NF), near Granite, Oregon. The mine sites are Monumental, Cap Martin, Sheridan, Tillicum, and Central. The SI was performed to determine if wastes at the sites pose an immediate or potential threat to human health and the environment, and to collect information to support a decision regarding the need for further action.

The abandoned mine sites are located within 2 mi of each other in the upper portion of the Granite Creek watershed in Grant County. Four of the mine sites are located adjacent to the creek and one, Monumental Mine, is located near a tributary that forms part of the headwaters of Granite Creek. Monumental Mine is the largest of the 5 mines sites and contains the remnants of a former mill.

Tasks performed during the SI included background research and file review, onsite and offsite reconnaissance, and collection and analysis of soil, waste rock material, surface water, pore water, sediment, plant tissue, and benthic macroinvertebrate samples. Field activities were performed during July 2003. Results of the SI indicated the following:

- The analytical results indicate that metals from the sites are not notably impacting surface water, pore water, or sediments in Granite Creek in the area of the sites. Although there were a number of metals that were detected above the screening criteria, none were notably above upstream reference sample concentrations.
- A number of metals were detected at levels above the comparison criteria in surface water samples collected from the seeps and upper settling pond at the Monumental Mine. According to the analytical results, these metals are not impacting surface water in Granite Creek.
- There does not appear to be significant benthic habitat impairment or decreased benthic macroinvertebrate diversity and abundance along Granite Creek within the project area.
- Numerous metals were detected at levels above applicable screening criteria in surface and subsurface soil and waste material at the sites; many of these metals also exceeded the concentrations detected in background soil samples.
- Bull trout (*Salvelinus confluentus*) were observed in small numbers throughout the study area. Bull trout are listed as threatened under the Endangered Species Act (ESA) and are listed as critical by the state of Oregon. Two small *Oncorhynchus* spp., either west slope cutthroat trout (*Oncorhynchus clarki lewisi*) or redband trout (*O. mykiss gardneri*), were also observed at locations along Granite Creek. Both species are federally listed as Species of Concern (SOC) and identified as vulnerable by the Oregon Fish and Wildlife Commission.

Based on the elevated concentrations of metals detected in onsite soil and waste rock samples at all 5 mine sites, as well as onsite surface water samples collected at the Monumental Mine, EA recommends performance of an Engineering Evaluation/Cost Analysis (EE/CA) at the Granite Creek sites. As part of the EE/CA, a risk assessment should be performed to assess the human and ecological impacts, establish site removal cleanup standards, and evaluate remediation technologies.

1. INTRODUCTION

EA Engineering, Science, and Technology, Inc. (EA) performed a site inspection (SI) for the U.S. Department of Agriculture, Forest Service (Forest Service) at the Granite Creek Mine sites, located in the Wallowa-Whitman NF near Granite, Oregon. The work was performed under Contract Number 10181-1-D010, Delivery Order R6-14-03-16. The SI was performed in general accordance with U.S. Environmental Protection Agency (USEPA) guidance for performing Site Inspections under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA).

The objectives of the SI were to (1) assess the immediate or potential threat that wastes at the site pose to human health and the environment, and (2) to collect information to support a decision regarding the need for further action under CERCLA and the Superfund Amendments and Reauthorization Act (SARA). Potential contaminant sources identified at the abandoned Granite Creek Mine sites included waste rock and discharges from mine adits.

Tasks performed during the SI included background research and file review, onsite and offsite reconnaissance, and collection and analysis of soil, waste, surface water, pore water, sediment, plant tissue, and benthic macroinvertebrate samples. Fieldwork for the SI was performed from 8 to 16 July 2003. The SI was performed in accordance with the project plans including the Work Plan (EA 2003a) and Sampling and Analysis Plan (EA 2003b), Health and Safety Plan (EA 2003c), and Standard Operating Procedures (EA 2003d). A number of modifications to the sampling locations and techniques were made in the field, based on site observations and field conditions, and with concurrence of the Forest Service On-Scene Coordinator (OSC). These modifications are documented in Appendix A. This report is organized into the following sections:

- Descriptions of the sites, their operational history, wastes generated and previous investigations are provided in Section 2.
 - The results of the SI, along with discussions of the groundwater, surface water, soil, and air exposure pathways, are provided in Section 3.
 - A summary and conclusions are provided in Section 4.
 - References are provided in Section 5.
 - The appendixes include the following: a list of deviations from the project plans (Appendix A), site photographs (Appendix B), a General Information Form (Appendix C), copies of supporting information (Appendix D), aquatic and terrestrial species tables (Appendix E), a detailed wetlands description (Appendix F), aquatic survey results summary tables (Appendix G), waste pile calculations (Appendix H), soil sample descriptions (Appendix I), and laboratory analytical reports (Appendix J).
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2. SITE DESCRIPTION, OPERATIONAL HISTORY, AND WASTE CHARACTERISTICS

2.1 DESCRIPTION AND LOCATION

The locations of the 5 Granite Creek Mines are shown on Plate 1. All of the sites are within 5-8 mi (areal distance) from the town of Granite, in Grant County, Oregon. The sites, which are within the Granite Mining District, are accessed using Forest Service (FS) Road 7345. Waste pile volumes were calculated by Anderson Perry and Associates, Inc., La Grande, Oregon. Refer to Appendix H for details.

Monumental Mine

Monumental Mine is situated on moderate to steep hillsides at the headwaters of Granite Creek. The site location is included on the Mt. Ireland Quadrangle U.S. Geological Survey (USGS) 7.5-minute topographic map. The location description for the site is:

- Latitude 44° 51' 37"N
- Longitude 118° 21' 04"W
- Sections 18 and 19, Township 8 South, Range 36 East.

The site is currently inactive and covers approximately 10 acres. Maps showing existing site features are presented as Figures 1a and 1b. The site generally consists of the following:

- An upper adit with a collapsed portal and no water drainage (Figure 1a).
 - A second, lower adit that is partially stabilized and does have water drainage. The water drains through a constructed ditch to the lower settling pond (Figure 1b).
 - A shaft located approximately 200 ft uphill of the upper adit.
 - Three settling ponds in series. All 3 ponds contained water during the SI field investigation. The upper and middle ponds have largely been filled with depositional sediment and have become more marsh-like rather than ponded. The upper pond is the largest (approximately 100 by 60 ft) and at the time of the field investigation was dry at the upper end and wet at the lower. The middle pond is approximately 30 by 15 ft and had both an inlet from the upper pond and an outlet. Water from this outlet flowed to the most downgradient settling pond located near the lower adit. The most downgradient pond is approximately 50 by 25 ft and the water in the pond was approximately 6 in. deep at the time of the field investigation. This pond contained flow from both the upper settling ponds and the lower adit. No outlet from this pond was observed during the SI field investigation.
 - One relatively small and 2 large waste rock piles. The upper pile is located below the upper adit and is approximately 5,200 yds³ in size. The lower pile is located below the lower adit and is approximately 7,000 yds³ in size. The small pile (approximately 40 yds³) is located near the shaft in the upper portion of the site.
 - An old mill site containing wood debris on moderate to steep slopes in the vicinity of the upper adit. The mill site consists of the remains of a 20-stamp mill and a floater. The remains of a crusher were also identified near the lower adit.
-

A small stream, referred to in this report as an unnamed tributary, forms in a marshy area below the lower waste pile. The unnamed tributary flows into Granite Creek as part of the headwaters; its confluence is located between the Sheridan and Cap Martin mines (Figure 3).

Cap Martin Mine

Cap Martin Mine is located on both sides of Granite Creek near the creek's headwaters. The site is included on the Mt. Ireland Quadrangle USGS 7.5-minute topographic map. The location description for the site is:

- Latitude 44° 51' 24"N
- Longitude 118° 22' 11"W
- Section 24, Township 8 South, Range 35.5 East.

The site is currently inactive and covers an area of approximately 8 acres on moderately steep hillsides. A map showing existing site features is presented as Figure 2. The site generally consists of the following:

- Two adits, both collapsed at the portal. One adit is located on the south side of Granite Creek and the other is located on the north side of the creek. Water was not draining from either adit during the field investigation. A third adit reportedly exists; however, it could not be located during the field investigation.
- Three waste rock piles. The largest waste pile (approximately 200 yds³) is located in the southern area of the site near the foot path. The third adit (unidentified) is expected to be located in this general area. An outwash fan from the waste rock pile emanates onto the flat area south of the creek. The second waste pile (approximately 130 yds³) is situated below the northern collapsed adit and the third waste pile (approximately 10 yds³) is situated near the collapsed adit located in the southwest area of the site.

Sheridan Mine

Sheridan Mine is located on the south side of Granite Creek and the east bank of an unnamed tributary of Granite Creek. The mine is located approximately 0.25 mi downstream of the Cap Martin Mine. The site is included on the Mt. Ireland Quadrangle USGS 7.5-minute topographic map. The location description for the site is:

- Latitude 44° 51' 25"N
- Longitude 118° 22' 30"W
- Section 24, Township 8 South, Range 35.5 East.

The site is currently inactive and covers approximately 3 acres on moderately steep hillsides. A map showing existing site features is presented as Figure 3. The site generally consists of the following:

- One adit collapsed at the portal, with a seep emanating from it, and a second possible adit. No staining from acid mine drainage (AMD) was observed at either location. Discharge from the seep forms a marshy area uphill from the creek in a flat area.
-

- One waste rock pile located downgradient of the identified collapsed adit. The dimensions of this pile has been calculated to contain approximately 125 yds³ of material.

Tillicum Mine

Tillicum Mine is located on the north bank of Granite Creek. Approximately 0.25 mi downstream of Sheridan Mine. The site is included on the Granite Quadrangle USGS 7.5-minute topographic map. The location description for the site is:

- Latitude 44° 51' 23"N
- Longitude 118° 22' 55"W
- Section 23, Township 8 South, Range 35.5 East.

The site is currently inactive and covers approximately 3 acres on moderately steep hillsides. A map showing existing site features is presented as Figure 4. The site generally consists of the following:

- There are 2 primary adits, although it was reported that several more small adits and pits exist at the site (Brooks et al. 1982). The 2 primary adits were observed during the SI field investigation. These consist of an upper and a lower, which are approximately 75 ft apart vertically. Both adits are collapsed at the portal; no discharges were observed during the field investigation.
- Two small waste rock piles. The pile near the upper adit is approximately 50 yds³ in size, and the pile below the lower adit is approximately 250 yds³. There is also some waste pile material east and west of the excavated area near the lower adit; the volume of this material was not determined.

Central Mine

Central Mine is located on the north side of Granite Creek, southeast of the intersection of FS Road 73 (Elkhorn Drive Scenic Byway) and FS Road 7345. The site is located approximately 0.6 mi downstream of Tillicum Mine and is included on the Granite Quadrangle USGS 7.5-minute topographic map. The location description for the site is:

- Latitude 44° 51' 19"N
- Longitude 118° 23' 29"W
- Section 23, Township 8 South, Range 35.5 East.

The site is currently inactive and covers approximately 2 acres on moderately steep hillsides. A map showing existing site features is presented as Figure 5. The site generally consists of the following:

- Two adits, both of which are collapsed at the portal. Neither adit had water draining from it during the field investigation. A third adit reportedly exists; however, it could not be located during the field investigation.
 - Three small waste rock piles. The smallest waste pile (approximately 20 yds³) is situated below the upper adit. The second waste pile (approximately 300 yds³) is located below the lower adit at the foot of the slope, and the third waste pile (approximately 50 yds³) is situated on a bench above Granite Creek.
-

- A waste rock berm which runs in an east-west direction along the slope approximately 75-100 ft above the creek (Figure 5). This berm was created as a result of hydraulic mining activities.

2.2 OPERATIONAL HISTORY AND WASTE CHARACTERISTICS

Mining in the Granite Creek area began as early as the 1860s and was a significant part of Oregon's mineral industry prior to World War II. Dredge mining was the primary form of mining in the region until the mineral production that could be achieved using hand-operated equipment began to decline. In the late 1880s, lode mining became the most profitable form of mining because of the advent of large-scale drilling and crushing equipment and chemical extraction methods (to extract the gold from its alloys). In the 1920s, dredging for gold in the rivers again became profitable using large-scale dredging equipment. Numerous dredge tailings piles are still visible along these creeks (USDA 2002). After many of the placer claims were abandoned (no date provided), hundreds of Chinese men, who were brought to Oregon from China by the China Company, leased the land in order to re-work the placer ground. They employed the hydraulic mining method, which involved working the ground using sluices and sorting the tailings by hand (Tabor 1988). Rows of hand-piled rocks still remain along the shoreline and within Granite Creek at many of the mine sites.

Monumental Mine

A list of known owners and operators of the Monumental Mine and mill site is provided in Appendix D. A brief history of the site follows, based on available references and a site summary provided by the Forest Service office located in Baker City:

- 1870 - The mine was discovered by Harvey Robbins, Isaac Nail, and Isaac Klopp (Tabor 1988), and operated intermittently until 1928.
- 1875 through 1906 - Several new claims were established and several of the original claims were relocated. A claims map from 1902 indicates there were 11 claims at that time. They were named: Monumental #1, Monumental #2, Monumental #3, Monumental #3 Extension South, Commercial Ledge, S.W.R. Ledge, S.W.R. Ledge Extension, Mill Ledge, Mill Ledge Extension North, North Star, and Colorado. Development consisted of 2 tunnels, 2 shafts, several raises, and a stoop that daylight to the surface near one of the shafts, all totaling approximately 4,000 ft (Visconty 2003).
- 1875 - A ton of the ore, with a value of \$1500, was shipped to San Francisco in order to attract investors (Tabor 1988). With the added capital, a 20-stamp mill was constructed on the site. The Monumental Gold and Silver Mining Co. operated both the mine and the mill in the late 1880's.
- 1902 - The mine and mill site were included in a report on the Portland Reduction and Mining Co. The mill at that time included a chlorination plant, but records do not indicate if other mill processes were in use (Visconty 2003). The total output through 1928 has been estimated at \$100,000 (Brooks and Ramp 1968).

Cap Martin Mine

Very little historical information exists for this site. It is not known exactly what date the mine was established, nor are any production records available. It was discovered by Cap Martin (Tabor 1988) and consisted of 3 adits totaling approximately 300 ft (Ferns et. al. 1982).

Sheridan Mine

There is very little historical information for this site. It is not currently known when the mine was established or the amount of production that occurred. The amount and type of development is also not clear, though it is known the mine consists of 2 short adits (Ferns et. al. 1982).

Tillicum Mine

It is not currently known when this site was established. It is known that production was very small, and that development occurred in approximately 400 ft of 5 or more adits, 2 of which were the primary adits (Brooks et. al. 1982).

Central Mine

Historical information for this mine is limited. It is not known when the mine was established, but production was very small and development consisted of approximately 500 ft in 3 adits (Brooks et. al. 1982).

2.3 PREVIOUS INVESTIGATIONS

Very few previous investigative activities have been conducted on these sites. In 2002, the Forest Service conducted an Environmental Impact Statement (EIS) on Granite Area Mining Projects, including the upper Granite Creek watershed. The Columbia River bull trout and Mid-Columbia steelhead, both of which occur in the Granite Creek watershed, are listed as threatened under the Federal Endangered Species Act. In addition, several of the streams within the watershed are on the State of Oregon 303(d) list of impaired waters, as described by the Clean Water Act. Given these facts, an EIS was necessary when the Forest Service proposed to approve Plans of Operation on 16 mining claims located within the watershed (USDA 2002). However, none of these claims was part of the 5 sites investigated as part of this SI.

The Forest Service conducted Abbreviated Preliminary Assessments (APAs) on both Monumental and Tillicum Mines in order to determine whether the potential exists for a release of hazardous contaminants to the environment, and to further characterize the sites. Summaries of these APAs are provided below.

Monumental Mine

The Abbreviated Preliminary Assessment (APA) of Monumental Mine was performed in 2002, and included the use of a Niton 700 series X-Ray Fluorescence (XRF) spectrum analyzer to field analyze samples. Three samples from the waste rock piles and 2 of tailings from the ponds were analyzed. The results indicated that arsenic, lead, and mercury exceeded USEPA Region 9 Preliminary Remediation Goals (PRGs; USFS 2003a).

Tillicum Mine

The Forest Service also conducted the APA of Tillicum Mine in 2002, and again used an XRF meter to analyze samples collected in the field. One waste rock sample was collected and was found to exceed USEPA Region 9 PRGs for arsenic and lead (USFS 2003b).

3. PATHWAY AND ENVIRONMENTAL HAZARD ASSESSMENT

3.1 GROUNDWATER PATHWAY

3.1.1 Geology

The Granite Creek Mines occur in the Granite Mining District, within the Elkhorn Mountains area of the Blue Mountains geomorphic province. The lode mines of the Granite District lie along the southwestern edge of the Bald Mountain Batholith, a large granodiorite body with an outcrop area of more than 170 square miles. The principal lode mines occur in a northeast-trending belt of veins and mineralized shear zones about 2 mi wide and 5 mi long (Brooks and Ramp 1968). Within the district, the veins occur primarily in older argillite of the Elkhorn Ridge Argillite. However, of the 5 mines included in this report, 4 (Monumental, Cap Martin, Sheridan, and Tillicum) penetrate the Bald Mountain Batholith and only one (Central) occurs within the Elkhorn Ridge Argillite.

The Bald Mountain Batholith is of Lower Cretaceous and Upper Jurassic age. It primarily consists of granodiorite and tonalite, with small amounts of norite and quartz monzonite (Ferns et. al. 1982). Dikes and sills of similar compositions occur along the borders of the batholith.

