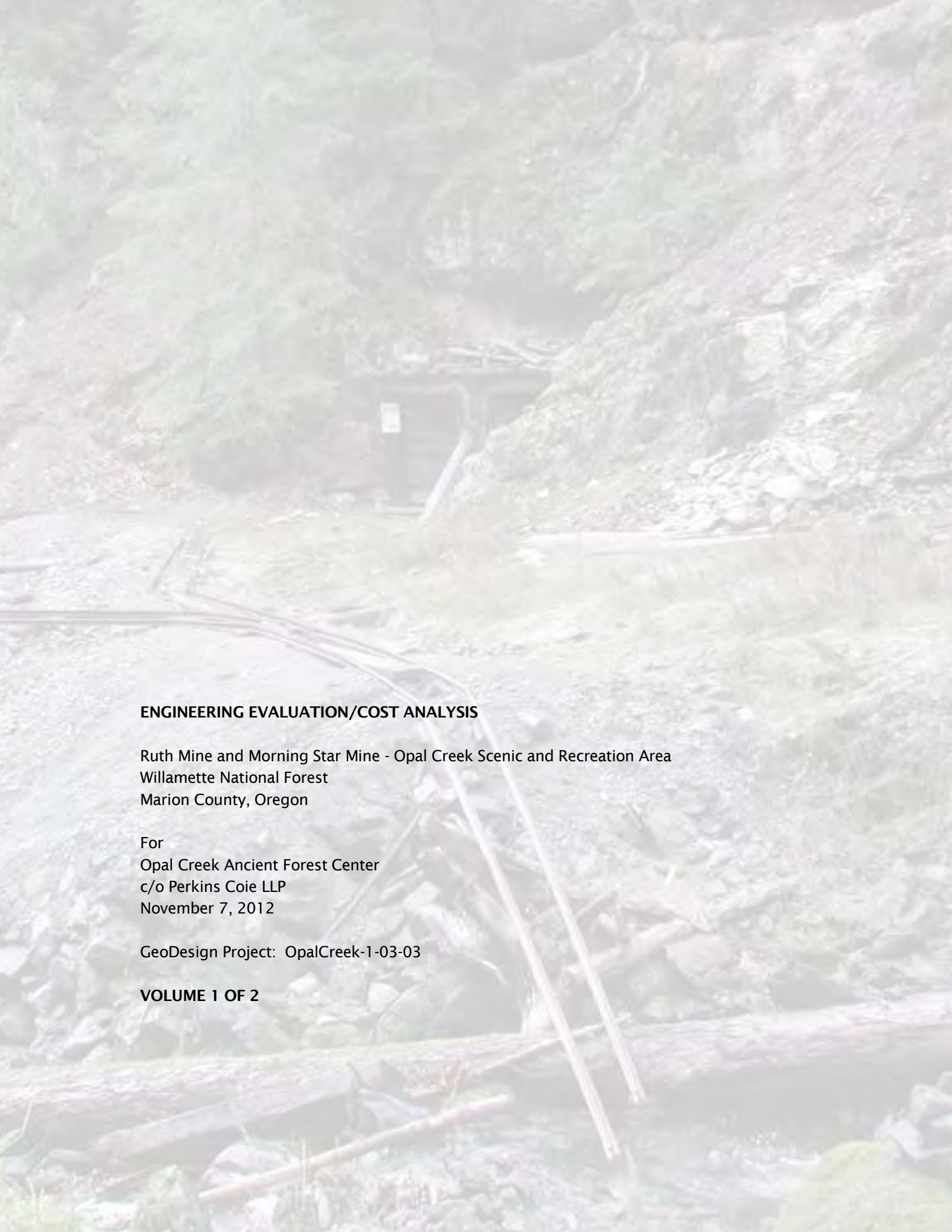

ENGINEERING EVALUATION/COST ANALYSIS

Ruth Mine and Morning Star Mine - Opal Creek Scenic and Recreation Area
Willamette National Forest
Marion County, Oregon

For
Opal Creek Ancient Forest Center
c/o Perkins Coie LLP
November 7, 2012

GeoDesign Project: OpalCreek-1-03-03

VOLUME 1 OF 2

GEODESIGN INC

November 7, 2012

U.S. Forest Service
Regional 6 On-Scene Coordinator, Oregon
645 Washington Street
Ashland, OR 97520

Attention: Mr. Peter A. Jones

Engineering Evaluation/Cost Analysis
Ruth Mine and Morning Star Mine - Opal Creek Scenic and Recreation Area
Willamette National Forest
Marion County, Oregon
GeoDesign Project: OpalCreek-1-03-03

On behalf of Opal Creek Ancient Forest Center, GeoDesign, Inc. is pleased to submit this Engineering Evaluation/Cost Analysis report for the Ruth Mine and Morning Star Mine sites located in the Opal Creek Scenic and Recreation Area in Marion County, Oregon. The report was completed in general accordance with the Administrative Settlement Agreement and Order on Consent with the effective date of August 19, 2008.

♦ ♦ ♦

Please call if you have questions concerning this submittal.

Sincerely,

GeoDesign, Inc.

Craig W. Ware, R.G.
Principal Geologist

cc: Mr. Chris Rich, Perkins Coie, LLP (via email only)
Mr. James E. Alexander, U.S. Department of Agriculture, Office of the General Counsel (via email only)
Ms. Julie Creed, U.S. Department of Agriculture, Forest Service (via email only)
Ms. Sara Colangelo, U.S. Department of Justice (via email only)
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SCN:CWW:kt
Attachments
Two copies submitted
Document ID: OpalCreek-1-01-03-110712-envr-Ruth_Mine_EECA.docx
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ACRONYMS

ALM	Adult Lead Methodology
ARAR	applicable or relevant and appropriate requirements
BS	blank spike
BSD	blank spike duplicate
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
COC	chain-of-custody
COI	contaminant of interest
COPC	contaminant of potential concern
CPEC	contaminant of potential ecological concern
CTE	central tendency exposure
DEQ	Oregon Department of Environmental Quality
ECR	excess cancer risk
EE/CA	Engineering Evaluation/Cost Analysis
EPA	U.S. Environmental Protection Agency
ERA	Ecological Risk Assessment
FR	Forest Road
gvw	gross vehicle weight
H:V	horizontal to vertical
HHRA	Human Health Risk Assessment
IEUBK	Integrated Exposure Uptake BioKinetic
mg/day	milligrams per day
mg/Kg	milligrams per kilogram
mg/L	milligrams per liter
MOM	monitoring, operations, and maintenance
MRL	method reporting limit
MS	matrix spike
MSD	matrix spike duplicate
MSL	mean sea level
NCP	National Oil and Hazardous Substances Pollution Contingency Plan (more commonly called the National Contingency Plan)
NPV	net present value
OAR	Oregon Administrative Rule
OCAFC	Opal Creek Ancient Forest Center
OPSW	Oregon Plan for Salmon and Watersheds
OWRD	Oregon Water Resources Department
PRG	preliminary remediation goal
QC	quality control
RAO	removal action objective
RME	reasonable maximum exposure
SI	Site Inspection
SLV	screening level value
SRMC	Shiny Rock Mining Company
TAL	Target Analyte List

UCL	upper confidence limit
µg/dL	micrograms per deciliter
WQC	Water Quality Criteria
XRF	x-ray fluorescence

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EXECUTIVE SUMMARY

GeoDesign, Inc. has prepared this Engineering Evaluation/Cost Analysis (EE/CA) for the Ruth Mine and Morning Star Mine sites, in the Opal Creek Scenic Recreation Area of the Willamette National Forest, in Marion County Oregon. The Ruth Mine site consists of two levels, Adit 4 and Adit 5. Waste rock piles related to the former mining activities are located at each adit (mine entrance). The Adit 5 level is located approximately 20 to 40 feet upslope of Battle Ax Creek, while Adit 4 is located approximately 35 feet from Ruth Creek, a seasonally intermittent stream, and approximately 700 feet from Battle Ax Creek. The Morning Star Mine site consists of a single adit with a waste rock pile just below the adit. The adit is located approximately 15 feet east of Blue Jay Creek and approximately 1,500 feet upslope from Battle Ax Creek.

The EE/CA was performed pursuant to the August 2008 *Administrative Settlement Agreement and Order on Consent For a Site Inspection and an Engineering Evaluation/Cost Analysis* (AOC) with additional Work as agreed on April 30, 2012 (Forest Service, 2008); in accordance with the *Work Plan; Engineering Evaluation/Cost Analysis, Ruth Mine – Opal Creek Scenic and Recreation Area; Site Inspection, Morning Star Mine – Opal Creek Scenic and Recreation Area; Willamette National Forest; Marion County, Oregon* (GeoDesign, 2008)*;* and under the U.S. Environmental Protection Agency's (EPA) *Guidance on Conducting Non-Time-Critical Removal Actions Under Comprehensive Environmental Response, Compensation and Liability Act* (Office of Solid Waste and Emergency Response Directive 9360.0-32) (USEPA, 1993). The purpose of the EE/CA is to evaluate hazardous substance concentrations in waste rock/soil, sediments, and surface water; to conduct risk assessments to determine whether the Ruth Mine site or the Morning Star Mine site poses unacceptable risk to human health or the environment; and to develop and evaluate removal action alternatives for the sites as outlined in 40 Code of Federal Regulations 300.415.

As part of the EE/CA, human health and ecological risk assessments were performed under EPA and Oregon Department of Environmental Quality guidance documents as set forth in the AOC. The risk assessments were performed to evaluate any potential adverse environmental or human health effects from current and likely future receptor exposures to site media in the absence of mitigation. The risk assessments concluded that no unacceptable risk is posed by the Ruth Mine or Morning Star Mine site under current conditions. Based on the slope stability evaluations, a significant change in conditions is not expected at Ruth Mine Adit 5. There is some potential for mass wasting at Ruth Mine Adit 4. Based on the Forest Service slope stability evaluation, there is some potential for mass wasting at Morning Star Mine in the future.

The removal action objectives (RAOs) for the sites are to prevent future releases of hazardous substances associated with waste rock, maintain acceptable levels of risk to human and ecological receptors, and to meet applicable or relevant and appropriate requirements to the extent practicable. Based on the slope stability evaluation, there is potential for mass wasting at Ruth Mine Adit 4. Based on the Forest Service slope stability evaluation, there is potential for mass wasting at the Morning Star Mine that could affect future protectiveness. The proposed actions to meet the RAOs at the Ruth Mine Adit 4 and Morning Star Mine location are intended to stabilize the waste rock, and by addressing the mass wasting potential, to prevent potential future exposure beyond current conditions. Other than the risk for mass wasting, the current conditions at Adit 4 and Morning Star Mine do not present an unacceptable risk.

No significant mass wasting is expected at Adit 5 in the future that would alter risk assessment results for current conditions. Therefore, the EE/CA recommends no action for the Adit 5 waste rock, with the exception of limiting vehicle access to prevent the potential off-site removal and transport of waste rock in the future.

Adit water was evaluated in the risk assessments and did not represent a risk under current or likely future conditions. Because of this, adit water did not rise to the level of a threat to public health or welfare of the environment currently requiring a removal action, in accordance with the National Contingency Plan. However, adit water discharging hazardous substances into surface waters may exceed established water quality criteria. The Forest Service plans to continue Comprehensive Environmental Response, Compensation, and Liability Act monitoring of adit water discharge and to evaluate passive water treatment through water treatability studies, as warranted.

Per EE/CA guidance, potential removal action alternatives are to be screened, evaluated, and then compared using balancing criteria of effectiveness, implementability, and cost. Four removal action alternatives were developed for the combined mine sites.

1. No Action
2. Institutional Controls: Signage and Removal Restrictions
3. Slope Stabilization, Consolidation, and Rock Buttressing at Ruth Mine Adit 4; Vehicle Access Restrictions at Ruth Mine Adit 5 Access Road; Waste Rock Pull Back, Slope Stabilization and Consolidation at Morning Star Mine
4. Removal and Off-Site Disposal for Ruth Adit 4 and Morning Star Waste Rock, Vehicle Access Restrictions at Adit 5 Access Road

The alternatives were compared using the criteria of effectiveness, implementability, and cost. Alternatives 3 and 4 would meet the RAOs and were determined to be effective. Alternatives 2 through 4 would require mobilization to the site. Alternative 4, although effective, presented the highest risk to site workers and the local ecology, was determined to be the most difficult to implement, and had the highest cost. Alternatives 1 and 2 would meet the RAOs for current conditions and had low costs; however, they may not meet the RAOs for potential future conditions. Alternative 3 met the RAOs, is moderately implementable, and carries a medium cost. Based on the results of the risk assessment and comparative analysis, Alternative 3 is the most appropriate and cost effective, meets the RAOs, and is recommended.

1.0 INTRODUCTION AND OBJECTIVES

This report presents the results an Engineering Evaluation/Cost Analysis (EE/CA) conducted for the Ruth Mine and Morning Star Mine sites in the Opal Creek Scenic Recreation Area of the Willamette National Forest in Marion County, Oregon. The Ruth Mine EE/CA and the Morning Star Mine Site Inspection (SI) were performed under the August 2008 *Administrative Settlement Agreement and Order on Consent For a Site Inspection and an Engineering Evaluation/Cost Analysis* (AOC) with additional Work as agreed on April 30, 2012 (Forest Service, 2008); in accordance with the *Work Plan; Engineering Evaluation/Cost Analysis, Ruth Mine – Opal Creek Scenic and Recreation Area; Site Inspection, Morning Star Mine – Opal Creek Scenic and Recreation Area; Willamette National Forest; Marion County, Oregon* (GeoDesign, 2008)*;* and under the U.S. Environmental Protection Agency's (EPA's) *Guidance on Conducting Non-Time-Critical Removal Actions Under Comprehensive Environmental Response, Compensation and Liability Act* (Office of Solid Waste and Emergency Response Directive 9360.0-32) (USEPA, 1993). The scope of work was developed to conduct appropriate sampling and analysis to evaluate the concentrations of hazardous substances in waste rock/soil, sediments, and surface water; to conduct appropriate risk assessment to determine whether the Ruth Mine or Morning Star Mine sites pose unacceptable risk to human health or the environment; and to develop and evaluate removal action alternatives for the sites. The scope was developed during a November 2007 scoping conference call between Mr. Paul Seidel of the Oregon Department of Environmental Quality (DEQ), Mr. Dennis Boles of the Forest Service, and GeoDesign.

The scope of work for the Ruth Mine EE/CA and Morning Star Mine SI included the collection of samples of waste rock/soil, background rock/soil, stream surface water, stream sediment, sediment pore water, mine adit water, and benthic macroinvertebrate samples from the areas around the Ruth and Morning Star mines, Ruth Creek, and Battle Ax Creek. The mine sites are in relative close proximity to each other, both are tributaries to Battle Ax Creek, and have similar physical characteristics. The media samples collected at and around each mine site were utilized for both individual studies for each mine and also for the broader investigation for the mine sites and subsequent EE/CA. The scope of the EE/CA also incorporated analytical data collected during Focused Site Inspection (SI) of the Ruth Mine site (GeoDesign, 2006) and the SI of the Morning Star Mine (GeoDesign, 2009a). The field effort also included the collection of non-sampling data for the EE/CA and was completed in October 2008 and April, June, and July 2009. Subsequent to collection of analytical data, the EE/CA included performance of a Human Health Risk Assessment (HHRA) and Screening Ecological Risk Assessment (ERA) for each mine site. A January 2009 working session, including the Forest Service, DEQ, GeoDesign, and Dr. Gary Pascoe, discussed the approach to be taken when conducting the HHRAs and Screening ERAs. A draft EE/CA for the Ruth Mine was submitted to the Forest Service for review in March 2009, and comments were provided by the Forest Service and DEQ in May 2009. Subsequent to the submission of comments, collaboration between the Forest Service, DEQ, and GeoDesign occurred via teleconferences and meetings in the summer and fall of 2009. During a July 7, 2009 meeting it was determined that DEQ concurred with the risk assessment methods and findings.

Slope stability evaluations for the Ruth Mine and Morning Star mines were conducted by GeoDesign (GeoDesign, 2009b and 2009c) and the Forest Service (Forest Service, 2012). The slope stability evaluations both concluded that there was potential for future mass wasting at Ruth Mine Adit 4 but not at Ruth Mine Adit 5. The GeoDesign slope stability evaluation did not indicate significant potential for mass wasting at the Morning Star Mine while the Forest Service evaluation did conclude there was potential for mass wasting in the future. In order to resolve the discrepancy, the parties agreed to incorporate the Morning Star Mine into the EE/CA via an April 30, 2012 modification to the AOC Work. The HHRAs and Screening ERAs for the Ruth Mine and Morning Star mine are presented in Appendices A through D.

2.0 SITE DESCRIPTION AND OPERATIONAL HISTORY

2.1 DESCRIPTION AND LOCATION

2.1.1 Ruth Mine

The Ruth Mine site is located on the south side of Battle Ax Creek in a rugged and remote area in Section 27 of Township 8 South, Range 5 East of the Willamette Meridian in Marion County, Oregon, at Latitude 44° 51' 11"N and Longitude 122°11' 23"W, U.S. Geological Survey quadrangle Battle Ax. The site lies within the Opal Creek Scenic Recreation Area of the Willamette National Forest that is administered by the Forest Service. The Ruth Mine is approximately 1 aerial mile east-northeast of Jawbone Flats, an historical mining camp. The elevation of the Ruth Mine varies from approximately 2,360 feet above mean sea level (MSL) at Adit 5 to approximately 2,660 feet above MSL at Adit 4. The Ruth Mine site is shown relative to the surrounding vicinity on Figures 1 and 2. Whetstone Mountain forms the north steep slope of this portion of Battle Ax Creek drainage (Figures 1 and 2). Whetstone Mountain at Battle Ax Creek is also the southern boundary of the Opal Creek Wilderness area of the Cascade Mountain range.

The Ruth Mine is in the North Santiam mining district. Gold and base metal mineralization is related to dioritic plugs and breccia pipes consisting of basalt, andesite, basaltic andesite, quartz monzanite, and granodiorite. Quartz veins serve as the host for mineralization in the Ruth Mine, with lead and zinc as the predominant metals. Sphalerite is the predominant sulfide mineral, with galena, chalcopyrite, and bornite found in lower abundance (Pollock and Cummings, 1985).

The Ruth Mine area includes the Adit 4 and Adit 5 areas, access roads that spur southeast and northwest off of Forest Road (FR) 2209 leading to the adits, and waste rock piles near the adits. The general layout of the Adit 5 and Adit 4 areas, including sample locations, are provided on Figures 5 and 6, respectively. Photographs of the site and vicinity are provided on Figures 8 through 12. Ruth Creek runs in a south to north direction and is located approximately 35 feet to the west of Adit 4. The waste rock pile at Adit 4 is located adjacent to Ruth Creek. Ruth Creek runs steeply down to meet Battle Ax Creek approximately 400 feet east of Adit 5 from an elevation of approximately 3,500 feet above MSL to approximately 2,320 feet above MSL in a distance of approximately 3,000 feet. The Adit 5 area, including waste rock piles, varies from approximately 20 to 40 feet upslope from Battle Ax Creek. Based on field observations, stream flow in Ruth Creek is seasonally intermittent. Battle Ax Creek is a perennial stream.

Battle Ax Creek flows generally east to west through a steep-sloped ravine between Whetstone Mountain and the north-facing hillside where the Ruth Mine is located. Battle Ax Creek is at an approximate elevation of 2,320 feet above MSL at the confluence of Ruth Creek and Battle Ax Creek. The elevation of Battle Ax Creek at the former Amalgamated Mill site, approximately 1 mile downstream of the Ruth Creek confluence, is approximately 2,160 feet above MSL. This is a drop in elevation of approximately 160 feet in less than 1 mile. Several small tributaries, other than Ruth Creek, also flow into Battle Ax Creek along this stretch before its confluence with Opal Creek. Opal Creek and Battle Ax Creek converge to form the Little North Santiam River. Farther downstream, the Little North Santiam River converges with the North Santiam River, then the Santiam River to the Willamette River.

2.1.2 Morning Star Mine

The Morning Star Mine site is located on the south side of Battle Ax Creek in a rugged and remote area in Section 27 of Township 8 South, Range 5 East of the Willamette Meridian in Marion County, Oregon, at Latitude 44˚ 51' 14"N and Longitude 122˚10' 43"W, U.S. Geological Survey quadrangle Battle Ax. The site lies within the Opal Creek Scenic Recreation Area of the Willamette National Forest that is administered by the Forest Service. The Morning Star Mine is approximately 1.5 aerial miles east-northeast of Jawbone Flats, an historical mining camp. The elevation of the Morning Star Mine is approximately 2,800 feet above MSL. The Morning Star Mine site is shown relative to the surrounding vicinity on Figures 1 and 2. Whetstone Mountain forms the north steep slope of this portion of Battle Ax Creek drainage (Figures 1 and 2). Whetstone Mountain at Battle Ax Creek is also the southern boundary of the Opal Creek Wilderness area of the Cascade Mountain range.

The Morning Star Mine area includes the adit area (Figure 7), a small access road that spurs southeast off of FR 2209 leading to the adit, and a waste rock pile below the adit. Photographs of the site and vicinity are provided as Figures 13 through 17. Based on GeoDesign's field measurements, the estimated volume of waste material at the adit, including the primary waste rock pile, downslope material, and roadbed material, is approximately 700 cubic yards. Blue Jay Creek flows in a south to north direction and is located approximately 15 feet to the east of the adit. Blue Jay Creek runs steeply down to Battle Ax Creek from an elevation of approximately 3,100 feet above MSL to approximately 2,400 feet above MSL in a distance of approximately 1,500 feet. Surface water flows in Blue Jay Creek are seasonally intermittent.

2.2 SURROUNDING LAND USE, POPULATIONS, AND ACCESS

The Ruth Mine site and Morning Star Mine site are located in the Opal Creek Scenic Recreation Area, bordered by the Opal Creek Wilderness. There are no workers or residents near the mine sites. The nearest residents are full-time employees of the Opal Creek Ancient Forest Center (OCAFC), approximately 1 mile away from Ruth Mine at Jawbone Flats (approximately 2 miles via FR 2209). Public use of the area is not currently restricted, although access is limited to foot, bicycle, or horse traffic.

Access to the Ruth Mine and Morning Star Mine is via FR 2209. Currently, public access by vehicle is restricted at a locked gate approximately 5 and 5.5 miles from the Ruth Mine and Morning Star Mine, respectively. Access limitations along FR 2209 at the time of the field investigation included weight and width limits on bridges at the Gold Creek Bridge, Half-Bridges,

Log Stringer, and Battle Ax Creek Bridge. Based on a Forest Service Engineering Memorandum dated December 12, 2007, with an update on December 5, 2008, the structural capacity of the Gold Creek and Half-Bridges were limited to 3 tons per axle or 5 tons per axle for dual-tired vehicles. The weight limit at Battle Ax Creek Bridge is 7,700 pounds gross vehicle weight (gvw). Two August 16, 2011 Forest Service Engineering Memoranda indicated that the Half-Bridges and Gold Creek Bridge were recommended to be closed because of an inability to assign a load rating to the bridges. The bridges were given the lowest rating on the National Bridge Inventory of 1, indicating "imminent failure condition." This would eliminate vehicle access to the Ruth Mine and Morning Star Mine unless bridge repairs are completed. The Ruth Mine and Morning Star Mine areas are not accessible by vehicle in the winter because of snow, typically between November and April. To access the Ruth Mine Adit 5 area, a branch road from FR 2209 runs northwest toward Battle Ax Creek. This access road is limited in width to 7 feet in some places and consists of steep grades between 25 and 29 percent for approximately 300 feet, with loose cobbles. To access Adit 4, a branch road from FR 2209 runs southeast and is limited in width to 7 feet approaching the adit and then narrows to foot trail width for the last segment to Ruth Creek, which does not have a bridge, road, or trail crossing it. The adit is located directly across Ruth Creek. The underground workings behind the adits are inaccessible due to bat gates. FR 2209, currently inaccessible by passenger vehicle past Ruth Creek, passes by the Morning Star Mine site approximately 200 feet below the adit location. The historical road is currently overgrown beyond Ruth Creek. To access the Morning Star Mine an overgrown branch road from FR 2209 leads southeast to the adit area. The underground workings are inaccessible due to bat gates.

The Ruth Mine and Morning Star Mine sites are located in the North Santiam River watershed. A review of the Oregon Water Resources Department (OWRD) well log database indicates that water wells are not located within a 4-mile radius of the mine sites.

2.3 CLIMATE

The sites are located in the western Cascades. Based on data from the Western Regional Climate Center, approximately one-half of the annual precipitation falls between the months of December and February, approximately one-fourth in the spring and fall, and very little during the summer months. The average total precipitation on the western slopes of the Cascades increases with elevation. The Detroit, Oregon, weather monitoring station was used to obtain the following data based on the distance from the Ruth Mine. The Detroit, Oregon, monitoring station is located approximately 8 miles southeast of the Ruth Mine site at an elevation of approximately 1,590 feet above MSL. Since the Ruth Mine and Morning Star Mine sites are approximately 1,200 feet higher in elevation than the Detroit monitoring station, they receive more total precipitation and have lower minimum and maximum temperatures than the Detroit monitoring station. For the Detroit monitoring station, total precipitation is approximately 82.51 inches per year. The average minimum temperature is 26.9 degrees Fahrenheit and occurs in January. The average maximum temperature is 81.7 degrees Fahrenheit and occurs in July. Temperature extremes range between -10 degrees Fahrenheit in the winter and 107 degrees Fahrenheit in the summer.

2.4 HISTORICAL OPERATIONS AND OWNERSHIP

The Ruth Mine is located in the North Santiam Mining District. Based on information presented in *The Santiam Mining District of the Oregon Cascades: A Cultural Property Inventory and Historical Survey,* by Anthony J. George, P.E., the Ruth Group claims can be traced back to the 1860s. The Ruth Mine site claims were located in 1896 and were sold to the Lewis & Clark Mining & Milling Company in 1903. The Ruth Mine was operated and/or leased by several mining companies (including the Lewis & Clark Mining & Milling Company, the Amalgamated Mining & Milling Company formed in 1929, the Columbia Mines Development Company formed in 1930, Amcol [a joint venture of the Amalgamated and Columbia Mines Development Company] formed in 1934, the Pacific Smelting & Refining Company formed in 1941, and the Shiny Rock Mining Company [SRMC] formed in 1972). The Morning Star Lode claim was made in 1925 by R.I. Dawes and then transferred to the Columbia Mines Development Company in 1930. The Morning Star Mine may have been operated by a number of different entities, including the Amcol Mining and Milling Company, later by the Gold Creek Mining and Milling Company, which was formed in 1937 as a controlling company for Amcol. Mining operations at the Ruth Mine and Morning Star Mine sites did not include the processing of mined ore. Ore processing occurred at either the Amalgamated Mill in the 1930s and 1940s or the Starvation Mill between 1973 and the late 1980s. The Amalgamated Mill site was located downstream along Battle Ax Creek while the Starvation Mill site was located closer to Opal Creek near Jawbone Flats. The Ruth vein and Morning Star Mine were mined primarily for lead and zinc, although small amounts of gold, silver, and copper were also present.

In 1972, SRMC acquired the patented (fee title) and unpatented mining claims and mill site rights of the Amalgamated Mining & Milling Company, the Columbia Mines Development Company, and the Gold Creek Mining and Milling Company for certain areas that included the Ruth Mine and Morning Star Mine. In 1992, SRMC donated fee title to land, including the Ruth Mine, Morning Star Mine, and other patented and unpatented mining claims and mill sites, to the Friends of Opal Creek (now known as OFAFC). In 1998, the Friends of Opal Creek transferred fee title to land, including the Ruth Mine, to the United States, which continues to hold that title.

2.5 PREVIOUS INVESTIGATIONS

2.5.1 Ruth Mine

Removal actions at the Ruth Mine site have been limited to hazardous materials cleanup conducted in 1997. The cleanup was limited to removal of petroleum products; electrical equipment; blasting caps; a small volume of petroleum-stained soil; and miscellaneous hose, scrap metal, and plastic piping. This cleanup was reported as completed by the Forest Service in a letter to the Friends of Opal Creek dated October 9, 1997. Removal of waste rock material was not conducted. A removal action was completed for the Amalgamated Mill site in 1997. The ore-crushing Starvation Mill was cleaned up in 1996 and 1997.