Monumental Mine

Production at Monumental Mine was from quartz veins within the granodiorite of the Bald Mountain Batholith. According to Brooks and Ramp (1968), 12 narrow veins were explored in the mine, with most of the work done on four. The veins occur at a strike of North to 20° Northeast and a dip of 65° Northwest. Sulfides in the veins include pyrite, arsenopyrite, sphalerite, galena, and tetrahedrite. The ore lenses mined were a maximum of 18 in. wide and stope lengths were less than 100 ft. Approximately 4,000 ft of development took place, reaching a depth of about 700 ft below the outcrop. The gold-to-silver ratio in the ore was reported as 1:20.

Cap Martin Mine

The Cap Martin Mine penetrates the granodiorite of the Bald Mountain Batholith. Several northeast trending quartz veins with sulfides were accessed via 3 adits (Ferns et. al. 1982).

Sheridan Mine

The Sheridan Mine penetrates the granodiorite of the Bald Mountain Batholith. According to Ferns et. al. (1982), short adits at the mine accessed quartz veinlets containing pyrite, chalcopyrite, and tetrahedrite.

Tillicum Mine

The Tillicum Mine penetrated several narrow shear zones with quartz veinlets within the Bald Mountain Batholith. According to Brooks and Ramp (1968), the mine accessed 2 parallel veins 40-50 ft apart, with a strike of 30° Northeast and dip of 50° Southwest. Koch (1959) described the principal mine workings as 2 adits, 50 ft apart vertically, although the report states that there were other small adits and pits. Most of the work appears to have been done on short veins and stringers of less than a foot in thickness (Koch 1959). The ore consisted of quartz-impregnated limonitic gouge (Brooks and Ramp 1968), and the gold occurred primarily as free gold (Brooks et. al. 1982).

Central Mine

The Central Mine penetrates 2 parallel shear zones 90 ft apart within the “mixed rock terranes” unit of the Elkhorn Ridge Argillite (Brooks et. al. 1982). The Elkhorn Ridge Argillite (Triassic, Permian, and Pennsylvanian) is described as a mainly dark-colored argillite, siliceous argillite and chert, with small amounts of fine-grained felsic tuff, sandstone, and conglomerate. Brooks, et. al. (1982) described the mixed rock terranes as consisting of ultramafic and mafic rocks in structurally chaotic juxtaposition with a wide variety of other rocks, including diorite, quartz diorite, basalt, argillite, chert, volcaniclastic rocks, and limestone, all metamorphosed to the greenschist facies.

3.1.2 Hydrogeology

No discussion or documentation of groundwater conditions at the site or in the site vicinity has been found. Shallow groundwater likely does not form a laterally continuous aquifer in the study area due to the presence of igneous intrusions and shallow bedrock. Localized shear zones and faults may also control groundwater flow to some extent. Shallow groundwater in the site area likely flows into Granite Creek.

No groundwater samples were collected during the SI field investigation. However, water samples were collected from a groundwater spring and a settling pond which collects adit discharge from the lower adit at the Monumental Mine site. Because these discharges impact local surface water quality, analytical results for these samples are discussed with the surface water samples in Section 3.2.5.

3.1.3 Groundwater Targets

The target distance for groundwater has been defined as a 4-mi radius from the sites (Plate 1). Potential receptors include drinking water wells and wellhead protection areas. Based on a search of the Oregon Water Resources Department (OWRD) database for water wells, one drinking water well is located within a 4-mi radius of the sites (OWRD 2003). The town of Granite obtains its drinking water from an improved spring in the area (USEPA 1997a). There are no wellhead protection areas within a 4-mi radius of the site.

The groundwater well is located approximately 4 mi southwest of the sites in the town of Granite in Township 9 South, Range 35.3 East, Section 4. Completed in 1994 at a total depth of 340 ft, it is used for domestic drinking water purposes. The static water level was reported at 22 ft bgs.

3.1.4 Groundwater Pathway Summary

Based on the available information, no release of hazardous substances from any of the mine sites to local groundwater systems is suspected. The closest drinking water well is approximately 4 mi from the nearest mine and is several hundred feet deep; no impacts from the mines would be expected. Therefore, the groundwater pathway appears to be incomplete. Groundwater that discharges from the adits may impact nearby surface water bodies; these sources are discussed in the following sections.

3.2 SURFACE WATER PATHWAY

3.2.1 Hydrologic Setting

All 5 mine sites are situated along the upper reaches of Granite Creek, which empties into the North Fork John Day River approximately 13 mi downstream of Central Mine, the site located the furthest downstream.

The Granite Creek watershed encompasses approximately 120-150 square miles (USEPA 1997a), with a portion of the headwaters originating at the Monumental Mine site. There are no stream gauging stations located in the study area (USGS 2003). Most of the total water yield in the area occurs as snowmelt in May and June, and, except for periodic and localized thunderstorms, rainfall is generally sparse from July to September. Therefore, summer base flows are relatively low compared to the spring snowmelt period. The average annual precipitation ranges from about 10 in. in the lower valleys to 45 in. in the mountains (Brooks et. al. 1968). In the study area, annual rainfall is roughly 30 in., about half of which falls as snow (Koch 1959).

The hydrologic functioning of Granite Creek and many of its tributaries has been highly impacted by historical placer mining, including both dredge and hydraulic mining. This in turn has significantly altered stream channel morphology and hence floodplain functionality (USDA 2002). The following observations were made during the SI field investigation regarding the hydrology near the mine sites:

- **Monumental Mine.** Flow from the upper spring drains under FS Road 7345, through the upper and middle settling ponds and eventually collects in the downstream pond, where flow from the lower adit also collects (Figures 1a and 1b). No outlet from the lower pond was observed during the field investigation. An unnamed tributary, which is part of the headwaters of the Granite Creek drainage, forms in a marshy area located downhill from the lower adit and waste pile. The tributary flows into Granite Creek between the Cap Martin and Sheridan mines (Figure 3).
 - **Cap Martin Mine.** An unnamed stream flows through a wide ravine located in the northern portion of the site. The creek flows from under the access road located north and upgradient of the site and eventually forms a marshy area near the collapsed cabin (Figure 2). The ravine has been altered significantly by placer mining, as evidenced by boulder piles located all the way up to the access road. There is also a large amount of downed timber in this area. Evidence of placer mining (i.e. piled stones) was also observed along Granite Creek. A small tributary, as well as flow from a spring, form part of the headwaters of Granite Creek immediately upstream of the site.
 - **Sheridan Mine.** Granite Creek near the mine site has been significantly altered by placer mining, as evidenced by large boulder piles and stone channels (Figure 3). Two tributaries enter Granite Creek in the area of the mine: one which flows from Monumental Mine on the north side of the creek and the other from the south side of the creek. There is also a seep near the collapsed portal that forms a marshy area upgradient of the waste pile. No staining or mineralization was observed in this area.
 - **Tillicum Mine.** No overland flow was observed at the mine site during the field investigation. Two erosion channels (dry during the field investigation) were observed coming from the collapsed adits and lower waste pile (Figure 4). No staining was observed along the channels. Water likely runs through these channels over the waste material during periods of high rainfall and snowmelt.
 - **Central Mine.** No overland flow was observed at the mine site during the field investigation. A runoff channel (dry during the field investigation) was observed coming from the waste pile near the lower adit (Figure 5). Water likely runs through this channel into Granite Creek during periods of high rainfall and snowmelt. A waste rock berm, the result of hydraulic mining activities, was observed along the slope above the creek. Immediately downstream of the mine, Granite Creek flows under the Scenic Highway through a large culvert.
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3.2.2 Surface Water Targets

A target distance of 15 mi downstream has been identified for the surface water pathway. The surface water drainage route is shown on Plate 2. Potential targets include surface water intakes supplying drinking water, fisheries, sensitive environments (e.g., wetlands), and aquatic species of concern. The 15-mi target distance limit (TDL) for the mines extends downstream from the Central Mine 12.9 mi along Granite Creek to the confluence with the North Fork John Day River and then the remaining 2.1 mi on the river. The last approximately 4 mi of the TDL are within the North Fork John Day Wilderness Area; this includes reaches of both Granite Creek and the North Fork John Day River. The 2.1 mi of the TDL on the North Fork John Day River are also a part of the North Fork John Day Wild and Scenic River corridor.

Because the TDL extends into a Designated Federal Wilderness Area, there appears to be few human targets. There are no designated, developed campsites within the TDL; however, there are numerous dispersed campsites located along open roads outside the Wilderness Area as well as primitive campsites inside the Wilderness Area. A dispersed campsite is one developed by the user, is typically located next to an open road, and often consists of a parking spot and a fire ring. Campers using either type of campsite, along with the occasional miner working a claim, may withdraw drinking water on an individual basis from one of the streams within the TDL.

With the exception of tribal fishing, commercial fishing within the TDL is not allowed. In addition, the Oregon Department of Fish and Wildlife (ODFW) has prohibited all recreational fishing in Granite Creek and its tributaries since 1997 in order to protect Chinook salmon (USEPA 1997a).

Sensitive Environments

The sensitive environments present within the 15-mi TDL include:

- North Fork John Day Wilderness Area
- North Fork John Day Wild and Scenic River
- Migratory pathways and spawning areas critical to the maintenance of anadromous fish species
- Habitat potentially used by federal-designated threatened species
- Wetlands as defined by 40 Code of Federal Regulations (CFR) 230.3.

Prior to conducting the fieldwork, a list of Threatened and Endangered (T&E) aquatic wildlife species and SOC potentially occurring in Grant County was generated with data obtained from the Oregon Natural Heritage Program (Appendix E, Table E-1, ONHP 2001). In addition, the Oregon Natural Heritage Information Center (ONHIC) was contacted regarding any recorded observations of rare or T&E species within a 2-mi radius of the sites (the search range available [OHNIC 2003]).

The aquatic species observed near the Granite Creek Mine sites during the field investigation are included in Table E-2 (Appendix E). The ONHIC reported the Columbia spotted frog (*Rana luteiventris*), a state-sensitive species (undetermined status), was observed within a 2-mi radius of the site (on the Boulder Creek drainage, approximately 1 mi upstream from the town of Granite). None were observed during SI field activities.

In addition, the ONHIC noted 2 Federal-listed threatened aquatic species within a 2-mi radius of the sites. These are the bull trout (*Salvelinus confluentus*) and steelhead (*Oncorhynchus mykiss*), which have been documented as being present in the North Fork John Day River and its tributaries. These species are

designated by the State of Oregon as sensitive-critical (bulltrout) and sensitive-vulnerable (steelhead). The westslope cutthroat trout (*Oncorhynchus clarki lewisi*), designated as a federal SOC and a state sensitive-vulnerable species, was also reported as observed within 2 mi of the sites by the ONHIC.

During seining activities in Granite Creek, bull trout (*Salvelinus confluentis*) were observed at 5 stations. In addition, *Oncorhynchus* spp., which could have been either west slope cutthroat trout (*Oncorhynchus clarki lewisi*) or redband trout (*O. mykiss gairdneri*; they were too small to positively identify in the field), were observed at 2 stations. The fish species observed during the SI field investigation are discussed further in Section 3.2.4.

Birds and Waterfowl

Species of birds that are associated with streams and riparian areas are of concern due to their potential exposure to contaminants released from the mines. During the SI field investigation, no waterfowl were observed near the sites. The only bird species observed along Granite Creek were American robin (*Turdus migratorius*), northern flicker (*Colaptes auratus*), MacGillivray's warbler (*Oporornis tolmiei*), and song sparrow (*Melospiza melodia*). Given the eating and foraging habits of these species they are likely common in both riparian and non-riparian areas. All the other bird species observed were in the forested hillsides surrounding the sites. Bird species observed during the field investigation are listed on Table E-2 (Appendix E). Other notable species observed near the sites include:

- American kestrel (*Falco sparverius*)
- Olive-sided flycatcher (*Contopus cooperi*)
- Hairy woodpecker (*Picoides villosus*)
- Pine siskin (*Carduelis pinus*).

The olive-sided flycatcher (*Contopus cooperi*) is a federal SOC and a state sensitive-vulnerable species. During the field investigation it was heard calling in the area of the mine sites several times, but was never seen. These birds are associated with the tops of large snags from which they catch insects and build their nests. Exposure in these birds would be restricted to the ingestion of flying insects.

Because it was past nesting season at the time of the field investigation, no such activity was observed. The time of the year and weather conditions also reduced the amount of songbird activity. All of the species observed could potentially be exposed to contamination from the mines through a variety of means, such as dermal contact with contaminated waste rock or tailings or the ingestion of contaminated water, sediment, or prey.

Wetlands Assessment

The National Wetlands Inventory (NWI) Database 7.5-minute topographic maps (USFWS 1994) were examined and compared to wetlands observed in the project area. For a detailed description of the wetlands, refer to Appendix F.

The entire upper reach of Granite Creek is classified on the NWI map as *Riverine, Upper Perennial, Unconsolidated Bottom, Permanently Flooded* (R3UBH). This classification does not generally meet the federal definition of a wetland as stated in 40 CFR 230.3.

Mapped units that do correspond to the federal wetland definition are located along the 15-mi TDL and consist mainly of ponds adjacent to Granite Creek, near the town of Granite. It is estimated that these are

located along approximately 1.5 mi of the 15-mi TDL. These units were likely created through historical placer mining activities, and are mapped by the NWI as:

- PSSC – *Palustrine Scrub-Shrub Vegetation, Seasonally Flooded*
- PSSCx – *Palustrine Scrub-Shrub Vegetation, Seasonally Flooded, excavated*
- PEMF – *Palustrine Emergent Vegetation, Semi-permanently Flooded*
- PEMFx – *Palustrine Emergent Vegetation, Semi-permanently Flooded, excavated.*

3.2.3 Stream/Surface Water Sampling Locations

Locations of stream and spring samples collected during the field investigation are indicated on Figures 1a, 1b and 2 through 5. A number of modifications to the sampling locations and techniques were made in the field, based on site observations and field conditions, and with concurrence of the Forest Service OSC. These modifications are documented in Appendix A in Table A-1. The stream sampling locations, as well as the on site surface water sample locations are described in Table A-2 (also in Appendix A).

3.2.4 Aquatic Survey Results

Aquatic surveys were conducted to assess the impact, if any, of the Granite Creek mines on the benthic macroinvertebrate community, presence of fish species, and habitat. With the exception of Monumental Mine, the sampling sites coincided with stream surface and pore water sampling locations. The creek near the Monumental Mine was too small to likely support a permanent fishery. As such, biological sampling was not conducted at the Monumental Mine site.

Field collection efforts were conducted according to the methods stated in the project plans (EA 2003a, 2003d). Results of the aquatic survey are presented in Appendix G (Tables G-1 through G-4). General stream characteristics are presented, from upstream to downstream, in the following table:

Station	Habitat (%)			Dominant Substrate	Water Depth (in.)		Current Velocity (ft/sec)	
	Riffle	Pool	Run		Riffle	Pool	Riffle	Pool
CAPM-03	60	10	30	Riffle - sand Pool - sand	0.5-1.5	7	1.53	0.00
CAPM-04	60	10	30	Riffle - sand Pool - sand	4-6	7-9	2.35	0.00
SHER-05	60	10	30	Riffle - sand Pool - sand	3	12	2.11	0.34
SHER-06	50	10	40	Riffle - sand Pool - sand	1.5-3	24	1.52	0.23
TILL-07	40	20	40	Riffle - sand Pool - sand	3.5-4.75	3-12	1.14	0.21
TILL-08	60	10	30	Riffle - sand Pool - sand	2.5-6.25	6-24.5	0.95	0.10
CENT-09	40	10	50	Riffle - sand Pool - sand	2.25-7	2.75- 24.5	1.63	0.00
CENT-10	20	20	60	Riffle - sand Pool - sand	4-8	10.5- 4	1.42	0.00

Seining and fish observations were conducted as part of this SI. Seining efforts were limited to those areas where the biologist could successfully deploy the seine. The effort was by no means exhaustive, so it is likely other species may be present and that the species collected are considerably more abundant than the data suggest. Numerous low barriers (approximately 1-3 ft high) were identified at several points along Granite Creek, particularly upstream of the Central Mine (Photo 70) and at the Tillicum Mine. However, based on the distribution of fish within Granite Creek, these barriers do not appear to impede the upstream movement of fish.

Seining was conducted at stations located upstream and immediately downstream (the “at mine” location) of Central, Tillicum, and the “at mine” site at Sheridan. Due to the confirmed presence of bull trout, a federally listed species, in the study area, seining was not conducted at the upstream Sheridan station or at either of the Cap Martin stations. Instead, the stream was surveyed visually to determine the presence or absence of fish at these stations. Due to the small size of the unnamed tributary at the Monumental site and the likelihood that this stream does not support a permanent fishery, visual observations were made instead of seining. As expected, no fish were observed at the Monumental stations. The results of the seining and fish observations during the SI sampling event are presented in Appendix G (Table G-1). The results are summarized as follows:

- Bull trout (*Salvelinus confluentus*) were observed in small numbers throughout the study area with no spatial patterns being apparent. Bull trout are listed as threatened under the ESA and are listed as critical by the state of Oregon.
- Two small *Oncorhynchus* spp. were observed at Station 04 downstream of Cap Martin, and a third was collected at Station 10 downstream of Central. Because of their small size, they could not be identified to species but were likely either west slope cutthroat trout (*Oncorhynchus clarki lewisi*) or redband trout (*O. mykiss gairdneri*). Both species are federally listed as SOC and identified as vulnerable by the Oregon Fish and Wildlife Commission.
- Both bull trout and *Oncorhynchus* species are undoubtedly more common in Granite Creek than the limited seining effort indicated.