Characterization activities at the Ruth Mine site, previous to this EE/CA, have included the *Preliminary Site Assessment – Ruth Quartz Mine No. 1* (Forest Service, 1997); *Abbreviated Preliminary Assessment Ruth Mine #1, Willamette National Forest, Marion County, OR* (hereinafter referred to as the "Forest Service APA"), with a revised date of October 2004 (Forest Service, 2004); and the Focused SI (GeoDesign, 2006).

The preliminary site assessment provided a list of materials to be removed from the Ruth Mine site, as described above, prior to acceptance of the property by the Forest Service. The Forest Service's APA investigation included field screening of waste rock materials at the Ruth Mine site utilizing a Niton X-ray fluorescence detector (XRF). Field screening results indicated that the metals arsenic, chromium, iron, lead, manganese, and nickel were detected at concentrations exceeding EPA industrial soil preliminary remediation goals (PRGs).

In November 2005, GeoDesign completed the field work for the Focused SI for the Ruth Mine to assess concentrations of hazardous substances in waste rock and the media potentially affected by mass wasting of the waste rock materials. The Focused SI sampling activities included collection of waste rock/soil samples, background rock/soil samples, adit water samples, surface water samples, sediment samples, and pore water samples. Analytical results indicated that the waste rock materials had concentrations of hazardous substances elevated over background concentrations and, in some cases, over human health and ecological screening values. Sediments and surface water analytical results in some cases also showed concentrations of hazardous substances exceeding screening values. Human health and ecological risk assessments were conducted for the Focused SI. Based on the risk assessments, no unacceptable risk to human or ecological receptors was noted. Tables summarizing analytical results from the Focused SI, as well the sampling program from this EE/CA and figures showing sample locations, are provided in this report.

2.5.2 Morning Star Mine

Characterization activities for the Morning Star Mine, previous to this EE/CA, have included the *Preliminary Site Assessment – Morning Star Lode* (Forest Service, 1996); *Abbreviated Preliminary Assessment – Morning Star Mine, Willamette National Forest, Marion County, OR* (hereinafter referred to as the "Forest Service Morning Star APA") (Forest Service, 2005); and the *Site Inspection, Human Health Risk Assessment, and Ecological Risk Assessment, Morning Star Mine – Opal Creek Scenic and Recreation Area, Willamette National Forest, Marion County, Oregon* (GeoDesign, 2009a).

During the Forest Service Morning Star APA, the Forest Service completed field screening of waste rock using an XRF. Based on the results of the Forest Service Morning Star APA, the Forest Service recommended an SI for the Morning Star Mine, including sampling and analysis of waste rock, adit water, surface water, sediment, pore water, and benthic invertebrates.

In November 2005, GeoDesign completed field work for a Focused SI for the Ruth Mine. The field work was completed under a November 2, 2005 Work Plan, which included collecting background samples as well as surface water samples in Battle Ax Creek. Results of the field work were incorporated in the *Focused Site Inspection, Ruth Mine – Opal Creek Scenic and Recreation Area, Willamette National Forest,* dated June14, 2006. After reviewing the Focused SI report, the Forest Service recommended investigation at the Morning Star Mine. The OCAFC agreed to complete an SI and Site Conditions Summary for the Morning Star Mine site under the AOC.

A November 27, 2007 scoping conference call between GeoDesign, DEQ, and the Forest Service was held to discussed the scope of a work plan for the Morning Star Mine. The scoping conference call included discussion of collecting additional background samples to supplement existing background data for use as basin-wide background. The background samples were to be collected in representative area-wide ambient locations without a bias towards mineralized areas. DEQ requested that additional surface water, sediment, and pore water samples should be collected at, above, and below the confluences of Blue Jay Creek and Battle Ax Creek and that the samples should be analyzed for Target Analyte List (TAL) 23 metals to help distinguish potential hazardous substances contributions to Battle Ax Creek from the tributaries. The discussion points from this scoping conference were incorporated into the Work Plan. A working session regarding the approach for conducting the HHRA and Screening ERA under the AOC was held in January 2009 and was attended by representatives of DEQ, the Forest Service, and GeoDesign. During the working session, analytical results, risk assessment guidance, and exposure assumptions were discussed.

In October 2008, field work was completed in accordance with the July 22, 2008 Work Plan (GeoDesign, 2008). The SI sampling activities included collection of waste rock/soil samples, background rock/soil samples, adit water samples, surface water samples, sediment samples, pore water samples, and benthic macroinvertebrate samples. Results of the investigation were discussed in the 2009 SI for the Morning Star Mine, which included human health and ecological risk assessments. A slope stability evaluation was completed for the Morning Star Mine in 2009 (GeoDesign, 2009b). The slope stability evaluation concluded that there was very low potential that a mass wasting event would result in the downslope movement of a significant amount of waste rock and that the conditions at the time of the evaluation were considered representative of present and likely future conditions. Based on the results of the SI, it was determined that no unacceptable risk was present at the site in its conditions at the time of the assessment.

Evaluation by the Forest Service, including a January 2012 *Morning Star Waste Rock Stability Evaluation* (Forest Service, 2012), indicated that localized channel bank failures from flood scour and collapse of rotting mine timber in the waste rock pile could result in waste rock erosion into the downslope stream systems. To resolve the different conclusions between slope stability evaluation reports, the parties agreed to modify the AOC Work to include the Morning Star Mine site in the EE/CA and evaluate removal action alternatives that could lower the potential for release of waste rock to Blue Jay Creek and Battle Ax Creek in the event of future mass wasting of waste rock in proximity to Blue Jay Creek.

3.0 SOURCE, NATURE, AND EXTENT OF CONTAMINATION

3.1 SOURCE AND DEFINITION OF CONTAMINATION

The waste rock piles at both adits of the Ruth Mine and Morning Star Mine sites are comprised of rock extracted from the mines. Based on the previous investigations (Forest Service, 2004 and GeoDesign, 2006) and 2008 and 2009 investigation activities at the Ruth Mine and Morning Star Mine summarized herein, the concentrations of hazardous substances (e.g., arsenic, cadmium, copper, lead, and zinc) in waste rock exceed background soil concentrations and preliminary screening values. Samples of surface water and sediments collected from Ruth Creek, Blue Jay Creek, and Battle Ax Creek in some cases also had concentrations of hazardous substances

exceeding preliminary screening values. Summaries of chemical analytical data are provided in Tables 1 through 4 and discussed in Sections 3.3 and 3.4 of this report. A description of sampling methods and procedures is presented in Appendix E, and the analytical laboratory reports are presented in Appendix F.

3.2 LOCATION, VOLUME, AND PHYSICAL ATTRIBUTES OF THE WASTE ROCK

3.2.1 Ruth Mine

At the Adit 4 area, the waste rock pile forms a flat bench to the west of the adit and then a slope that drops to Ruth Creek. Based on measurements collected in the field, the volume of waste rock at Adit 4 is approximately 925 cubic yards. At the Adit 5 area, the waste rock is located in three areas: (1) a pile of waste rock used to create an embankment to raise cart tracks, (2) a thin, discontinuous layer of waste rock that covers the roadbed, and (3) a side-cast berm varying in depth along the northern edge of the road. Based on field measurements, the volume of waste rock at Adit 5 is approximately 275 yards. Field dimensions collected in October 2008 used to calculate approximate volumes are included in the description of sampling activities in Appendix E.

In June 2009, GeoDesign completed a site reconnaissance to evaluate the stability of the waste rock piles at Adits 4 and 5 and determined the potential for mass wasting of materials to Ruth Creek and Battle Ax Creek. The waste rock material at Adit 4 is situated on a slope. The waste rock is supported on the slope by a rock buttress on the side adjacent to Ruth Creek. The waste rock pile slope is generally at a 70 percent slope with the exception of a portion in the central part of the pile that does not have rock buttressing. This central portion is at a slope of 100 percent. The slope stability evaluation, presented in Appendix G (GeoDesign, 2009c), conducted for the Ruth Mine site indicates that this portion of the waste rock slope has slumped. This slope failure was interpreted to be from seasonal flows in Ruth Creek undercutting the waste rock pile. Based on the slope stability evaluation, the waste pile is stable and the rock buttressing is adequate for the 70 percent slopes. The unbuttressed section is potentially susceptible to mass wasting in extreme water flow events in Ruth Creek. The waste rock is a coarse-grained material that has low susceptibility to rain-splatter mobilization and rill erosion. A cut bank in Ruth Creek located upstream of the waste rock pile was noted and there is some potential for this cut bank to continue to erode into the waste rock pile in the future. The removal of material behind the waste rock pile via the cut bank erosion could result in instability of the Adit 4 waste rock pile in the future.

The waste rock material at Adit 5 is situated on a bench used as a road from the adit and also on the slope above Battle Ax Creek at the northern edge of the bench. Based on the slope stability evaluation, the bank upon which the waste rock is deposited is underlain by bedrock. Because of this, large-scale landslide erosion and erosion or undercutting by Battle Ax Creek is unlikely. The height of the roadbed would prevent debris flow in Battle Ax Creek from impacting the stability of the waste rock pile. The side-cast berm has evidence of small-scale erosional channels from seasonal surface water runoff. The estimated volume of material lost to date is 20 cubic yards. This is interpreted to be from a period of over 50 years. Less significant loss of material from the side-cast berms is expected to continue to take place in the future since the surface water channels are established and have removed the more susceptible material already.

3.2.2 Morning Star Mine

The Morning Star Mine waste rock is located below the adit, approximately 200 feet above FR 2209. The approximate volume of waste rock material included in the waste rock pile and roadbed is 700 cubic yards, visible on Figure 13.

On April 27, 2009, GeoDesign completed a site reconnaissance to evaluate the stability of the waste rock pile and determine the potential for mass wasting of materials into Blue Jay Creek. Based on observations, historical information (George and Weber, 1985), and interviews with OCAFC staff, GeoDesign determined that a large debris flow of mining material occurred during the December 1964 flood event. An embankment was originally utilized at the Morning Star adit to provide a working space for miners. This embankment failed, releasing up to 1,500 cubic yards of waste rock material down Blue Jay Creek and reaching Battle Ax Creek. The waste rock material from this embankment failure has been present in the creek bed for approximately 45 years. The observations in the field and the relatively small drainage basin of Blue Jay Creek indicate that a large volume, natural debris flow would represent an extremely rare event (GeoDesign, 2009b).

The current waste rock pile below the adit is a well-graded, coarse material that neither shows evidence of rain-splatter and rill erosion nor evidence of slumping or land sliding. The large debris flow of 1964 resulted in the collapse of the structure and erosion of a significant volume of readily susceptible waste rock material. From the reconnaissance-level assessment, GeoDesign concluded that the potential for the occurrence of a similar magnitude event in the future is not likely and that there is very low potential that a mass wasting event could lead to a downslope movement of a significant volume of the waste rock in the future. The slope stability evaluation report by GeoDesign is included in Appendix H.

In contrast to the reconnaissance-level assessment conducted by GeoDesign, Forest Service specialists have observed conditions at Blue Jay Creek and the remaining portions of the Morning Star waste rock pile for more than two decades. The local veteran Forest Service hydrologist and engineering geologist observed waste pile scour from the 1996 flood event and have also determined that localized channel bank failures and collapse of rotting mine timber in the waste pile could result in continued waste rock erosion into Blue Jay Creek and Battle Ax Creek. The Forest Service hydrologist reports that the waste rock and mine timbers continue to migrate downslope toward Blue Jay Creek after being undermined by the 1996 event and has also observed that the toe of the waste pile continues to erode during annual high flows, as documented in their *Morning Star Waste Rock Stability Evaluation, 2012,* which is included in Appendix I.

Based on the evaluations discussed above, it is reasonable to conclude that future storm events are likely to continue to erode the remaining pile. With the likelihood of this occurrence it is also reasonable to conclude that unacceptable input of hazardous substances into Blue Jay Creek and Battle Ax Creek may continue.

3.3 SURFACE WATER AND SEDIMENTS

3.3.1 Sample Locations

GeoDesign collected samples of surface water, pore water, mine adit water, and stream sediment in the vicinity of the Ruth Mine and Morning Star Mine based on the proposed sampling locations set forth in the August 7, 2008 Work Plan attached as Appendix 2 of the AOC. Sample locations are presented on Figures 2, 3, and 4 and include locations of 25 surface water samples, 10 pore water samples, 7 adit water samples, and 18 sediment samples. The figures also show sample locations for the site investigation work completed in 2005, 2008, and 2009.

The samples of surface water, mine adit water, and sediments were collected because each medium has viable exposure potential for both human and ecological receptors and has different uptake characteristics for the receptor. Samples were collected upstream and downstream of the mine adit locations in both Ruth Creek and Battle Ax Creek for the Ruth Mine and upstream and downstream of the adit location in both Blue Jay Creek and Battle Ax Creek for the Morning Star Mine to provide data for comparison of hazardous substances concentrations above and below the former mining operations. In addition, benthic macroinvertebrate samples were collected, as shown on Figure 4. Macroinvertebrate samples were collected because they can be used as a more direct assessment of the impacts of chemicals in the sediments on the biological community, as compared to chemical screening values. The specific sample locations used in the assessments for each mine site are described in the following sections.

3.3.1.1 Ruth Mine

- Eight surface water samples (SW-1, SW-2, SW-7, SW-R-21, SW-R-22, SW-R-23, SW-R-24, and SW-R-24-DISS) in Battle Ax Creek downstream of the confluence of Ruth Creek and Battle Ax Creek.
- Three surface water samples (SW-3, SW-4, and SW-5) in Ruth Creek, including one upstream of the adit (SW-3) and two downstream of the adit (SW-4 and SW-5).
- Three surface water samples (SW-6, SW-R-19, and SW-R-20) in Battle Ax Creek upstream of the confluence of Ruth Creek and Battle Ax Creek.
- Six adit water samples (AW-4, AW-5, AW-4-2, AW-5-2, AW-4-2-DISS, and AW-5-2-DISS).
- Pore water samples in Battle Ax Creek downstream (PW-1, PW-R-22, and PW-R-23) and upstream (PW-2, PW-R-19, and PW-R-20) of its confluence with Ruth Creek.
- Sediment samples from Battle Ax Creek upstream of the confluence (SED-6, SED-R-19, and SED-R-20), downstream of the confluence (SED-1, SED-2, SED-R-21, SED-R-22, and SED-R-23), and the Ruth Creek locations (SED-3, SED-4, and SED-5).
- Benthic macroinvertebrate samples from Battle Ax Creek upstream of the confluence (BI-R-19 and BI-R-20) and downstream of the confluence (BI-R-22 and BI-R-23).
- Surface water samples (SW-8, SW-MS-14, SW-MS-15, and SW-MS-16) and sediment samples (SED-MS-14, SED-MS-15, and SED-MS-16) collected above the confluence of Blue Jay Creek and Battle Ax Creek were used in the risk assessments as background surface water samples since they are located upstream of the Ruth and Morning Star Mines.

3.3.1.2 Morning Star Mine

- Two surface water samples (SW-10 and SW-MS-18) in Battle Ax Creek downstream of the confluence of Blue Jay Creek and Battle Ax Creek
- Three surface water samples (SW-MS-11, SW-MS-12, and SW-MS-13) in Blue Jay Creek, including one upstream of the adit (SW-MS-11) and two downstream of the adit (SW-MS-12 and SW-MS-13)
- Two surface water samples (SW-9 and SW-MS-17) at the confluence of Blue Jay Creek and Battle Ax Creek
- Four surface water samples (SW-8, SW-MS-14, SW-MS-15, and SW-MS-16) in Battle Ax Creek upstream of the confluence of Blue Jay Creek and Battle Ax Creek
- One adit water sample (AW-MS-1)
- Pore water samples in Battle Ax Creek downstream (PW-MS-18) and upstream (PW-MS-14, PW-MS-15, and PW-MS-16) of its confluence with Blue Jay Creek
- Sediment samples from Battle Ax Creek upstream of the confluence (SED-MS-14, SED-MS-15, and SED-MS-16), at the confluence of Battle Ax Creek and Blue Jay Creek (SED-MS-17), downstream of the confluence (SED-MS-18), and the Blue Jay Creek locations (SED-MS-12 and SED-MS-13)
- Benthic macroinvertebrate samples from Battle Ax Creek upstream of the confluence (BI-MS-14, BI-MS-15, and BI-MS-16) and downstream of the confluence (BI-MS-18)

Surface water samples were collected from approximately 6 inches below the stream surface and were collected in laboratory-supplied containers by submersing the inverted container approximately 6 inches below the surface and then slowly righting it. Surface water samples were preserved in the field following collection using nitric acid. The mine adit water sample was collected in a laboratory-supplied container from the flow from the adit.

Pore water samples were collected within sediment in the stream using a stainless steel probe with an approximately 4-inch screen located approximately 4 to 8 inches below the sediment surface, along with a peristaltic pump and dedicated tubing. Pore water samples were field-filtered using a 0.45-micron disposable filter. Pore water is the water within the sediments in the stream rather than the surface water flowing over the sediments. The pore water typically is exposed to the sediment for a longer duration, potentially allowing a higher concentration of solids to dissolve in the water. Pore water samples were collected using the peristaltic pump set at a low pumping rate (approximately 40 milliliters per minute) to ensure water uptake was from within the sediment pore space. Samples were collected in laboratory-supplied, preserved containers.

Sediment samples were collected by hand using the laboratory-supplied, wide-mouth glass jars to directly sample sediments from the stream. All field samples were stored in coolers on ice pending laboratory submittal.

Benthic macroinvertebrate samples were collected using a kick net in accordance with the Level 3 macroinvertebrate collection procedure provided in the Oregon Plan for Salmon and Watersheds (OPSW) *Water Quality Monitoring Guidebook* (OPSW, 1999). The samples were collected in laboratory-supplied containers and then preserved with alcohol, as directed by the laboratory.

Sampling activities are documented in Appendix E.

3.3.2 Analytical Results

Samples were submitted to Apex Laboratories, LLC of Tigard, Oregon, under chain-of-custody (COC) documentation. Surface water, adit water, and sediment samples were submitted for chemical analysis of total metals by EPA 6000/7000 Series Methods. Pore water samples and AW-4-2-DISS, AW-5-3-DISS, and SW-R-24-DISS were submitted for chemical analysis of dissolved metals by EPA 6000/7000 Series Methods. Laboratory results for surface water, pore water, and sediment samples are provided in Tables 1 and 3 for the Ruth Mine and Morning Star Mine, respectively. The macroinvertebrate enumeration and speciation was completed by EcoAnalysts of Moscow, Idaho. Sample collection methods are described in Appendix E. The laboratory reports, COC documentation, and our review of the laboratory quality control (QC) data are provided in Appendix F.

The analytical results for the collected samples were used in the completion of the HHRAs and the Screening ERAs. Samples collected in the adits, Ruth Creek, Blue Jay Creek, and Battle Ax Creek were used in the risk assessments. Detected hazardous substance concentrations were screened against applicable regulatory screening values per the risk assessment guidance documents referenced in the Work Plan (Appendix 2 of the AOC). For human health purposes, the sediment (and soil) concentrations of contaminants of interest (COIs) were screened against industrial soil PRGs, which are risk-based concentrations used as screening tools to identify chemicals that may pose a risk and need to be further evaluated or if they do not require further evaluation. The PRGs used for this investigation are considered to be conservative in comparison to a recreational exposure scenario because the exposure frequency and duration are much lower than the industrial exposure scenario. The surface water concentrations of COIs were compared to the tap water PRGs considered conservative for exposure to surface waters, because the ingestion rates would be much lower than tap water used as drinking water.

For the Screening ERA, DEQ Level II screening level values (SLVs) were used based on the 2001 DEQ *Guidance for Ecological Risk Assessment: Level II Screening.* DEQ Water Quality Criteria (WQC) was also referenced as conservative screening values where applicable (Oregon Administrative Rule [OAR] 340-041-0033 Table 20). The WQC are criteria for waters of the state of Oregon that are not to be exceeded in order to protect aquatic life and human health. Concentrations of hazardous substances in various media, including some background soils, exceed Level II SLVs. The SLVs are considered to be conservative screening tools to identify potential risk rather than representing actual site-specific risk, as per the above-referenced DEQ guidance. After the SLVs are used to identify potential risks, additional considerations are used to assess actual risk. Comparisons of results to screening values from each mine site are presented in the following sections.

3.3.2.1 Ruth Mine

Water samples collected from Adit 4 were the only surface water samples with concentrations of hazardous substances exceeding tap water PRGs. Cadmium was detected at concentrations of 0.0221, 0.035, and 0.0363 milligrams per liter (mg/L) in AW-4, AW-4-2, and AW-4-2-DISS, respectively, in the Adit 4 water samples. These concentrations exceed the PRG of 0.018 mg/L by between 1.2 and 2.0 times. Lead was detected at concentrations of 0.0377, 0.0271, and 0.0223 mg/L in AW-4, AW-4-2, and AW-4-2-DISS, respectively, in the Adit 4 water samples. These concentrations exceed the PRG of 0.015 mg/L by between 1.5 and 2.5 times. Cadmium and lead were determined to be the contaminants of potential concern (COPCs) for surface water. Samples collected in 2009 included analysis of total and dissolved concentrations. Based on the analytical results, the dissolved concentrations are very similar to total concentrations. In some cases, dissolved concentration data exceeded total data, which although not theoretically possible, falls within a permissible range of precision from the analytical laboratory. Based on this information, total and dissolved metals concentrations have been used in the same manner for comparisons to screening criteria.

Arsenic concentrations in sediment samples SED-2 through SED-6, SED-R-20, SED-R-22, and SED-R-23 ranged from 1.85 to 15.7 milligrams per kilogram (mg/Kg) and exceeded the industrial soil PRG of 1.6 mg/Kg by factors between 1.5 and 9.8 times. Arsenic was considered the COPC in sediment for the HHRA.

The metals analytical results for surface water samples SW-1 through SW-5, SW-7, SW-R-21 through SW-R-24, and SW-R-24-DISS were either not detected above laboratory method reporting limits (MRLs) or were below the Level II SLVs for fresh surface waters and WQC, with the exceptions of barium, cadmium, lead, and zinc. The SLVs for barium, cadmium, and zinc were exceeded by up to 1.2, 2.3, and 12.6 times, respectively, in samples SW-R-24 and SW-R-24-DISS. Lead exceeded the SLV in sample SW-1 by 1.2 times and in samples SW-4 and SW-5, taken from Ruth Creek, by 1.6 and 1.8 times, respectively. In surface water samples SW-R-24 and SW-R-24-DISS, the WQC for cadmium and zinc were exceeded by up to 4.7 and 13.8 times, respectively.

The hazardous substances concentrations in adit water samples AW-4, AW-4-2, AW-4-2-DISS, AW-5, AW-5-2, and AW-5-2-DISS were either not detected above laboratory MRLs or were below the Level II SLVs for fresh surface waters and WQC, with the exceptions of barium, cadmium, copper, lead, and zinc. The SLVs for barium, cadmium, copper, lead, and zinc were exceeded by up to 2.8 (AW-4-2-DISS), 16.5 (AW-4-2-DISS), 1.6 (AW-4), 15 (AW-4), and 55.6 times (AW-4-2), respectively. The WQC for cadmium, copper, lead, and zinc were exceeded by up to 33 (AW-4-2-DISS), 1.2 (AW-4), 11.7 (AW-4), and 60.6 times (AW-4-2), respectively, in water collected from Adit 4. The WQC for cadmium and zinc were exceeded by up to 4.9 (AW-5) and 14.1 times (AW-5-2), respectively, in water collected from Adit 5.

Sediment sample concentrations included the detection of several hazardous substances above SLVs, including arsenic, cadmium, copper, lead, manganese, nickel, and zinc. The SLVs for these hazardous substances were exceeded by up to 2.6 (SED-R-22), 9.3 (SED-R-22), 12.9 (SED-4), 7.9 (SED-5), 3.9 (SED-5), 2.8 (SED-R-22), and 11.3 times (SED-R-22), respectively. Concentrations of hazardous substances in various media that exceed screening criteria are highlighted in the analytical data tables.

3.3.2.2 Morning Star Mine

Arsenic was the only hazardous substance to exceed the tap water PRG (samples AW-MS-1, SW-9, SW-MS-12, SW-MS-13, and SW-MS-17) and was determined to be the COPC for surface water. The exceedance of the arsenic PRG in these surface water samples is addressed in the risk calculations presented in the HHRA and discussed below. Arsenic concentrations in sediment samples SED-MS-12, SED-MS-13, and SED-MS-17 exceeded the soil PRG and the concentration of lead in SED-MS-12 exceeded the soil PRG. Arsenic and lead were considered COPCs in sediment for the HHRA.

The total metals analytical results for surface water samples SW-8 through SW-10, AW-MS-1, and SW-MS-11 through SW-MS-18 were either non-detect above laboratory MRLs or were below the Level II SLVs for fresh surface waters and WQC with the exception of aluminum and lead (Table 2). There were two detected concentrations of lead exceeding the Level II SLV (SW-MS-13 and SW-MS-17). The aluminum concentration exceeded the Level II SLV and WQC only in sample SW-MS-17. Based on this data, aluminum and lead were considered contaminants of potential ecological concern (CPECs) for surface water for aquatic species.

Sediment sample concentrations included the detection of several hazardous substances above SLVs, and arsenic, cadmium, copper, lead, manganese, nickel, and zinc were determined to be CPECs for sediment. Based on individual risk ratios, further detailed in the Screening ERA, cadmium, lead, and zinc were determined to be the highest risk sediment CPECs for freshwater benthos and potential wildlife bioaccumulation.

Dissolved hazardous substances were not detected above laboratory MRLs or were less than the regulatory screening values in pore water samples (Table 2).

3.4 SOIL AND AIR

3.4.1 Sample Locations

Waste rock/soil samples for the Ruth Mine investigation (WRS-R-11 through WRS-R-30) were collected in October 2008 in the direct vicinity of the Adit 5 and Adit 4 areas as shown on Figures 5 and 6, respectively, based on the Work Plan prepared for the Ruth Mine as well as GeoDesign's exercise of professional judgment during the field activities. These samples were added to the existing data set of waste rock samples WRS-1 through WRS-10 collected in November 2005. The sample locations included materials from the waste piles as well as from the roadbed at the Adit 5 location. Rock/soil samples were collected using a stainless steel trowel and digging approximately 6 to 8 inches below the soil surface, or approximately 12 to 18 inches below the surface for samples WRS-R-14 and WRS-R-17, as shown on Figure 10. Eleven waste rock/soil samples were collected at Adit 5, and 10 waste rock/soil samples were collected at Adit 4. For the Morning Star Mine investigation, waste rock/soil samples (WRS-MS-1 through

WRS-MS-11) were collected during the 2008 sampling activities in the direct vicinity of the adit area as shown on Figure 5 based on the Work Plan prepared for the Morning Star Mine as well as GeoDesign's exercise of professional judgment during the field activities. The sample locations included materials from the waste pile as well as from the access roadbed up to 130 feet west of the waste pile. Rock/soil samples were collected using a stainless steel trowel and digging approximately 6 to 8 inches below the soil surface as shown on Figure 17. The samples were collected and placed in laboratory-supplied glass jars with Teflon®-lined lids.

In addition, 20 background rock/soil samples were collected from areas around the Ruth Mine and Morning Star Mine areas, which appeared to have not been affected by the mining activities. Ten samples were collected in November 2005 and 10 more in October 2008 to provide basin-wide background concentrations as discussed with DEQ and the Forest Service during the November 2007 scoping meeting. Air samples were not collected during the field activities.

3.4.2 Analytical Results

The waste rock/soil samples and background rock/soil samples were submitted under COC to Apex Laboratories, LLC of Tigard, Oregon, for analysis of total TAL of 23 analytes by EPA Method 6020. Analytical results for waste rock/soil are summarized in Tables 3 and 4 for the Ruth Mine and Morning Star Mine, respectively. Laboratory reports and COC documentation are provided in Appendix F. Comparisons of analytical results to SLVs for the Ruth and Morning Star Mines are provided in the following sections.