Benthic macroinvertebrates were sampled in pool and riffle habitat at all stations except near the Monumental Mine, where the stream was too small to sample. Field collection and laboratory sorting of benthic macroinvertebrate samples was conducted in accordance with Oregon Department of Environmental Quality (ODEQ) methods and evaluated using a multi-metric analysis, Level 3 Assessment (ODEQ 2001). Three orders of insects, Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies), collectively referred to as EPT, are considered to be the most sensitive or responsive groups to impairment within the system. Therefore, the richness of each of these groups is included in the multi-metric analysis. The number and relative abundance of the taxa collected are provided in Tables G-2a (pool habitat) and G-2b (riffle habitat) in Appendix G. A summary of the metrics and scores are provided in Table G-3. No mine-related differences were apparent in the Index scores at any of the riffle locations and at only one of the pool locations along Granite Creek. It should be noted that the ODEQ methods for index and metric scoring for streams in Eastern Oregon remain in development; therefore, interpretation of these values should be conducted with caution until the index and scoring criteria are finalized.

- No upstream/downstream differences in pool Index scores were observed at the Cap Martin or Sheridan Mines.
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- The Index score in the pool downstream of the Central Mine was lower than in the pool upstream of it, likely due to poorer habitat, especially more sedimentation.
- The pool Index score at Station TILL-07, upstream of Tillicum was lower than at any other station. The reason for this lower score is unclear.
- Based on Index scores and individual metrics, no spatial patterns were evident in the pools.
- Index scores in the riffles downstream of each mine were comparable to or higher than those upstream of each mine. Therefore, no mine-related impacts to the riffle benthic community were found.
- Riffle Index scores at the 8 Granite Creek riffle stations were comparable to those at riffle stations GRAN-53 and GRAN-54 near Lucas Gulch, about 0.5 mi downstream of the Central Mine.
- Collectively, there was nothing in the benthic results to indicate that the benthic community in Granite Creek would benefit significantly from remediation of the mines studied as part of this project.

Habitat was evaluated at all the stream stations except near the Monumental Mine. Methods used followed those described in the project plan; habitat scores are presented in Table G-4 in Appendix G. The following was noted regarding habitat;

- Habitat was fair to good, and comparably similar at all stations except Station CENT-10, located at Central Mine.
- The habitat score at Station 10 was noticeably lower than at any other station due to more siltation/embeddedness and a poorer/narrower riparian zone.
- The increased siltation/embeddedness likely account for the lower pool benthic Index Score at Station 10.

3.2.5 Analytical Results

Analytical water quality results for surface water, pore water, and sediment samples are presented in Tables 1, 2, and 3, respectively. Only those constituents detected in one or more samples are included in the summary tables. Dissolved metals concentrations were used for comparison with surface water screening criteria. Photographs of selected sample locations are provided in Appendix B. Copies of the laboratory reports are included in Appendix J.

Field water quality parameters were measured in conjunction with sampling efforts. Surface water quality parameters were measured in the pool habitat at each station. Pore water quality parameters were measured in water samples extracted from pool habitat. Field parameters for the surface water and pore water are reported in Tables 1 and 2, respectively.

- Field parameters consisted of: hexavalent chromium, temperature, dissolved oxygen, specific conductance, pH, turbidity, oxidation/reduction (redox) potential, and stream depth and current velocity (surface water only).
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- The pH values for all of the water samples were within the acceptable range (6.5-9).
- Field water quality measurements did not indicate that any of these parameters were a limiting factor which would preclude sustainable benthic macroinvertebrate and fish communities at any of the stream stations sampled.

Laboratory analyses performed include the following:

- Surface water – pH, Target Analyte List (TAL) metals (total and dissolved), arsenic III and V (total metals only), cyanide, TDS, total suspended solids (TSS, organic, and inorganic), hardness, alkalinity, specific conductance, redox potential, and sulfate.
- Pore water –dissolved TAL metals, arsenic III and V (total metals only), and cyanide.
- Sediment – TAL metals, cyanide, total organic carbon (TOC), grain size, and clay mineralogy (for samples collected in pools only).

Criteria for comparing measured concentrations of metals in surface water and pore water consist of the following human health and ecological screening values:

- ODEQ Water Quality Criteria, Protection of Aquatic Life, Fresh Chronic Criteria (Oregon Administrative Record [OAR] 340-041-001); hardness-based criteria for cadmium, chromium III, copper, lead, nickel, and zinc were calculated based on the hardness values for the surface water samples collected on Granite Creek.
 - ODEQ Water Quality Criteria, Protection of Human Health, Water, and Fish Ingestion (OAR 340-041-001).
 - ODEQ (1998) Guidance for Ecological Risk Assessment, Level II Screening Values for surface water; these values are based on previous USEPA water quality criteria that have been superseded by the USEPA (2002) recommendations for ambient water quality criteria for freshwater organisms.
 - USEPA (2002) recommended ambient water quality criteria for freshwater aquatic organisms, chronic; criteria for the hardness-dependant values were calculated based on the hardness results for the surface water samples collected on Granite Creek.
 - USEPA (2002) recommended ambient water quality criteria for freshwater aquatic organisms, Tier II secondary chronic values calculated by Oak Ridge National Laboratory (Suter and Tsao 1996).
 - USEPA (2002) recommended ambient water quality criteria for protection of human consumption of fish; hardness-dependent values are normalized to 128 mg/L (mean stream hardness).
 - Oak Ridge National Laboratory, U.S. Department of Energy (Efromyson et. al. 1997), Preliminary Remediation Goals.
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Of these screening values, comparisons were made with the lowest value available. Results of the metals analyses for surface water and pore water are discussed in the following table and presented in Tables 1 and 2, respectively.

Summary of Surface Water and Pore Water Metals Data

Sample Type/Mine	Data Table	Dissolved Metals Exceeding One or More Comparison Criteria	Trends Observed and Comments
Stream Surface Water	Table 1		
Monumental Mine (spring and tributary samples)		Arsenic, barium, lead, manganese and selenium.	Arsenic was detected at notable concentrations in MONU-18 and 19. Manganese was also detected at a notable concentration in the upper spring sample (MONU-51).
Cap Martin Mine		Aluminum and barium	Aluminum was detected at a concentration that was notably above the reference concentration. Barium was comparable to the reference sample.
Sheridan Mine		Barium	Barium was detected in the “at mine” sample at a concentration that was comparable to the upstream sample, as well as the most upstream reference sample collected on Granite Creek (CAPM-03).
Tillicum Mine		Barium and lead.	Barium was detected in the “at mine” sample at a concentration that was comparable to the upstream sample concentration, as well as the most upstream reference sample concentration. Lead was elevated above the comparison criteria in the upstream sample, but the concentration was not notably above the most upstream reference sample collected on Granite Creek.
Central Mine		Barium	Barium was detected in the “at mine” sample at a concentration that was comparable to the upstream sample concentration, as well as the most upstream reference sample concentration.
Upstream and downstream of Lucas Gulch Confluence on Granite Creek.		Arsenic, barium and mercury	Arsenic and mercury were detected at elevated concentrations in both samples, collected upstream and downstream of the Lucas Gulch confluence. The concentrations in both samples were not notably above the most upstream reference sample collected on Granite Creek. Arsenic and mercury were not detected in the Central mine samples.
Pore Water	Table 2		
Cap Martin Mine Sheridan Mine Tillicum Mine		Barium	Barium was detected at concentrations above the comparison criteria in the “at mine” samples and the upstream samples at similar concentrations at all 3 mines. The concentrations were not notably above the most upstream reference concentration on Granite Creek.
Central Mine		Barium and lead.	Barium was detected in the “at mine” sample at an elevated concentration, but not notably above the upstream sample concentration or the most upstream reference sample concentration. Lead was detected at a concentration that was elevated above the comparison criteria in both the “at mine” and upstream samples, but not notably above the most upstream reference concentration.
Downstream of Central Mine (upstream and downstream of the Lucas Gulch confluence)		Barium and mercury	Barium was detected at an elevated concentration, but not notably above the reference concentration. Mercury was detected in the “at mine” sample at a concentration that was elevated above the comparison criteria, but not notably above the upstream sample concentration or the most upstream reference concentration.

Criteria for comparing measured concentrations of metals in sediments were based on the following:

- Threshold Effects Level (TEL) and Probable Effects Level (PEL) from USEPA National Sediment Quality Survey, Screening Values for Chemicals Evaluated (http://www.epa.gov/waterscience/cs/vol1/appdx_d.pdf).
- Effects Range-Low (ER-L) and Effects Range-Medium (ER-M), National Oceanic and Atmospheric Administration (NOAA), from USEPA (1997b) National Sediment Quality Survey, Screening Values for Chemicals Evaluated.
- ODEQ (1998) Guidance for Ecological Risk Assessment, Level II Screening Values for freshwater sediment.

Similar to the surface water and pore water samples, the sediment results were compared to the lowest screening criteria available. The analytical results for the sediment samples are provided in Table 3 and are summarized in the following table.

Sample Type	Data Table	Metals Exceeding One or More Comparison Criteria	Trends Observed and Comments
Stream Sediment	Table 3		
Cap Martin Mine (including the most upstream reference sample location CAPM-03)		Arsenic, chromium and silver	Arsenic was detected in the “at mine” samples, as well as the upstream reference samples. The result for the “at mine” riffle sample was slightly elevated above the upstream sample. Chromium was detected in the upstream pool sample at a concentration that was above all of the downstream samples on Granite Creek. Silver was detected in the “at mine” riffle sample at a concentration that was elevated above the comparison criteria, but not notably above the reference sample concentration.
Sheridan Mine		Arsenic	Arsenic was detected at elevated concentrations in both the riffle and pool “at mine” samples, but not notably above the upstream sample concentrations or the concentrations detected in the most upstream reference samples collected on Granite Creek.
Tillicum Mine		Arsenic and silver	Arsenic was detected in the “at mine” samples at elevated concentrations in both the riffle and pool samples, but not notably above the upstream concentrations or most upstream reference concentrations. Silver was detected in the upstream samples (pool and riffle) at an elevated concentration. The levels were just slightly above the most upstream sample concentrations on Granite Creek.

Sample Type	Data Table	Metals Exceeding One or More Comparison Criteria	Trends Observed and Comments
Central Mine		Arsenic, cadmium, lead, and silver	Arsenic was detected at an elevated concentration in all of the samples. The result for the “at mine” pool sample was slightly elevated above the upstream sample. The result for the upstream riffle sample was notably above the most upstream reference sample concentration. Cadmium and lead were also detected in the upstream riffle sample at concentrations that were notably above the most upstream reference sample concentrations. Neither cadmium nor lead were detected in any of the samples collected upstream of this sample station. Silver was also detected at an elevated concentration in both the upstream and “at mine” riffle locations, though not notably above the concentrations detected in the most upstream reference sample collected on Granite Creek.
Upstream of the Lucas Gulch Confluence on Granite Creek (long-range sample/reference location)		Arsenic, cadmium, lead, silver, and zinc	With the exception of silver, all were detected at concentrations that were notably above the Central Mine sample results, as well as the most upstream reference sample collected on Granite Creek. Silver was detected at a concentration that was just slightly above the Central Mine sample concentrations.
Downstream of the Lucas Gulch confluence on Granite Creek (to document contribution from Lucas Gulch)		Antimony, arsenic, cadmium, copper, lead, mercury, silver, and zinc	All of these metals were detected at concentrations that were above the upstream sample (GRAN-53) concentrations and the most upstream reference sample concentrations on Granite Creek. Of these, arsenic and lead were notably above the upstream sample results.

3.2.6 Surface Water Pathway Summary

Observations of the biological and analytical results follows:

- Based on the analytical results of surface water samples collected during this SI sampling event, metal contamination from the sites does not appear to be impacting surface water in Granite Creek (when compared to the upstream reference sample results on Granite Creek). This was a one-time sampling event that occurred during dry weather; therefore, seasonal variations should be considered when evaluating the results. The metals that were detected above the comparison criteria in the Granite Creek surface water samples (aluminum, arsenic, barium, lead, and mercury) have concentrations that are similar to those reported in the upstream reference sample (CAPM-03; Table 1).
- There is evidence of a release of metals from the upper seep at Monumental Mine (lead and manganese), as well as the upper settling pond (arsenic). Elevated metals were also detected in the unnamed tributary that flows from a seep at lower Monumental Mine to Granite Creek (arsenic, lead, and selenium). These metals were not detected in the sample collected at the Sheridan Mine, downstream of where the unnamed tributary flows into Granite Creek (Table 1).
- Based on the analytical results of pore water samples collected during the SI sampling event, metals from the mine sites do not appear to be impacting the pore water in the samples collected from Granite Creek (Table 2). Again, seasonal variations should be considered when evaluating the results of this one-time sampling event.

- The sediment within the area of the mine sites along Granite Creek does not appear to be significantly impacted by metals from the sites, when compared to the results from the most upstream reference sample collected on Granite Creek (CAPM-03, collected upstream of the Cap Martin Mine site). Arsenic was detected at concentrations above the comparison criteria in all of the samples, including the upstream reference sample. Arsenic, cadmium and lead were detected above the comparison criteria and notably above the most upstream reference sample concentrations in the riffle sample collected at the upstream location at Central Mine (CENT-09). Of these, only arsenic was detected in the “at mine” sample collected at Tillicum (TILL-08), upstream of the Central Mine sample location. However, the concentration was comparable to the most upstream reference sample concentration.
- Elevated concentrations of metals were detected in the sediment samples collected near the confluence of Lucas Gulch (GRAN 53 and 54), approximately 600 yards downstream of Central Mine. Of the metals detected in both samples, only arsenic, lead, and silver were detected in the downstream sample at concentrations that were notably above the upstream sample results, suggesting some contaminant contribution from Lucas Gulch.
- Bull trout (*Salvelinus confluentis*) were observed in small numbers throughout the study area. Bull trout are listed as threatened under the ESA and are listed as critical by the state of Oregon.
- Two small *Oncorhynchus* spp.; either west slope cutthroat trout (*Oncorhynchus clarki lewisi*) or redband trout (*O. mykiss gardneri*), were observed at locations along Granite Creek. Both species are federally listed as SOC and identified as vulnerable by the Oregon Fish and Wildlife Commission.
- There does not appear to be significant benthic habitat impairment or decreased benthic macroinvertebrate diversity and numbers along Granite Creek within the project area.

3.3 SOIL EXPOSURE PATHWAY

3.3.1 Targets

There are no onsite workers at any of the mine sites, and no people live onsite or within 200 ft of areas of suspected contamination related to the sites. The closest regularly occupied building appears to be located on the fringes of the town of Granite, approximately 3 mi from the sites. The town of Granite is located approximately 3.5-4 mi from the sites (straight-line distance). It is reported that approximately 24 people live in the town of Granite (USCB 2002). Furthermore, it is estimated that there are approximately 50 permanent residents located within a 4-mi radius of the mine sites.

The sites are open to public access and no warning signs were observed during SI field activities. Land uses within a 4-mi radius of the sites include recreation (hiking, fishing, swimming, camping, all-terrain-vehicle use, etc.), mining on nearby claims, and limited timber harvesting.

Soil exposure targets also include sensitive environments located both on the mine sites and within a 4-mi radius of the sites, and are discussed in Section 3.3.2. Terrestrial sensitive environments consist of habitat reported to be used by federal or state T&E species or SOC, and includes the North Fork John Day Wilderness Area.

3.3.2 Plant and Wildlife Surveys

Habitat reconnaissance surveys were conducted at the mine sites to establish existing habitat conditions, species composition, and the presence of wetlands and T&E species along Granite Creek and at reference/background stations.

To accomplish the surveys, two approaches were used. While conducting sampling activities, the site was monitored for wildlife. In addition, flora was located using a timed-meander-search (TMS) procedure. Vegetation was classified using the National Vegetation Classification System (NVCS) to determine the habitat types at the mine sites, with the riparian and forested slopes being the major types (FGDC 1997). All observed species at the site were recorded on a field data sheet as they were encountered and unknown plant species were collected, preserved, and later keyed for identification using reference materials.

Site Habitat Description and Vegetation

Using the NVCS system combined with a simple habitat assessment, the dominant plant species including canopy and understory species, were documented. The following observations of the area were made:

- The 4 lower mines (Cap Martin, Sheridan, Tillicum, and Central) are situated along Granite Creek in or adjacent to riparian areas. The upper mine, Monumental, is located 800-1,200 ft higher in elevation and springs occur in the upper and lower portions of the site. Drainage from the lower spring, in the marshy area downhill of the lower waste rock pile, forms a tributary that flows into Granite Creek immediately upstream of the Sheridan Mine site.
- The 4 lower mines are located within a large valley ranging from 0.25 to 0.5 mi wide and approximately 500 ft deep, with steep slopes in many areas.
- Granite Creek divides the coniferous forest on the hillsides into 2 distinct habitat types. A drier ponderosa pine (*Pinus ponderosa*)- Douglas fir (*Psudeotsuga menziesii*) woodland is present on the southern side (NVCS code II.B.2.N.a). A moister forest dominated by lodgepole pine (*Pinus contorta*), larch (*Larix lyallii*) and silver fir (*Abies amabilis*) exists on the northern side (NVCS code II.A.4.N.a).
- Granite Creek is typically less than one meter wide and the riparian zone less than 20 meters wide. Vegetation consists of sparse deciduous plants dominated by red alder (*Alnus rubra*). The NVCS code most closely describing this habitat is a temporarily flooded cold-deciduous shrubland (III.B.2.N.d.).
- Monumental Mine occurs in a elevationally higher forest dominated by spruce (*Picea* sp.). The NVCS code is I.A.8.N.c.

There are essentially 4 habitat types in the area of the sites:

- The drier southern facing slopes
 - The moister northern facing slopes
 - The riparian zone along Granite Creek
 - The spruce forest at Monumental Mine.
-

The hillside forest recruitment is a typical one for the Blue Mountains (Franklin and Dyrness 1973). There is almost a complete absence of understory shrubs with the species present consisting of grasses, whortleberry (*Vaccinium* sp.) and scattered forbs. Wild strawberry (*Fragaria virginiana*), the plant species selected for plant tissue collection (see below), was widespread in a variety of habitats.

Evidence of fire and possible insect infestations was observed. The area above Cap Martin Mine appears to have been logged and portions were in various stages of reforestation. Areas devoid of vegetation were not common except at waste rock piles. No visual indicators of stressed vegetation were recorded at background areas.

Prior to conducting the fieldwork, a list of T&E plant species and SOC was generated with data obtained from the Wallowa-Whitman National Forest (Appendix E, Table E-3). In addition, the ONHIC was contacted regarding any specific recorded observations of T&E plant species and SOC within a 2-mi radius of the sites (the search range available). Two species of *Carex*, northern sedge (*Carex concinna*) and meadow sedge (*Carex praticola*), were noted in data obtained from the OHNIC (Appendix D). These sedge species are not a Federal- or State-listed species, but are considered sensitive and are not commonly found in the area. No T&E species or SOC on the Wallowa-Whitman list were observed during the field investigation. The plant species that were observed during the field activities are listed in Appendix E (Table E-4).

Wildlife

Prior to conducting the fieldwork, a list of T&E terrestrial wildlife species and SOC potentially occurring in Grant County was generated with data obtained from the OHNP (Appendix E, Table E-1). In addition, the ONHIC was contacted regarding any specific recorded observations of T&E wildlife species and SOC within a 2-mi radius of the sites (Appendix D). The Columbia spotted frog (*Rana luteiventris*), a state-sensitive species (undetermined status), was observed within a 2-mi radius of the sites (on the Boulder Creek drainage, approximately 1 mi upstream from the town of Granite). None were observed during SI field activities however.

Very few wildlife species were observed at the Granite Creek Mine sites during the field investigation (Appendix E, Table E-2). Six species of mammals were documented through either direct observation or signs of their presence. No reptiles, amphibians, or terrestrial T&E wildlife species or SOC were observed during the field activities.

3.3.3 Soil/Waste Rock and Plant Tissue Sample Locations

Soil and plant tissue sample locations are presented on Figures 1 through 5. Locations for the onsite surface and subsurface soil and/or waste samples are summarized in Appendix A, Table A-3. Background surface soil samples were collected at off-site locations that did not appear to be impacted by mining activity. The descriptions of the background sample locations are also provided on Table A-3.

3.3.4 Plant Tissue Collection

Plant tissue specimens were collected from 6 onsite stations (waste rock piles) and from 4 background stations. The samples were analyzed for cyanide and TAL Metals. Three of the background stations were located on the hillsides within the Granite Creek drainage and one was located within the Lucas Gulch drainage. The samples were collected at locations outside of the mining activity and were co-located with surface soil samples. Wild strawberry (*Fragaria virginiana*), the targeted plant species,

was chosen because it occurred on the often barren waste rock piles and both the vegetation and fruit is consumed by wildlife.

While wild strawberry is not the most important food species, its prevalence on the waste rock piles and other locations impacted by mining make it a potentially useful species for future use in a food chain analysis of ecological risks. Another strawberry species that occurs in the area of the sites is *Fragaria vesca*. Neither species was flowering at the time of the field investigation and therefore speciation of the plants was difficult. Only leaves were collected for samples.

Plant tissue specimens were collected from waste rock pile locations and were co-located with the waste-rock samples, as indicated on Table A-3 in Appendix A.

3.3.5 Analytical Results

All soil and/or waste samples collected at the Granite Creek Mines were analyzed for pH, TAL metals, and cyanide. Synthetic Precipitation Leaching Procedure (SPLP) and Acid Base Accounting (ABA) parameters were also included, as appropriate.

Criteria for comparing measured concentrations of metals in soils consisted of the following human health and ecological screening values:

- ODEQ (1998) Guidance for Ecological Risk Assessment, Level II Screening Values.
- USEPA Region 9 PRGs for Industrial Soils (<http://www.epa.gov/region09/waste/sfund/prg/index.htm>).
- USEPA (2000a) Generic Soil Screening Levels (SSLs), for protection of human health.
- USEPA (2000b) Ecological Soil Screening Levels (EcoSSLs).
- Oak Ridge National Laboratory PRGs for protection of plants, wildlife, or soil invertebrates, U.S. Department of Energy (Efroymsen et al. 1997).

Analytical data were compared to the lowest available screening criteria.

The plant tissue samples were analyzed for cyanide and TAL Metals. No comparison criteria are available for plant tissue; these data may be used in a food chain model, if required in the future. The plant tissue samples were compared to background samples for discussion purposes.

Surface and Subsurface Soil/Waste Samples

A summary of the analytical results for surface and subsurface soil/waste samples is provided in Table 4. Refer to Appendix I for soil sample descriptions and Appendix J for laboratory reports. Surface and subsurface soil sample analytical results are summarized in the following table:

Sample Type	Table/ Sample Nos.	Metals Exceeding One or More Comparison Criteria (in at least one sample)	Metals Notably Above Highest Background Concentration (in at least one sample)	Trends Observed and Comments
Background				
Surface Soil	GRAN-34 GRAN-35 GRAN-36 LUCA-19	Aluminum, arsenic, barium, beryllium, total chromium, manganese, mercury, selenium, vanadium, and zinc.	NA	The pH values in the background soil samples ranged from 5.9 to 6.7. In general, some of the higher concentrations were detected in the soil sample collected near Lucas Gulch.
Monumental				
Surface and Subsurface Soil/Waste Rock:	MONU-12 MONU-13 MONU-14* MONU-15* MONU-16 MONU-17 MONU-38	Aluminum, antimony, arsenic, barium, beryllium, cadmium, chromium, copper, lead, manganese, mercury, selenium, silver, thallium, vanadium, and zinc	Antimony, arsenic, cadmium, lead, mercury, silver, and zinc.	Soil pH measurements ranged from 3.5 to 8.6. The lower pH values were found in the surface soil samples collected at 3 locations: at MONU-16, near the floater at the upper mill site (4.6), MONU-38, at the crusher near the lower adit (3.5), and MONU-13, from the waste pile near the upper shaft (4.0). The other waste material/soil samples ranged from 6.4 to 8.6. Overall, it appears that the highest concentrations were detected in the samples collected from around the mill, the crusher near the lower adit, and the upper settling pond.
Cap Martin Mine				
Subsurface Soil/Waste Rock:	CAPM-20 CAPM-21 CAPM-22 CAPM-39	Aluminum, arsenic, barium, beryllium, cadmium, chromium, lead, manganese, mercury, selenium, silver, vanadium, and zinc	Arsenic, cadmium, and zinc.	Soil pH measurements ranged from 4.9 to 8. The lowest value, 4.9, was measured in the sample collected at the waste pile located near the collapsed adit in the western portion of the site (CAPM-39). No staining was noted at this sampling location and AMD was not observed draining from the adit during the field investigation. In general, the highest concentrations were detected in sample CAPM-21 collected from the waste rock pile near the north adit.
Sheridan Mine				
Subsurface Soil/Waste Rock	SHER-23 SHER-25	Aluminum, antimony, arsenic, barium, beryllium, chromium, copper, iron, manganese, mercury, selenium, silver, vanadium, and zinc	Arsenic (both samples), antimony (SHER-23), mercury (SHER-23), and silver (SHER-23)	Soil pH measurements in the 2 samples were 6.8 and 7. In general, the highest concentrations of metals were detected in the sample collected from the waste rock pile (SHER-23).
Tillicum Mine				
Surface and Subsurface Soil/Waste Rock:	TILL-26 TILL-27* TILL-28 TILL-30	Aluminum, arsenic, barium, beryllium, cadmium, chromium, lead, manganese, mercury, selenium, silver, thallium, vanadium, and zinc	Arsenic, lead, and zinc.	Soil pH measurements ranged from 6.6 to 8.6. In general, the concentrations in the onsite samples were in the same range.

Sample Type	Table/ Sample Nos.	Metals Exceeding One or More Comparison Criteria (in at least one sample)	Metals Notably Above Highest Background Concentration (in at least one sample)	Trends Observed and Comments
Central Mine				
Surface and Subsurface Soil/Waste Rock:	CENT-31* CENT-32 CENT-33	Aluminum, antimony, arsenic, barium, beryllium, chromium, copper, lead, manganese, mercury, selenium, silver, thallium, vanadium, and zinc	Arsenic, lead, and zinc.	Soil pH measurements ranged from 6.5 to 7.2. In general, the concentrations in the onsite samples were in the same range; however, surface soil sample CENT-31 collected from the lower waste rock pile contained concentrations of antimony, copper, and silver that the other samples did not. This sample also contained higher concentrations of arsenic, lead, manganese, vanadium, and zinc.
* - Surface and subsurface sample collected at this location.				

Plant Tissue Samples

A summary of the plant tissue analytical data is provided in Table 5. For most metals, concentrations detected in the onsite plant tissue samples fell within the range of background. No comparison criteria are currently available for plant tissue. The plant tissue results are summarized in the following table:

Sample Type	Table/ Sample Nos.	Metals Exceeding the Highest Background Concentration (in at least one sample)	Metals Notably Above Highest Background Concentration (in at least one sample)	Trends Observed and Comments
Background				
Plant Tissue	GRAN-34, GRAN-35, GRAN-36, LUCA-19	NA	NA	Antimony, arsenic, cobalt, and mercury were not detected in any of the background samples.
Monumental Mine				
Plant Tissue	MONU-14 and MONU-15	Cadmium, iron, lead, and vanadium.	Arsenic and zinc.	Arsenic was also detected at notably high concentrations in both of the co-located soil samples. Zinc was detected at a notably high concentration in one of the co-located soil samples (MONU-14).
Cap Martin Mine				
Plant Tissue	CAPM-20	Mercury	None	Mercury was detected at a very low concentration (estimated).
Sheridan Mine				
Plant Tissue	SHER-23	Cadmium, lead, and zinc.	None	Lead and zinc were detected just above the highest background concentrations. Cadmium was detected at a very low concentration (estimated).
Tillicum Mine				
Plant Tissue	TILL-27	Total chromium, iron, lead, mercury,	Cadmium and zinc.	Cadmium was not detected at a concentration above the comparison criteria in the co-located soil sample. Zinc was detected above the comparison criteria in the co-located soil sample, but not notably above the highest background concentration.
Central Mine				
Plant Tissue	CENT-31	Beryllium, cadmium, chromium, copper, iron, lead, magnesium, mercury, vanadium, and zinc.	Total chromium and zinc.	Total chromium and zinc were not detected at notable concentrations in the co-located soil sample. Beryllium, cadmium, chromium, copper, mercury, and vanadium were detected at very low concentrations (estimated) in the plant tissue.

3.3.6 Soil Exposure Pathway Summary

Data collected during the field investigation provide evidence that the release of site-related constituents to soils at all 5 of the mine sites has occurred. The following observations are applicable to each of the mine sites:

- The erosion of fine-grained waste material and soil was evident at the sites, particularly on the slopes of the waste rock piles. This erosion was caused by surface water run-off, and is likely a contributor to contaminants migrating offsite and entering the surface water pathway. Surface water runoff would occur at the mines during periods of high rainfall and snowmelt.
- The Columbia spotted frog (*Rana luteiventris*), a state-sensitive species (undetermined status), has been observed within a 2-mi radius of the sites (on the Boulder Creek drainage, approximately 1 mi upstream from the town of Granite). However, none was observed during field activities. No other listed terrestrial species have been reported in the vicinity of the site (ONHIP 2003); however, during the field investigation the olive-sided flycatcher (*Contopus*

cooperi) was heard calling in the area of the mine sites several times, but was never seen. This bird is a federal SOC and a state sensitive-vulnerable species.

The following metals were detected in onsite soil/waste samples at concentrations both exceeding the comparison criteria and notably above background:

- Monumental Mine: antimony, arsenic, cadmium, lead, mercury, silver, and zinc. Arsenic and zinc were also detected at concentrations notably above background in the 2 co-located plant tissue samples.
- Cap Martin Mine: arsenic, cadmium, and zinc.
- Sheridan Mine: antimony, arsenic, mercury, and silver.
- Tillicum Mine: arsenic, lead, and zinc. Cadmium and zinc were also detected at concentrations notably above background in the co-located plant tissue sample.
- Central Mine: arsenic, lead, and zinc. Total chromium and zinc were also detected at concentrations notably above background in the co-located plant tissue sample.

3.4 AIR PATHWAY

3.4.1 Targets

The target distances for the air pathway have been defined as one and 4-mi radii from the sites. It is estimated that 50 people live within 4 mi of the sites. The shortest distance from potential sources of contamination at the sites to any residence or regularly occupied building is estimated to be approximately 3 mi.

Within a 4-mi radius of the mine sites, the majority of the NWI mapped units corresponding to federal wetland definitions are outside the Granite Creek drainage. These are largely associated with wet meadows located north of the sites, and were mapped by the NWI as:

PEMH - *Palustrine Emergent Vegetation, Permanently Flooded*

PEMA - *Palustrine Emergent Vegetation, Temporarily Flooded*

PEMB - *Palustrine Emergent Vegetation, Saturated conditions*

PEMC - *Palustrine Emergent Vegetation, Seasonally Flooded.*

For a detailed description of wetlands, refer to Appendix F.

3.4.2 Air Pathway Summary

Air samples were not collected as part of this SI. The most likely air pathway at the mine sites is through inhalation of particulate matter. Arsenic was detected in 4 surface soil samples collected at the Monumental Mine at concentrations exceeding the available USEPA soil screening level for inhalation of particulates (750 mg/kg). Although the potential for an observed release to air is considered possible, the likelihood of exposure from dust particles is low. Because the air pathway is directly related to the soil exposure pathway, addressing and/or eliminating contaminated soils at the site would likely render the air pathway incomplete.

4. SUMMARY AND CONCLUSIONS

Based on site observations and the results of field and laboratory analyses, the following site characteristics and conclusions have been identified:

Groundwater Pathway:

- Based on available records, one drinking water well is located within the 4-mi TDL; this well is located approximately 4 mi southwest of the sites in the town of Granite. Impacts to this well would not be expected, based on the distance from the sites to the well and the depth of the well. Any impacted shallow groundwater at the site is expected to be very localized in nature, and to present a risk to nearby surface water bodies, in the form of springs and seeps.

Surface Water Pathway:

- Based on analytical results, metals from sources at the mines do not appear to be significantly impacting surface water or pore water in Granite Creek.
- Water flowing from the upper seep and surface water in the upper settling pond at Monumental Mine contained several metals at high concentrations. Samples collected from the unnamed tributary that flows from the lower seep at Monumental Mine (located near the lower waste rock pile) to Granite Creek also contained several metals at concentrations above the comparison criteria. This unnamed tributary is too small to support fish populations.
- Based on the analytical results, stream sediment within the area of the mine sites along Granite Creek does not appear to be significantly impacted by metals from the sites.
- Elevated concentrations of metals were detected in the sediment samples collected in Granite Creek near the confluence of Lucas Gulch (GRAN 53 and 54). Of the metals detected in both samples, only arsenic and lead were detected in the downstream sample at concentrations that were notably above the upstream sample results, suggesting some contaminant contribution from Lucas Gulch to Granite Creek.
- Bull trout (*Salvelinus confluentis*) and 2 small *Oncorhynchus* spp. (either west slope cutthroat trout [*Oncorhynchus clarki lewisi*] or redband trout [*O. mykiss gardneri*]) were observed at locations along Granite Creek. Bull trout are listed as threatened under the ESA and are listed as critical by the state of Oregon. *Oncorhynchus* spp are federally listed as SOC and identified as vulnerable by the Oregon Fish and Wildlife Commission.
- There does not appear to be significant benthic habitat impairment or decreased benthic macroinvertebrate diversity and abundance along Granite Creek within the project area.

Soil Exposure Pathway:

- A number of metals were detected in surface and subsurface soil samples at concentrations exceeding comparison criteria. Of these, only arsenic and/or zinc were detected in soil and/or waste rock material at concentrations that were notably above the background concentrations.
-

Elevated levels of mercury were also detected at notable concentrations in 2 samples collected at the Monumental Mine.

- Arsenic was detected in the plant tissue samples collected at Monumental Mine at concentrations that were notably above the background levels. Arsenic was also detected at concentrations that were notably above the background concentrations in the co-located surface soil samples.
- The erosion of fine-grained waste material and soil was evident at the sites, particularly on the slopes of the waste rock piles. This erosion was caused by surface water run-off, and is likely a contributor to contaminants migrating offsite and entering the surface water pathway. Surface water runoff would occur at the mines during periods of high rainfall and snowmelt.
- During SI field activities, the olive-sided flycatcher (*Contopus cooperi*) was heard calling in the area of the mine sites several times. This bird is a federal SOC and a state sensitive-vulnerable species.

Air Pathway:

- The air pathway is considered complete, as arsenic was detected in surface soil samples collected at the Monumental Mine at concentrations above the USEPA soil screening level for inhalation of particulates. However, because the air pathway is directly related to the soil pathway, reducing or eliminating contaminated soils at the site would likely render the air pathway incomplete. Further assessment of the air pathway is not considered necessary.