3.4.2.1 Ruth Mine

Arsenic and lead were detected in waste rock/soil samples at concentrations greater than the corresponding EPA PRG for industrial soil. Arsenic was detected in waste rock at concentrations ranging from 3.87 to 46.2 mg/Kg. Arsenic in waste rock exceeded the PRG of 1.6 mg/Kg by 2.4 to 28.9 times. The concentration of arsenic in all background samples was greater than the EPA PRG for industrial soil by factors ranging from 1.2 to 19 times. Lead was detected in waste rock at concentrations ranging from 346 to 34,000 mg/Kg, exceeding the EPA PRG for lead in industrial soil of 800 mg/Kg by up to 42.5 times. Lead was detected above the EPA PRG for lead in industrial soil in three background samples (BG-4, BG-5, and BG-7) by up to 6.8 times. Concentrations of the other hazardous substances analyzed in the waste rock/soil samples did not exceed the EPA PRGs for industrial soil. Based on the exceedance of background concentrations, several hazardous substances detected in waste rock/soil samples were determined to be COIs. Since the concentrations of COIs in waste rock exceeded background concentrations, background rock/soil sample analytical results were not used while completing the HHRA, and recreational users were assumed to be exposed only to waste rock/soil at the Ruth Mine site. This is considered a more conservative input parameter for the risk calculations.

3.4.2.2 Morning Star Mine

Arsenic and lead were detected in waste rock/soil samples at concentrations greater than the corresponding EPA PRG for industrial soil (lead ranging from 279 to 11,700 mg/Kg and arsenic from 7.23 to 30 mg/Kg). The concentration of lead exceeds PRG values by up to 14 times, and the concentration of arsenic exceeds PRG values by up to 19 times. The exceedance of PRG values is used as a screening tool to evaluate the need for a site-specific risk assessment process, as completed for the Morning Star Mine. The concentration of arsenic in all background

samples (1.97 to 30.5 mg/Kg) was greater than the EPA PRG for industrial soil by up to 19 times. Lead was detected above the EPA PRG for lead in industrial soil in three background samples (BG-4, BG-5, and BG-7) by up to 6.8 times. Concentrations of the other hazardous substances analyzed in the waste rock/soil samples did not exceed the EPA PRGs for industrial soil.

Several hazardous substances detected in waste rock/soil samples were determined to be COIs. Since the concentrations of COIs in waste rock exceeded background concentrations, background rock/soil sample analytical results were not used while completing the HHRA and recreational users were assumed to be exposed only to waste rock/soil at the Morning Star Mine site, a more conservative input parameter for the risk calculations.

3.5 TARGETS

3.5.1 Groundwater Exposure Pathway

Targets are receptors for a particular pathway within a target distance. For the groundwater pathway, the target distance was defined as 4 miles (as indicated in the Comprehensive Environmental Response, Compensation, and Liability Act [CERCLA] SI guidance; USEPA, 1992) and targets include drinking water wells and wellhead protection areas. Based on information obtained from the OWRD database, drinking water wells are not located within 4 miles of the Ruth Mine or Morning Star Mine. Wellhead protection areas were not noted within 4 miles of the mine sites. Employees of the nearby OCAFC (the only residents within 4 miles) rely on surface water from Opal Creek for drinking water.

Based on this information, groundwater within 4 miles of the Ruth Mine and Morning Star Mine is not used for beneficial use, including drinking water. The groundwater pathway is, therefore, incomplete and no further assessment is necessary. A conceptual site model is presented on Figure 2-2 in the HHRA.

3.5.2 Surface Water and Sediments Exposure Pathway

The target distance for exposure to potential elevated hazardous substances concentrations in the surface water was defined as 15 miles (as indicated in the CERCLA SI guidance; USEPA, 1992) and includes residences withdrawing surface waters for domestic usage. Based on information obtained from the OWRD database, a point of diversion water rights for domestic use of the Little North Santiam River water was issued to one family located approximately 12 miles downstream of the confluence of Ruth Creek and Battle Ax Creek. Approximately 40 tributary creeks flow into Battle Ax Creek and the Little North Santiam River downstream of the confluence of Battle Ax Creek and Ruth Creek, and prior to this point of diversion. Eighteen surface water samples were collected from Ruth Creek and Battle Ax Creek for the Ruth Mine investigations, and analytical results indicate that hazardous substances concentrations in these samples do not exceed the EPA tap water PRGs. Based on this information, the exposure pathway is incomplete and the downstream point of diversion is not considered a target. However, surface water sample analytical results were evaluated in the HHRA and are discussed in Section 4.1. Residents and guests of the Jawbone Flats area use surface water from Opal Creek (rather than Battle Ax Creek) for domestic use and, therefore, were not selected as a target for drinking water.

Residents, school-age and adult students, and guests of the Jawbone Flats area, as well as recreational users (including campers, hikers, fisherman, and hunters), are assumed to be exposed to surface waters and sediments in the area of the Ruth Mine and Morning Star Mine. The Forest Service has identified the Battle Ax Creek area, the location of the Ruth Mine site, as a "low use" management intensity zone for the Opal Creek Scenic Recreation Area, as presented on Figure 3-1 of the HHRA (Appendix A). The use intensity map is located at the Willamette National Forest website http://www.fs.fed.us/r6/willamette/manage/opalcreek/maps.html, and the Opal Creek Scenic Recreation Area Management Plan was presented in a decision notice by the Detroit Ranger District of the Willamette National Forest on June 26, 2002.

Ecological receptors considered included various mammals and birds, amphibians, fish, and aquatic invertebrates. A list of receptors of concern and exposures is provided in Table 2-2 of the Screening ERA.

3.5.3 Soil and Air Exposure Pathway

There are no workers or residents near the Ruth Mine or Morning Star Mine sites. The nearest residents are full-time employees of OCAFC, approximately 1 and 1.5 aerial miles away from the Ruth and Morning Star Mine, respectively, at Jawbone Flats (approximately 2 miles via FR 2209). Public use of the area is not currently restricted, although access is limited to foot, bicycle, or horse traffic. Public vehicular access is prohibited via a locked gate approximately 5 miles from the Ruth Mine site. In addition, access is limited seasonally by snow and the ground is frequently covered with snow during the winter months. Recreational users are the most likely receptors, and the exposure assumptions are discussed in Section 4.1. The exposure scenarios from soil and air (fugitive particulate dust) are discussed in detail in the HHRAs.

Ecological receptors include various mammals and birds, terrestrial plants, and invertebrates. A list of receptors of concern and associated exposures is provided in Table 2-2 of the Screening ERAs.

4.0 RISK ASSESSMENTS

The statement of work for the Ruth Mine EE/CA included completing HHRA and Screening ERAs for the mine sites. These risk assessments were performed using EPA and DEQ guidance as set forth in the Work Plan of the AOC (DEQ, 2000; USEPA, 1989, 1991, 1997, 1998, 2008). The HHRA is an analysis of the potential for adverse health effects that could result from current or future human receptor exposures to site media in the absence of mitigation. The Screening ERA analyzes the potential for adverse effects to the local ecology, including terrestrial and aquatic receptors. The risk assessments in this EE/CA address the exposure of receptors to hazardous substances related to the Ruth Mine site and are discussed in the following sections. A working session regarding the approach for conducting the HHRAs and Screening ERAs under the AOC was held in January 2009 and was attended by Mr. Paul Seidel, Mr. Peter Jones, Dr. Gary Pascoe, and GeoDesign. During the working session, analytical results, risk assessment guidance, and exposure assumptions were discussed and were incorporated into the risk assessments in this report. During the July 2009 meeting, DEQ concurred with the findings and conclusions of the risk assessments. The HHRA and Screening ERA reports are included as Appendices A through D.

4.1 HHRA - SURFACE WATER AND SEDIMENT EXPOSURE PATHWAY

Samples were collected from various media because the potential human and ecological receptors have various exposures to each media. Possible contaminants affect receptors differently depending on exposure frequency and duration, as well as the method of chemical intake and the size or age of the receptor.

Potential human receptors at the Ruth Mine and Morning Star Mine include residents of Jawbone Flats, school-age and adult students, and guests of the Jawbone Flats area, as well as recreational users (including campers, hikers, fisherman, and hunters). Based on information from interviews with OCAFC staff, programs and workshops offered are typically two to six days in duration. Of the students that participate in these programs, there is less than 1 percent return rate. Based on the "low use" recreational designation and observed area use by OCAFC staff, the exposure assumptions discussed below are considered to be conservative.

The exposure and toxicity models use specific exposure parameters to determine uptake and effects. In completing the HHRA portions of the Focused SI and SI, conservative exposure duration and frequency scenarios were utilized. The human targets selected for the various exposure scenarios include adult and child recreational users. Adults, people of the ages between 7 and 70 years old (per the DEQ guidance [DEQ, 2000]), were assumed to be exposed between 4 and 20 days per year, every year for 9 to 30 years. The 20-day value is the reasonable maximum exposure (RME), which is an estimate of worst-case conditions, while the 4-day value is the central tendency exposure (CTE), which is an estimate of more typical adult exposure. Children between the ages of 0 and 6 years old were assumed to be exposed between 4 and 20 days per year, every year for 2 to 6 years, establishing the children's CTE and RME, respectively. The exposure times for surface water and sediment were between 0.5 and 1 hour per day for the CTE and RME exposures, respectively, for both adults and children. These exposure scenarios are believed to represent significantly higher rates of use than has been observed by OCAFC, as previously discussed. The exposure scenarios are discussed in greater detail in the Ruth and Morning Star Mine HHRAs presented in Appendices A and C.

The exposure routes for adults and children at the site include ingestion of waste rock and soil, surface water, and sediments; direct skin contact with rock and soil, surface water, and sediments; and inhalation of dust comprised of waste rock soil. This section is limited to the surface water and sediment exposure analysis while exposures to waste rock, soil, and dust are further discussed in Section 4.3.

Non-cancer risks are expressed numerically as compared to the hazard quotient of 1.0. If the calculated risk is below 1.0, then there is no concern that adverse health effects will be observed in the exposed population. If the hazard quotient is 1.0 or greater, risk of adverse health effects exists. For cancer risks, the probability of an individual developing cancer over a lifetime as a result of exposure to a contaminant is used for expressing risk. If the probability of developing cancer is equal to or less than 1 in 1 million (1.0 E-6), the DEQ-acceptable cancer risk level as defined in OARs 340-122-115(2)(a), (3)(a), and (4)(a) is an acceptable cancer risk. This is also the low end of the EPA range of cancer risk thresholds of 1.0 E-4 to 1.0 E-6. CERCLA risk thresholds are discussed in the National Contingency Plan (40 Code of Federal Regulations [CFR] 300). In assessing the carcinogenic risks posed by a site, EPA established an excess cancer risk (ECR) of

1.0 E-6 (1 chance in 1 million) as a "point of departure" for establishing risk thresholds of concern. Where the cumulative ECR to an individual based on the RME for current and future land use is less than 1.0 E-4 (1 chance in 10,000) and the non-carcinogenic hazard index is less than 1, action generally is not warranted unless there are adverse environmental impacts (USEPA, 1991).

Risks from exposure to lead are not evaluated by the toxicological methods used for other contaminants. Regulatory agencies, including EPA and DEQ, recommend evaluating lead by using models to predict blood lead levels. Lead concentrations were evaluated using the Integrated Exposure Uptake BioKinetic (IEUBK) model and the Adult Lead Methodology (ALM) model (USEPA, 1999). The models predict blood lead levels in adults, children, and fetuses of pregnant mothers based on exposures, concentrations, and ingestion and uptake rates and are further discussed in the soil and air exposure pathways (Section 4.3). The HHRAs are presented in Appendices A and C.

4.1.1 Ruth Mine

In the HHRA, cadmium and lead were identified as non-carcinogenic COPCs for surface water. Arsenic was identified as a non-carcinogenic, as well as a carcinogenic COPC for stream sediments. The surface water concentrations that were used to determine the applicability of the COPCs included the mine adit water samples, the samples collected in Ruth Creek, and the samples collected downstream of the confluence in Battle Ax Creek. The upstream surface water samples (SW-MS-14 through SW-MS-16, SW-6, SW-8, SW-R-19, and SW-R-20) were not used in the human receptor exposure assumptions because they are considered to represent background concentrations. The mine adit water samples were included in the HHRA because the potential receptors have equal opportunity for exposure to stream surface water or mine adit water.

The HHRA risk calculation results, provided in Tables A-5 through A-32 in Attachment A of the HHRA, indicate that non-carcinogenic risk and carcinogenic risks from incidental ingestion or dermal contact from the elevated cadmium in surface water and arsenic in sediments were below regulatory thresholds for adults and children. The results of the HHRA determined that there were no unacceptable cancer human health risks due to dermal contact or incidental ingestion of surface water or sediments at the Ruth Mine site. The HHRA results also determined there were no unacceptable non-cancer human health risks due to dermal contact or incidental ingestion of surface water or sediments at the Ruth Mine site. Tables 5 and 6 summarize the results of the non-cancer hazard quotients and the cancer risks, respectively.

4.1.2 Morning Star Mine

In the HHRA, arsenic was identified as a carcinogenic and non-carcinogenic COPC for surface water. Arsenic was identified as a non-carcinogenic, as well as a carcinogenic COPC for stream sediments. Lead was also identified as a non-carcinogenic COPC in sediment. The surface water concentrations that were used to determine the applicability of the COPCs included the mine adit water sample, the samples collected in Blue Jay Creek, and the samples collected at the confluence of Blue Jay Creek and Battle Ax Creek as well as downstream of the confluence in Battle Ax Creek. The upstream samples (SW-MS-14 through SW-MS-16) were not used because

they are considered to represent background concentrations. The mine adit water sample was included in the HHRA because the potential receptors have equal opportunity for exposure to stream surface water or mine adit water.

The HHRA risk calculation results indicate that non-carcinogenic risk and carcinogenic risks from incidental ingestion or dermal contact from the elevated arsenic in surface water and arsenic in sediments were below regulatory thresholds for adults and children. The results of the HHRA determined that there were no unacceptable cancer human health risks due to dermal contact or incidental ingestion of surface water or sediments at the Morning Star Mine site. The HHRA results also determined there were no unacceptable non-cancer human health risks due to dermal contact or incidental ingestion of surface water or sediments at the Morning Star Mine site. Tables 7 and 8 summarize the results of the non-cancer hazard quotients and the cancer risks, respectively.

4.2 SCREENING ERA – SURFACE WATER AND SEDIMENT EXPOSURE PATHWAY

Screening ERAs were completed for the Ruth Mine and Morning Star Mine sites to assess potential risk to ecological targets. The Screening ERAs were completed following 2001 DEQ *Guidance for Ecological Risk Assessment: Level II Screening* (DEQ, 2001) and consistent with the EPA *Guidelines for Ecological Risk Assessment* (USEPA, 1998). Various ecological receptors, including terrestrial plants and wildlife, as well as birds, invertebrates, and aquatic organisms, were considered. Tables 2-2 and 2-3 in the Screening ERAs provide ecological receptors of concern, and assessment endpoints and measures of effect and exposure, respectively. In addition, the benthic macroinvertebrate population was evaluated following DEQ's guidance for macroinvertebrate analysis (OPSW, 1999). A benthic macroinvertebrate evaluation provides a more direct and site-specific assessment of the creek sediment biological community than comparison of sediment data to screening value criteria. The results of the Screening ERAs are discussed, as applicable, below. The complete Screening ERAs are presented as Appendices B and D.

For the Screening ERAs, DEQ Level II SLVs were used (DEQ, 2001). Concentrations of hazardous substances in various media exceed Level II SLVs. The SLVs are considered to be conservative screening tools to identify potential risk rather than representing actual site-specific risk, as per the above-referenced DEQ guidance. After the SLVs are used to identify potential risks, additional considerations are used to assess actual risk.

4.2.1 Ruth Mine

The results of the Screening ERA indicate that cadmium, copper, lead, and zinc were elevated above the applicable Level II SLVs in surface water collected from the adit water samples. Lead was detected above the applicable SLV in Ruth Creek samples SW-4 and SW-5. Cadmium, lead, and zinc were determined to be CPECs for aquatic organism exposure to surface water. Surface water samples collected from Battle Ax Creek downstream from the Ruth Mine area and Ruth Creek confluence did not have hazardous substances detected at concentrations exceeding SLVs. The adits and Ruth Creek do not represent suitable habitat for aquatic organisms because of one or more of the following: a lack of quality food source, very steep gradient, or intermittent flow.

The cadmium, copper, lead, and zinc concentrations in surface water samples were below the applicable Level II SLVs for birds and mammals exposed to the surface water. Table 1 presents the surface water chemical analytical results.

The Screening ERA identified several hazardous substances as CPECs in the sediment from Ruth Creek and Battle Ax Creek, with cadmium, lead, and zinc showing the highest potential risk to ecological receptors. Tables in Attachment A of the Screening ERA present the SLV screening, CPECs, and risk ratios for each medium (waste rock, surface water, and sediments). The risks were predicted for freshwater sediment benthos and wildlife bioaccumulation. The concentrations of cadmium and zinc exceed the wildlife bioaccumulation SLVs by the greatest amount, suggesting the risk is related to organisms using the sediment as a food source. Based on the field observations, Ruth Creek does not provide adequate habitat for food source due to its lack of organic sedimentary material, intermittent flows (including dry periods), and steep gradient; therefore, sediment benthos are not a realistic population to be encountered in Ruth Creek and wildlife bioaccumulation is not applicable. For Battle Ax Creek, sediment benthos would be expected to be present as a food source and a source of hazardous substances to wildlife from sediment if they are bioavailable. Accordingly, the effect of these hazardous substances to sediment populations is further evaluated in the macroinvertebrate analysis.

The evaluation of the macroinvertebrate community was completed using the methods in OPSW (OPSW, 1999). The evaluation utilizes data, provided by the enumeration and speciation of macroinvertebrate samples collected in Battle Ax Creek, to complete an OPSW metrics scoring procedure. The scores related to the overall condition of the macroinvertebrate community. Four classes of disturbance for the stream include no impairment, slight impairment, moderate impairment, and severe impairment. Based on the results of the analysis, two sample locations upstream of the confluence of Battle Ax Creek and Ruth Creek (BI-R-19 and BI-R-20) show no impairment to the macroinvertebrate community, as defined by OPSW. The downstream sample locations (BI-R-22 and BI-R-23) indicate no impairment of the benthic macroinvertebrate community in Battle Ax Creek and have similar macroinvertebrate community qualities to the upstream locations.

Ecological risk assessment indicated that although concentrations of hazardous substances in waste rock and sediments may pose risk to ecological receptors, a macroinvertebrate evaluation indicated that benthic macroinvertebrate communities showed no impairment. This suggests that hazardous substances in sediment and waste rock are not bioavailable at significant concentrations. Further discussion of the relationship between hazardous substances concentrations and the macroinvertebrate community is provided in the Screening ERA. In addition, the synthetic precipitation leaching procedure results from the 2005 sampling (GeoDesign, 2006) indicate that conditions simulating natural precipitation do not result in significant leaching of hazardous substances from the waste rock. The laboratory report of the enumeration and speciation completed by EcoAnalysts is provided in Appendix F.

4.2.2 Morning Star Mine

The results of the Screening ERA indicate that aluminum and lead were elevated above the applicable Level II SLVs in surface water collected from Blue Jay Creek (lead only) and in one confluence sample location in Battle Ax Creek (SW-MS-17) and were determined to be CPECs for

aquatic organism exposure to surface water. Aluminum was detected in one sample only (SW-MS-17) and was not detected in adit water or surface water collected from Blue Jay Creek. Blue Jay Creek does not represent suitable habitat for aquatic organisms because of a lack of quality food source, very steep gradient, and intermittent flow. The aluminum and lead in surface water samples were below the applicable Level II SLVs for birds and mammals exposed to the surface water, presented in Table A-2 of the Screening ERA. Table 3 presents the surface water chemical analytical results.

The Screening ERA indicated that several hazardous substances were selected as CPECs in the sediment from Blue Jay Creek and Battle Ax Creek with cadmium, lead, and zinc showing the highest potential risk to ecological receptors. Tables in Appendix A of the Screening ERA present the SLV screening, CPECs, and risk ratios for each medium (waste rock, surface water, and sediments). The risks were predicted for freshwater sediment benthos and wildlife bioaccumulation. The highest concentrations of cadmium, lead, and zinc exceeding SLVs in sediment were in the samples collected down gradient of the adit in Blue Jay Creek (SED-MS-12 and SED-MS-13). The concentrations exceed the wildlife bioaccumulation SLV by the greatest amount, suggesting the risk is related to organisms using the sediment as a food source. Based on the field observations, Blue Jay Creek does not provide adequate habitat or food source due to its lack of organic sedimentary material, intermittent flows (including dry periods), and steep gradient; therefore, sediment benthos are not a realistic population to be encountered in Blue Jay Creek and wildlife bioaccumulation is not applicable. CPECs in sediment from Battle Ax Creek included cadmium, copper, lead, nickel, and zinc. These concentrations of hazardous substances at the confluence of Blue Jay Creek and Battle Ax Creek indicate higher exceedances of the screening values, but downstream the concentrations appear to be only slightly above background. Accordingly, the effect of these hazardous substances to sediment populations is further evaluated in the macroinvertebrate analysis.

The evaluation of the macroinvertebrate community was completed using the methods in OPSW (OPSW, 1999). The evaluation utilizes data, provided by the enumeration and speciation of macroinvertebrate samples collected in Battle Ax Creek, to complete an OPSW metrics scoring procedure. The scores related to the overall condition of the macroinvertebrate community. Four classes of disturbance for the stream include no impairment, slight impairment, moderate impairment, and severe impairment. Based on the results of the analysis, there appears to be two sample locations upstream of the confluence of Battle Ax Creek and Blue Jay Creek with no impairment, as defined by OPSW. One station upstream (BI-MS-15) indicates slight impairment, possibly related to the lack of habitat at that station. The downstream sample location (BI-MS-18) indicates no impairment of the benthic macroinvertebrate community in Battle Ax Creek and has a similar macroinvertebrate community to the upstream locations. These results suggest that hazardous substances in the sediments are not sufficiently bioavailable to result in risks to the ecological receptors present. This lack of bioavailability is likely related to the hazardous substances being bound in a hard rock matrix. Further discussion of the relationship between hazardous substances concentrations and the macroinvertebrate community is provided in the Screening ERA. The laboratory report of the enumeration and speciation completed by EcoAnalysts is provided in Appendix F.

4.3 HHRA – SOIL AND AIR EXPOSURE PATHWAY

Arsenic and lead were determined to be COPCs for waste rock/soil at both the Ruth Mine and the Morning Star Mine. The risk calculations used conservative factors for exposure frequency and duration as well as assuming that those receptors exposed would be exposed only to waste rock/soil rather than general soil and rock in the area of the mine sites to simulate worst-case conditions, as background sample concentrations were not used in the calculations. The exposure scenarios are discussed previously in Section 4.1. Air exposure inhalation rates were taken from EPA 1997 *Exposure Factors Handbook* (USEPA, 1997) and represent exposure to fugitive particulate dust. The HHRA calculation results for each mine indicate that non-carcinogenic risk and carcinogenic risks for incidental ingestion, dermal contact, or inhalation of dust particles for arsenic are below the DEQ-acceptable cancer risk level, the more conservative threshold in the range of EPA thresholds (ECRs of 1.0 E-4 to 1.0 E-6). Soil "hot spot" assessment for human exposure is required only in instances where baseline risk exceeds acceptable risk levels as defined in OAR 340-122-115(1), under DEQ guidance (DEQ, 1998). Based on the HHRA, baseline risk is acceptable and, therefore, the "hot spot" assessment is not applicable or required.

At the January 2009 working session (discussing risk assessment approaches), DEQ requested additional calculations with an increased frequency of exposure when assessing potential risk. This was incorporated into each of the HHRAs. Increasing the number of days to 30 or 40 days a year would increase the ECR to 1.5 E-6 and 2.0 E-6, respectively, at each mine site. If a child was to play on a waste rock pile for 200 days a year, the ECR would be 1.0 E-5 and for 365 days a year, the ECR would increase to 2.0 E-5. These are still within the range of EPA ECR thresholds of 1.0 E-4 to 1.0 E-6. These results are discussed in the HHRAs presented as Appendices A and C.

The risk from lead at both the Ruth Mine and Morning Star was evaluated using EPA models (IEUBK and ALM; USEPA, 1999) to predict blood lead levels based on exposure frequency, duration, as well as pathways (such as inhalation or ingestion). The exposures to Ruth Mine and Morning Star Mine site waste rock/soil were considered an additional "alternate source" of lead to the EPA guidance default levels for lead exposure. Conservative estimates of exposure of 20 days per year for the first 7 years of a child's life were used for each of the HHRAs, which, given the actual usage of the Ruth Mine and Morning Star Mine sites by day hikers including students of OCAFC (Section 4.1), is conservative. Since the model uses a continuous exposure assumption (24 hours a day, 365 days each year), a time-weighted concentration was developed for each mine site based on the mean waste rock concentrations (4,643 mg/Kg for the Ruth Mine and 4,731 mg/kg for the Morning Star Mine) for 20 days a year and the assumption that children are exposed to a certain amount of lead (200 mg/Kg) at their residence on a daily basis as well. This resulted in time-weighted averages of 443 mg/Kg and 448 mg/kg for the Ruth Mine and Morning Star Mine sites, respectively. Based on the results of the HHRA completed using EPA guidance documents for the IEUBK model, it was determined that when ingestion rates of waste rock is 100 milligrams per day (mg/day), the predicted blood lead levels in children are below the EPA action level of 10 micrograms per deciliter (µg/dL). Lower ingestion rates predict lower blood lead levels. In adults, the RME ingestion rate of 25 mg/day of waste rock resulted in predicted blood lead levels below the EPA action level of 10 µg/dL. For additional evaluations, an increase in the frequency of exposure of 30- and 40-day exposures resulted in geometric mean blood lead levels of 8.0 and 9.1 µg/dL, respectively, for a child 0.5 year to 7 years old. The

increase of frequency of exposure of 30- and 40-day exposures resulted in geometric mean blood lead levels of 8.1 and 9.2 µg/dL, respectively, for the Morning Star Mine for a child 0.5 year to 7 years old. The time-weighted soil concentration that resulted in the blood lead level threshold in children was found to be 800 mg/Kg, the EPA PRG for industrial soil. This time-weighted soil concentration would correspond with an exposure of 49 days per year to the soils at the Ruth Mine waste pile or 48 days per year to the soils at the Morning Star Mine waste pile. Based on the risk assessment work, the exposure of recreational users to waste rock was not found to result in unacceptable risk to human health at either the Ruth Mine or the Morning Star Mine.

4.4 SCREENING ERA – SOIL AND AIR EXPOSURE PATHWAY

The Screening ERA for the Ruth Mine indicated that soil CPECs, which represented potential risk for terrestrial plants, invertebrates, birds, and mammals, included arsenic, cadmium, copper, lead, iron, lead, manganese, selenium, silver, and zinc. With the exception of the background samples, all of the samples were collected from the waste pile or roadbed locations. Of the 10 CPECs for soil, 9 were found to have 95 percent upper confidence limit (UCL) background concentrations exceeding the Level II SLVs, as shown in Table 5-1 of the Screening ERA. The Screening ERA for the Morning Star Mine indicated that soil CPECs included several hazardous substances, including cadmium, copper, iron, lead, manganese, silver, and zinc, that represented potential risk for terrestrial plants, invertebrates, birds, and mammals. With the exception of the background samples, all of the samples were collected from the waste pile or roadbed locations. Of the nine hazardous substances determined to be CPECs for soil, eight were found to have 95 percent UCL background concentrations exceeding the Level II SLVs, as shown in Table 5-1 of the Morning Star Screening ERA.

The potential ecological risks to different biological communities do not take into account the suitability of habitat; however, observations regarding habitat are commonly evaluated by risk assessors to provide context in the overall risk assessment process. The waste piles and roadbed at each of the mine sites do not provide a quality habitat or food source for plants and animals because of the hard surface and minimal organic content. When considering the area of the waste rock pile in relation to typical habitat sizes and the other available higher quality, more suitable habitat surrounding the waste rock pile, it is not expected that birds and/or mammals would spend a significant amount of time foraging for food at the waste rock pile. In addition, the presence of rock, regardless of hazardous substances content, would not represent a quality habitat for plants or invertebrates, including their use as food. The ecological risks from the waste rock/soil at the Ruth and Morning Star Mines are considered to be insignificant due to limited exposure.