Recommendations

Based on the elevated concentrations of metals detected in onsite soil and waste rock samples at all 5 mine sites, as well as onsite surface water samples collected at the Monumental Mine, EA recommends performance of an Engineering Evaluation/Cost Analysis (EE/CA) at the Granite Creek sites. As part of the EE/CA, a risk assessment should be performed to assess the human and ecological impacts, establish site removal cleanup standards, and evaluate remediation technologies.

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Figures

LOCATED AND MISSING FLAGS TABLE				
* FOUND FLAGS		** DID NOT FIND FLAGS		
MINE SITE	STREAM	OTHER SURFACE WATER	SOIL	PLANT
MONUMENTAL	NONE	* MONU-18 * MONU-19 ** MONU-51	** MONU-12 ** MONU-13 ** MONU-14 * MONU-15 ** MONU-16 * MONU-17 * MONU-38	** MONU-14 ** MONU-15

LEGEND

- W WETLAND
- + TAILINGS
- ⊗ SAMPLE LOCATION AND NO.
- △ APA ALUMINUM CAP WITH SURVEY MARKER NO., ELEVATION, AND DESCRIPTION
- APA CONTROL POINT NO., ELEVATION, AND DESCRIPTION
- COLLAPSED ADIT
- OVERLAND FLOW
- ▭ WASTE ROCK PILE
- ▨ EXCAVATION
- ▩ POND

HORZ. DATUM NAD83 (1991) OREGON STATE PLANE SOUTH ZONE
VERT. DATUM NAVD88

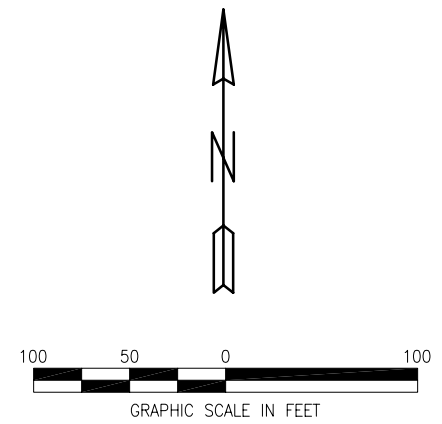
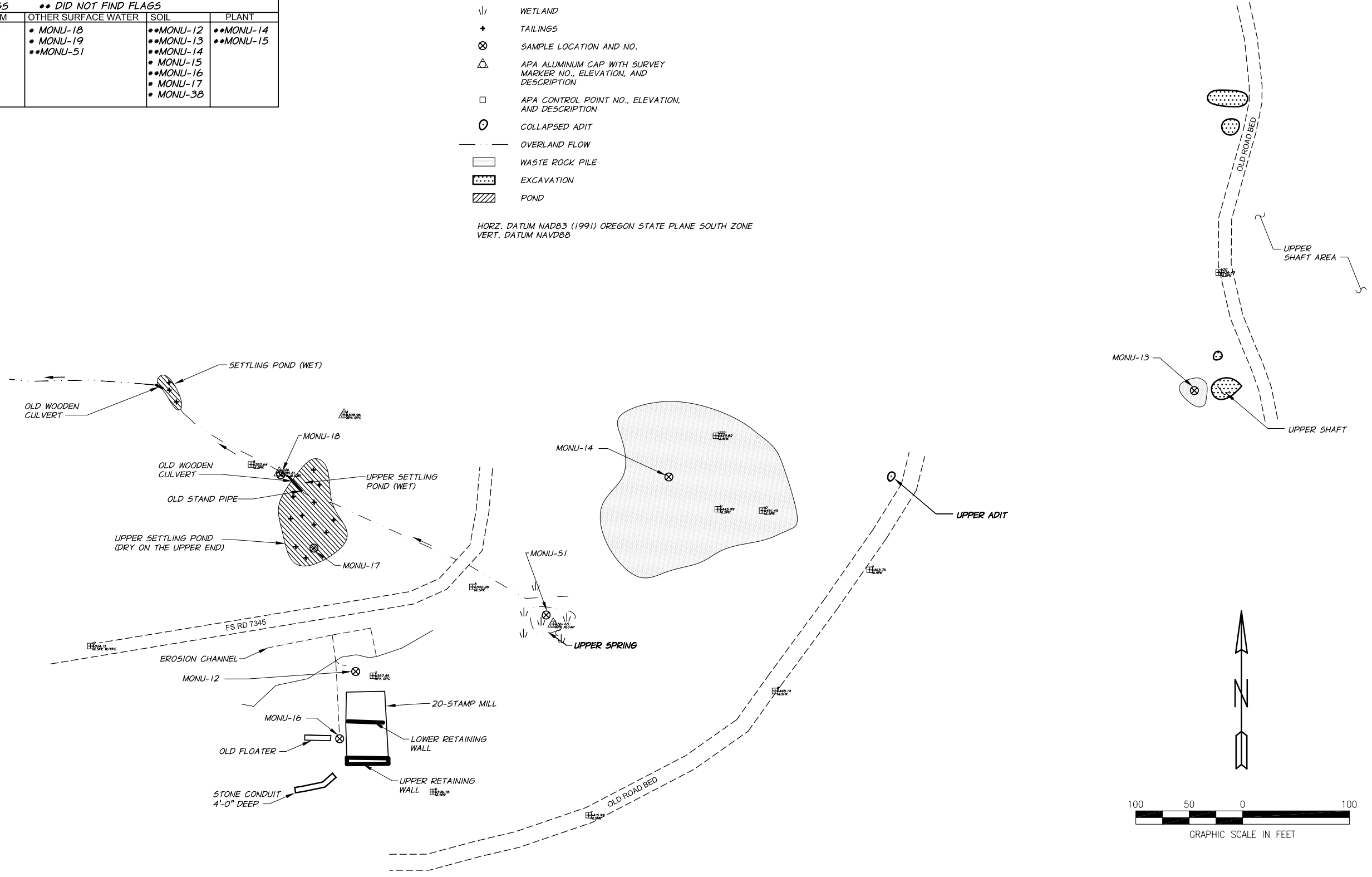


Figure 1a. UPPER MONUMENTAL MINE SITE



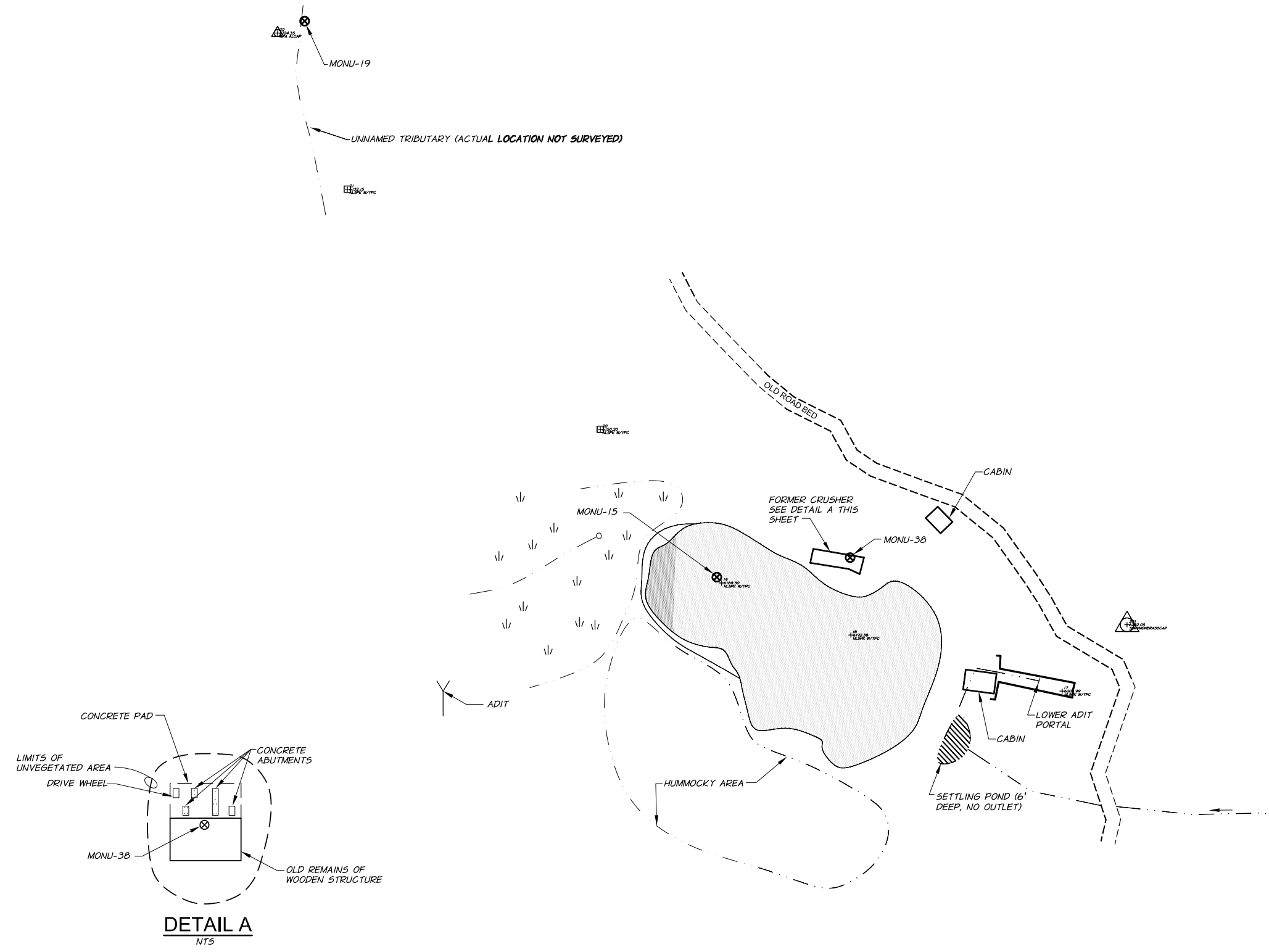
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LOCATED AND MISSING FLAGS TABLE				
* FOUND FLAGS		** DID NOT FIND FLAGS		
MINE SITE	STREAM	OTHER SURFACE WATER	SOIL	PLANT
MONUMENTAL	NONE	* MONU-18 * MONU-19 ** MONU-51	** MONU-12 ** MONU-13 ** MONU-14 * MONU-15 ** MONU-16 * MONU-17 * MONU-3B	** MONU-14 ** MONU-15

LEGEND

- ∨ WETLAND
- + TAILINGS
- ⊗ SAMPLE LOCATION AND NO.
- △ APA ALUMINUM CAP WITH SURVEY MARKER NO., ELEVATION, AND DESCRIPTION
- APA CONTROL POINT NO., ELEVATION, AND DESCRIPTION
- COLLAPSED ADIT
- OVERLAND FLOW
- ▭ WASTE ROCK PILE
- ▨ POND

HORZ. DATUM NAD83 (1991) OREGON STATE PLANE SOUTH ZONE
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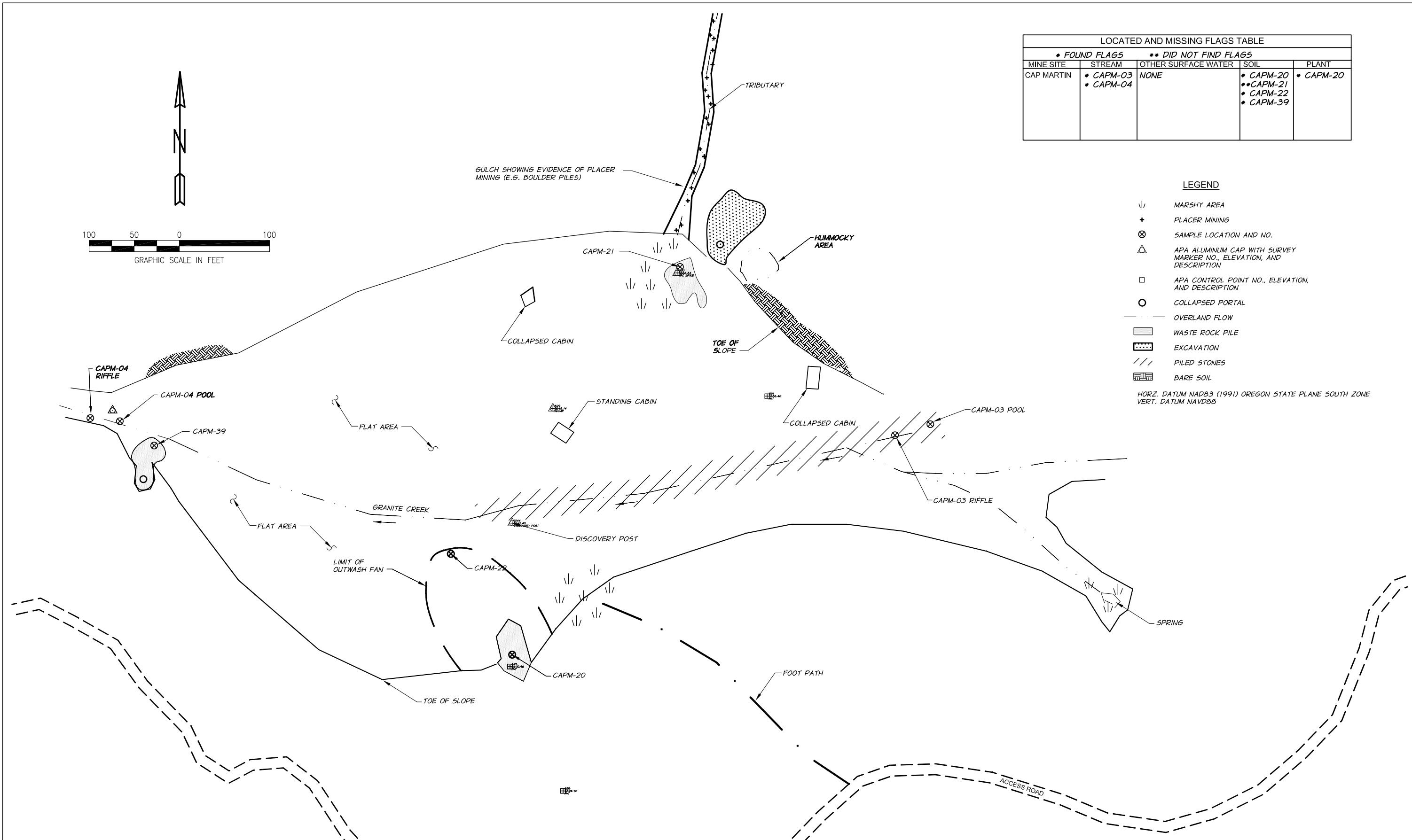


100 50 0 100
 GRAPHIC SCALE IN FEET

Figure 1b. LOWER MONUMENTAL MINE SITE



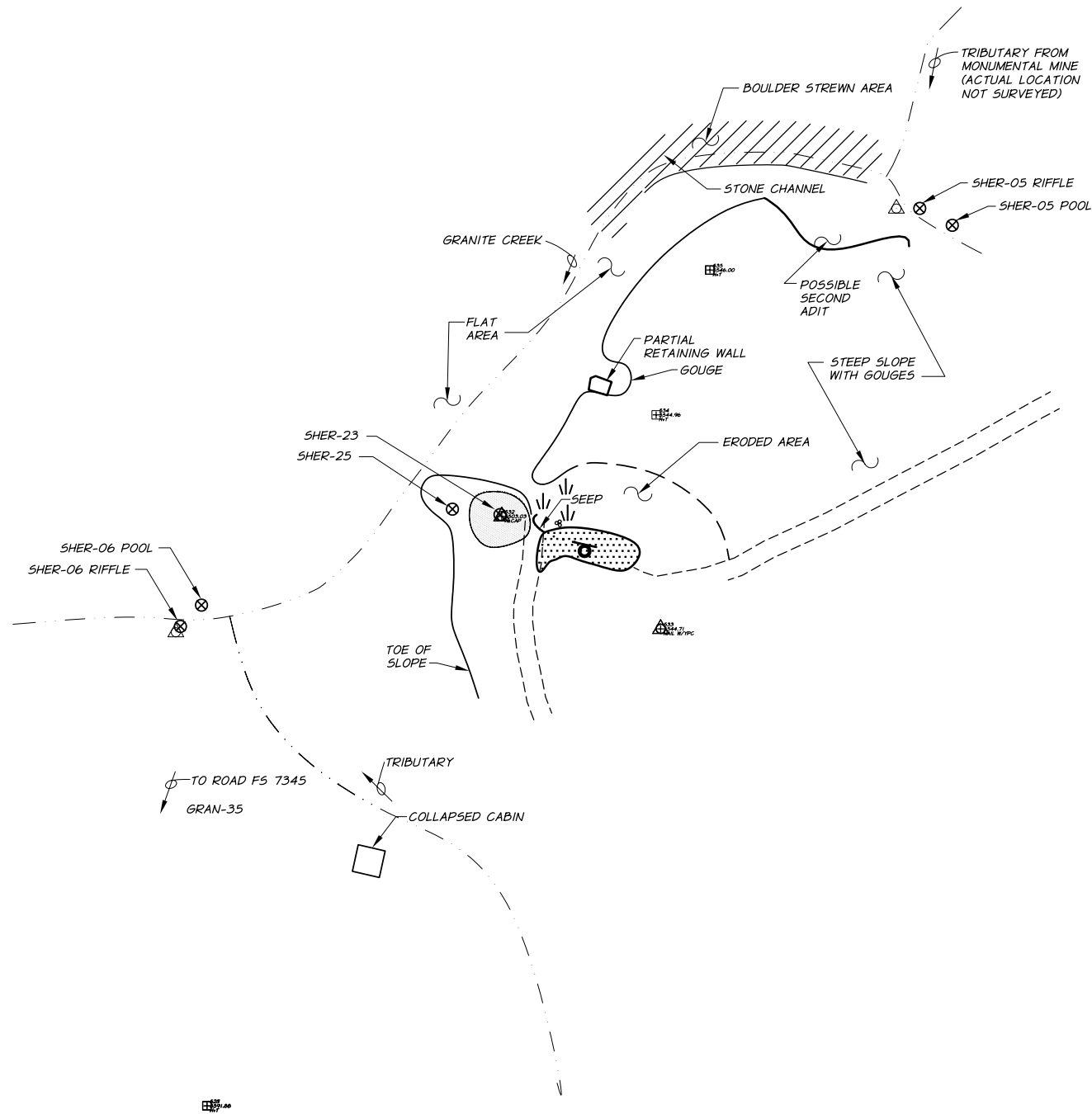
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DRAWING NAME: \\13890.13\FIGURES\CAP MARTIN\FIG2.DWG
DATE:12/09/2003 TIME:11:00 DRAWN BY: EJM



LOCATED AND MISSING FLAGS TABLE				
MINE SITE	* FOUND FLAGS		** DID NOT FIND FLAGS	
	STREAM	OTHER SURFACE WATER	SOIL	PLANT
SHERIDAN	* SHER-05 * SHER-06	NONE	* SHER-23 * SHER-25	* SHER-23



LEGEND

- ∩ MARSHY AREA
- ⊗ SAMPLE LOCATION AND NO.
- △ APA ALUMINUM CAP WITH SURVEY MARKER NO., ELEVATION, AND DESCRIPTION
- APA CONTROL POINT NO., ELEVATION, AND DESCRIPTION
- COLLAPSED PORTAL
- - - OLD ROAD BED
- STONE CHANNEL
- ⊗ RUSTED DRUMS
- ▭ WASTE ROCK PILE
- ▨ EXCAVATION
- ▩ BOULDER STREWN AREA

HORZ. DATUM NAD83 (1991) OREGON STATE PLANE SOUTH ZONE
VERT. DATUM NAVD88

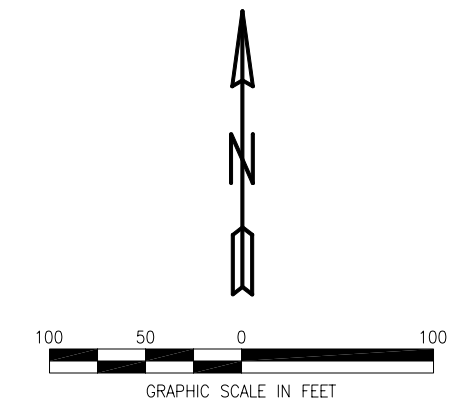
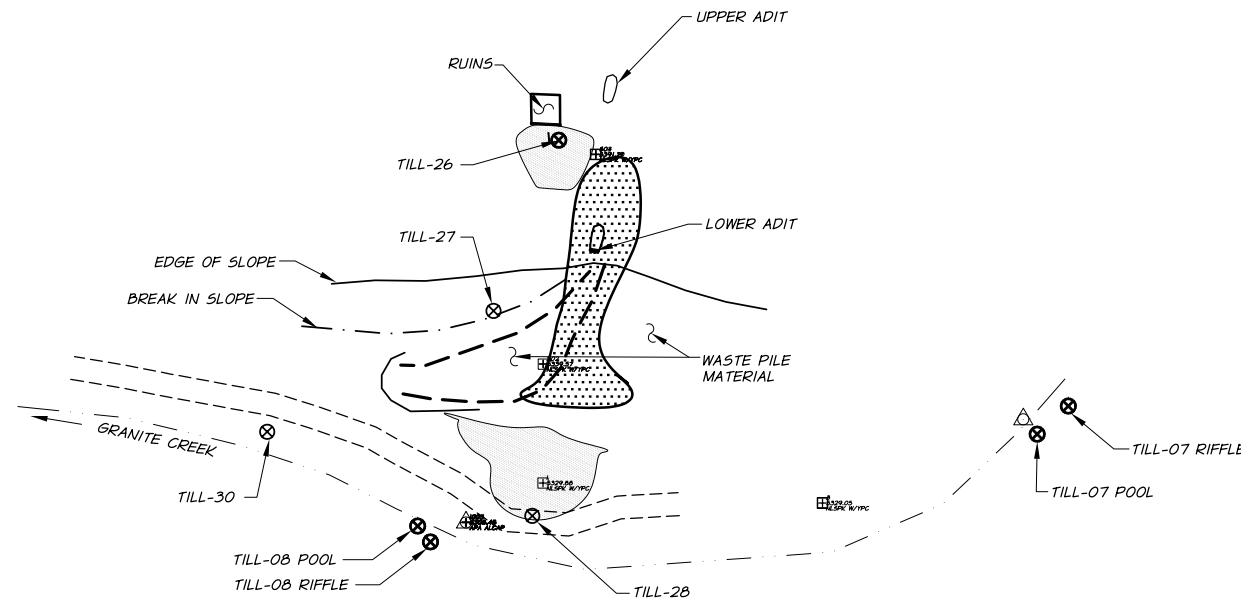


Figure 3. SHERIDAN MINE SITE



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LOCATED AND MISSING FLAGS TABLE				
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MINE SITE	STREAM	OTHER SURFACE WATER	SOIL	PLANT
TILlicUM	* TILL-07 * TILL-08	NONE	* TILL-26 ** TILL-27 * TILL-28 ** TILL-30	** TILL-27



LEGEND

- ⊗ SAMPLE LOCATION AND NO.
- △ APA ALUMINUM CAP WITH SURVEY MARKER NO., ELEVATION, AND DESCRIPTION
- APA CONTROL POINT NO., ELEVATION, AND DESCRIPTION
- COLLAPSED PORTAL
- OLD ROAD BED
- EROSION CHANNEL
- WASTE ROCK PILE
- ⋯ EXCAVATION

HORZ. DATUM NAD83 (1991) OREGON STATE PLANE SOUTH ZONE
VERT. DATUM NAVD88

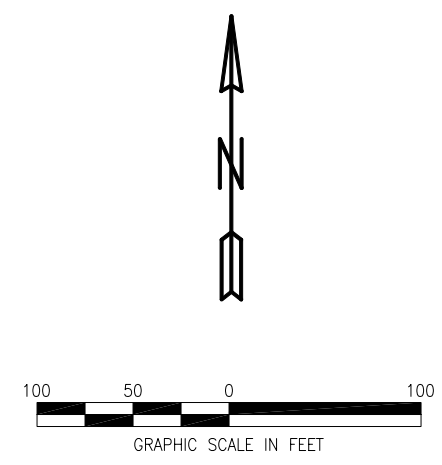


Figure 4. TILlicUM MINE SITE



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DATE:12/09/2003 TIME:11:00 DRAWN BY: EJM

LOCATED AND MISSING FLAGS TABLE				
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MINE SITE	STREAM	OTHER SURFACE WATER	SOIL	PLANT
CENTRAL	* CENT-09 * CENT-10	NONE	**CENT-21 **CENT-31 **CENT-32 **CENT-33	**CENT-31

LEGEND

- ⊗ SAMPLE LOCATION AND NO.
 - △ APA ALUMINUM CAP WITH SURVEY MARKER NO., ELEVATION, AND DESCRIPTION
 - APA CONTROL POINT NO., ELEVATION, AND DESCRIPTION
 - COLLAPSED PORTAL
 - - - OVERLAND RUNOFF ROUTE
 - ▨ WASTE ROCK PILE
 - ▩ EXCAVATION
 - ▧ BERM
- HORZ. DATUM NAD83 (1991) OREGON STATE PLANE SOUTH ZONE
VERT. DATUM NAVD88

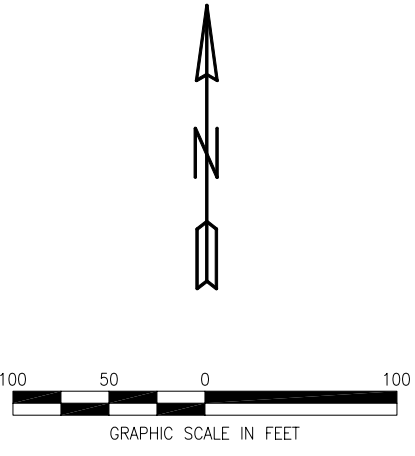
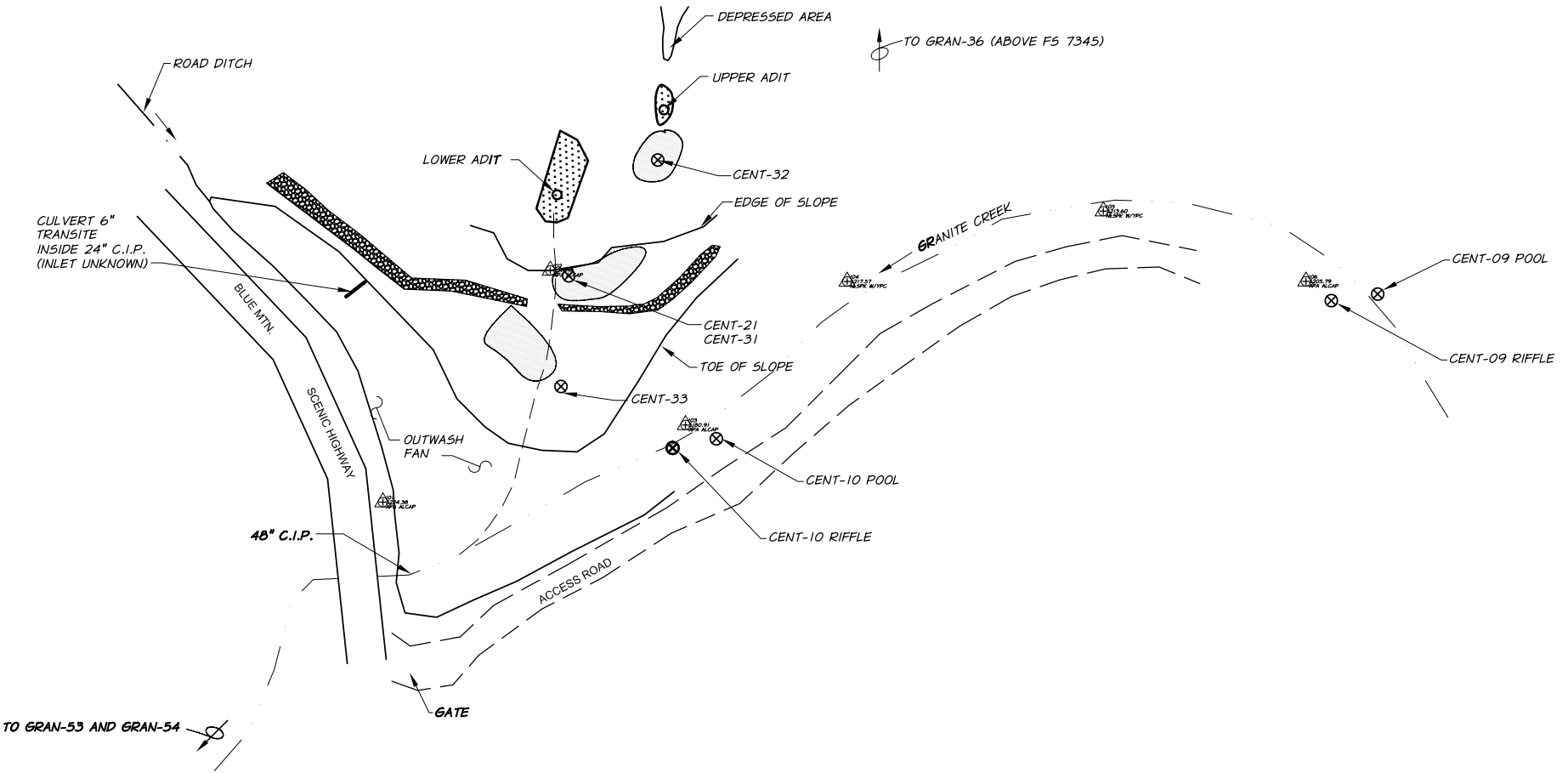


Figure 5. CENTRAL MINE SITE



DRAWING NAME: \\13890.13\FIGURES\CENTRAL\FIG5.DWG
DATE:12/09/2003 TIME:11:00 DRAWN BY: EJM

Tables

Table 1 Granite Creek Surface Water Analytical Results

			TAL Metals, µg/L													
			ALUMINIUM	ARSENIC	BARIUM	CALCIUM	CHROMIUM, TOTAL	IRON	LEAD	MAGNESIUM	MANGANESE	MERCURY	POTASSIUM	SELENIUM	SODIUM	ZINC
Sample No.																
Seeps	MONU	SP-SFW-18	<63.1U	81.8	67.7B	17400	<1.9U	<66.7U	<1.5U	4660B	2.9B	<0.1U	2440B	<1.7U	2940B	27.6
		SP-SFW-19	<63.1U	21.4	99.5B	22600	<1.9U	<66.7U	2.3B	7150	6.7B	<0.1U	2720B	2.6B	3310B	15.6B
		SP-SFW-51	<63.1U	<6U	75.6B	17800	<1.9U	<66.7U	2.1B	4530B	55.4	<0.1U	1610B	<1.7U	2630B	5B
Stream Samples	CAPM	ST-SFW-03	<23.6U	<4.8U	34.9B	5560	<1.4U	<33.3U	<1.3U	998B	<0.7U	<0.1U	1210B	<3.4U	2810B	2B
		ST-SFW-04	126B	<4.8U	41.5B	7060	<1.4U	94.1B	<1.3U	1320B	5.7B	<0.1U	1750B	<3.4U	3160B	2.6B
	SHER	ST-SFW-05	<23.6U	<4.8U	38.5B	7130	<1.4U	<33.3U	<1.3U	1330B	0.88B	<0.1U	2340B	<3.4U	3260B	2.5B
		ST-SFW-06	<23.6U	<4.8U	45.6B	8450	<1.4U	<33.3U	<1.3U	1720B	0.72B	<0.1U	1990B	<3.4U	3220B	2.3B
	TILL	ST-SFW-07	<63.1U	<6U	45.5B	8700	<1.9U	<66.7U	1.7B	1760B	<1.9U	<0.1U	1590B	<1.7U	3160B	2.9B
		ST-SFW-08	<23.6U	<4.8U	48.5B	9010	<1.4U	<33.3U	<1.3U	1820B	1.1B	<0.1U	2670B	<3.4U	3420B	3B
	CENT	ST-SFW-09	<63.1U	<6U	50.9B	9690	<1.9U	<66.7U	<1.5U	2010B	<1.9U	<0.1U	1620B	<1.7U	3240B	3.3B
		ST-SFW-10	<63.1U	<6U	52.9B	9910	<1.9U	<66.7U	<1.5U	2070B	<1.9U	<0.1U	1630B	<1.7U	3140B	3.5B
	GRAN	ST-SFW-53	79.3B	13.1	55B	15300	<1.4U	<16.8U	<1.3U	3540B	10.3B	0.2B	1870B	<1.7U	3380B	3.1B
		ST-SFW-54	26.4B	9.6B	51B	15900	0.74B	32.3B	<1.3U	4040B	6.7B	0.1B	2490B	<1.7U	3650B	<5.7U
Comparison	Criteria	EPA-Ecological	87	150	4	NA	71.8 314.7	1000	0.8 5.2	NA	120	0.77	NA	5	NA	113.6 523.8 7400
		EPA-Human Health	NA	0.018	1000	NA	NA	300	NA	NA	50	NA	NA	170	NA	NA
		Oak Ridge PRG	87	NA	4	NA	11	1000	3.2	NA	120	1.3	NA	0.39	NA	110
		OR-Ecological	87	NA	4	116000	83.5 365.9	1000	1.0 10.1	82000	120	0.012	53000	5	680000	115.2 531.2
		OR-Human Health	NA	0.022	1000	NA	50	300	50	NA	50	0.144	NA	10	NA	NA