4.5 RISK ASSESSMENT SUMMARY

Based on the HHRAs, no unacceptable risk to human health, under RME conditions, from exposure to waste rock, surface water, adit water, airborne dust, and sediments was observed at either the Ruth Mine site or the Morning Star Mine site. Based on the Screening ERA, waste rock soils contain concentrations of hazardous substances that, in some cases, exceed ecological SLVs; however, the 95 percent UCL of background soils hazardous substances concentrations also exceed the ecological SLVs. In addition, the waste rock soil is not considered suitable habitat for the ecological receptors and is considered a small exposure area due to the large

amount of more suitable habitat surrounding the site; therefore, significant effects to species in the area is unlikely and risk is low. The concentrations of hazardous substances in surface water samples collected from Blue Jay Creek, Ruth Mine adit water, and Ruth Creek indicated a potential risk to aquatic ecological receptors but not to other ecological receptors (birds and mammals). Actual risks from the hazardous substances in surface waters from the Ruth Mine adits, Ruth Creek, and Blue Jay Creek are low since the adits, Ruth Creek, and Blue Jay Creek do not provide suitable habitat for aquatic receptors. The hazardous substances concentrations were not found to exceed ecological SLVs in Battle Ax Creek, with the exception of lead in one sample collected in 2005 and in surface water collected at the interface of the adit water discharge. Sediment samples were shown to have concentrations of hazardous substances exceeding ecological SLVs; however, the macroinvertebrate evaluations indicated that no impairment of the benthic community was observed downstream of the Morning Star Mine and Blue Jay Creek and the Ruth Mine and Ruth Creek.

Future mass wasting at Ruth Mine Adit 4 could result from extreme flood events, causing cut bank erosion advancing into the waste rock pile. This change in mass wasting at Adit 4 could result in conditions that differ from what have been evaluated in the risk assessments. This potential change could result in additional waste rock sedimentation in Ruth Creek and potentially Battle Ax Creek and represents a threat of a release of hazardous substances into the environment. According to the January 2012 Forest Service slope stability evaluation, future mass wasting at Morning Star Mine could also result from flood events and the rotting of timbers beneath the waste rock pile. This change could result in conditions that are different from those previously evaluated in the risk assessments and represents a threat of release of hazardous substances into Blue Jay and Battle Ax Creek. Based on the slope stability evaluation, mass wasting at Ruth Mine Adit 5 is not likely in the future.

Based on the results of the risk assessments, no unacceptable risk was related to adit water discharges at Ruth Mine or Morning Star Mine. Conditions related to adit water are not likely to change; however, the Forest Service plans to conduct additional monitoring as needed to verify future conditions.

5.0 IDENTIFICATION OF REMOVAL ACTION OBJECTIVES

5.1 REMOVAL ACTION JUSTIFICATION

In May and June 2009 and January 2012, slope stability evaluations (Appendices G, H, and I) were conducted at the Ruth Mine to address the potential for significant mass wasting at the site. The slope stability evaluations identified potential for significant future mass wasting of the waste rock pile at Ruth Mine Adit 4. The evaluations indicated that the Ruth Mine Adit 5 waste rock was stable and conditions were not expected to change significantly in the future. Under the Forest Service slope stability evaluation, there is potential for future mass wasting at Morning Star Mine. Future conditions at Ruth Mine Adit 4 and Morning Star Mine may change, resulting in more significant mass wasting of waste rock and consequently risks greater than those outlined in the risk assessments.

The National Oil and Hazardous Substances Pollution Contingency Plan (NCP) indicates that a removal action is appropriate at a site when there is a threat to public health, welfare of the United States, or the environment. The determination of threat to public health or the environment is based on one or more of the eight factors outlined at 40 CFR 300.415(b)(2). The relevant factors in this EE/CA include the following:

- "Actual or potential exposure to nearby human populations, animals, or the food chain from hazardous substances, pollutants, or contaminants"
  - This factor is satisfied because there are features at the sites that are applicable, including waste rock with concentrations of hazardous substances exceeding screening level criteria. Based on the slope stability evaluations (GeoDesign, 2009b; GeoDesign 2009c; Forest Service, 2012), the waste piles at Ruth Mine Adit 4 and Morning Star Mine may fail and release hazardous substances in the waste rock into Ruth Creek, Blue Jay Creek, and Battle Ax Creek. Such releases could increase exposures of animals and the food chain such that current risk assessments would understate the risks.
- "High levels of hazardous substances, pollutants, or contaminants in soils at or near the surface that may migrate"
  - This factor is satisfied because the waste rock contains elevated concentrations of hazardous substances. At Ruth Mine Adit 4 and Morning Star Mine, there is potential for cut bank erosion to result in increased mass wasting of waste rock. Based on the slope stability evaluations, small-scale erosion of contaminated waste rock has occurred at the sites for several years.
- "Weather conditions that may cause hazardous substances, pollutants, or contaminants to migrate or be released"
  - This factor is satisfied because the sites receive significant precipitation, which, based on the slope stability evaluations, creates potential for additional migration of contaminated waste rock materials from Ruth Mine Adit 4 and the Morning Star Mine.

EE/CA guidance indicates that "risk evaluation can justify removal actions and identify what current or potential exposures should be prevented." There is potential for waste rock conditions at Ruth Mine Adit 4 and Morning Star Mine to change in the future. The level of this risk warrants a response action at Ruth Mine Adit 4 and Morning Star Mine to address the instability of the waste rock piles at those locations.

Once the lead agency determines, based on the above factors, that there is a threat, "the agency may take any appropriate action to abate, prevent, minimize, stabilize, mitigate, or eliminate the release or threat of release." 40 CFR 300.415(b)(1).

5.2 REMOVAL ACTION OBJECTIVES

The objectives of a removal action at the Ruth Mine site are to prevent future releases of hazardous substances associated with waste rock, maintain acceptable levels of risk to human and ecological receptors, and to meet applicable or relevant and appropriate requirements (ARARs) to the extent practicable.

Adequately addressing stability of the Ruth Mine Adit 4 and Morning Star Mine waste rock piles is expected to satisfy the removal action objective (RAO) to maintain acceptable risk in the future.

5.3 ARARs

ARARs are used to evaluate the extent of removal action needed, develop removal action alternatives, and guide the implementation and operation of the preferred alternative. For removal actions, the NCP provides that ARARs shall be considered to the extent practicable. Specifically, 40 CFR 300.415(j) states "Fund-financed removal actions under CERCLA section 104 and removal actions pursuant to CERCLA section 106 shall, to the extent practicable considering the exigencies of the situation, attain ARARs under federal environmental or state environmental citing laws." ARARs are to be identified on a site-specific basis to determine if the ARAR is applicable and if not, if it is relevant and appropriate.

Applicable requirements are those cleanup standards; control standards; and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that specifically address a hazardous substance, pollutant, contaminant, or remedial action. Relevant and appropriate requirements are those cleanup standards; control standards; and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that, while not "applicable" to a hazardous substance, pollutant, contaminant, or remedial action, address problems or situations sufficiently similar (relevant) to those encountered and are well-suited (appropriate) to circumstances at the particular site.

Table 9 presents a summary discussion of potential ARARs for the Ruth Mine and Morning Star Mine sites based on site-specific conditions.

6.0 IDENTIFICATION AND ANALYSIS OF REMOVAL ACTION ALTERNATIVES

As discussed in Section 4.0, there is a threat of release of hazardous substances due to mass wasting at Ruth Mine Adit 4 and Morning Star Mine that may pose an unacceptable risk to human health or welfare or the environment. Because of this threat, this EE/CA identifies and evaluates removal action alternatives to address the stability of the waste rock piles. To aid in determining alternative options, management and treatment technologies are screened to eliminate those options that are not feasible or do not meet goals and objectives. Potential treatment technologies for inorganics include in situ physical or chemical treatment, ex situ physical or chemical treatment (assuming excavation), containment, and disposal. Through screening, alternatives that involve management, engineering controls, as well as disposal were retained. Both in situ and ex situ physical and chemical treatment technologies were screened out due to questionable effectiveness, difficult implementation, and high cost related to both implementation and treatment studies necessary to determine effectiveness.

The removal action alternatives for the Ruth Mine and Morning Star Mine sites are as follows:

1. No Action
2. Institutional Controls: Signage and Removal Restrictions

3. Slope Stabilization, Consolidation, and Rock Buttressing at Ruth Mine Adit 4; Vehicle Access Restrictions at Ruth Mine Adit 5 Access Road; Waste Rock Pull Back, Slope Stabilization and Consolidation at Morning Star Mine
4. Removal and Off-Site Disposal for Ruth Adit 4 and Morning Star Waste Rock, Vehicle Access Restrictions at Adit 5 Access Road

Based on the results of the risk assessments, Alternatives 3 and 4 would meet the waste rock stabilization RAO. Alternatives 1 and 2 do not meet the RAO of stabilizing waste rock piles at Ruth Mine Adit 4 and Morning Star Mine. The criteria used to evaluate the removal action alternatives are effectiveness, implementability, and cost. Specific components of effectiveness include overall protectiveness of human health and the environment, ability to achieve RAOs and ARARs as practicable, and the short- and long-term effectiveness. Implementability involves the technical and administrative feasibility, availability of resources, and community acceptance. Costs were determined using professional judgment and experience in remedial excavation projects. Cost variances are -30 percent/+50 percent and include capital cost as well as design and administrative costs.

Each alternative is further described in the following sections. The cost estimates for Alternatives 2 through 4 are provided in Appendix J.

6.1 NO ACTION (ALTERNATIVE 1)

The No Action alternative leaves both the Ruth Mine and Morning Star Mine sites in their current condition. Based on the slope stability evaluations, there is potential for significant mass wasting in the future at Ruth Mine Adit 4. The Forest Service slope stability evaluation indicated potential for future mass wasting at the Morning Star Mine. There is a threat of release at both Ruth Mine Adit 4 and Morning Star Mine. Alternative 1 would not be effective in the long-term. Other alternatives will be compared to the baseline represented by the No Action alternative. Management or treatment technologies are not utilized by this alternative. No Action-specific ARARs are applicable. This alternative would be easily implemented. Disturbance of the local ecology would not occur and inspection or monitoring would not be required. There is no capital or long-term monitoring or maintenance costs associated with the No Action alternative.

6.2 INSTITUTIONAL CONTROLS (ALTERNATIVE 2)

The Institutional Controls alternative would include prohibiting waste rock removal and placing signs at Ruth Mine Adit 5 and Adit 4 and at Morning Star Mine locations to inform the public about the physical and contamination risks. Road access limitations already in place would continue to limit public access. This option would limit recreational exposure via distance from public vehicle access and on a voluntary basis based on education. Reducing access would potentially reduce human receptor exposures. This would prevent the possible use of the waste rock materials at locations outside the area of the mines. Action-specific ARARs are not applicable. Implementation would be relatively easy and require minimal sign maintenance. It is assumed that two signs would be placed at each adit location with final locations to be determined. Minimal disturbance of the local ecology would occur. This alternative would not meet the RAO of preventing potential future mass wasting of waste rock at Ruth Mine Adit 4 and Morning Star Mine that presents an unacceptable risk to human health and the environment and would not meet ARARs. Cost for institutional controls would be minimal and require minimal

periodic maintenance/replacement of signage. The estimated cost for determining the sign language, obtaining the signs, and installing the signs at the adit locations is $5,200 and the estimated cost for writing and administratively processing the removal restrictions is $4,600. The total estimated cost for this alternative is $9,800.

6.3 SLOPE STABILIZATION, CONSOLIDATION, AND ROCK BUTTRESSING AT RUTH MINE ADIT 4; VEHICLE ACCESS RESTRICTIONS AT RUTH MINE ADIT 5 ACCESS ROAD; WASTE ROCK PULL BACK, SLOPE STABILIZATION, AND CONSOLIDATION AT MORNING STAR MINE (ALTERNATIVE 3)

Alternative 3 would involve slope stabilization and consolidation of the waste rock pile at Ruth Mine Adit 4 and rock buttressing the toe of the waste rock pile, as well as the stream cut bank just upstream of the waste rock pile. At Ruth Mine Adit 4, there is potential for significant mass wasting of the waste rock material due to slope failure related to the current slope configuration and stream erosion. The cut bank upstream of the waste rock pile may continue into the waste rock pile, causing the slope to fail. In addition, the current rock buttress at the toe of the slope of the waste rock pile does not extend the entire length of the pile. This unprotected area shows evidence of previous slope failure.

The access road to Ruth Mine Adit 5 would be blocked to vehicular traffic by placing large boulders at the intersection with FR 2209. This would be accomplished using the Spider Excavator. This would prevent unpermitted removal of contaminated material from Adit 5. The current and expected future access to the area prevents motor vehicle access by the public at the locked gate approximately 5 miles away on FR 2209.

Based on the Forest Service evaluation, the waste rock at Morning Star Mine could be subject to mass wasting during extreme flood events and from further rotting of the timbers supporting a portion of the waste rock pile. Alternative 3 would also involve the pull back and consolidation of waste rock at Morning Star Mine. A stepped stream channel would be created with riprap.

This alternative would stabilize waste rock at Ruth Mine Adit 4 and Morning Star Mine, consistent with the recommendations presented in the Forest Service slope stability evaluation, and would prevent potential discharge of waste rock materials to Ruth Creek and Blue Jay Creek, respectively. Therefore, this alternative would meet the RAOs by preventing future releases of hazardous substances associated with waste rock, maintaining acceptable levels of risk to human and ecological receptors, and meeting ARARs to the extent practicable.

At Ruth Mine Adit 4 this alternative would pull waste rock material back, re-grade the slope to a slope approaching 2 horizontal to 1 vertical (H:V), and buttress the toe of the slope of the waste rock pile to stabilize and protect the slope. The cut bank that is located upstream of the waste rock pile would also be buttressed with large rocks for stabilization. This alternative would place erosion control materials, including erosion control mats, and plant native seed. The resulting cover would further protect human health and the environment by reducing potential exposure to the hazardous substances in the consolidated waste piles.

At Morning Star Mine this alternative would pull back the fine waste rock material from the Blue Jay Creek stream channel while separating out the lumber and wood debris. The waste rock material would then be consolidated at the hillside below the adit and graded at a slope approaching 2H:1V. Stockpiled lumber and wood debris would be placed over the waste rock pile for cover and erosion control. Large rock would be separated out during the pull back for creating a stepped stream channel with on-site materials.

Prior to initiating the activities, an engineering geologist would complete the slope stability and grading design for each site. The excavation, consolidation, and re-grading of materials above Ruth Creek and Blue Jay Creek would require Best Management Practice measures, such as silt fencing to control spilling of waste rock materials downslope during excavation and re-grading activities. The pull back, grading, and consolidation activities would require the use of a Spider Excavator, which is suitable for working on steep slopes, and light support vehicles for fuel and supplies. Appropriate erosion control and re-vegetation measures would be implemented at all disturbed sites and along access roads.

Equipment and personnel access to the Ruth Mine Adit 4 and Morning Star Mine areas is limited by several factors, including bridge weight limits of 7,700 gvw at the Battle Ax Creek bridge, the inability to load rate the Gold Creek Bridge and Half-Bridges as determined in the Engineering Memorandums (Forest Service, 2011a and 2011b) provided by the bridge engineer for the Forest Service, and the potential road washout on FR 2209 prior to the Ruth Mine site. As of the July 2009 sampling event, the road was partially blocked by a landslide prior to the Ruth Mine access roads. It is assumed that appropriate bridge repair would be completed to allow safe access of the Spider Excavator to the sites. Although the specifics of bridge repair are not discussed in this document, the estimated cost is $130,000 and $170,000. If bridge repair is not completed, the mobilization could be completed via helicopter. This additional mobilization cost provided by Columbia Helicopters is estimated at $150,000, with availability dependent on seasonal fire use.

Monitoring, operations, and maintenance (MOM) would include inspection of the slope and surface water sample collection in Battle Ax Creek at two locations downstream of the confluence of Ruth Creek after one, three, and five years following implementation. Surface water sampling would include a visual observation for turbidity and chemical analysis of total metals limited to arsenic, barium, cadmium, copper, lead, and zinc by EPA 6000/7000 Series Methods.

Alternative 3 is compared to the other alternatives with respect to effectiveness, implementability, and cost in Table 10.

The capital cost for Alternative 3 is estimated to range between $463,500 and $489,500 dependent on the bridge and road repairs or helicopter access. The net present value (NPV) for MOM is estimated at $9,300. The total cost range for Alternative 3 is estimated at $473,000 to $499,000. For purposes of this estimate, it is assumed that helicopter access would be required to complete Alternative 3. The cost detail is presented in Appendix J.

6.4 REMOVAL AND OFF-SITE DISPOSAL FOR RUTH MINE ADIT 4 AND MORNING STAR MINE WASTE ROCK, VEHICLE ACCESS RESTRICTIONS AT ADIT 5 ACCESS ROAD (ALTERNATIVE 4)

Alternative 4 would involve excavation and off-site disposal of waste rock materials from Ruth Mine Adit 4 and Morning Star Mine. The excavation and off-site disposal would reduce the potential for mass wasting at both Ruth Mine Adit 4 and Morning Star Mine. The access road to Adit 5 would be blocked to vehicular traffic at the intersection with FR 2209. This would prevent unpermitted removal of contaminated material from Adit 5. As with Alternative 3, prior to initiating activities, slope stability and grading design will be required.

Alternative 4 would meet the RAOs since it would prevent future releases of hazardous substances associated with waste rock, maintain acceptable levels of risk to human and ecological receptors, and would meet ARARs to the extent practicable.

Utilizing a Spider Excavator and conventional excavators, waste rock materials would be excavated from the Ruth Mine Adit 4 and Morning Star Mine areas and transported to a DEQ-permitted solid waste landfill. Waste characterization would be required to determine the final disposition of waste. Assuming the waste characteristics are similar to Synthetic Precipitation Leaching Procedure results from the 2006 Focused SI, a Subtitle D permitted landfill has been used for costing. The approximate volume of material to be excavated and removed from Ruth Mine Adit 4 and Morning Star Mine is 1,800 cubic yards. Following excavation of materials, the remaining slopes would be graded to slope per engineering design. Erosion control blankets and seeding for re-vegetation would be completed. Vegetation seeding will utilize native shade-specific plant seeds since the area is on the north slope of the drainage. Native vegetation types will require Forest Service approval.

Transport of materials would be completed by using 5-cubic-yard dumps from the site to a suitable location beyond the locked gate on FR 2209, where the material would be transferred to 20-cubic-yard dumps for transport to the landfill. Based on the Forest Service Engineering Memorandums, the bridges between the locked gate and the Ruth Mine site are not able to be load rated and would require, at a minimum, a repair to allow for the loaded 5-yard dumps. The specifics of the bridge improvement alternatives are not discussed in this EE/CA; however, the cost associated with the bridge repairs is estimated between $130,000 and $170,000. Access to the adit locations would require improvement such as road clearing and repair to allow access for dump trucks and support vehicles. A staging area for transfer of waste rock materials would be required.

The access road to Adit 5 would be blocked to vehicular traffic by placing large boulders at the intersection with FR 2209. This would be accomplished using the Spider Excavator. This would prevent unpermitted removal of contaminated material from Adit 5. The current and expected future access to the area prevents motor vehicle access by the public at the locked gate approximately 5 miles away on FR 2209. Appropriate erosion control and re-vegetation measures would be implemented at disturbed sites and along access roads.

MOM would include a visual inspection of the slopes at Adit 4 and Adit 5 and surface water sample collection in Battle Ax Creek at two locations downstream of the confluence of Ruth Creek after one, three, and five years following implementation. Surface water sampling would include a visual observation for turbidity and chemical analysis of total metals limited to arsenic, barium, cadmium, copper, lead, and zinc by EPA 6000/7000 Series Methods.

Alternative 4 is compared to the other alternatives in terms of effectiveness, implementability, and cost in Table 10.

The estimated capital cost utilizing 5-yard track dumps, including bridge repair, is $884,000. The estimate NPV MOM cost is $9,300, making the total $893,000. The cost detail is presented in Appendix J.

7.0 COMPARATIVE ANALYSIS OF REMOVAL ACTION ALTERNATIVES

The four alternatives were each evaluated based on the designated criteria in accordance with the NCP. The comparison of these retained alternatives is presented in Table 10 and includes evaluating each alternative based on the comparison criteria, which includes effectiveness, implementability, and cost.

7.1 EFFECTIVENESS

Based on the slope stability evaluation, there is some potential for future significant mass wasting at Ruth Mine Adit 4 due to the steep slope and limited buttressing of the waste rock pile and the cut bank in Ruth Creek upstream of the waste rock pile. Based on the Forest Service slope stability evaluation, there is some potential for additional mass wasting during extreme flood events at Morning Star Mine and upon further rotting of lumber within the waste rock pile. The potential at each site constitutes a threat of a further release of hazardous substances into the environment. Therefore, a response is necessary to protect public health or welfare or the environment. To meet the RAO of preventing exposure to levels of contaminants that would pose unacceptable risk, the potential for future mass wasting at Ruth Mine Adit 4 and Morning Star Mine should be addressed.

Alternatives 1 and 2 do not address potential future slope instability at Adit 4 and Morning Star Mine and would not meet the RAOs. Alternatives 3 and 4 meet the RAO of preventing exposure to hazardous substances that would pose unacceptable risk to humans and ecological receptors by addressing potential mass wasting at Adit 4 and Morning Star Mine; therefore, they are each effective. Each of these alternatives would meet ARARs, including the Oregon Cleanup Law requirements, since risk levels are acceptable (Oregon Revised Statute 465.315).

Alternatives 3 and 4 are further compared in terms of effectiveness; specifically, the protection of human health, workers, and the environment during implementation. Alternative 4 may reduce the risk of both human and ecological exposure most effectively since waste rock would be removed, but Alternative 3 would also be effective in terms of exposures. Alternative 4 would carry the highest risk to workers during implementation. The increased number of vehicle and equipment trips increases the time of implementation and corresponds to an increased risk to workers. It also increases risk to both vehicle and foot traffic of recreational users on the road

accessing the Opal Creek Scenic Recreation Area during the time of implementation. Alternative 4 would also create the most disturbances to the surrounding environment, including road clearing to the adits, greatest traffic through the area, greatest implementation time, and highest risk of spills of fuel or hydraulic fluids into the environment.

Because of the highest risk to workers and community, Alternative 4 is the least effective of the two waste rock handling alternatives. Based on the comparison of the alternatives, Alternative 3 is the most effective because, while meeting the RAOs, it carries the least risk to workers and community and the least disturbance to the environment.

7.2 IMPLEMENTABILITY

Alternative 1 would be the most easily implemented alternative technically and administratively. Alternative 2 would be similar, requiring limited mobilization for installation of signage and some administrative work for signage and institutional controls.

Alternatives 3 and 4 would have similar administrative requirements. Technically, Alternatives 3 and 4 are more difficult to implement than Alternatives 1 and 2. Of Alternatives 3 and 4, Alternative 4 would be the most difficult to implement. Each of these alternatives would require the use of special equipment (a Spider Excavator) to excavate the steep slopes of the waste rock piles.

Alternative 4 would also require the transport of materials away from the mine sites to a permitted solid waste landfill. The transport options are limited by the bridge capacities accessing the area. Full 5-yard dump trucks would exceed structural capacities of the bridges without improvements. Bridge improvements to allow for the use of 5-yard dump trucks would require significant design and construction time prior to initiating removal activities. Alternative 3 would be less difficult to implement than Alternative 4 and would not require material transport off site.

Alternative 3 is the most implementable of Alternatives 3 and 4.

7.3 COST

The costs of Alternative 1 would be the lowest cost at zero, while Alternative 2 would be the next lowest, at approximately $9,800. Alternative 3 has a medium cost of $473,000 to $499,000. Alternative 4 would carry the highest capital cost, estimated at $867,000 if implemented with bridge repair and waste rock transports of 5 yards per trip. Of the action alternatives that meet the RAOs, Alternative 3 is the most cost effective.

8.0 SUMMARY AND RECOMMENDED REMOVAL ACTION ALTERNATIVE

The Ruth Mine and Morning Star Mine EE/CA was completed to collect appropriate additional analytical data, assess the potential risk to human and ecological receptors, and analyze and evaluate potential alternatives for removal actions at the sites. Field visits for collection of samples, as well as slope stability evaluations, were conducted on October 6 through 10, 2008; July 7, 2009; July 24, 2009; and July 30, 2009. In addition, the Forest Service completed slope stability evaluations in January 2012. The field visits included observation of the layout of the

Ruth Mine and Morning Star Mine sites and the local vicinity; field surveying the slopes and waste rock piles of the adit areas; collection of waste rock/soil samples; and collection of surface water, pore water, mine adit water, and stream sediment samples. In addition, further background rock/soil samples were collected to add to the existing sample body collected in 2005. These environmental media samples were submitted for total and/or dissolved hazardous substances concentrations in the various media, the results of which are presented in Tables 1 through 4 along with laboratory reports included in Appendix F. These analytical results were used to complete HHRAs and Screening ERAs for each site, per EPA and DEQ guidance documents (as specified in the AOC), assessing the relative risk to human health and the environment presented by these materials.

The GeoDesign slope stability evaluation indicated that the Ruth Mine Adit 4 area has potential for future mass wasting. The Adit 5 area is stable with no significant future changes expected. The Forest Service slope stability evaluation indicated that the Morning Star Mine site has potential for future mass wasting. Based on the information gathered during the EE/CA for the Ruth Mine and Morning Star Mine sites and the results of the HHRAs and the Screening ERAs, no significant or unacceptable risk to human or ecological receptors was documented for the Ruth Mine and Morning Star Mine sites absent a change in current conditions, such as mass wasting at Adit 4 or Morning Star. DEQ concurred with these determinations.

Removal action alternatives were developed by screening management and treatment technologies by evaluating their feasibility and ability to meet the RAOs. The four alternatives were then compared using the criteria effectiveness, implementability, and cost.

Alternatives 3 and 4 address the potential for future mass wasting at Ruth Mine Adit 4 and Morning Star Mine. Based on the EE/CA guidance, the NCP, and the comparative analysis, Alternative 3 would meet the RAOs, would be the most cost effective of those meeting the RAOs, and is the most implementable of those meeting the RAOs. The Forest Service has reservations regarding the discharge of adit water into waterways that exceeds WQC. The Forest Service plans to continue to monitor adit water quality and will consider if passive treatment is necessary and feasible.

Sincerely,

GeoDesign, Inc.