Table 1 Granite Creek Surface Water Analytical Results, continued

			Laboratory General Chemistry										Field Parameters									
			ALKALINITY, BICARBONATE MG/L	CONDUCTANCE UMHOS/CM	HARDNESS MG/L	PH PH UNITS	REDOX POTENTIAL MV	SULFATE MG/L	SUSPENDED SOLIDS, TOTAL MG/L	SUSPENDED SOLIDS, VOLATILE MG/L	TOTAL ALKALINITY MG/L	TOTAL DISSOLVED SOLIDS MG/L	CHROMIUM, HEXAVALENT MG/L	CURRENT VELOCITY FT/SEC	DEPTH FT	DISSOLVED OXYGEN MG/L	PH PH UNITS	REDOX POTENTIAL MV	SPECIFIC CONDUCTANCE µS/CM ²	TEMPERATURE DEG C	TURBIDITY NTU	
Sample No.																						
Seeps	MONU	SP-SFW-18	47.1	141	104	6.9	289.5	24.6	36.1	8.1	47.1	116	0.01	NM	0.17	7.8	7.65	16.8	148	7.01	4.68	
		SP-SFW-19	72.1	182	132	7.5	261	23.5	50.7	19.8	72.1	123	0.01	0.14	0.17	10.21	7.9	17.8	185	10.64	0.72	
		SP-SFW-51	44.5	139	64	7	274.5	26	30.6	17.7	44.5	107	0.01	NM	0.38	7.35	7.76	-22.4	142	8.36	2.34	
Stream Samples	CAPM	ST-SFW-03	25.7	46.7	112	7.3	266.5	5	2.7	<5U	25.7	39	0.01	NM	0.58	11.29	7.96	30.0	48	9.58	0.44	
		ST-SFW-04	30.2	55	128	7.2	269	5.2	5.4	<5U	30.2	40	0.01	NM	0.67	10.7	7.87	42	57	10.7	0.71	
	SHER	ST-SFW-05	32	57	160	7.6	157	5.1	2.4	<5U	32	51	0.00	0.34	1.0	10.7	8.27	4.2	60	10.72	0.37	
		ST-SFW-06	35.4	69.3	88	7.6	162.5	5.9	1.3	<5U	35.4	64	0.01	0.23	2.0	10.73	8.28	0.8	70	11.14	0.41	
	TILL	ST-SFW-07	37.3	73.1	96	7.6	173	5.9	1.8	<5U	37.3	64	0.01	0.21	0.75	10.62	8.08	64.4	73	12.43	0.27	
		ST-SFW-08	37.7	73	100	7.7	156.5	6.2	9.2	<5U	37.7	65	0.01	0.1	1.54	10.24	8.08	54.3	75	12.31	0.48	
	CENT	ST-SFW-09	40.1	78	108	7.6	171.5	6	1.6	<5U	40.1	61	0.01	NM	1.14	10.78	8.1	8.7	80	10.49	0.57	
		ST-SFW-10	41	78.9	100	7.6	258.5	6.1	1.8	<5U	41	70	0.01	NM	0.6	10.37	8.09	16	80	13.02	0.4	
	GRAN	ST-SFW-53	46.9	108	80	7.6	184	14.8	7.2	<5U	46.9	100	0	0.03	0.58	10.2	7.81	78.4	122	14.96	0.58	
		ST-SFW-54	51.2	112	104	7.7	181	15.3	5	<5U	51.2	116	0	0.08	0.83	10.58	8.49	-7.5	133	14.04	5	
Comparison	Criteria	EPA-Ecological			>20	6.5-9			NA		NA				8	6.5-9						
		EPA-Human Health			NA	5-9			NA		250					NA	5-9					
		Oak Ridge PRG			NA	NA			NA		NA					NA	NA					
		OR-Ecological			NA	6.5-9			NA		500					6-11	6.5-9					
		OR-Human Health			NA	NA			NA		NA					NA	NA					

Table 1 Granite Creek Surface Water Analytical Results, continued**Notes**

- **Bold, shaded results indicate concentrations above the lowest applicable comparison criterion.**
- Cyanide (total) was analyzed for but not detected in any sample.
- All alkalinity was contributed by bicarbonate: carbonate and hydroxide were not detected in any samples.
- The following dissolved metals were analyzed for but not detected in any sample: antimony, beryllium, cadmium, cobalt, copper, nickel, silver, thallium, and vanadium.
- There were no comparison criteria for total chromium (Cr); therefore, the most conservative criteria, for Cr 6, were used.
- Hardness-based criteria for cadmium, chromium, copper, lead, nickel, and zinc were calculated for each sample. The range of calculated criteria is indicated, the top number indicating the lowest and the bottom number the highest.

U = Analyte was analyzed for but not detected.

B = Analyte was detected at a concentration between the method detection limit (MDL) and practical quantitation limit (PQL).

NA = Not available.

NM = Not measureable.

Empty cells in the table indicate no data.

Units:

DEG C = Degrees Celsius

MV = Millivolts

FT = Feet

NTU = Nephelometric turbidity units

FT/SEC = Feet per second

UG/L = Micrograms per liter

MG/L = Milligrams per liter

UMHOS/CM = Micro MHOS per centimeter

uS/CM³ = Microsiemens per cubic centimeter

Comparison Criteria

Oregon Ecological - Criteria are the lowest of:

- ODEQ Water Quality Criteria, Protection of Aquatic Life, Fresh Chronic Criteria (OAR 340-041-001), or
- ODEQ (1998b) Guidance for Ecological Risk Assessment, Level II Screening Values for surface water.

EPA Ecological - Criteria are the lowest of:

- USEPA (2002) recommended ambient water quality criteria for freshwater aquatic organisms, chronic; hardness dependent values were calculated for each sample, or
- USEPA (2002) recommended ambient water quality criteria for freshwater aquatic organisms, Tier II secondary chronic values calculated by Oak Ridge National Laboratory (Suter & Tsao 1996).

Oak Ridge PRGs - Oak Ridge National Laboratory Preliminary Remediation Goals (Efroymson et al 1997).

Oregon Human Health - ODEQ Water Quality Criteria, Protection of Human Health, Water and Fish Ingestion (OAR-340-041-001).

EPA Human Health - USEPA (2002) recommended ambient water quality criteria for protection of human consumption of fish; hardness dependent values were calculated for each sample, the range of values is indicated.

Table 2 Granite Creek Pore Water Analytical Results

			TAL Metals, µg/L													Field Parameters							
			ALUMINUM	ARSENIC	BARIUM	CALCIUM	IRON	LEAD	MAGNESIUM	MANGANESE	MERCURY	POTASSIUM	SELENIUM	SODIUM	THALLIUM	ZINC	CHROMIUM, HEXAVALENT MG/L	DISSOLVED OXYGEN MG/L	PH PH UNITS	REDOX POTENTIAL MV	SPECIFIC CONDUCTANCE µS/CM	TEMPERATURE DEG C	TURBIDITY NTU
Sample No.																							
Stream Samples	CAPM	ST-PWP-03	<23.6U	<4.8U	31B	5520	<33.3U	<1.3U	1010B	1.1B	<0.1U	514B	<3.4U	2840B	<5.7U	2.4B	0.00	10.07	7.94	21.4	49	11.29	53.0
		ST-PWP-04	<23.6U	<4.8U	36.2B	6730	<33.3U	<1.3U	1240B	2.3B	<0.1U	<393U	<3.4U	3060B	<5.7U	1.7B	0.01	9.57	8.09	19.2	57	12.51	36.5
	SHER	ST-PWP-05	<23.6U	<4.8U	36B	6910	<33.3U	<1.3U	1290B	0.7B	<0.1U	415B	<3.4U	2980B	<5.7U	2.8B	0.01	10.02	8.24	9.6	59	10.83	15.9
		ST-PWP-06	<23.6U	6.1B	38.4B	13200	<33.3U	<1.3U	2460B	1.1B	<0.1U	1060B	<3.4U	4550B	<5.7U	2.7B	0.01	9.64	8.24	5.7	75	10.48	34.4
	TILL	ST-PWP-07	<23.6U	6.1B	49.4B	8780	<33.3U	<1.3U	1800B	4B	<0.1U	1890B	3.5B	3600B	<5.7U	4.1B	0.01	10.4	8.14	20.8	81	12.65	18.3
		ST-PWP-08	<23.6U	<4.8U	44.3B	8320	<33.3U	<1.3U	1700B	1.5B	<0.1U	1640B	<3.4U	3540B	<5.7U	2.5B		9.53	8.32	22.9	70	14.56	18.3
	CENT	ST-PWP-09	<63.1U	<6U	49.6B	9940	<66.7U	2.4B	2110B	4.9B	<0.1U	1650B	<1.7U	3280B	<2.8U	3.1B	0.01	10.4	8.16	8.3	80	10.9	23.6
		ST-PWP-10	<63.1U	<6U	53.4B	11200	<66.7U	1.9B	2280B	<1.9U	<0.1U	1820B	<1.7U	3550B	<2.8U	4.8B	0.01	8.02	7.86	32.2	90	12.88	76.9
		ST-PWR-10	<63.1U	<6U	60.8B	9890	<66.7U	2.4B	2080B	5.1B	<0.1U	2390B	<1.7U	4070B	<2.8U	5.5B	0.01	7.9	8.0	50.9	87	12.9	231
	GRAN	ST-PWP-53	60.5B	16.7	47.6B	15500	23.3B	<1.3U	3580B	4B	<0.1U	2000B	<1.7U	3420B	4.1B	5.9B	0.00	9.35	8.2	83.9	124	15.9	61.8
ST-PWP-54		45.7B	13.2	45.9B	16700	<16.8U	<1.3U	4440B	4.4B	0.12B	1830B	<1.7U	3540B	<2.8U	5.4B	0	10.79	8.45	10.2	138	12.08	176	
Comparison	Criteria	EPA-Ecological	87	150	4	NA	1000	0.8 5.2	NA	120	0.77	NA	5	NA	12	113.6 523.8	8	6.5-9					
		Oak Ridge PRG	87	NA	4	NA	1000	3.2	NA	120	1.3	NA	5	NA	12	110	NA	NA					
		OR-Ecological	87	NA	4	116000	1000	1.0 10.1	82000	120	0.012	53000	5	680000	40	115.2 531.2	6-11	6.5-9					

Table 2 Granite Creek Pore Water Analytical Results, continued**Notes**

- **Bold, shaded results indicate concentrations above the lowest applicable comparison criterion.**
- Cyanide (total) was analyzed for but not detected in any sample.
- All alkalinity was contributed by bicarbonate; carbonate and hydroxide were not detected in any samples.
- The following dissolved metals were analyzed for but not detected in any sample: antimony, beryllium, cadmium, chromium, cobalt, copper, nickel, silver, and vanadium.
- There were no comparison criteria for total chromium (Cr); therefore, the most conservative criteria, for Cr 6, were used.
- Hardness-based criteria for cadmium, chromium, copper, lead, nickel, and zinc were calculated for each sample. The range of calculated criteria is indicated, the top number indicating the lowest and the bottom number the highest.

U = Analyte was analyzed for but not detected.

B = Analyte was detected at a concentration between the method detection limit (MDL) and practical quantitation limit (PQL).

NA = Not available.

Empty cells in the table indicate no data.

Units:

DEG C = Degrees Celsius

FT = Feet

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MG/L = Milligrams per liter

$\mu\text{S}/\text{CM}^3$ = Microsiemens per cubic centimeter

MV = Millivolts

NTU = Nephelometric turbidity units

UG/L = Micrograms per liter

Comparison Criteria

Oregon Ecological - Criteria are the lowest of:

- ODEQ Water Quality Criteria, Protection of Aquatic Life, Fresh Chronic Criteria (OAR 340-041-001), or
- ODEQ (1998b) Guidance for Ecological Risk Assessment, Level II Screening Values for surface water.

EPA Ecological - Criteria are the lowest of:

- USEPA (2002) recommended ambient water quality criteria for freshwater aquatic organisms, chronic; hardness dependent
- USEPA (2002) recommended ambient water quality criteria for freshwater aquatic organisms, Tier II secondary chronic

Oak Ridge PRGs - Oak Ridge National Laboratory Preliminary Remediation Goals (Efroymson et al 1997).

Oregon Human Health - ODEQ Water Quality Criteria, Protection of Human Health, Water and Fish Ingestion (OAR-340-041-001).

EPA Human Health - USEPA (2002) recommended ambient water quality criteria for protection of human consumption of fish; hardness dependent values were calculated for each sample, the range of values is indicated.

Table 3 Granite Creek Sediment Analytical Results

			TAL Metals, mg/kg																							
			ALUMINUM	ANTIMONY	ARSENIC	BARIUM	BERYLLIUM	CADMIUM	CALCIUM	CHROMIUM, TOTAL	COBALT	COPPER	IRON	LEAD	MAGNESIUM	MANGANESE	MERCURY	NICKEL	POTASSIUM	SELENIUM	SILVER	SODIUM	THALLIUM	VANADIUM	ZINC	
Sample No.																										
Stream Samples	CAPM	ST-PSD-03	4360	1.2B	13.8	76.3	0.32B	<0.053U	2050	45.6	6.4	2.5	40000	4.4	1520	162	<0.019U	5.5	950	0.88	0.22B	<41.6U	1.8	154	23	
		ST-PSD-04	6260	1.5B	19.5	127	0.38B	<0.053U	1650	5.2	6.3	3.1	11600	4.9	3330	159	<0.02U	4.3	2020	0.34B	0.58B	<41.9U	<0.25U	28.5	43.7	
		ST-RSD-03	3820	<0.4U	17.4	68.2	0.2B	<0.062U	1430	12.9	3.7B	1.3B	15400	4.1	1600	171	<0.019U	2.2B	1070	0.43B	<0.094U	96.8B	<0.29U	50.2	21.8	
		ST-RSD-04	5940	<0.41U	44.2	92.5	0.23B	0.074B	2070	6.1	4.7B	2.1B	12400	6.3	3390	203	<0.021U	2.7B	1320	0.35B	0.86B	120B	<0.31U	29.5	34	
	SHER	ST-PSD-05	6670	<0.39U	18.7	126	0.27B	<0.062U	1820	7	5.7	2.4B	14500	6.4	3530	187	<0.021U	3.2B	2190	0.5B	0.64B	<48.9U	<0.29U	36.6	41.9	
		ST-PSD-06	9210	<0.41U	18.6	170	0.36B	<0.065U	2130	8.1	8.2	3	18800	4.9	5550	343	0.027B	4.4	3000	0.57	0.54B	<50.9U	0.5B	45.3	63.3	
		ST-RSD-05	6030	<0.4U	23	105	0.24B	<0.063U	1950	9.7	4.6B	2.9	15200	3.8	2600	169	<0.023U	3.1B	1630	0.41B	<0.094U	76B	<0.29U	45.9	38.7	
		ST-RSD-06	4640	0.92B	9.3	92.1	0.32B	<0.059U	1900	24.9	6	2.4B	29900	4.4	2220	156	0.037B	4.3	1420	0.63	0.24B	<46.8U	1.1	113	35.6	
	TILL	ST-PSD-07	6980	<0.36U	21.6	127	0.3B	<0.057U	2040	11.5	5.7	10.6	19100	5.3	3080	202	0.087	3.6B	2100	0.4B	0.83B	<44.8U	0.3B	57.5	62.6	
		ST-PSD-08	11700	<0.55U	25.9	217	0.47B	<0.086U	2990	10.7	9.6	7.8	24600	6.7	6100	342	0.12	5.7B	3870	0.73	0.63B	<68U	0.44B	61.9	94.2	
		ST-RSD-07	9650	<0.42U	19.3	174	0.39B	<0.066U	2330	10.1	8	3.5	22000	4.3	5160	277	0.05	4.4	3500	0.37B	1.9	<52.2U	0.59B	58.5	57.7	
		ST-RSD-08	8350	<0.4U	14.8	158	0.39B	<0.063U	2310	15.3	8.2	7.7	25300	5.7	5210	283	0.058	4.8	3330	0.34B	0.73B	<49.8U	0.69B	76.2	58.1	
	CENT	ST-PSD-09	3990	<0.42U	9.6	52.3	0.11B	0.069B	1240	2.3	1.9B	1.5B	5650	2.2	1370	100	<0.019U	1.1B	762	0.29B	<0.1U	230B	<0.31U	13	20.7	
		ST-PSD-10	6680	0.74B	22.5	109	0.29B	0.12B	1710	9	5.1B	12.2	16100	8	2840	177	0.07	3.2B	2000	0.63	0.49B	79.7B	<0.33U	46	50.2	
		ST-RSD-09	6190	0.56B	57.9	101	0.27B	0.62	1820	10	5.2	7.7	16900	52.4	3130	177	0.031B	3.2B	1920	0.4B	1	<44.1U	0.51B	51.2	75.1	
		ST-RSD-10	6850	1B	29	116	0.36B	<0.068U	2300	24.3	7.9	8.9	33700	9.5	3490	193	0.034B	5.2	2410	0.58	0.92B	<53.2U	1.4	117	64.9	
	GRAN	ST-PSD-53	10200	2B	130	139	0.24B	0.96	2180	10.4	6.9	18.1	21600	38.2	4790	364	0.11	6.2	2840	0.44B	1.8	<45.2U	0.69B	52.1	150	
		ST-PSD-54	8910	5.1B	303	144	0.26B	2.8	2740	10.9	6.5	28	18900	148	3460	611	0.32	7.6	2400	0.8	7.9	70.2B	<0.67U	43	186	
		ST-RSD-53	9670	2.3B	126	127	0.25B	1.2	2230	9.9	6.2	18.6	19000	44.3	4030	360	0.12	6.5	2550	0.42B	4.9	<45.9U	0.73B	45.9	148	
		ST-RSD-54	7770	5.1B	246	126	0.21B	1.8	1750	8.3	6.4	30	18300	121	3380	560	0.12	7.3	2340	0.63	6.3	79.5B	0.76B	38.3	151	
Comparison	Criteria	ER-L	NA	NA	8.2	NA	NA	1.2	NA	81	NA	34	NA	47	NA	NA	0.15	21	NA	NA	1	NA	NA	NA	150	
		ER-M	NA	NA	70	NA	NA	9.6	NA	370	NA	270	NA	218	NA	NA	0.71	51.6	NA	NA	3.7	NA	NA	NA	410	
		OR	NA	3	NA	NA	NA	0.6	NA	37	NA	36	NA	35	NA	1100	0.2	18	NA	NA	4.5	NA	NA	NA	123	
		PEL	NA	NA	41.6	NA	NA	4.21	NA	160	NA	108	NA	112	NA	NA	0.696	42.8	NA	NA	1.77	NA	NA	NA	271	
		TEL	NA	NA	7.24	NA	NA	0.676	NA	52.3	NA	18.7	NA	30.2	NA	NA	0.13	15.9	NA	NA	0.733	NA	NA	NA	124	

Table 3 Granite Creek Sediment Analytical Results, continued

		Lab		Grain Size, percent					
		TOC LLOYD KHAN MG/KG	GRAVEL %	SAND, COARSE %	SAND, FINE %	SAND, MEDIUM %	SILT %	CLAY %	
Sample No.									
Stream Samples	CAPM	ST-PSD-03	2100	20.3	25.8	11.2	40.7	0.8	1.1
		ST-PSD-04	2550	0	14.9	8.7	73.7	2	0.6
		ST-RSD-03	133	16.2	29.4	13.6	38.4	1.3	1
		ST-RSD-04	<130U	10.5	28.4	10.9	47.4	2.3	0.5
	SHER	ST-PSD-05	<132U	6.8	23	16.1	52.6	0.9	0.6
		ST-PSD-06	<137U	0	10.6	12.9	73.2	2.7	0.5
		ST-RSD-05	2490	5.4	23.2	22.1	46.3	1.9	1.2
		ST-RSD-06	<114U	33.2	22.1	15.4	27.2	1.5	0.7
	TILL	ST-PSD-07	10500	3.5	29.9	17.9	43.2	3.3	2.1
		ST-PSD-08	3180	0.8	13.8	25.6	50.9	4.8	4.1
		ST-RSD-07	496	12.3	28.4	12	42.5	2.3	2.6
		ST-RSD-08	3240	19.2	44.7	5.2	23.7	6.9	0.3
	CENT	ST-PSD-09	381	6.7	44.6	8.3	35	4.5	0.9
		ST-PSD-10	941	6.1	38.8	6.9	46.7	0.9	0.6
		ST-RSD-09	4200	8.2	28.8	17.1	44.1	1.1	0.6
		ST-RSD-10	1000	5.5	26.7	14.4	50.7	2.2	0.5
	GRAN	ST-PSD-53	2670	8.8	12.2	28.3	42.1	5.1	3.5
		ST-PSD-54	27700	1.1	6.9	45.7	37.5	4.3	4.6
		ST-RSD-53	6750	14.7	8.7	36.2	34.2	3.8	2.2
		ST-RSD-54	<121U	7.4	11.8	28.1	48.3	2	2.4

Table 3 Granite Creek Sediment Analytical Results, continued**Notes**

Bold, shaded results indicate concentrations above the lowest applicable comparison criterion.

Cyanide (total) was analyzed for but not detected in any sample.

U = Analyte was analyzed for but not detected.

B = Analyte was detected at a concentration between the method detection limit (MDL) and practical quantitation limit (PQL).

NA = Not available.

Units:

MG/KG = Milligrams per kilogram

Comparison Criteria

- Threshold Effects Level (TEL) and Probable Effects Level (PEL) from USEPA National Sediment Quality Survey, Screening Values for Chemicals Evaluated, http://www.epa.gov/waterscience/cs/vol11/appdx_d.pdf.
- Effects Range-Low (ER-L) and Effects Range-Medium (ER-M), National Oceanic and Atmospheric Administration (NOAA), from USEPA (1997) National Sediment Quality Survey, Screening Values for Chemicals Evaluated.
- ODEQ (1998) Guidance for Ecological Risk Assessment, Level II Screening Values for freshwater sediment (there was no criterion for total arsenic; therefore, the most conservative criterion, for arsenic 3, was used).

Oak Ridge National Laboratory values are not included; they are compiled from TEL and ER-L values, and USEPA Assessment and Remediation of Contaminated Sediment (ARCS) program values which exceed TELs.

Sediment samples analyzed for clay mineralogy were collected in pool habitat only.

Table 4 Granite Creek Surface and Subsurface Soil Analytical Results, continued

			TAL Metals by SPLP, µg/L																							
			ALUMINUM	ANTIMONY	ARSENIC	BARIUM	BERYLLIUM	CADMIUM	CALCIUM	CHROMIUM, TOTAL	COBALT	COPPER	IRON	LEAD	MAGNESIUM	MANGANESE	MERCURY	NICKEL	POTASSIUM	SELENIUM	SILVER	SODIUM	THALLIUM	VANADIUM	ZINC	
Sample No.																										
Background	LUCA	BG-SSS-19(0.5)	534	<3.8U	<2.4U	9.9B	<0.2U	0.33B	1440B	1.1B	<1.8U	3.9B	266	1.7B	347B	31.4	<10U	<2U	711B	2B	<0.9U	5140	<2.8U	<2.2U	<5.7U	
	GRAN	BG-SSS-34(0.5)	1010	4.1B	<2.4U	11.5B	<0.2U	<0.3U	777B	0.99B	<1.8U	4.7B	405	3B	<293U	19.9	20	<2U	651B	3B	<0.9U	17400	<2.8U	<2.2U	13.2B	
		BG-SSS-35(0.5)	1380	<3.8U	<2.4U	13.3B	<0.2U	<0.3U	1200B	1.1B	<1.8U	5B	362	<1.5U	<293U	6.8B	14.4B	<2U	475B	2.3B	<0.9U	15500	<2.8U	<2.2U	7.8B	
		BG-SSS-36(0.5)	10100	3.9B	6.5B	165B	<0.2U	<0.3U	2040B	4.9B	2.4B	8.5B	5070	3.3	930B	211	21	5B	1770B	3.7B	<0.9U	18900	<2.8U	10.2B	25.2	
On Site	MONU	ML-SSS-12(0.7)	732	8.7B	8.5B	<7.3U	<0.2U	<0.3U	<223U	<0.6U	<1.8U	4.7B	744	2.9B	<182U	19.1	<10U	<2U	<250U	<1.7U	<0.9U	16500	<2.8U	2.9B	7.9B	
		ML-SSS-16(0.5)	354	463	719	51.6B	<0.2U	0.54B	22500	<0.6U	<1.8U	5.6B	<16.8U	3.4	207B	23	<10U	<2U	900B	<1.7U	<0.9U	11600	<2.8U	<2.2U	21.6	
		ML-SSS-38(0.5)	802	8.9B	7.2B	114B	<0.2U	2B	2110B	<0.6U	<1.8U	39.8	248	4	363B	28	<10U	<2U	<250U	<1.7U	<0.9U	15600	<2.8U	<2.2U	132	
		WP-SSS-13(1.0)	64.5B	4.8B	4B	18.5B	<0.2U	<0.3U	2070B	<0.6U	<1.8U	6.5B	<16.8U	<1.5U	350B	1.1B	<10U	<2U	1100B	<1.7U	<0.9U	97400	<2.8U	<2.2U	<5.7U	
		WP-SSS-17(1.0)	608	52.8B	716	<7.3U	<0.2U	1.3B	387B	<0.6U	<1.8U	27.2	437	101	189B	6.2B	35.9	<2U	<250U	<1.7U	5.1B	2330B	<2.8U	<2.2U	94.3	
		WP-SUS-14(3.5)	510	14.8B	36.2	14.5B	<0.2U	<0.3U	5340	<0.6U	<1.8U	10B	93.3B	1.8B	2470B	0.87B	<10U	<2U	385B	<1.7U	<0.9U	37800	<2.8U	2.2B	12.2B	
		WP-SUS-15(4.0)	254	8.8B	49.1	22.5B	<0.2U	<0.3U	6760	<0.6U	<1.8U	5B	148	2.7B	2740B	1.5B	<10U	<2U	349B	<1.7U	<0.9U	60600	<2.8U	<2.2U	6.9B	
	CAPM	WP-SUS-20(4.0)	7060	<3.8U	4.7B	53.1B	<0.2U	<0.3U	1270B	2.7B	<1.8U	6.1B	5440	2.2B	834B	54.7	16.5B	<2U	794B	<1.7U	<0.9U	6250	<2.8U	14.4B	22.3	
		WP-SUS-21(2.5)	126B	6.3B	21.2	16.1B	<0.2U	<0.3U	11200	0.96B	<1.8U	8.7B	255	2.3B	1190B	5B	20.2	<2U	2990B	3.3B	<0.9U	5610	<2.8U	<2.2U	36.3	
		WP-SUS-39(2.0)	3200	<3.8U	2.7B	32B	<0.2U	<0.3U	766B	1.9B	<1.8U	6B	2170	2.1B	320B	51	17.1B	<2U	479B	<1.7U	<0.9U	16100	<2.8U	4.3B	17.1B	
	SHER	WP-SUS-23(3.5)	737	5.7B	<2.4U	7.9B	<0.2U	<0.3U	453B	1.3B	<1.8U	6.3B	427	19.2	<293U	12.3B	11.2B	<2U	1080B	<1.7U	1.2B	1300B	<2.8U	<2.2U	13.7B	
		WP-SSS-28(0.8)	265	3.9B	<2.4U	12B	<0.2U	<0.3U	8680	<0.6U	<1.8U	2.8B	40.8B	<1.5U	1140B	<0.7U	<10U	<2U	1630B	<1.7U	<0.9U	5640	<2.8U	<2.2U	8.1B	
	TILL	WP-SUS-26(3.0)	1520	7.1B	18.5	53B	<0.2U	0.46B	10000	<0.6U	<1.8U	6.1B	1810	15.2	1670B	37.3	<10U	<2U	1590B	<1.7U	1.3B	7510	<2.8U	4.8B	31	
		WP-SUS-27(4.5)	3560	4.1B	9.6B	48B	<0.2U	<0.3U	1120B	<0.6U	<1.8U	3.5B	3130	8.1	588B	113	<10U	<2U	1040B	<1.7U	<0.9U	6830	<2.8U	8.4B	30.9	
WP-SUS-31(4.5)		5600	<4.7U	55.4	45.1B	<0.2U	<0.6U	1900B	4.8B	<2U	19.4B	5300	14.8	718B	75	<10U	3.8B	1270B	<3.4U	2.3B	60200	<5.7U	13.1B	39.6		
CENT	WP-SUS-32(4.0)	3920	<3.8U	23.2	32.8B	<0.2U	<0.3U	2240B	<0.6U	<1.8U	4.6B	2790	5.4	751B	48.4	<10U	3B	264B	<1.7U	<0.9U	70000	<2.8U	8.9B	18.1B		

Table 4 Granite Creek Surface and Subsurface Soil Analytical Results, continued

			Lab	Acid/Base Accounting							
Sample No.			PH PH UNITS	FIZZ RATING NO UNITS	MAXIMUM POTENTIAL ACIDITY KG CaCO ₃ /TON	NEUTRALIZATION POTENTIAL KG CaCO ₃ /TON	PASTE PH PH UNITS	SULFATE SULFUR WT. %	SULFIDE SULFUR WT. %	TOTAL SULFUR WT. %	NET NEUTRALIZATION POTENTIAL KG CaCO ₃ /TON
Background	LUCA	BG-SSS-19(0.5)	5.9	none	<0.6	-6.0	5.7	<0.01	< .02	< .02	-6.0
		GRAN	BG-SSS-34(0.5)	6.4	none	<0.6	-5.0	6.0	<0.01	< .02	< .02
		BG-SSS-35(0.5)	6.7	none	<0.6	-5.0	6.4	<0.01	< .02	< .02	-5.0
		BG-SSS-36(0.5)	6.6	none	<0.6	0.5	6.3	<0.01	< .02	< .02	0.5
On Site	MONU	ML-SSS-12(0.7)	6.4	none	<0.6	3.7	6.5	<0.01	<0.02	< .02	3.7
		ML-SSS-16(0.5)	4.6	none	2.2	-4.5	4.7	0.28	0.07	0.35	-6.7
		ML-SSS-38(0.5)	3.5	none	5.0	-6.0	3.2	0.24	0.16	0.4	-11.0
		WP-SSS-13(1.0)	4	none	1.9	-0.5	4.2	0.07	0.06	0.13	-2.4
		WP-SSS-14(0.7)	8.4								
		WP-SSS-15(0.5)	7.8								
		WP-SSS-17(1.0)	6.8	none	3.8	3.5	6.3	0.02	0.12	0.14	-0.3
		WP-SUS-14(3.5)	8.6	slight	14.4	31.7	8.1	<0.01	0.46	0.46	17.3
	WP-SUS-15(4.0)	8.5	slight	17.5	18.2	7.8	<0.01	0.56	0.56	0.7	
	CAPM	TA-SUS-22(1.5)	7.1								
		WP-SUS-20(4.0)	7.4	none	<0.6	3.3	7.2	<0.01	< .02	< .02	3.3
		WP-SUS-21(2.5)	8	none	7.8	11.0	7.7	<0.01	0.25	0.25	3.2
		WP-SUS-39(2.0)	4.9	none	<0.6	-1.3	5.1	<0.01	< .02	< .02	-1.3
	SHER	TA-SUS-25(1.5)	6.8								
		WP-SUS-23(3.5)	7	none	<0.6	4.8	7.2	<0.01	< .02	< .02	4.8
	TILL	TA-SSS-30(0.4)	6.9								
		WP-SSS-27(0.8)	6.6								
		WP-SSS-28(0.8)	8.6	moderate	23.1	86.4	8.0	<0.01	0.74	0.74	63.3
		WP-SUS-26(3.0)	6.6	none	5.3	8.7	7.0	0.01	0.17	0.18	3.4
		WP-SUS-27(4.5)	7.4	none	<0.6	2.2	7.5	<0.01	< .02	< .02	2.2
CENT	TA-SUS-33(1.5)	7									
	WP-SSS-31(0.5)	6.5									
	WP-SUS-31(4.5)	7.2	none	<0.6	2.5	7.1	<0.01	< .02	< .02	2.5	
	WP-SUS-32(4.0)	6.7	none	<0.6	2.2	7.0	<0.01	< .02	< .02	2.2	

Table 4 Granite Creek Surface and Subsurface Soil Analytical Results, continued**Notes**

Bold, shaded results indicate concentrations above the lowest applicable comparison criterion.

Cyanide (total) was analyzed for but not detected in any sample.

U = Analyte was analyzed for but not detected.

B = Analyte was detected at a concentration between the method detection limit (MDL) and practical quantitation limit (PQL).

NA = Not available.

Empty cells in the table indicate no data.

Units:

MG/KG = Milligrams per kilogram

UG/L = Micrograms per liter

Comparison Criteria

- OR Ecological - ODEQ (1998) Guidance for Ecological Risk Assessment, Level II Screening Values - lowest criteria for bird, plant, invertebrate, and mammal.
- EPA Ecological - EPA (2000b) Ecological Soil Screening Levels - Lowest Criteria Indicators for bird, plant, invertebrate, and mammal.
- Oak Ridge National Laboratory, US DOE (Efroymsen et al 1997), Preliminary Remediation Goals (PRGs) for protection of plants, wildlife, or soil invertebrates.
-
- EPA Human Health Criteria - Generic Soil Screening Levels (SSLs) for Protection of Human Health EPA (2000a).
- EPA Region 9 PRGS for industrial soil (<http://www.epa.gov/region09/waste/sfund/prg/index.htm>).

Table 5 Granite Creek Plant Tissue Analytical Results

			TAL Metals, mg/kg																	
			ALUMINUM	ARSENIC	BARIUM	BERYLLIUM	CADMIUM	CALCIUM	CHROMIUM, TOTAL	COPPER	IRON	LEAD	MAGNESIUM	MANGANESE	MERCURY	POTASSIUM	SELENIUM	SODIUM	VANADIUM	ZINC
Sample No.																				
Background	LUCA	BG-PLT-19	72.7	<1.3U	252	0.12B	<0.16U	12400	<0.37U	5.7B	132	1.1	4330	238	<0.051U	16500	1.4	330B	<0.52U	21.4
	GRAN	BG-PLT-34	143	<1.2U	341	0.071B	0.37B	13300	<0.36U	4.3B	181	1.1	4280	262	<0.045U	16800	<0.86U	311B	<0.51U	18.1
		BG-PLT-35	312	<1.3U	368	0.12B	<0.16U	10400	<0.37U	4.6B	315	0.91	4290	202	<0.052U	19600	1.2B	340B	0.94B	14.2
		BG-PLT-36	213	<1.1U	505	0.054B	<0.13U	17300	<0.31U	4.8B	247	0.38B	4570	324	<0.045U	16200	0.95B	285B	0.6B	13.4
On Site	MONU	WP-PLT-14	220	10.6	86.3	0.16B	1B	12000	<0.38U	5B	642	2.7	4640	118	<0.052U	15900	<0.92U	381B	1.2B	53.6
		WP-PLT-15	206	6.1	51.9B	0.13B	0.78B	9750	<0.38U	5.1B	535	1.2	4500	169	<0.046U	14900	<0.93U	428B	0.95B	35.9
	CAPM	WP-PLT-20	257	<1.2U	231	0.096B	<0.15U	12700	<0.36U	4.6B	262	0.5B	4030	162	0.063B	15900	<0.87U	289B	0.76B	16.7
	SHER	WP-PLT-23	153	<1.3U	247	0.11B	0.5B	12200	<0.37U	4.6B	197	1.3	4690	291	0.05B	16700	0.91B	370B	0.81B	27.2
	TILL	WP-PLT-27	284	1B	272	0.087B	2.6	20000	0.48B	5	427	2.7	4120	158	0.07B	13700	0.7B	262B	0.9B	70.2
	CENT	WP-PLT-31	251	<1.4U	290	0.13B	0.85B	17800	1.7B	6.1B	409	2.1	5310	191	0.092B	15100	<0.97U	338B	0.97B	43.7

Notes

Cyanide was analyzed for but was not detected in any sample.

The following metals were analyzed for but not detected in any sample: antimony, cobalt, nickel, silver, and thallium.

U = Analyte was analyzed for but not detected.

B = Analyte was detected at a concentration between the method detection limit (MDL) and practical quantitation limit (PQL).

Units:

MG/KG = Milligrams per kilogram