Stephen C. Nelson
Project Manager

Craig W. Ware, R.G.
Principal Geologist

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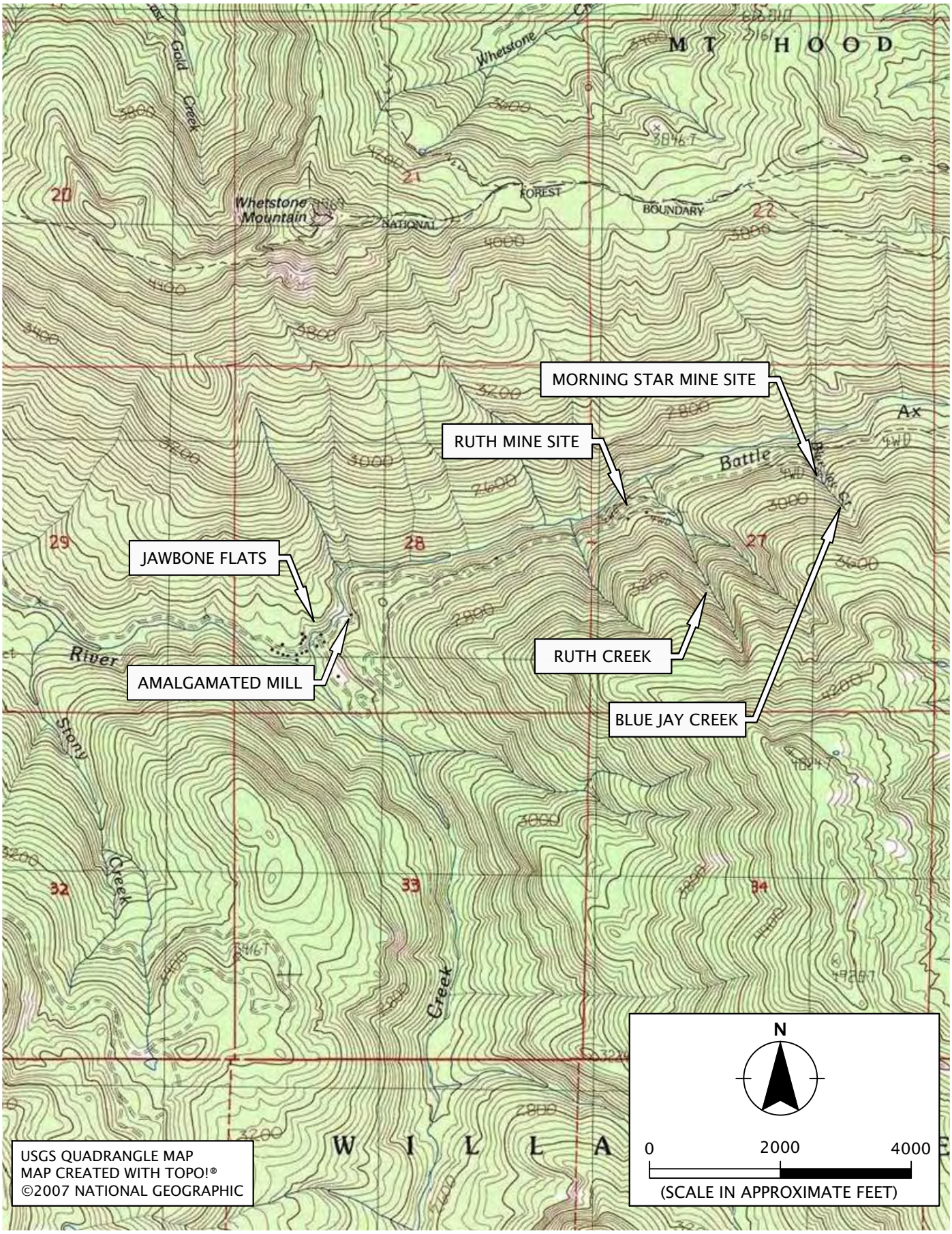
FIGURES



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OPALCREEK-1-03-03	**VICINITY MAP**	
NOVEMBER 2012	RUTH MINE AND MORNING STAR MINE EE/CA MARION COUNTY, OR	**FIGURE 1**

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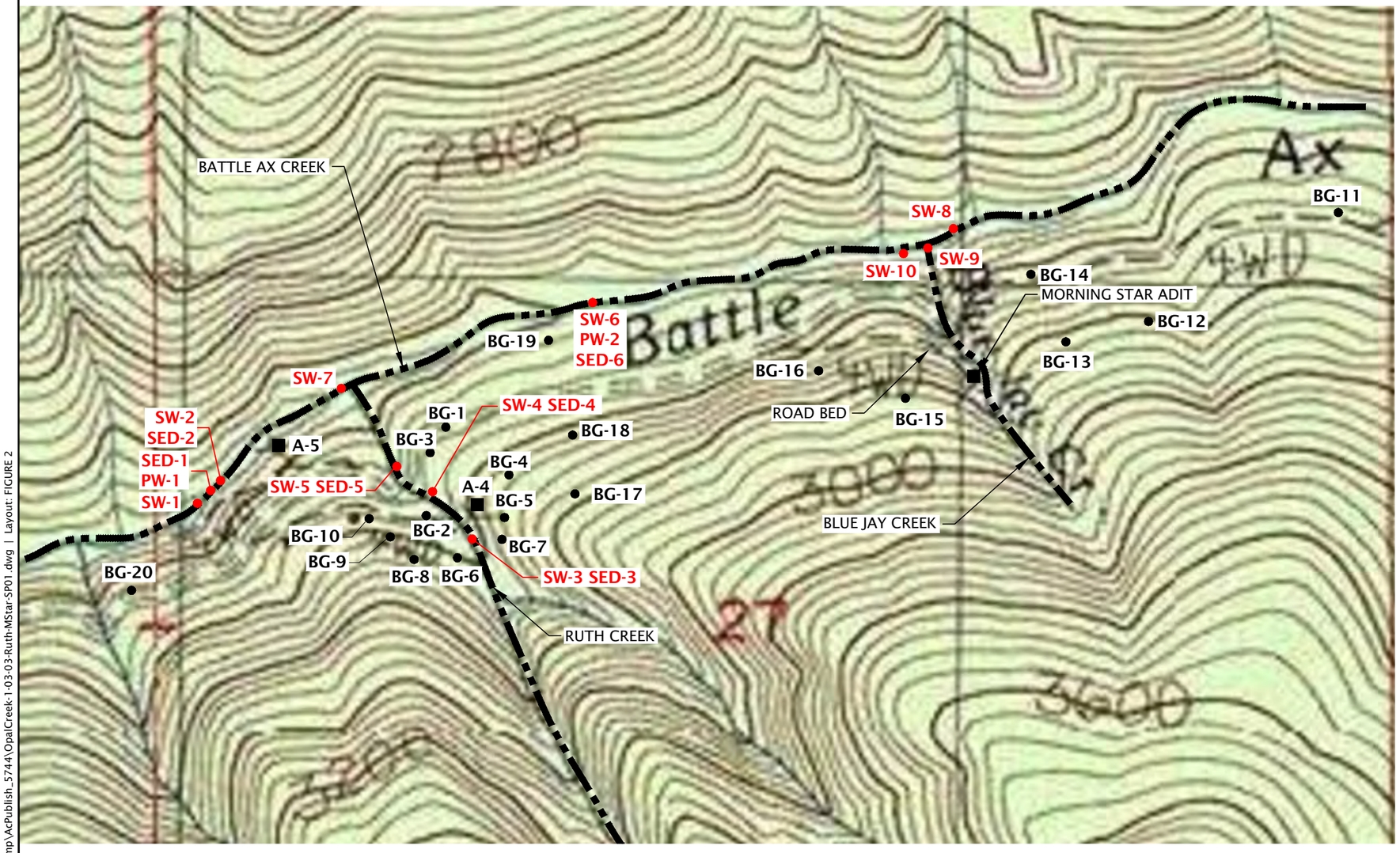
EXPLANATION:

A-4 ■ ADIT

BG-1 ● BACKGROUND SAMPLE LOCATION

SW-1 ● PREVIOUS SAMPLE LOCATION



NOTE:
PREVIOUS WASTE ROCK SAMPLE LOCATIONS NOT SHOWN ON FIGURE.

N

0 500 1000

(SCALE IN FEET)

USGS QUADRANGLE MAP
MAP CREATED WITH TOPO!®
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FIGURE 2

SITE PLAN

RUTH MINE AND MORNING STAR MINE EE/CA
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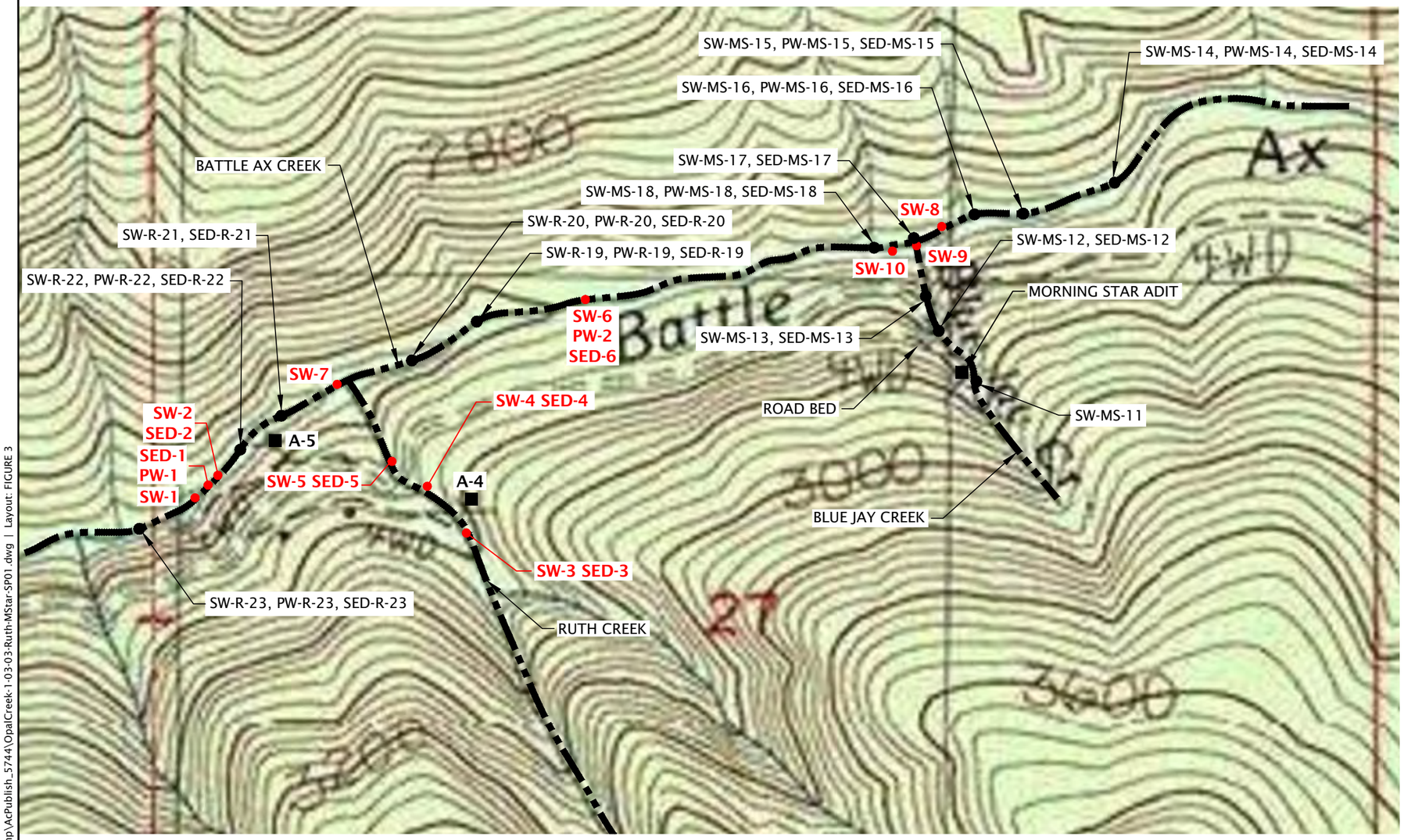

EXPLANATION:

A-4	■	ADIT
SW-1	●	PREVIOUS SAMPLE LOCATION
SW-11	●	SURFACE WATER SAMPLE
PW-14	●	PORE WATER SAMPLE
SED-12	●	SEDIMENT SAMPLE

NOTE:
PREVIOUS WASTE ROCK SAMPLE LOCATIONS NOT SHOWN ON FIGURE.

N

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(SCALE IN FEET)

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IN-STREAM SAMPLE LOCATIONS

RUTH MINE AND MORNING STAR MINE EE/CA
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FIGURE 3

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EXPLANATION:

A-4 ■ ADIT

BI-MS-14 ● MACROINVERTIBRATE SAMPLE (OCTOBER 2008)

NOTE:
PREVIOUS WASTE ROCK SAMPLE LOCATIONS NOT SHOWN ON FIGURE.

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MACROINVERTIBRATE SAMPLE LOCATIONS

FIGURE 4

RUTH MINE AND MORNING STAR MINE EE/CA
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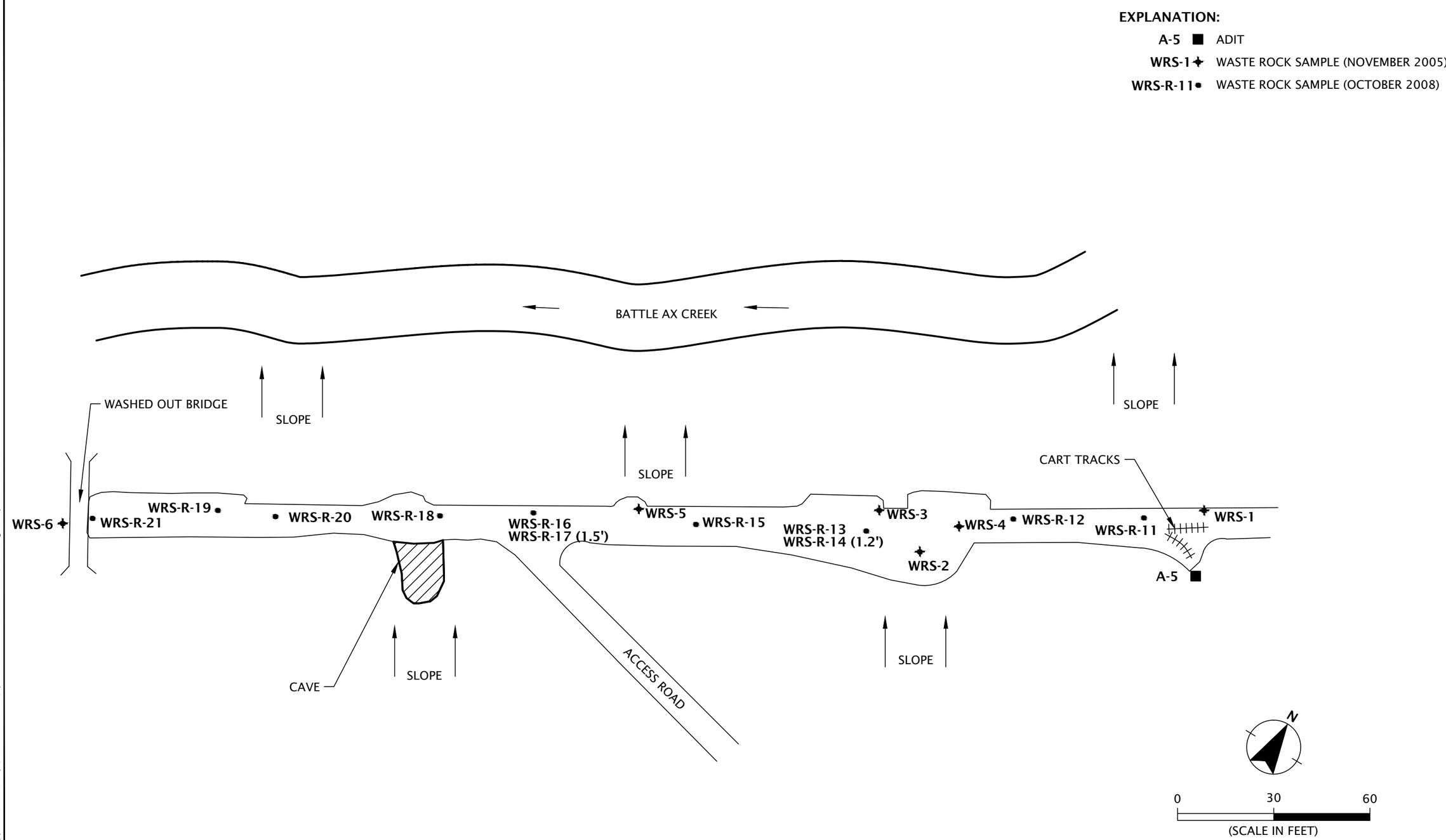

RUTH MINE ADIT 5 AREA

FIGURE 5

RUTH MINE AND MORNING STAR MINE EE/CA
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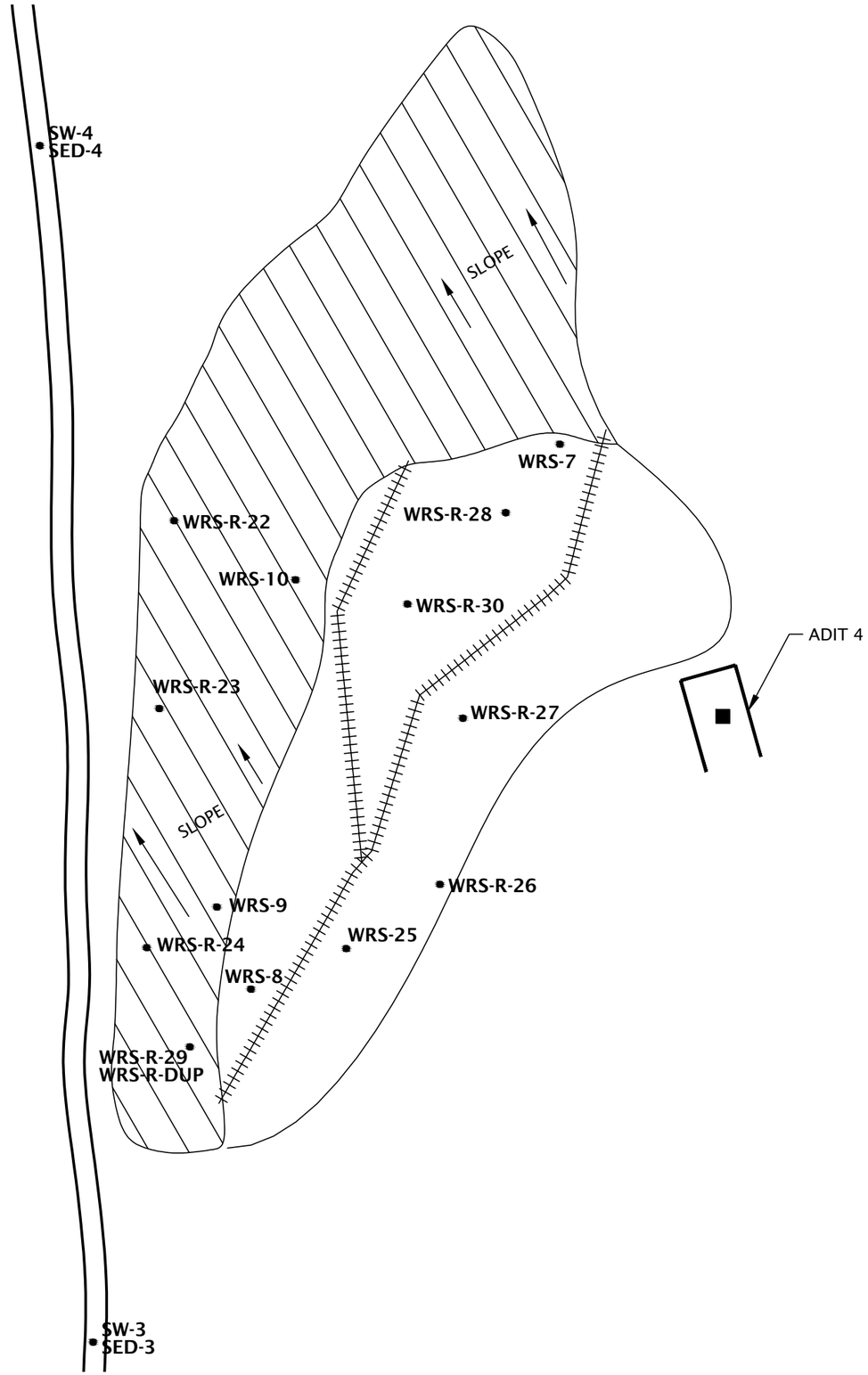

EXPLANATION:

- ■ ADIT
- **WRS-7** • WASTE ROCK SAMPLE (OCTOBER 2008)
- **WRS-R-22** • WASTE ROCK SAMPLE (NOVEMBER 2005)
- **SW-3 SED-3** • SURFACE WATER/SEDIMENT SAMPLE (NOVEMBER 2005)

N

0 10 20

(SCALE IN FEET)

RUTH MINE ADIT 4 AREA

RUTH MINE AND MORNING STAR MINE EE/CA
MARION COUNTY, OR

FIGURE 6

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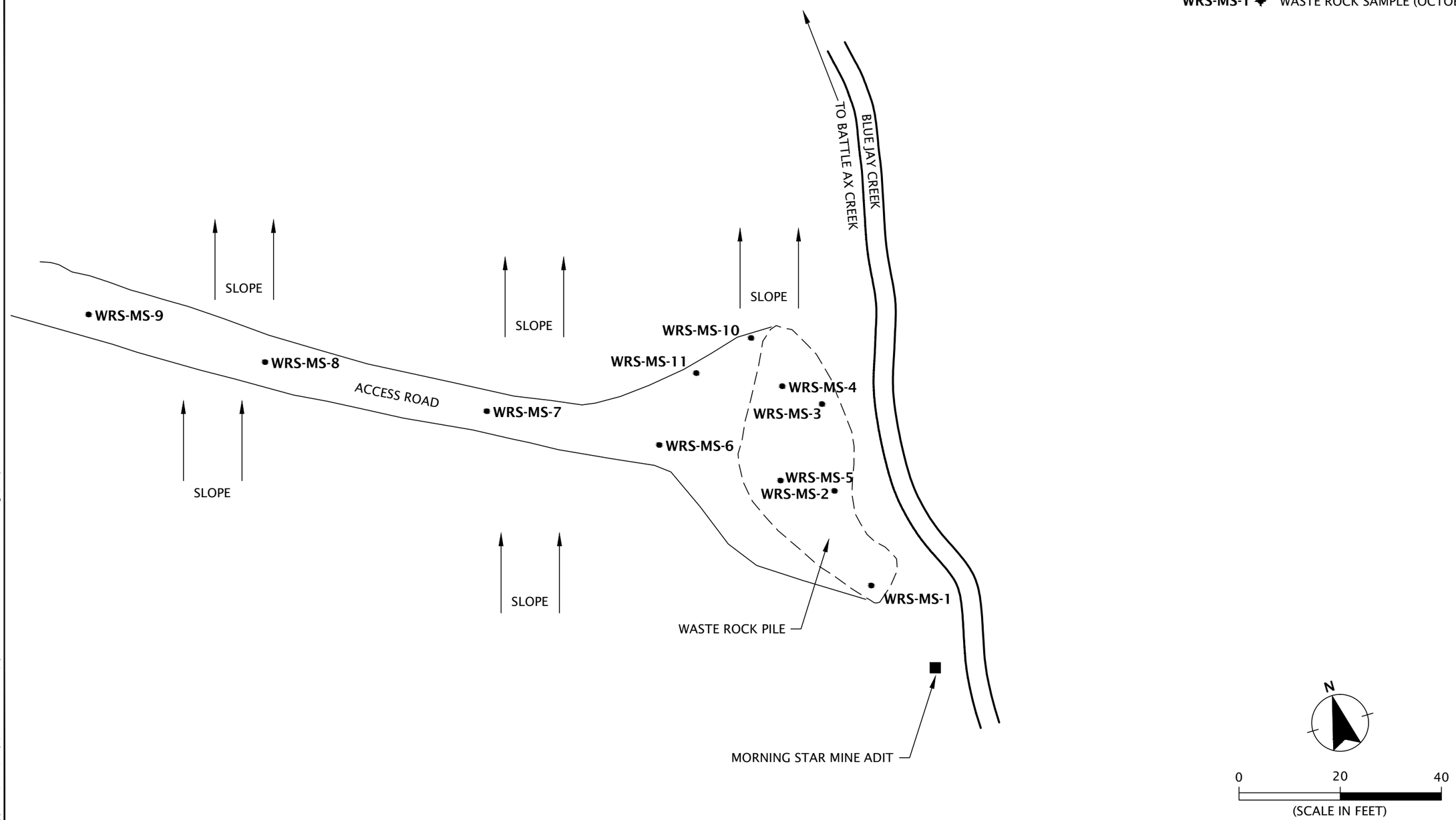

MORNING STAR MINE ADIT AREA

RUTH MINE AND MORNING STAR MINE EE/CA
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FIGURE 7

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ADIT 5. PHOTOGRAPH TAKEN FACING SOUTH.

EAST END OF ADIT 5 AREA. PHOTOGRAPH TAKEN FACING WEST.

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OPALCREEK-1-03-03	**PROJECT SITE PHOTOGRAPHS**	
NOVEMBER 2012	RUTH MINE AND MORNING STAR MINE EE/CA MARION COUNTY, OR	**FIGURE 8**

CENTRAL ADIT 5 AREA AT CART TRACKS. PHOTOGRAPH TAKEN FACING EAST.

WEST END OF ADIT 5 AREA. PHOTOGRAPH TAKEN FACING EAST.

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NOVEMBER 2012	RUTH MINE AND MORNING STAR MINE EE/CA MARION COUNTY, OR	**FIGURE 9**

WEST END OF ADIT 5 AREA. PHOTOGRAPH TAKEN FACING EAST.

WASTE ROCK SAMPLE WRS-R-17.

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OPALCREEK-1-03-03	**PROJECT SITE PHOTOGRAPHS**	
NOVEMBER 2012	RUTH MINE AND MORNING STAR MINE EE/CA MARION COUNTY, OR	**FIGURE 10**

VIEW OF THE WASTE ROCK PILE AND ROCK BUTTRESS SOUTH OF THE RUTH MINE ENTRANCE.

BANK EROSION DIRECTLY UPSTREAM FROM 4TH LEVEL WASTE ROCK PILE.

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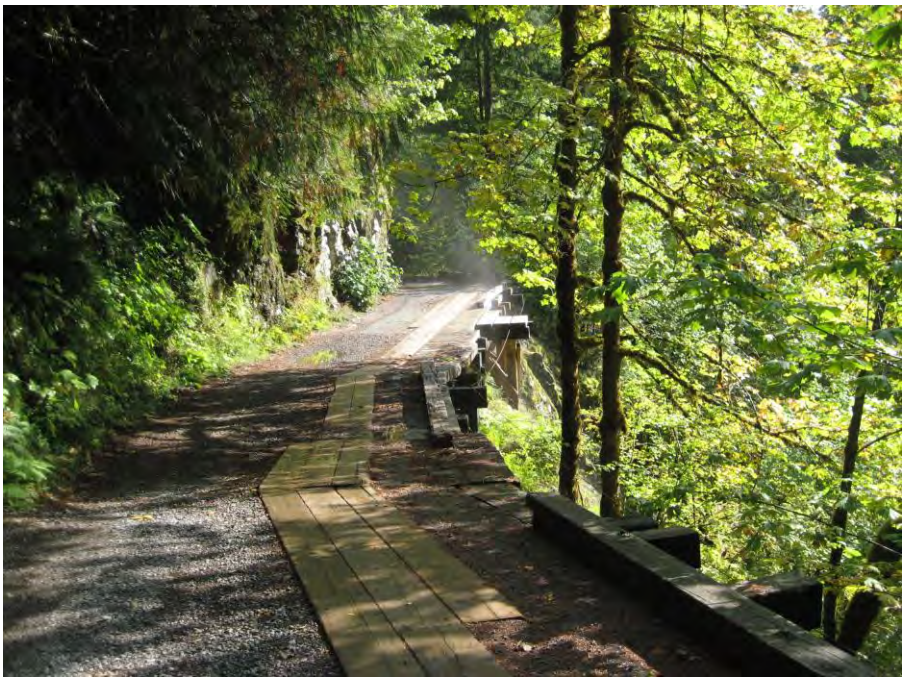
OPALCREEK-1-03-03	**PROJECT SITE PHOTOGRAPHS**	
NOVEMBER 2012	RUTH MINE AND MORNING STAR MINE EE/CA MARION COUNTY, OR	**FIGURE 11**

ADIT 4 AREA. PHOTOGRAPH TAKEN FACING EAST.



HALF-BRIDGES ALONG FOREST ROAD 2209. PHOTOGRAPH TAKEN FACING SOUTHEAST.

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OPALCREEK-1-03-03	**PROJECT SITE PHOTOGRAPHS**	
NOVEMBER 2012	RUTH MINE AND MORNING STAR MINE EE/CA MARION COUNTY, OR	**FIGURE 12**

MORNING STAR WASTE ROCK PILE. PHOTOGRAPH TAKEN FACING EAST.

ACCESS ROAD AT MORNING STAR MINE. PHOTOGRAPH TAKEN FROM WASTE ROCK PILE FACING WEST.

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OPALCREEK-1-03-03	**PROJECT SITE PHOTOGRAPHS**	
NOVEMBER 2012	RUTH MINE AND MORNING STAR MINE EE/CA MARION COUNTY, OR	**FIGURE 13**

MORNING STAR MINE ADIT WITH ADIT WATER VISIBLE. PHOTOGRAPH TAKEN FACING WEST.

VIEW UP BLUE JAY CREEK WITH ADIT VISIBLE AT UPPER RIGHT. PHOTOGRAPH TAKEN FACING SOUTH.

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OPALCREEK-1-03-03	**PROJECT SITE PHOTOGRAPHS**	
NOVEMBER 2012	RUTH MINE AND MORNING STAR MINE EE/CA MARION COUNTY, OR	**FIGURE 14**

BLUE JAY CREEK FROM MORNING STAR MINE TO FOREST ROAD 2209. PHOTOGRAPH TAKEN FACING NORTH.

BLUE JAY CREEK FROM FOREST ROAD 2209 TO BATTLE AX CREEK. PHOTOGRAPH TAKEN FACING NORTHEAST.

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OPALCREEK-1-03-03	**PROJECT SITE PHOTOGRAPHS**	
NOVEMBER 2012	RUTH AND MORNING STAR MINE SITES, OPAL CREEK MARION COUNTY, OR	**FIGURE 15**

BLUE JAY CREEK AT CONFLUENCE OF BATTLE AX CREEK. PHOTOGRAPH TAKEN FACING SOUTH.

BATTLE AX CREEK NEAR SAMPLE LOCATION SW-MS-14. PHOTOGRAPH TAKEN FACING EAST.

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OPALCREEK-1-03-03	**PROJECT SITE PHOTOGRAPHS**	
NOVEMBER 2012	RUTH MINE AND MORNING STAR MINE EE/CA MARION COUNTY, OR	**FIGURE 16**

WASTE ROCK SAMPLE WRS-MS-3. PHOTOGRAPH TAKEN FACING WEST.

WASTE ROCK SAMPLE WRS-MS-9. PHOTOGRAPH TAKEN FACING WEST.

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OPALCREEK-1-03-03	**PROJECT SITE PHOTOGRAPHS**	
NOVEMBER 2012	RUTH MINE AND MORNING STAR MINE EE/CA MARION COUNTY, OR	**FIGURE 17**

TABLES

TABLE 1
Summary of Chemical Analytical Data for Surface Water and Sediment[1]
Ruth Mine Site at Opal Creek
Marion County, Oregon

Sample I.D.	Date	Media	Total Metals by EPA Method 6000/7000 Series (mg/L)																						
			Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead	Magnesium	Manganese	Mercury	Nickel	Potassium	Selenium	Silver	Sodium	Thallium	Vanadium	Zinc
AW-4	11/08/05	adit water	---	---	ND<0.0010	0.00694	---	0.0221	---	ND<0.0010	---	0.0148	0.0475	0.0377	---	0.0235	ND<0.00020	ND<0.0020	---	ND<0.0020	ND<0.0010	---	---	---	3.08
AW-4-2	07/24/09	adit water	---	---	ND<0.0010	0.0106	---	0.035	69	---	---	0.00727	---	0.0271	1.35	---	---	---	---	---	---	---	---	---	6.67
AW-5	11/08/05	adit water	---	---	ND<0.0010	0.00322	---	0.00539	---	ND<0.0010	---	0.0046	0.0739	0.00262	---	0.0309	ND<0.00020	ND<0.0020	---	ND<0.0020	ND<0.0010	---	---	---	1.27
AW-5-2	07/24/09	adit water	---	---	ND<0.0010	0.00411	---	0.00499	42.9	---	---	ND<0.0040	---	ND<0.0010	1.02	---	---	---	---	---	---	---	---	---	1.55
SW-1	11/08/05	surface water	---	---	ND<0.0010	ND<0.0010	---	ND<0.0010	---	ND<0.0010	---	ND<0.0020	0.0117	0.00295	---	ND<0.0020	ND<0.00020	ND<0.0020	---	ND<0.0020	ND<0.0010	---	---	---	0.0193
SW-2	11/08/05	surface water	---	---	ND<0.0010	0.00104	---	ND<0.0010	---	ND<0.0010	---	ND<0.0020	0.0258	ND<0.0010	---	ND<0.0020	ND<0.00020	ND<0.0020	---	ND<0.0020	ND<0.0010	---	---	---	0.00775
SW-3	11/08/05	surface water	---	---	ND<0.0010	ND<0.0010	---	ND<0.0010	---	ND<0.0010	---	ND<0.0020	ND<0.010	ND<0.0010	---	ND<0.0020	ND<0.00020	ND<0.0020	---	ND<0.0020	ND<0.0010	---	---	---	0.0186
SW-4	11/08/05	surface water	---	---	ND<0.0010	ND<0.0010	---	ND<0.0010	---	ND<0.0010	---	ND<0.0020	0.0434	0.00392	---	0.004	ND<0.00020	ND<0.0020	---	ND<0.0020	ND<0.0010	---	---	---	0.0516
SW-5	11/08/05	surface water	---	---	ND<0.0010	ND<0.0010	---	ND<0.0010	---	ND<0.0010	---	ND<0.0020	ND<0.010	0.00444	---	ND<0.0020	ND<0.00020	ND<0.0020	---	ND<0.0020	ND<0.0010	---	---	---	0.0856
SW-6	11/09/05	surface water	---	---	ND<0.0010	ND<0.0010	---	ND<0.0010	---	ND<0.0010	---	ND<0.0020	ND<0.010	ND<0.0010	---	ND<0.0020	ND<0.00020	ND<0.0020	---	ND<0.0020	ND<0.0010	---	---	---	ND<0.0050
SW-7	11/09/05	surface water	---	---	ND<0.0010	ND<0.0010	---	ND<0.0010	---	ND<0.0010	---	ND<0.0020	ND<0.010	ND<0.0010	---	ND<0.0020	ND<0.00020	ND<0.0020	---	ND<0.0020	ND<0.0010	---	---	---	0.0174
SW-8**	11/09/05	surface water	---	---	ND<0.0010	ND<0.0010	---	ND<0.0010	---	ND<0.0010	---	ND<0.0020	ND<0.010	ND<0.0010	---	ND<0.0020	ND<0.00020	ND<0.0020	---	ND<0.0020	ND<0.0010	---	---	---	ND<0.0050
SW-R-19	10/08/08	surface water	0.375	ND<0.0010	ND<0.0010	0.00208	ND<0.0010	ND<0.0010	4.29	0.00103	ND<0.0020	ND<0.0040	0.187	ND<0.0010	0.559	0.00682	ND<0.00010	ND<0.0010	0.167	ND<0.0010	ND<0.0020	1.42	ND<0.0010	ND<0.0020	0.00861
SW-R-20	10/08/08	surface water	ND<0.1	ND<0.0010	ND<0.0010	ND<0.0010	ND<0.0010	ND<0.0010	4.08	ND<0.0010	ND<0.0020	ND<0.0040	ND<0.10	ND<0.0010	0.482	ND<0.0010	ND<0.00010	ND<0.0010	0.113	ND<0.0010	ND<0.0020	1.37	ND<0.0010	ND<0.0020	0.00667
SW-R-21	10/09/08	surface water	ND<0.1	ND<0.0010	ND<0.0010	ND<0.0010	ND<0.0010	ND<0.0010	4.01	ND<0.0010	ND<0.0020	ND<0.0040	ND<0.10	ND<0.0010	0.467	ND<0.0010	ND<0.00010	ND<0.0010	ND<0.100	ND<0.0010	ND<0.0020	1.31	ND<0.0010	ND<0.0020	0.0148
SW-R-22	10/09/08	surface water	ND<0.1	ND<0.0010	ND<0.0010	ND<0.0010	ND<0.0010	ND<0.0010	4.12	ND<0.0010	ND<0.0020	ND<0.0040	ND<0.10	ND<0.0010	0.48	0.00136	ND<0.00010	ND<0.0010	0.105	ND<0.0010	ND<0.0020	1.39	ND<0.0010	ND<0.0020	0.0187
SW-R-23	10/09/08	surface water	ND<0.1	ND<0.0010	ND<0.0010	ND<0.0010	ND<0.0010	ND<0.0010	4.11	0.0011	ND<0.0020	ND<0.0040	ND<0.010	ND<0.0010	0.467	ND<0.0010	ND<0.00010	ND<0.0010	0.108	ND<0.0010	ND<0.0020	1.33	ND<0.0010	ND<0.0020	0.0167
SW-R-24	07/24/09	surface water	---	---	ND<0.0010	0.00447	---	0.005	43.2	---	---	ND<0.0040	---	ND<0.0010	1	---	---	---	---	---	---	---	---	---	1.52
SW-MS-14	10/08/08	surface water	ND<0.1	ND<0.0010	ND<0.0010	ND<0.0010	ND<0.0010	ND<0.0010	4.05	ND<0.0010	ND<0.0020	ND<0.0040	ND<0.10	ND<0.0010	0.483	ND<0.0010	ND<0.00010	ND<0.0010	0.11	ND<0.0010	ND<0.0020	1.32	ND<0.0010	ND<0.0020	0.00689
SW-MS-15	10/08/08	surface water	ND<0.1	ND<0.0010	ND<0.0010	ND<0.0010	ND<0.0010	ND<0.0010	4.03	ND<0.0010	ND<0.0020	ND<0.0040	ND<0.10	ND<0.0010	0.473	ND<0.0010	ND<0.00010	ND<0.0010	0.108	ND<0.0010	ND<0.0020	1.29	ND<0.0010	ND<0.0020	0.0107
SW-MS-16	10/08/08	surface water	ND<0.1	ND<0.0010	ND<0.0010	ND<0.0010	ND<0.0010	ND<0.0010	3.91	ND<0.0010	ND<0.0020	ND<0.0040	ND<0.10	ND<0.0010	0.466	ND<0.0010	ND<0.00010	ND<0.0010	0.117	ND<0.0010	ND<0.0020	1.3	ND<0.0010	ND<0.0020	0.00978

Sample I.D.	Date	Media	Dissolved Metals by EPA Method 6000/7000 Series (mg/L)																						
			Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead	Magnesium	Manganese	Mercury	Nickel	Potassium	Selenium	Silver	Sodium	Thallium	Vanadium	Zinc
PW-1	11/08/05	pore water	---	---	ND<0.0010	0.00201	---	0.00149	---	ND<0.0010	---	ND<0.0020	ND<0.010	ND<0.0010	---	ND<0.0020	ND<0.00020	ND<0.0020	---	ND<0.0020	ND<0.0010	---	---	---	0.277
PW-2	11/09/05	pore water	---	---	ND<0.0010	ND<0.0010	---	ND<0.0010	---	ND<0.0010	---	ND<0.0020	ND<0.010	ND<0.0010	---	ND<0.0020	ND<0.00020	ND<0.0020	---	ND<0.0020	ND<0.0010	---	---	---	ND<0.0050
PW-R-19	10/08/08	pore water	ND<0.10	ND<0.0010	ND<0.0010	0.00104	ND<0.0010	ND<0.0010	3.7	ND<0.0010	ND<0.0020	ND<0.0050	ND<0.10	ND<0.0010	0.465	0.00191	ND<0.00010	ND<0.0010	0.111	ND<0.0010	ND<0.0020	1.41	ND<0.0010	ND<0.0020	0.00712
PW-R-20	10/09/08	pore water	ND<0.10	ND<0.0010	ND<0.0010	0.00117	ND<0.0010	ND<0.0010	4.4	ND<0.0010	ND<0.0020	ND<0.0050	ND<0.10	ND<0.0010	0.491	0.0041	ND<0.00010	ND<0.0010	0.138	ND<0.0010	ND<0.0020	1.41	ND<0.0010	ND<0.0020	0.00589
PW-R-22	10/09/08	pore water	ND<0.10	ND<0.0010	ND<0.0010	0.00136	ND<0.0010	ND<0.0010	4.05	ND<0.0010	ND<0.0020	ND<0.0050	ND<0.10	0.00153	0.452	0.00434	ND<0.00010	ND<0.0010	0.144	ND<0.0010	ND<0.0020	1.37	ND<0.0010	ND<0.0020	0.103
PW-R-23	10/09/08	pore water	ND<0.10	ND<0.0010	ND<0.0010	0.00236	ND<0.0010	ND<0.0010	8.41	ND<0.0010	ND<0.0020	ND<0.0050	ND<0.10	ND<0.0010	0.648	0.00484	ND<0.00010	ND<0.0010	0.159	ND<0.0010	ND<0.0020	1.95	ND<0.0010	ND<0.0020	0.0783
AW-4-2-DISS	07/24/09	adit water	---	---	ND<0.0010	0.011	---	0.0363	67.2	---	---	0.00518	---	0.0223	1.36	---	---	---	---	---	---	---	---	---	6.44
AW-5-2-DISS	07/24/09	adit water	---	---	ND<0.0010	0.0045	---	0.00538	41.8	---	---	ND<0.004	---	ND<0.0010	1.01	---	---	---	---	---	---	---	---	---	1.51
SW-R-24-DISS	07/24/09	surface water	---	---	ND<0.0010	0.00483	---	0.0052	41.5	---	---	ND<0.004	---	ND<0.0010	1	---	---	---	---	---	---	---	---	---	1.43
DEQ Level II SLVs - Surface Water Fresh (mg/L)			0.087	1.6	0.15	0.004	0.0053	0.0022	116	0.074	0.023	0.009	1	0.0025	82	0.12	0.00077	0.052	53	0.005	0.00012	680	0.04	0.02	0.12
EPA PRGs - Tap Water (mg/L)			37	0.015	0.000045	7.3	0.073	0.018	NA	0.11*	0.011	1.5	26	0.015	NA	0.88	0.011	0.73	NA	0.05	0.18	NA	0.0024	0.18	11
Water Quality Criteria (Freshwater Chronic)[2] (mg/L)			0.087***	0.146***	0.19	1.0***	0.000068***	0.0011	NA	0.011	NA	0.012	1	0.0032	NA	0.05***	0.000012	0.16	NA	0.035	0.00012	NA	0.00024***	NA	0.11

TABLE 1
Summary of Chemical Analytical Data for Surface Water and Sediment[1]
Ruth Mine Site at Opal Creek
Marion County, Oregon

Sample I.D.	Date	Media	Total Metals by EPA Method 6000/7000 Series (mg/Kg)																						
			Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead	Magnesium	Manganese	Mercury	Nickel	Potassium	Selenium	Silver	Sodium	Thallium	Vanadium	Zinc
SED-1	11/08/05	sediment	---	---	1.08	22.9	---	0.66	---	12.9	---	29.1	11,700	35.6	---	339	ND<0.0927	27.9	---	ND<0.588	ND<0.588	---	---	---	246
SED-2	11/08/05	sediment	---	---	1.95	30.4	---	ND<0.657	---	11.2	---	20.4	13,100	38.1	---	948	ND<0.107	23.7	---	ND<0.657	ND<0.657	---	---	---	290
SED-3	11/08/05	sediment	---	---	2.00	35.7	---	1.06	---	14.6	---	63.9	16,500	244	---	1,440	ND<0.0643	15.7	---	ND<0.618	ND<0.618	---	---	---	648
SED-4	11/08/05	sediment	---	---	3.68	34.6	---	1.87	---	13.8	---	465	20,800	265	---	2,280	ND<0.0633	18.8	---	ND<0.652	0.745	---	---	---	953
SED-5	11/08/05	sediment	---	---	11.7	12.2	---	0.989	---	9.86	---	39.6	23,100	278	---	4,290	ND<0.102	17.4	---	ND<0.706	ND<0.706	---	---	---	577
SED-6	11/09/05	sediment	---	---	2.60	82.3	---	ND<0.661	---	14.0	---	35.9	15,200	12.8	---	768	ND<0.0748	30.6	---	ND<0.661	ND<0.661	---	---	---	119
SED-R-19	10/08/08	sediment	17,300	ND<1.42	ND<1.42	30.4	ND<2.84	ND<1.42	5,010	13.1	10.0	21.5	20,500	8.58	8,480	383	ND<0.114	26.9	630	ND<1.42	ND<2.84	283	ND<1.42	36.7	67.9
SED-R-20	10/08/08	sediment	22,400	ND<1.34	2.39	27.2	ND<2.68	ND<1.34	7,170	11.6	11.2	29.9	25,000	4.75	9,060	439	ND<0.107	17.5	643	ND<1.34	ND<2.68	167	ND<1.34	38.9	62.2
SED-R-21	10/09/08	sediment	19,500	ND<1.33	1.53	35.9	ND<2.67	ND<1.33	6,060	16.5	12.6	30.8	25,300	55.5	10,300	728	ND<0.107	23.8	715	ND<1.33	ND<2.67	372	ND<1.33	48.2	174
SED-R-22	10/09/08	sediment	23,000	ND<1.43	15.70	54	ND<2.86	5.59	6,700	20.8	16.1	34.6	33,400	83.2	13,000	2,110	ND<0.115	50.2	973	ND<1.43	ND<2.86	354	ND<1.43	55.6	1,390
SED-R-23	10/09/08	sediment	30,100	ND<1.32	1.85	59.2	ND<2.64	ND<1.32	8,700	22.6	15.8	109	32,100	43.8	12,100	567	ND<0.106	45.5	1,230	ND<1.32	ND<2.64	572	ND<1.32	66.5	299
SED-MS-14	10/08/08	sediment	17,900	ND<1.32	1.42	32.8	ND<2.63	ND<1.32	7,490	11.4	9.6	15.5	16,000	2.97	7,330	424	ND<0.105	16.3	844	ND<1.32	ND<2.63	267	ND<1.32	28.8	36.1
SED-MS-15	10/08/08	sediment	24,100	ND<1.20	1.25	51.6	ND<2.4	ND<1.2	6,460	22.3	12.5	24.3	25,000	3.44	10,600	466	ND<0.0962	28.7	843	ND<1.2	ND<2.4	396	ND<1.2	43.4	50.5
SED-MS-16	10/08/08	sediment	19,600	ND<1.31	ND<1.31	39.9	ND<2.61	ND<1.31	6,090	10.7	10.3	20.8	19,100	2.27	9,640	359	ND<0.105	21.2	547	ND<1.31	ND<2.61	445	ND<1.31	36.3	39.6
EPA PRGs - Industrial Soil (mg/Kg)			990,000	410	1.6	190,000	2,000	810	NE	1,400	300	41,000	720,000	800	NE	23,000	310	20,000	NE	5,100	5,100	NE	66	5,200	310,000
DEQ Level II SLVs - Fresh Water Sediments (mg/Kg)			NA	3	6	NA	NA	0.6	NA	37	NA	36	NA	35	NA	1,100	0.2	18	NA	NA	4.5	NA	NA	NA	123

Notes:
1. 2005 chemical analyses performed by North Creek Analytical of Beaverton, Oregon. 2008 and 2009 chemical analysis performed by Apex Laboratories, LLC of Tigard, Oregon.
2. Oregon Department of Environmental Quality Water Quality Criteria
* The Chromium VI value was used because it is more conservative
** surface water sample Morning Star Mine (SW-8)
*** no Water Quality Criteria available, value is taken from available guidance not criteria.
AW: adit water sample Ruth Mine
DEQ: Oregon Department of Environmental Quality
EPA: U.S. Environmental Protection Agency
mg/Kg: milligrams per kilogram
mg/L: milligrams per liter
NA: not applicable
ND: not detected
NE: not established
PW and PW-R: pore water sample Ruth Mine
PRG: preliminary remediation goal
SED-MS: sediment sample Morning Star Mine
SED and SED-R: sediment sample Ruth Mine
SVL: screening level value
SW and SW-R: surface water sample Ruth Mine
SW-MS: surface water sample Morning Star Mine
shading indicates an exceedance of the PRG
shading indicates an exceedance of the SLV and/or the Water Quality Criteria
shading indicates an exceedance of both PRG and SLV

TABLE 2
Summary of Chemical Analytical Data for Waste Rock/Soil and Background Rock/Soil[1] (Total Metals)
Ruth Mine Site at Opal Creek
Marion County, Oregon

Sample I.D.	Date	Total Metals by EPA Method 6000/7000 Series and Total Mercury by EPA Method 7471A (mg/Kg)																							Hexavalent Chromium by EPA Method 3060A (mg/Kg)
		Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead	Magnesium	Manganese	Mercury	Nickel	Potassium	Selenium	Silver	Sodium	Thallium	Vanadium	Zinc	
WRS-1	11/08/05	---	---	7.88	56.6	---	3.95	---	23.1	---	94.5	30,300	346	---	1,220	0.135	19.2	---	ND<0.545	ND<0.545	---	---	---	918	ND<1.12
WRS-2	11/08/05	---	---	46.2	7.94	---	307	---	16.6	---	7,600	77,000	2,050	---	10,200	1.87	17.6	---	9.98	9.19	---	---	---	64,900	ND<1.09
WRS-3	11/08/05	---	---	22.8	10.2	---	171	---	37.6	---	1,120	68,200	14,000	---	15,900	0.548	23.7	---	6.56	7.62	---	---	---	43,600	ND<1.06
WRS-4	11/08/05	---	---	23.7	10.0	---	422	---	19.6	---	2,780	77,000	34,000	---	12,900	0.431	18.7	---	16.5	7.1	---	---	---	98,900	ND<1.05
WRS-5	11/08/05	---	---	22.0	11.5	---	227	---	23.2	---	5,480	74,000	10,800	---	13,000	0.378	22.9	---	6.67	9.66	---	---	---	54,800	ND<1.17
WRS-6	11/08/05	---	---	26.9	17.5	---	76.8	---	18.0	---	541	35,100	4,030	---	5,480	1.11	23.1	---	3.03	10.0	---	---	---	17,100	ND<0.758
WRS-7	11/08/05	---	---	10.8	28.1	---	17.2	---	26.5	---	134	26,800	2,440	---	5,300	ND<0.0880	31.6	---	2.97	4.98	---	---	---	4,370	ND<0.689
WRS-8	11/08/05	---	---	15.4	34.7	---	66.1	---	32.9	---	363	33,500	2,670	---	7,730	0.126	40.6	---	2.05	5.51	---	---	---	14,800	ND<0.637
WRS-9	11/08/05	---	---	17.9	16.3	---	33.3	---	34.6	---	202	36,800	1,480	---	6,360	0.37	35.7	---	1.02	3.63	---	---	---	7,630	ND<0.671
WRS-10	11/08/05	---	---	26.9	28.2	---	68.4	---	13.8	---	462	24,200	2,410	---	4,640	0.341	22.7	---	2.06	6.49	---	---	---	15,200	ND<0.715
WRS-R-11	10/07/08	29,200	1.52	13.8	40.7	ND<2.63	33.9	4,350	24.6	20.1	409	51,500	937	9,790	1,890	0.25	26.6	1,340	ND<1.32	ND<2.63	168	ND<1.32	56.5	8,590	---
WRS-R-12	10/07/08	43,000	ND<1.23	11.8	62.5	ND<2.45	29.3	1,770	33.3	21.5	318	58,000	2,160	11,100	3,610	0.429	27.7	1,640	1.51	6.51	ND<123	ND<1.23	80.7	7,080	---
WRS-R-13	10/07/08	30,200	1.71	19.6	66.1	ND<2.28	132	17,300	26.7	25.2	688	64,500	5,550	14,300	7,100	0.387	26.4	3,540	3.13	11.2	ND<114	ND<1.14	53.4	29,900	---
WRS-R-14	10/07/08	34,300	1.53	18.0	56.0	ND<2.29	80	34,400	33	25.7	1,050	71,700	4,460	16,900	9,340	0.217	27.5	4,280	4.07	14.7	ND<114	ND<1.14	53	19,200	---
WRS-R-15	10/07/08	34,600	1.85	23	48	ND<2.24	156	27,200	27.4	31.4	6,330	80,400	5,760	16,400	8,910	0.516	24.2	3,970	7.37	27	ND<112	ND<1.12	52.6	35,800	---
WRS-R-16	10/07/08	38,300	1.78	21.9	38.8	ND<2.40	212	16,800	28.4	31	1,790	94,400	8,830	18,000	11,500	0.467	27.7	4,020	4.96	18.8	ND<120	ND<1.20	54.9	51,400	---
WRS-R-17	10/07/08	41,800	1.64	11.2	72.6	ND<2.69	39	5,540	29.8	19	336	48,200	1,260	10,300	2,520	0.175	27.9	1,660	1.51	3.31	184	ND<1.34	69	8,940	---
WRS-R-18	10/07/08	34,500	1.72	19.6	35.6	ND<2.23	255	21,600	30	34.2	6,500	87,000	8,330	16,000	9,280	0.592	26.5	2,970	7.03	28.6	ND<112	ND<1.12	54.1	60,300	---
WRS-R-19	10/07/08	31,900	1.75	20.8	39.5	ND<2.42	89.1	16,800	33	25.5	824	72,900	4,540	15,300	8,120	0.314	27.1	3,380	2.66	10.5	138	ND<1.21	50.7	22,200	---
WRS-R-20	10/07/08	36,400	1.89	24.9	53.6	ND<2.35	226	16,100	30.3	31.9	2,170	81,800	7,460	15,900	9,130	0.446	26.7	5,280	4.86	17.8	ND<117	ND<1.17	53.5	54,200	---
WRS-R-21	10/07/08	38,400	1.75	23.5	59	ND<2.23	188	17,200	28.4	32.6	1,470	94,600	6,400	17,400	12,500	0.357	27.2	5,490	4.86	17.5	ND<111	ND<1.11	50.3	46,000	---
WRS-R-22	10/07/08	21,200	ND<1.13	16.8	50.5	ND<2.26	19.3	11,800	29.8	13.4	152	31,400	1,190	12,400	4,020	0.0902	24.3	3,500	ND<1.13	2.49	ND<113	ND<1.13	30	5,000	---
WRS-R-23	10/07/08	19,500	ND<1.12	8.16	59.6	ND<2.25	16.9	16,500	31.5	14.4	102	29,100	682	10,100	3,270	ND<0.0899	27.9	2,750	ND<1.12	ND<2.25	ND<112	ND<1.12	31.2	4,170	---
WRS-R-24	10/07/08	24,700	ND<1.19	5.39	42.5	ND<2.38	16.4	14,200	25.6	16.9	1,190	39,100	1,130	13,300	3,480	0.131	24.7	2,140	ND<1.19	5.16	150	ND<1.19	47.4	3,510	---
WRS-R-25	10/07/08	23,400	1.36	10.7	95.3	ND<2.28	32.2	23,300	33.5	14.8	128	34,700	1,450	8,870	5,040	0.388	28.5	3,000	ND<1.14	3.13	ND<114	ND<1.14	37.8	7,510	---
WRS-R-26	10/07/08	34,600	ND<1.23	9.14	124	ND<2.47	8.02	5,510	32.3	21.5	198	42,700	1,130	13,600	3,890	0.111	25.8	2,610	ND<1.23	ND<2.47	161	ND<1.23	65.7	2,020	---
WRS-R-27	10/07/08	25,300	ND<1.21	37.2	42.8	ND<2.43	43.5	18,500	26.9	24.3	272	59,700	1,850	13,600	6,700	0.911	26.9	3,570	2.73	7.84	ND<121	ND<1.21	30.3	10,500	---
WRS-R-28	10/07/08	23,200	ND<1.10	13.2	61.2	ND<2.21	17.6	18,300	31.4	15.7	155	36,900	1,230	13,400	4,460	0.132	26.1	2,750	1.44	4.15	ND<110	ND<1.10	35.5	4,690	---
WRS-R-29	10/07/08	23,100	1.13	11.6	40.2	ND<2.14	47.5	17,500	24.3	16.7	437	35,400	1,210	13,100	5,270	ND<0.0854	22.1	2,320	2.07	5.5	ND<107	ND<1.07	33.5	10,600	---
WRS-R-DUP	10/07/08	27,200	1.23	3.87	102	ND<2.14	12.8	38,500	21.5	13.6	100	31,500	905	13,500	4,640	ND<0.0856	19.3	2,780	1.34	ND<2.14	ND<107	ND<1.07	42.1	2,730	---
WRS-R-30	10/07/08	27,000	ND<1.11	30.3	66.3	ND<2.23	34	24,900	24.4	14.5	223	38,700	3,230	12,300	4,670	0.145	22.4	6,770	2.03	7.4	ND<111	ND<1.11	34	8,100	---
BG-1	11/08/05	---	---	2.55	92.3	---	ND<0.657	---	17.0	---	42.9	17,700	26.0	---	516	ND<0.0876	22.2	---	ND<0.657	ND<0.657	---	---	---	126	ND<1.27
BG-2	11/09/05	---	---	2.41	40.7	---	ND<0.570	---	18.4	---	48.7	16,200	25.1	---	807	ND<0.0891	24.2	---	ND<0.570	ND<0.570	---	---	---	469	ND<1.16
BG-3	11/09/05	---	---	3.23	75.7	---	ND<0.595	---	18.8	---	57.4	19,100	2.9	---	450	ND<0.0972	25.6	---	ND<0.595	ND<0.595	---	---	---	86.7	NA
BG-4	11/09/05	---	---	30.5	21.4	---	98.4	---	20.5	---	868	47,700	5,450	---	7,700	ND<0.0593	23.8	---	3.56	9.09	---	---	---	24,600	ND<1.15
BG-5	11/09/05	---	---	17.3	66.7	---	3.28	---	38.5	---	365	29,200	2,020	---	5,340	0.121	30.9	---	1.3	3.33	---	---	---	1,700	ND<1.21
BG-6	11/09/05	---	---	2.48	42.1	---	ND<0.608	---	18.0	---	40.0	16,700	16.7	---	722	ND<0.0627	25.4	---	ND<0.608	ND<0.608	---	---	---	83.0	ND<1.24
BG-7	11/09/05	---	---	12.0	22.2	---	23.5	---	28.3	---	506	24,000	936	---	3,620	0.123	31.0	---	1.18	2.39	---	---	---	4,160	ND<1.12
BG-8	11/09/05	---	---	2.54	63.3	---	ND<0.581	---	14.9	---	51.9	17,600	27.3	---	648	ND<0.103	23.8	---	ND<0.581	ND<0.581	---	---	---	107	ND<1.19
BG-9	11/09/05	---	---	3.43	69.6	---	1.16	---	21.4	---	196	15,400	146	---	893	ND<0.0879	27.7	---	ND<0.586	ND<0.586	---	---	---	2,470	ND<1.19
BG-10	11/09/05	---	---	8.45	110	---	ND<0.599	---	16.7	---	73.5	16,900	68.2	---	959	ND<0.0659	21.9	---	ND<0.599	ND<0.599	---	---	---	268	ND<1.16
BG-11	10/06/08	33,200	ND<1.55	7.37	55.2	ND<3.11	ND<1.55	2,690	22.8	7.03	25.3	33,800	13.5	4,270	234	0.14	14.1	944	ND<1.55	ND<3.11	ND<155	ND<1.55	81.8	52.4	---
BG-12	10/06/08	28,800	1.53	4.97	121	ND<2.55	ND<1.27	2,170	11.1	11.3	15	32,800	8.53	4,680	1,050	ND<0.102	7.49	1,300	ND<1.27	ND<2.55	295	ND<1.27	73.6	69.5	---
BG-13	10/06/08	35,500	ND<1.43	5.86	92.9	ND<2.86	ND<1.43	2,090	12.2	13.7	21.7	32,400	8.38	6,440	1,270	ND<0.144	11.7	834	ND<1.43	ND<2.86	196	ND<1.43	69.8	77.5	---
BG-14	10/06/08	19,700	ND<1.50	5.1	48.2	ND<3.01	ND<1.50	727	19.2	4.54	14.5	34,100	15.8	2,270	169	ND<0.120	7.96	533	ND<1.50	ND<3.01	ND<150	ND<1.50	88	42.9	---
BG_15	10/06/08	31,700	ND<1.72	3.88	78.7	ND<3.44	ND<1.72	1,280	19.9	7.4	23.5	29,700	22.1	3,340	367	ND<0.137	12.1	780	ND<1.72	ND<3.44	ND<172	ND<1.72	63.4	69.2	---

TABLE 2
Summary of Chemical Analytical Data for Waste Rock/Soil and Background Rock/Soil[1] (Total Metals)
Ruth Mine Site at Opal Creek
Marion County, Oregon

Sample I.D.	Date	Total Metals by EPA Method 6000/7000 Series and Total Mercury by EPA Method 7471A (mg/Kg)																							Hexavalent Chromium by EPA Method 3060A (mg/Kg)
		Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead	Magnesium	Manganese	Mercury	Nickel	Potassium	Selenium	Silver	Sodium	Thallium	Vanadium	Zinc	
BG-16	10/06/08	40,400	ND<1.21	4.86	123	ND<2.42	ND<1.21	2,130	24.7	12.9	50.6	39,300	160	6,470	773	0.121	20	1,480	ND<1.21	ND<2.42	138	ND<1.21	76.4	352	---
BG-17	10/06/08	45,300	ND<1.17	5.8	75.3	ND<2.34	ND<1.17	983	19.7	8.45	30.8	33,600	105	2,630	641	0.117	12.7	708	ND<1.17	ND<2.34	201	ND<1.17	68.2	520	---
BG-18	10/06/08	49,900	1.48	5.68	103	ND<2.49	ND<1.25	1,180	29	13.3	48	42,700	66.4	6,320	742	ND<0.0996	21.1	1,260	ND<1.25	ND<2.49	139	ND<1.25	78.1	392	---
BG-19	10/06/08	34,800	ND<1.53	5.47	67.6	ND<3.07	ND<1.53	2,080	23.5	11.1	38.4	31,700	80.9	5,670	750	0.138	18.9	1,030	ND<1.53	ND<3.07	ND<153	ND<1.53	64.8	264	---
BG-20	10/06/08	12,700	ND<1.36	1.97	42	ND<2.72	ND<1.36	2,880	12	3.69	5.78	15,300	8.31	1,890	437	0.109	5.78	459	ND<1.36	ND<2.72	171	ND<1.36	47	33.8	---
DEQ Level II Screening Level Values - Soil (mg/Kg)		NE	5	10	85	10	4	NE	0.4	20	50	10	16	NE	100	0.1	30	NE	1	2	NE	1	2	50	410
EPA PRGs - Industrial Soil (mg/Kg)		990,000	410	1.6	190,000	2,000	810	NE	1,400	300	41,000	720,000	800	NE	23,000	310	20,000	NE	5,100	5,100	NE	66	5,200	310,000	64

Notes:
1. Chemical analyses performed by North Creek Analytical of Beaverton, Oregon.
BG: background rock/soil sample
DEQ: Oregon Department of Environmental Quality
EPA: U.S. Environmental Protection Agency
mg/Kg: milligrams per kilogram
NA: The data for this sample was compromised during the laboratory extraction.
ND: not detected
NE: not established
PRG: preliminary remediation goal
WRS and WRS-R: waste rock/soil sample Ruth Mine
---: not submitted for analysis
shading indicates an exceedance of the PRG
shading indicates an exceedance of the SLV
shading indicates an exceedance of both PRG and SLV

TABLE 3
Summary of Chemical Analytical Data for Surface Water and Sediment[1]
Morning Star Mine Site at Opal Creek
Marion County, Oregon

Sample I.D.	Date	Media	Total Metals by EPA Method 6000/7000 Series (mg/L)																							
			Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead	Magnesium	Manganese	Mercury	Nickel	Potassium	Selenium	Silver	Sodium	Thallium	Vanadium	Zinc
AW-MS-1	10/07/08	adit water	ND<0.1	ND<0.0010	0.00476	ND<0.0010	ND<0.0010	ND<0.0010	12.1	ND<0.0010	ND<0.0020	ND<0.0040	ND<0.10	0.00223	0.263	ND<0.0010	ND<0.00010	ND<0.0010	0.24	ND<0.0010	ND<0.0020	6.87	ND<0.0010	ND<0.0020	0.0565
SW-8	11/09/05	surface water	---	---	ND<0.0010	ND<0.0010	---	ND<0.0010	---	ND<0.0010	---	ND<0.0020	ND<0.010	ND<0.0010	---	ND<0.0020	ND<0.00020	ND<0.0020	---	ND<0.0020	ND<0.0010	---	---	---	ND<0.0050
SW-9	11/09/05	surface water	---	---	0.00133	ND<0.0010	---	ND<0.0010	---	ND<0.0010	---	ND<0.0020	ND<0.010	0.00252	---	ND<0.0020	ND<0.00020	ND<0.0020	---	ND<0.0020	ND<0.0010	---	---	---	0.0724
SW-10	11/09/05	surface water	---	---	ND<0.0010	ND<0.0010	---	ND<0.0010	---	ND<0.0010	---	ND<0.0020	ND<0.010	ND<0.0010	---	ND<0.0020	ND<0.00020	ND<0.0020	---	ND<0.0020	ND<0.0010	---	---	---	ND<0.0050
SW-MS-11	10/07/08	surface water	ND<0.1	ND<0.0010	ND<0.0010	0.00173	ND<0.0010	ND<0.0010	3.3	ND<0.0010	ND<0.0020	ND<0.0040	ND<0.10	0.00171	0.337	ND<0.0010	ND<0.00010	ND<0.0010	0.127	ND<0.0010	ND<0.0020	1.11	ND<0.0010	ND<0.0020	0.0229
SW-MS-12	10/07/08	surface water	ND<0.1	ND<0.0010	0.001	ND<0.0010	ND<0.0010	ND<0.0010	4.98	ND<0.0010	ND<0.0020	ND<0.0040	ND<0.10	0.00248	0.28	ND<0.0010	ND<0.00010	ND<0.0010	0.141	ND<0.0010	ND<0.0020	2.16	ND<0.0010	ND<0.0020	0.0415
SW-MS-13	10/07/08	surface water	ND<0.1	ND<0.0010	0.00134	ND<0.0010	ND<0.0010	ND<0.0010	5.25	ND<0.0010	ND<0.0020	ND<0.0040	ND<0.10	0.00344	0.258	ND<0.0010	ND<0.00010	ND<0.0010	0.137	ND<0.0010	ND<0.0020	2.18	ND<0.0010	ND<0.0020	0.00646
SW-MS-14	10/08/08	surface water	ND<0.1	ND<0.0010	ND<0.0010	ND<0.0010	ND<0.0010	ND<0.0010	4.05	ND<0.0010	ND<0.0020	ND<0.0040	ND<0.10	ND<0.0010	0.483	ND<0.0010	ND<0.00010	ND<0.0010	0.11	ND<0.0010	ND<0.0020	1.32	ND<0.0010	ND<0.0020	0.00689
SW-MS-15	10/08/08	surface water	ND<0.1	ND<0.0010	ND<0.0010	ND<0.0010	ND<0.0010	ND<0.0010	4.03	ND<0.0010	ND<0.0020	ND<0.0040	ND<0.10	ND<0.0010	0.473	ND<0.0010	ND<0.00010	ND<0.0010	0.108	ND<0.0010	ND<0.0020	1.29	ND<0.0010	ND<0.0020	0.0107
SW-MS-16	10/08/08	surface water	ND<0.1	ND<0.0010	ND<0.0010	ND<0.0010	ND<0.0010	ND<0.0010	3.91	ND<0.0010	ND<0.0020	ND<0.0040	ND<0.10	ND<0.0010	0.466	ND<0.0010	ND<0.00010	ND<0.0010	0.117	ND<0.0010	ND<0.0020	1.3	ND<0.0010	ND<0.0020	0.00978
SW-MS-17	10/08/08	surface water	0.101	ND<0.0010	0.0013	ND<0.0010	ND<0.0010	ND<0.0010	5.3	ND<0.0010	ND<0.0020	ND<0.0040	ND<0.10	0.0127	0.27	0.00493	ND<0.00010	ND<0.0010	0.137	ND<0.0010	ND<0.0020	2.34	ND<0.0010	ND<0.0020	0.0817
SW-MS-18	10/08/08	surface water	ND<0.1	ND<0.0010	ND<0.0010	ND<0.0010	ND<0.0010	ND<0.0010	4.05	ND<0.0010	ND<0.0020	ND<0.0040	ND<0.10	ND<0.0010	0.481	ND<0.0010	ND<0.00010	ND<0.0010	0.11	ND<0.0010	ND<0.0020	1.37	ND<0.0010	ND<0.0020	0.0196

Sample I.D.	Date	Media	Dissolved Metals by EPA Method 6000/7000 Series (mg/L)																							
			Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead	Magnesium	Manganese	Mercury	Nickel	Potassium	Selenium	Silver	Sodium	Thallium	Vanadium	Zinc
PW-MS-14	10/08/08	pore water	ND<0.10	ND<0.0010	ND<0.0010	0.0015	ND<0.0010	ND<0.0010	3.9	ND<0.0010	ND<0.0020	ND<0.0050	ND<0.10	ND<0.0010	0.502	0.00521	ND<0.00010	0.00227	0.175	ND<0.0010	ND<0.0020	1.52	ND<0.0010	ND<0.0020	0.00547
PW-MS-15	10/08/08	pore water	ND<0.10	ND<0.0010	ND<0.0010	0.00106	ND<0.0010	ND<0.0010	3.83	ND<0.0010	ND<0.0020	ND<0.0050	ND<0.10	ND<0.0010	0.494	0.00447	ND<0.00010	0.00213	0.138	ND<0.0010	ND<0.0020	1.37	ND<0.0010	ND<0.0020	0.00513
PW-MS-16	10/08/08	pore water	ND<0.10	ND<0.0010	ND<0.0010	ND<0.0010	ND<0.0010	ND<0.0010	3.8	ND<0.0010	ND<0.0020	ND<0.0050	ND<0.10	ND<0.0010	0.478	0.00191	ND<0.00010	ND<0.0010	0.101	ND<0.0010	ND<0.0020	1.35	ND<0.0010	ND<0.0020	ND<0.0040
PW-MS-18	10/08/08	pore water	ND<0.10	ND<0.0010	ND<0.0010	ND<0.0010	ND<0.0010	ND<0.0010	3.76	ND<0.0010	ND<0.0020	ND<0.0050	ND<0.10	ND<0.0010	0.47	0.00257	ND<0.00010	ND<0.0010	0.103	ND<0.0010	ND<0.0020	1.37	ND<0.0010	ND<0.0020	ND<0.0040
DEQ Level II SLVs - Surface Water Fresh (mg/L)			0.087	1.6	0.15	0.004	0.0053	0.0022	116	0.074	0.023	0.009	1	0.0025	82	0.12	0.00077	0.052	53	0.005	0.00012	680	0.04	0.02	0.12
EPA Region 6 PRGs - Tap Water (mg/L)			37	0.015	0.000045	7.3	0.073	0.018	NA	0.11*	0.011	1.5	26	0.015	NA	0.88	0.011	0.73	NA	0.05	0.18	NA	0.0024	0.18	11
Water Quality Criteria[2] (mg/L)			0.087	0.146	0.01	1	0.000068	0.0011	NA	0.011	NA	0.012	0.3	0.0032	NA	0.05	0.00002	0.0134	NA	0.01	0.00012	NA	0.00024	NA	0.11

Sample I.D.	Date	Media	Total Metals by EPA Method 6000/7000 Series (mg/Kg)																							
			Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead	Magnesium	Manganese	Mercury	Nickel	Potassium	Selenium	Silver	Sodium	Thallium	Vanadium	Zinc
SED-MS-12	10/08/08	sediment	17,400	ND<1.16	41.40	15.3	ND<2.32	9.86	3,750	18.4	16.0	231	37,600	1,370	11,500	2,820	0.162	20.5	1,410	ND<1.16	2.6	ND<116	ND<1.16	29.2	2,920
SED-MS-13	10/08/08	sediment	10,300	ND<1.09	5.91	20.1	ND<2.19	3.54	4,740	19.3	13.1	140	26,500	660	10,300	1,340	ND<0.0874	18.7	1,300	ND<1.09	ND<2.19	135	ND<1.09	31.4	1,480
SED-MS-14	10/08/08	sediment	17,900	ND<1.32	1.42	32.8	ND<2.63	ND<1.32	7,490	11.4	9.6	15.5	16,000	2.97	7,330	424	ND<0.105	16.3	844	ND<1.32	ND<2.63	267	ND<1.32	28.8	36.1
SED-MS-15	10/08/08	sediment	24,100	ND<1.20	1.25	51.6	ND<2.4	ND<1.2	6,460	22.3	12.5	24.3	25,000	3.44	10,600	466	ND<0.0962	28.7	843	ND<1.2	ND<2.4	396	ND<1.2	43.4	50.5
SED-MS-16	10/08/08	sediment	19,600	ND<1.31	ND<1.31	39.9	ND<2.61	ND<1.31	6,090	10.7	10.3	20.8	19,100	2.27	9,640	359	ND<0.105	21.2	547	ND<1.31	ND<2.61	445	ND<1.31	36.3	39.6
SED-MS-17	10/08/08	sediment	18,600	ND<1.30	2.31	56	ND<2.61	2.11	5,960	18.5	15.7	32.8	35,700	50.8	15,200	525	ND<0.104	89.1	839	ND<1.30	ND<2.61	355	ND<1.30	47.2	608
SED-MS-18	10/08/08	sediment	21,600	ND<1.40	ND<1.40	46.5	ND<2.8	ND<1.4	7,280	16.0	13.4	40.7	23,700	6.69	10,400	484	ND<0.112	47.6	860	ND<1.40	ND<2.8	374	ND<1.40	38.3	68.5
EPA Region 6 PRGs - Industrial Soil (mg/Kg)			990,000	410	1.6	190,000	2,000	810	NE	1,400	300	41,000	720,000	800	NE	23,000	310	20,000	NE	5,100	5,100	NE	66	5,200	310,000
DEQ Level II SLVs - Fresh Water Sediments (mg/Kg)			NA	3	6	NA	NA	0.6	NA	37	NA	36	NA	35	NA	1,100	0.2	18	NA	NA	4.5	NA	NA	NA	123

Notes:
1. Chemical analyses performed by North Creek Analytical of Beaverton, Oregon (2005) and Apex Laboratories, LLC of Tigard, Oregon (2008).
2. The most conservative value among Fresh Acute Criteria, Fresh Chronic Criteria, Water and Fish Consumption, and Drinking Water maximum contaminant level.
* The Chromium VI value was used because it is more conservative
--: not submitted for analysis
AW-MS: adit water sample Morning Star Mine
DEQ: Oregon Department of Environmental Quality
EPA: U.S. Environmental Protection Agency
mg/Kg: milligrams per kilogram
mg/L: milligrams per liter
NA: not applicable
ND: not detected
NE: not established
PW-MS: pore water sample Morning Star Mine
PRG: preliminary remediation goal
SED-MS: sediment sample Morning Star Mine
SLV: screening level value
SW and SW-MS: surface water sample Morning Star Mine
shading indicates an exceedance of the PRG
shading indicates an exceedance of the SLV and/or the Water Quality Criteria
shading indicates an exceedance of both PRG and SLV

TABLE 4
Summary of Chemical Analytical Data for Waste Rock/Soil and Background Rock/Soil[1] (Total Metals)
Morning Star Mine Site at Opal Creek
Marion County, Oregon

Sample I.D.	Date	Total Metals by EPA Method 6000/7000 Series and Total Mercury by EPA Method 7471A (mg/Kg)																							Hexavalent Chromium by EPA Method 3060A (mg/Kg)
		Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead	Magnesium	Manganese	Mercury	Nickel	Potassium	Selenium	Silver	Sodium	Thallium	Vanadium	Zinc	
WRS-MS-1	10/07/08	20,400	2.25	25.3	29.1	ND<2.35	171	11,600	15.4	17.8	2,210	49,800	5,310	9,620	4,150	0.471	16.3	3,450	1.45	21.9	ND<118	ND<1.18	30.1	42,800	---
WRS-MS-2	10/07/08	16,000	1.42	18.6	19.8	ND<2.35	144	7,620	14.1	21.5	4,040	44,200	2,050	7,460	2,360	0.458	19.2	2,490	1.2	15.6	ND<117	ND<1.17	21.8	35,100	---
WRS-MS-3	10/07/08	18,200	ND<1.12	7.54	25.5	ND<2.24	37.6	34,300	18.7	16.1	806	33,800	2,940	9,880	3,000	0.47	21.2	3,030	ND<1.12	5.91	ND<112	ND<1.12	26.8	11,800	---
WRS-MS-4	10/07/08	19,200	1.52	14.7	25.4	ND<2.38	49.9	8,640	18.7	16	1,030	38,500	3,100	10,300	3,550	0.429	19.7	2,780	ND<1.19	7.31	ND<119	ND<1.19	27.3	15,400	---
WRS-MS-5	10/07/08	22,600	3.9	30	20.5	ND<2.20	112	29,300	15.3	16.8	679	46,100	8,390	11,300	5,300	0.627	16.5	2,550	2.11	20.8	ND<110	ND<1.10	32	30,300	---
WRS-MS-6	10/07/08	19,600	3.28	24.7	27.6	ND<2.42	215	23,000	14.9	16.7	668	48,400	11,700	9,600	5,080	0.617	16.4	2,410	1.57	12.6	ND<121	ND<1.21	30.1	51,900	---
WRS-MS-7	10/07/08	28,400	1.53	13.4	68	ND<2.49	405	4,070	21.7	16	408	37,200	3,600	10,800	2,510	0.46	21.2	3,100	ND<1.24	10.2	174	ND<1.24	47.5	23,700	---
WRS-MS-8	10/07/08	33,100	ND<1.33	5.89	73.6	ND<2.67	4.3	4,950	24	15.2	173	33,200	279	11,100	771	0.213	27	1,650	ND<1.33	ND<2.67	171	ND<1.33	46.7	884	---
WRS-MS-9	10/07/08	27,200	ND<1.20	7.23	60.4	ND<2.4	3.33	4,370	24.2	17.3	96.9	34,300	409	12,300	997	0.132	26.7	921	ND<1.20	ND<2.40	190	ND<1.20	48.9	718	---
WRS-MS-10	10/07/08	20,000	2.07	24.3	21.2	ND<2.29	39	5,470	12.5	14.2	696	41,900	7,790	9,530	5,020	0.229	16.3	2,350	1.3	8.45	ND<115	ND<1.15	27.9	15,700	---
WRS-MS-11	10/07/08	34,800	2.11	25.8	45.2	ND<2.70	33.7	8,650	19	20.3	412	71,900	6,470	14,100	7,810	0.364	21	3,220	1.39	8.89	ND<135	ND<1.35	50.3	9,220	---
BG-1	11/08/05	---	---	2.55	92.3	---	ND<0.657	---	17.0	---	42.9	17,700	26.0	---	516	ND<0.0876	22.2	---	ND<0.657	ND<0.657	---	---	---	126	ND<1.27
BG-2	11/09/05	---	---	2.41	40.7	---	ND<0.570	---	18.4	---	48.7	16,200	25.1	---	807	ND<0.0891	24.2	---	ND<0.570	ND<0.570	---	---	---	469	ND<1.16
BG-3	11/09/05	---	---	3.23	75.7	---	ND<0.595	---	18.8	---	57.4	19,100	2.9	---	450	ND<0.0972	25.6	---	ND<0.595	ND<0.595	---	---	---	86.7	NA
BG-4	11/09/05	---	---	30.5	21.4	---	98.4	---	20.5	---	868	47,700	5,450	---	7,700	ND<0.0593	23.8	---	3.56	9.09	---	---	---	24,600	ND<1.15
BG-5	11/09/05	---	---	17.3	66.7	---	3.28	---	38.5	---	365	29,200	2,020	---	5,340	0.121	30.9	---	1.3	3.33	---	---	---	1,700	ND<1.21
BG-6	11/09/05	---	---	2.48	42.1	---	ND<0.608	---	18.0	---	40.0	16,700	16.7	---	722	ND<0.0627	25.4	---	ND<0.608	ND<0.608	---	---	---	83.0	ND<1.24
BG-7	11/09/05	---	---	12.0	22.2	---	23.5	---	28.3	---	506	24,000	936	---	3,620	0.123	31.0	---	1.18	2.39	---	---	---	4,160	ND<1.12
BG-8	11/09/05	---	---	2.54	63.3	---	ND<0.581	---	14.9	---	51.9	17,600	27.3	---	648	ND<0.103	23.8	---	ND<0.581	ND<0.581	---	---	---	107	ND<1.19
BG-9	11/09/05	---	---	3.43	69.6	---	1.16	---	21.4	---	196	15,400	146	---	893	ND<0.0879	27.7	---	ND<0.586	ND<0.586	---	---	---	2,470	ND<1.19
BG-10	11/09/05	---	---	8.45	110	---	ND<0.599	---	16.7	---	73.5	16,900	68.2	---	959	ND<0.0659	21.9	---	ND<0.599	ND<0.599	---	---	---	268	ND<1.16
BG-11	10/06/08	33,200	ND<1.55	7.37	55.2	ND<3.11	ND<1.55	2,690	22.8	7.03	25.3	33,800	13.5	4,270	234	0.14	14.1	944	ND<1.55	ND<3.11	ND<155	ND<1.55	81.8	52.4	---
BG-12	10/06/08	28,800	1.53	4.97	121	ND<2.55	ND<1.27	2,170	11.1	11.3	15	32,800	8.53	4,680	1,050	ND<0.102	7.49	1,300	ND<1.27	ND<2.55	295	ND<1.27	73.6	69.5	---
BG-13	10/06/08	35,500	ND<1.43	5.86	92.9	ND<2.86	ND<1.43	2,090	12.2	13.7	21.7	32,400	8.38	6,440	1,270	ND<0.144	11.7	834	ND<1.43	ND<2.86	196	ND<1.43	69.8	77.5	---
BG-14	10/06/08	19,700	ND<1.50	5.1	48.2	ND<3.01	ND<1.50	727	19.2	4.54	14.5	34,100	15.8	2,270	169	ND<0.120	7.96	533	ND<1.50	ND<3.01	ND<150	ND<1.50	88	42.9	---
BG_15	10/06/08	31,700	ND<1.72	3.88	78.7	ND<3.44	ND<1.72	1,280	19.9	7.4	23.5	29,700	22.1	3,340	367	ND<0.137	12.1	780	ND<1.72	ND<3.44	ND<172	ND<1.72	63.4	69.2	---
BG-16	10/06/08	40,400	ND<1.21	4.86	123	ND<2.42	ND<1.21	2,130	24.7	12.9	50.6	39,300	160	6,470	773	0.121	20	1,480	ND<1.21	ND<2.42	138	ND<1.21	76.4	352	---
BG-17	10/06/08	45,300	ND<1.17	5.8	75.3	ND<2.34	ND<1.17	983	19.7	8.45	30.8	33,600	105	2,630	641	0.117	12.7	708	ND<1.17	ND<2.34	201	ND<1.17	68.2	520	---
BG-18	10/06/08	49,900	1.48	5.68	103	ND<2.49	ND<1.25	1,180	29	13.3	48	42,700	66.4	6,320	742	ND<0.0996	21.1	1,260	ND<1.25	ND<2.49	139	ND<1.25	78.1	392	---
BG-19	10/06/08	34,800	ND<1.53	5.47	67.6	ND<3.07	ND<1.53	2,080	23.5	11.1	38.4	31,700	80.9	5,670	750	0.138	18.9	1,030	ND<1.53	ND<3.07	ND<153	ND<1.53	64.8	264	---
BG-20	10/06/08	12,700	ND<1.36	1.97	42	ND<2.72	ND<1.36	2,880	12	3.69	5.78	15,300	8.31	1,890	437	0.109	5.78	459	ND<1.36	ND<2.72	171	ND<1.36	47	33.8	---
DEQ Level II Screening Level Values - Soil (mg/Kg)		NE	5	10	85	10	4	NE	0.4	20	50	10	16	NE	100	0.1	30	NE	1	2	NE	1	2	50	410
EPA Region 6 PRGs - Industrial Soil (mg/Kg)		990,000	410	1.6	190,000	2,000	810	NE	1,400	300	41,000	720,000	800	NE	23,000	310	20,000	NE	5,100	5,100	NE	66	5,200	310,000	64

Notes:
1. Chemical analyses performed by North Creek Analytical of Beaverton, Oregon (2005) and Apex Laboratories, LLC of Tigard, Oregon (2008).
---: not submitted for analysis
BG: background rock/soil sample
DEQ: Oregon Department of Environmental Quality
EPA: U.S. Environmental Protection Agency
mg/Kg: milligrams per kilogram
NA: The data for this sample was compromised during the laboratory extraction.
ND: not detected
NE: not established
PRG: preliminary remediation goal
SLV: screening level value
WRS-MS: waste rock/soil sample Morning Star Mine
shading indicates an exceedance of the PRG
shading indicates an exceedance of the SLV
shading indicates an exceedance of both PRG and SLV

TABLE 5
Summary of Non-Cancer Hazard Quotients
Ruth Mine Site at Opal Creek
Marion County, Oregon

Route of Exposure	Children		Adults	
	CTE	RME	CTE	RME
Incidental Ingestion of Surface Soil	0.001	0.03	0.0001	0.001
Dermal Contact with Surface Soil	0.0001	0.01	0.00005	0.0003
Inhalation of Particles from Surface Soil	0.00001	0.00003	0.000002	0.00001
Incidental Ingestion of Surface Water	0.00004	0.0004	0.00001	0.0001
Dermal Contact with Surface Water	0.0003	0.004	0.0001	0.001
Incidental Ingestion of Sediment	0.001	0.014	0.0001	0.001
Dermal Contact with Sediment	0.0001	0.003	0.00003	0.00003

Notes:
CTE: central tendency exposure
RME: reasonable maximum exposure

TABLE 6
Summary of Cancer Risks
Ruth Mine Site at Opal Creek
Marion County, Oregon

Route of Exposure	Children		Adults	
	CTE	RME	CTE	RME
Incidental Ingestion of Surface Soil	2.00E-08	1.00E-06	8.00E-09	3.00E-07
Dermal Contact with Surface Soil	1.00E-09	2.00E-07	3.00E-09	6.00E-08
Inhalation of Particles from Surface Soil	2.00E-11	4.00E-10	3.00E-11	5.00E-10
Incidental Ingestion of Surface Water	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Dermal Contact with Surface Water	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Incidental Ingestion of Sediment	9.00E-09	6.00E-07	4.00E-09	2.00E-07
Dermal Contact with Sediment	7.00E-10	1.00E-07	2.00E-09	3.00E-08

Notes:
CTE: central tendency exposure
RME: reasonable maximum exposure

TABLE 7
Summary of Non-Cancer Hazard Quotients
Morning Star Mine Site at Opal Creek
Marion County, Oregon

Route of Exposure	Children		Adults	
	CTE	RME	CTE	RME
Incidental Ingestion of Surface Soil	0.001	0.03	0.0001	0.001
Dermal Contact with Surface Soil	0.0001	0.01	0.00005	0.0003
Inhalation of Particles from Surface Soil	0.00001	0.00003	0.000002	0.00001
Incidental Ingestion of Surface Water	0.00002	0.0002	0.000005	0.00005
Dermal Contact with Surface Water	0.00001	0.0001	0.000002	0.00003
Incidental Ingestion of Sediment	0.002	0.036	0.0002	0.002
Dermal Contact with Sediment	0.001	0.008	0.00007	0.00007

Notes:
CTE: central tendency exposure
RME: reasonable maximum exposure

TABLE 8
Summary of Cancer Risks
Morning Star Mine Site at Opal Creek
Marion County, Oregon

Route of Exposure	Children		Adults	
	CTE	RME	CTE	RME
Incidental Ingestion of Surface Soil	0.00000002	1E-06	8E-09	3E-07
Dermal Contact with Surface Soil	1E-09	2E-07	3E-09	6E-08
Inhalation of Particles from Surface Soil	3E-11	4E-10	3E-11	5E-10
Incidental Ingestion of Surface Water	3E-10	8E-09	3E-10	9E-09
Dermal Contact with Surface Water	1E-10	4E-09	1E-10	6E-09
Incidental Ingestion of Sediment	2E-08	1E-06	1E-08	4E-07
Dermal Contact with Sediment	2E-09	3E-07	4E-09	9E-08

Notes:
CTE: central tendency exposure
RME: reasonable maximum exposure

TABLE 9
Summary of ARARs
Ruth Mine Site at Opal Creek
Marion County, Oregon

Standard, Requirement, Criteria, or Limitation	Citation	Description	Applicable	Relevant or Appropriate	Not Applicable	Comments
CHEMICAL SPECIFIC						
FEDERAL						
Safe Drinking Water Act	40 USC 300					
National Primary Drinking Water Regulations	40 CFR Part 141	Health-based standards, maximum contaminant levels, for public water systems.			X	Groundwater and surface water are not complete pathways to public water systems.
National Secondary Drinking Water Regulations	40 CFR Part 143	Aesthetic standards, secondary maximum contaminant levels, for public water systems.			X	Groundwater and surface water are not complete pathways to public water systems.
Clean Water Act	33 USC 1251 - 1387					
National Ambient Water Quality Criteria	40 CFR Part 131	Sets criteria for water quality based on toxicity to aquatic organisms and human health.		X		State of Oregon has been delegated this program. The Clean Water Act has been addressed in State ARARs.
Clean Air Act	42 USC 7409					
National Primary and Secondary Ambient Air Quality Standards	40 CFR Part 50	Establishes air quality levels that protect public health.			X	Only major sources are subject to requirements, defer to State for fugitive dust emissions.
RCRA	40 USC 7601					
List of Hazardous Wastes	40 CFR Part 261	Defines solid wastes that are regulated as hazardous wastes under RCRA.			X	Mine waste is exempt under the Bevill Amendment.
PRGs for Industrial Soil and Water	USEPA. 2008. USEPA Human Health Medium-Specific Screening Levels 2008. U.S. Environmental Protection Agency. Updated September, 2008.	PRGs are risk-based concentrations that are used to assist risk assessors in initial screening level risk assessments. They are generic and calculated without site-specific information. PRGs are EPA guidelines not legally enforceable standards.		X		PRGs were considered during initial screening level assessments at the mine sites, and further evaluated as part of the comprehensive human health and ecological risk assessments.
EPA Guidance						
Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities	EPA Directive 9355.4-12, July 1994	Guidance on establishing cleanup levels for lead.		X		Guidance incorporated into comprehensive lead exposure assessment and human health and ecological risk assessments.
STATE						
Standards for degree of cleanup required	ORS 465.315	Establishes level of acceptable risk for human health and ecological receptors determined through risk assessments.	X			Baseline human health and ecological risk assessments conducted in accordance with ORS 465.315, and response actions developed to maintain current and future acceptable risk.

TABLE 9
Summary of ARARs
Ruth Mine Site at Opal Creek
Marion County, Oregon

Standard, Requirement, Criteria, or Limitation	Citation	Description	Applicable	Relevant or Appropriate	Not Applicable	Comments
STATE (continued)						
Hazardous Substances Remedial Action Rules	OAR 340-122-84 and 115	DEQ guidelines for human health and ecological risk assessments.	X			Baseline human health and ecological risk assessments conducted in accordance with ORS 465.315, and response actions developed to maintain current and future acceptable risk.
Water Quality Standards: Beneficial Uses, Policies, and Criteria for Oregon	OAR 340-041	Regulates the management of quality of public waters within the state of Oregon.	X			Water quality benchmarks referenced and screened as part of the Site Investigation and Risk Assessment process; no significant impairments to beneficial uses identified.
Groundwater Quality Protection	OAR 340-040	Establish mandatory minimum groundwater quality protection requirements.			X	Groundater discharges to surface water in the mine site drainage basins. With the exception of discharge to surface water, no other beneficial groundwater uses are present. Site invesigations have identified no significant adverse impacts to surface water, and no unacceptable human or ecological risks were identified.
Oregon Water Pollution Control Statutes	ORS 468B.005-190	Addresses permit requirements for discharges to public waters.	X			Potentially applicable during removal action implementation, such that substantial requirements are met and waste rock or equipment releases are not likely to escape or be carried in the waters of the state.
LOCATION SPECIFIC						
FEDERAL						
RCRA	40 USC 7601					
Hazardous and Solid Waste Regulations	40 CFR Part 264.18	Location standards and restrictions for hazardous waste treatment, storage, and disposal facilities.	X			Applicable only for off-site transportation and disposal alternative of solid or hazardous waste.
National Historic Preservation Act	16 USC 470; 40 CFR Part 6.301(b); 36 CFR Part 800	Regulates inventory, assessment, and consultation on project effects and protection measures for cultural properties on federal lands.	X			The Forest Service will review existing documentation and, as warranted, conduct additional survey.
The Historical and Archeological Preservation Act	16 USC 469; 40 CFR 6.301(c)	Establishes procedures to provide for preservation of significant scientific, prehistoric, historic, and archeological data.	X			The Forest Service will review existing documentation and, as warranted, conduct additional survey.

TABLE 9
Summary of ARARs
Ruth Mine Site at Opal Creek
Marion County, Oregon

Standard, Requirement, Criteria, or Limitation	Citation	Description	Applicable	Relevant or Appropriate	Not Applicable	Comments
FEDERAL (continued						
Endangered Species Act	16 USC 1531-1543; 50 CFR Parts 17, 402; 40 CFR 6.302(b)	Regulates the protection of threatened or endangered species and critical habitat.	X			Applicable, with substantive requirements met during removal action implementation.
Bald Eagle Protection Act	16 USC 668	Ensures that cleanup of sites does not unnecessarily adversely affect the bald or golden eagle.	X			Applicable, with substantive requirements met during removal action implementation.
Migratory Bird Treaty Act	16 USC 703	Ensures that cleanup of sites does not unnecessarily adversely impact migratory birds.	X			Applicable, with substantive requirements met during removal action implementation.
Protection of Wetlands Executive Order No. 11990	40 CFR Part 6; 40 CFR 6.302(a)	Requires avoiding adverse impacts associated with destruction or loss of wetlands and avoid support of new construction in wetlands if an alternative exists.			X	Wetlands not identified in proximity to the mine sites.
Floodplain Management Executive Order No. 11988	40 CFR Part 6; 40 CFR 6.302(b)	Requires evaluation of the potential effects of actions taken in a floodplain to avoid adverse effects associated with direct or indirect development of a floodplain.			X	The mine sites are not located within a floodplain
Dredge and Fill Regulations	33 CFR Part 323	Regulates permits for discharges of dredged or fill material into waters of the United States.			X	The limited removal action does not constitute dredge or fill operations; therefore, rule is not considered to be applicable.
Fish and Wildlife Coordination Act	16 USC Chapter 49 Parts 2901-2912	Requires coordination with federal and state agencies to provide protection of fish and wildlife.	X			Applicable during removal action implementation.
National Forest Management Act, Land Implementation Regulation and Resource Management Plan for Willamette National Forest (1990)	16 USC 1600 - 1614	The Willamatte National Forest LRMP and Opal Creek Scenic Recreation Area Management Plan provide standards and guidelines for actions to be taken on National Forest System lands. These include, but are not limited to Road Systems standards and guidelines.	X			Applicable during removal action implementation.
Opal Creek Wilderness and Scenic Recreation Area Act	16 USC 545B	Restricts construction or road improvements to maintaining the character of the road as it existed in Novermber 1996. Authorizes environmental response actions under CERCLA.	X			Appilcable during removal action implementation.

TABLE 9
Summary of ARARs
Ruth Mine Site at Opal Creek
Marion County, Oregon

Standard, Requirement, Criteria, or Limitation	Citation	Description	Applicable	Relevant or Appropriate	Not Applicable	Comments
STATE						
Wildlife Diversity Program	OAR 635-100	Provides rules for maintaining Oregon's wildlife diversity by protecting and enhancing populations and habitats of native wildlife at self-sustaining levels throughout geographic ranges.	X			Applicable during removal action implementation.
Plants: Wildflowers and Endangered, Threatened and Candidate Species	OAR 635-100	Provides for protection of certain plants, wildflowers, and shrubs; guidelines on the listing, reclassification, and delisting of plant species as threatened or endangered.	X			Applicable during removal action implementation.
ACTION SPECIFIC						
FEDERAL						
Clean Water Act	33 USC 1342					
NPDES	40 CFR Part 122	Requires permits for discharge of pollutants from any point source into waters of the United States.			X	Permit exemption under CERCLA with substantive compliance.
Hazardous Materials Transportation Act	49 USC 1801-1813	Regulates transportation of hazardous materials.	X			Potentially applicable if material transported off site.
RCRA	42 USC 6901					
Disposal of Solid Waste	40 CFR Part 257	Facilities or practices in floodplains will not restrict flow of basic flood, reduce temporary water storage capacity of the floodplain or otherwise result in a washout of solid waste			X	Mine sites are not located in a floodplain.
STATE						
Ambient Air Quality Standards and PSD Increments	OAR 340-202	Ambient air quality standard is an established concentration, exposure time, and frequency of occurrence of an air contaminant or multiple contaminants in the ambient air that must not be exceeded	X			Potentially applicable during removal action.
Solid Waste: Land Disposal Sites other than Municipal Solid Waste Landfills	OAR 340-95	Regulates the siting, operation and maintenance of any non-municipal land disposal site.	X			Potentially applicable for consolidation of solid waste during removal action. Substantial compliance with intent of Solid Waste Letter Authorization anticipated.
Storage, Treatment and Disposal of Hazardous Waste	ORS 466	Regulates transportation and disposal of hazardous waste.	X			Potentially applicable if off-site disposal selected.

TABLE 9
Summary of ARARs
Ruth Mine Site at Opal Creek
Marion County, Oregon

Standard, Requirement, Criteria, or Limitation	Citation	Description	Applicable	Relevant or Appropriate	Not Applicable	Comments
STATE (continued)						
Regulations for NPDES and Water Pollution Control Facility Permits	OAR 340-45	Limitations on discharges of waste and requirements.	X			Permit exemption under CERCLA with substantive compliance.
Contaminated Sites Action Levels Regulations	OAR 340-122	Establishes standards and procedures to be used under ORS 465.200 through 465.455 and 465.900 for the determination of removal and remedial action necessary to assure protection of the present and future public health, safety and welfare, and the environment in the event of a release or threat of release of a hazardous substance.		X		Substantial compliance with standards and procedures develop through Site Investigation, Risk Assessments, and removal action alternatives analysis.
Reduction of use of Toxic Substances and Hazardous Waste Generation	ORS 465.200 - 455, 900	Establishes DEQ remedial action program		X		Removal action to be conducted in substantial compliance with intent of rules.
Groundwater Quality Protection	OAR 340-040	Establish mandatory minimum groundwater quality protection requirements			X	Groundwater pathways determined to be incomplete and no unacceptable risk identified.
Oregon Mined Land Reclamation Rules	OAR 632-030	Regulates permitting of surface mining activities and specifies reclamation plan requirements as part of permitting process.			X	Regulations developed relevant to permitting requirements for surface mining activities not germain to the scope of the Ruth and Morning Star Mine sites.

Notes:
ARAR: applicable or relevant and appropriate requirements
CERCLA: Comprehensive Environmental Response, Compensation, and Liability Act
CFR: Code of Federal Regulations
DEQ: Oregon Department of Environmental Quality
EPA: U.S. Environmental Protection Agency
NPDES: National Pollutant Discharge Elimination System
OAR: Oregon Administrative Rule
ORS: Oregon Revised Statute
PRG: preliminary remediation goal
PSD: prevention of significant deterioration
RCRA: Resource Conservation and Recovery Act
USC: U.S. Code

TABLE 10
Comparative Alternative Analysis
Ruth Mine Site and Morning Star Mine Site at Opal Creek
Marion County, Oregon

Assessment Criteria	Subcriteria	Alternative 1: No Action	Alternative 2: Institutional Controls: Signage and Removal Restrictions	Alternative 3: Slope Stabilization, Consolidation, and Rock Buttressing at Adit 4. Vehicle Access Restrictions at Adit 5 Access Road. Waste Rock Pull Back, Slope Stabilization, and Consolidation at Morning Star Mine	Alternative 4: Removal and Off-Site Disposal for Ruth Mine Adit 4 and Morning Star Waste Rock and Vehicle Access Restrictions at Adit 5
Effectiveness	**Protectiveness**				
	Protective of Public Health	Alternative 1 would be protective of human health under current conditions at the Ruth Mine adits and Morning Star Mine based on the results of the Human Health Risk Assessments. In the long term, there is potential for significant mass wasting at Adit 4 and Morning Star Mine, which would not be addressed by the No Action alternative.	Institutional controls would be protective of human health at Ruth Mine Adit 4 and Adit 5 and Morning Star Mine based on the results of the Human Health Risk Assessments. Institutional controls would not address the potential for future mass wasting at Adit 4 or Morning Star Mine.	Under current conditions no unacceptable human health risks were identified at Adit 4, Adit 5, or Morning Star Mine. Alternative 3 would address the potential for future mass wasting at Adit 4 and Morning Star Mine. This alternative would also further limit vehicle access to Adit 5 to address any future potential risks related to unpermitted removal of waste rock materials.	Alternative 4 would be protective of human health both based on removal of materials with elevated metals concentrations and the Human Health Risk Assessment. Risks to the community would also include possible accidents along access roads related to the high equipment traffic related to transport of materials off site.
	Protective of Workers	Alternative 1 would be protective of workers as no on-site work would be required. There would be no risks of impacts to the community or the environment during implementation.	This alternative would be protective of workers as very limited on-site work would be required. No risks of impacts to the community or the environment during implementation.	Alternative 3 would require standard as well as limited access health and safety procedures for site workers during consolidation and rock buttressing activities. Some worker risk is inherent due to limited access and steep working slopes. The requisite equipment should meet structural loading requirements for existing bridges from the locked gate through Jawbone Flats. If helicopter mobilization is required, there is increased risk during mobilization/demobilization.	Alternative 4 would require standard as well as limited access health and safety procedures for workers and drivers during excavation, removal, and disposal activities. Risks related to steep slopes and heavy equipment would be greater than Alternative 3 because loading and transport trips with dumps and equipment would increase several fold. Five-yard dump trucks, even unloaded, exceed structural loading limits for existing bridges from the locked gate through Jawbone Flats. Without additional bridge reinforcements, risk to workers is unacceptably high. Even with bridge improvements or alternatively using smaller 2 yard dumps, this alternative would subject workers/drivers to significantly increased risk due to normal road conditions and bridge transport requirements.
	Protective of the Environment	Alternative 1 would be protective of the environment in current conditions at both Ruth Mine adits and Morning Star Mine based on the Ecological Risk Assessments. Based on the slope stability evaluations, there is potential for significant future mass wasting at Adit 4 and Morning Star Mine, which results in uncertainty in the long-term protectiveness of ecological receptors.	Based on the Ecological Risk Assessments, institutional controls would be protective of the environment under current conditions at Ruth Mine Adit 4 and Adit 5 and Morning Star Mine. There is potential for future conditions at Adit 4 and Morning Star Mine to change based on the slope stability evaluation making ecological protectiveness uncertain.	Environmental impacts would include temporary disturbance of local species and potential habitat of burrowing species from areas where soil is removed and placed. Erosional control measures would be used during site work, and new exposed surfaces of waste rock would be covered with organic soils and/or erosion control materials such as jute matting to promote eventual plant growth and address long-term erosion. Risks of impact to the community would be negligible.	Compared to the other alternatives there would be additional increased risk to the environment related to more equipment with more potential for spills of the materials being removed and/or spills specific to the machinery. A higher disturbance to the local environment would occur related to higher traffic and longer implementation time.
	Achieves ARARs	Alternative 1 would meet the Oregon Cleanup Law requirements to reduce risk to human health and the environment since the current risks are at acceptable levels at both Ruth Mine adits and Morning Star Mine. The potential for change at Adit 4 and Morning Star Mine could possibly result in varied risk assessment results and, therefore, in the future may not comply.	Alternative 2 would meet the Oregon Cleanup Law requirements to reduce risk to human health and the environment at Ruth Mine Adit 4 and Adit 5 and Morning Star Mine based on the results of the risk assessments for current conditions. The institutional controls would provide additional protection to human health through educational signage. May not fully meet ARARs since the potential for mass wasting at Ruth Mine Adit 4 and Morning Star Mine could result in conditions that may represent a greater risk to ecological receptors.	The alternative would meet the Oregon Cleanup Law requirements since the current risk levels are acceptable. Re-grading the waste rock pile and rock buttressing the toe of slopes as well as the stream cut bank would provide future protectiveness. Further, restricting vehicle access to Adit 5 would ensure that materials are not removed from the site. This alternative would comply with the CERCLA preference for treatment.	This alternative would meet the Oregon Cleanup Law requirements since the current risk levels are acceptable. Removal of materials would provide for additional future protectiveness. Further, restricting vehicle access to Adit 5 would ensure that materials are not removed from the site.

TABLE 10
Comparative Alternative Analysis
Ruth Mine Site and Morning Star Mine Site at Opal Creek
Marion County, Oregon

Assessment Criteria	Subcriteria	Alternative 1: No Action	Alternative 2: Institutional Controls: Signage and Removal Restrictions	Alternative 3: Slope Stabilization, Consolidation, and Rock Buttressing at Adit 4. Vehicle Access Restrictions at Adit 5 Access Road. Waste Rock Pull Back, Slope Stabilization, and Consolidation at Morning Star Mine	Alternative 4: Removal and Off-Site Disposal for Ruth Mine Adit 4 and Morning Star Waste Rock and Vehicle Access Restrictions at Adit 5
Effectiveness (continued)	Meets Removal Action Goals and Objectives	Alternative 1 would meet the RAOs at Ruth Mine Adit 4 and Adit 5 and Morning Star Mine under current conditions. The potential for conditions at Ruth Mine Adit 4 and Morning Star Mine to change in the future makes the long-term solution uncertain for meeting the RAOs at Adit 4 and Morning Star.	Alternative 2 would meet the RAOs at both Ruth Mine adits and Morning Star Mine for current conditions, with additional protection of public health through institutional controls. The potential for a change of conditions at Adit 4 and Morning Star makes the long-term solution uncertain for meeting the RAOs.	Alternative 3 would meet the RAOs at Ruth Mine Adit 4 and Adit 5 and Morning Star Mine for current and likely future conditions based on the risk assessments and the slope stability evaluations.	This alternative would meet the RAOs for both Ruth Mine Adit 4 and Adit 5 and Morning Star Mine for current and likely future conditions based on the risk assessments and the slope stability evaluations.
	Level of Treatment/ Containment Expected	No treatment or containment specified.	No treatment or containment specified.	Limited containment is specified on site at the Adit 4 level and Morning Star Mine.	Anticipated removal of materials in question at Ruth Mine Adit 4 and Morning Star Mine.
	Will Maintain Control Until Long-Term Solution	Will not implement any controls.	The alternative proposed is the long-term solution.	The alternative proposed is the long-term solution.	The alternative proposed is the long-term solution.
	No Residual Effect Concerns	Residual effects are expected to remain as current with risk at acceptable levels. Does not address potential future residual risk in the event of significant mass wasting at Ruth Mine Adit 4 or Morning Star Mine.	Residual effects are expected to remain as current with risk at acceptable levels. Does not address potential future residual risk in the event of significant mass wasting at Ruth Mine Adit 4 or Morning Star Mine.	Residual effects are expected to remain as current with risk at acceptable levels at areas not re-graded. At Ruth Mine Adit 4 and Morning Star Mine, the long-term residual effects are effectively addressed.	Residual effects are reduced compared to current conditions, with short-term, acute effects possible to Battle Ax Creek. Ecological disturbance would be the greatest in the short and long term with this alternative since it has the longest implementation time, most required access improvements, and most required equipment and personnel.
Implementability	Technical Feasibility				
	Construction and Operational Considerations	No construction or operations required.	Minimal construction required. Limited sign maintenance is anticipated.	Rock buttressing and re-grading would require special machinery to complete work on steep, rocky slopes. Follow-up monitoring one, three and five years after implementation would require scheduling, access, and documentation.	Removal will require special machinery to complete work on steep, rocky slopes of Ruth Mine Adit 4 and Morning Star Mine. The technology for working steep slopes is available within the area. The transportation would require small dumps, possibly 4-wheel-drive. Based on the engineering memo, without structural improvements, the vehicle capacity of the bridges along Forest Road 2209 is not adequate for even passenger vehicles. Completing temporary, one season, bridge improvements will be required to utilize small dumps. Utilizing 2-yard track dumps would require a significant time increase and, therefore, increased cost and risk in implementation.
	Demonstrated Performance/Useful Life	Performance and useful life of technology not applicable.	Performance and useful life of technology not applicable	Rock buttressing and slope stabilization is expected to have adequate performance and lifespan based on the slope stability evaluation.	Removal is expected to have adequate performance and useful life.
	Adaptable to Environmental Conditions	Environmental conditions are not expected to change significantly at Ruth Mine Adit 5. There is potential for additional erosional processes at Ruth Mine Adit 4 and Morning Star Mine, with Alternative 1 offering no adaptation to address potential future conditions.	Environmental conditions are not expected to change at Ruth Mine Adit 5. There is potential for additional erosional processes at Ruth Mine Adit 4 and Morning Star Mine, with Alternative 2 offering no adaptation to address potential future conditions.	Rock buttressing, consolidation and re-grading are readily adaptable to the site and will enhance long-term stability without significant impact to environmental conditions.	The removal alternative will require additional road clearing to Morning Star Mine for access of 2-yard dumps. In addition, final grading of the slopes at the adits will be required to provide stability for future changing conditions.
	Can Be Implemented in One Year	Can be implemented in one year.	Can be implemented in one year	Can be implemented in one year.	Would likely take longer than one year to implement considering access constraints and probable road and bridge assessments and improvements.

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Implementability (continued)	**Availability**				
	Equipment	Requires no equipment.	Requires minimal equipment related to signage installation.	Rock buttressing and re-grading would be completed using available specialized equipment.	The technology and equipment for working on steep slopes is available within the area.
	Personnel and Services	Requires no personnel or services.	Requires minimal personnel.	Personnel and services available with prior scheduling.	Personnel and services are available with advanced scheduling.
	Outside Laboratory Testing Capacity	Requires no outside testing.	Requires no outside testing.	Laboratory services are available for follow-up monitoring, if warranted.	Laboratory services available if confirmation sampling is deemed necessary.
	Off-Site Treatment and Disposal Capacity	Does not require disposal or treatment capacity	Does not require disposal or treatment capacity.	No off-site treatment and/or disposal capacity required.	Off-site disposal capacity is available within the state.
	Administrative Feasibility:				
	Permits Required	No permits required	No permits required	No permit requirements anticipated.	Disposal permit would be required.
	Easements or ROW Required	No easements or ROWs are required.	No easements or ROWs are required.	No easements or ROWs are required.	No easements or ROWs are required.
	Impact to Adjoining Property	Would not impact adjoining property.	Would not impact adjoining property.	Would not impact adjoining property.	Would likely impact Battle Ax Creek for significant distance downstream on a temporary basis.
	Ability to Impose Institutional Controls	No institutional controls would be imposed.	Institutional controls required.	Institutional controls not anticipated to be required.	No institutional controls would be imposed.
Cost		$0	$9,800	$473000 - $499,000	$893,000
RANKING					
Effectiveness Ranking		Although current risk levels are acceptable, there is potential for mass wasting to occur in a manner different than the ongoing erosional processes. This may not be protective for future conditions. It carries the least risk to workers. Overall it ranks low for effectiveness	Institutional controls will add some protection to human health by providing information and limiting vehicle access. Although the alternative carries low risk, this alternative does not address the potential future mass wasting at Ruth Mine Adit 4 or Morning Star Mine and, therefore, it ranks low for effectiveness.	The current risk levels at the site are protective of human health and the environment. Slope stabilization at Ruth Adit 4 and Morning Star would address the potential for future mass wasting by providing rock buttress and/or grading to support the waste rock material as well as protecting the waste rock material from the upstream cut bank erosion. The effort would require special equipment and trained personnel; therefore, risk to workers would be moderate. Erosion controls could be utilized at both locations and no impact to the community is expected. Overall ranking for effectiveness is high.	The removal and disposal alternative would be protective of human health and the environment in the long term. Risk to workers, the environment and the community is the highest for this alternative because of increased traffic and possible spills related to waste rock material as well as fuels. Without major structural bridge improvements, the risk to workers/drivers of dump trucks is unacceptable. Overall removal and disposal ranks high/medium for effectiveness.

TABLE 10
Comparative Alternative Analysis
Ruth Mine Site and Morning Star Mine Site at Opal Creek
Marion County, Oregon

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Implementability Ranking		Alternative 1 is the easiest to implement technically and administratively. Overall it ranks high for implementation	The implementation of Alternative 2 would not require special equipment or personnel. Technically it would be easy to implement and administrative effort would be low. Overall it ranks high for implementation	The slope stabilization and re-grading would require specialized equipment that is available with prior scheduling. The work could be completed without impacting the community. Overall rank for implementability is high.	Alternative 4 is the most difficult to implement. Without structural bridge improvements it carries unacceptable risk to drivers. The use of smaller transport equipment increases time and, therefore, costs and risks of implementation. It carries the highest risk during implementation related to increased traffic and increased time on the job. It creates the most disturbance the ecological community during access improvements and implementation. It also carries high risk to the environment related to the potential for off-site spills. Overall it ranks lowest for implementability.
Cost Ranking		Lowest Cost	Low Cost	Medium Cost	Highest Cost

Notes:
ARAR: Applicable or Relevant and Appropriate Requirements
CERCLA: Comprehensive Environmental Response, Compensation, and Liability Act
RAO: removal action objective
ROW: right-of-way

APPENDIX A

PASCOE environmental consulting

Human Health Risk Evaluation

Ruth Mine Site
Willamette National Forest, Oregon

FINAL

December 2009

Prepared for

GeoDesign, Inc.
Portland, Oregon

210 Taylor Street, Room 15 ▲ Port Townsend ▲ WA 98368

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1 INTRODUCTION

A screening-level human health risk evaluation (HHRE) was performed for the Ruth Mine Site, Willamette National Forest, Marion County, Oregon, in support of the Engineering Evaluation/Cost Analysis (EE/CA) for the site. This document is Appendix A to the EE/CA for the Ruth Mine Site (GeoDesign 2009). The human health risk evaluation analyzes the potential for health risks associated with recreational activities at the mine site that might occur by members of the public. The evaluation addresses present and future health risks due to the presence of metals at the site, in the absence of any changes in site conditions. The evaluation does not address other types of risks that may be associated with the mine.

The evaluation incorporates analytical data collected from environmental media at the mine in 2005 and in 2008 with information on potential exposure pathways to provide an understanding of the potential human health risks. The 2005 data were evaluated in a previous human health risk evaluation as part of the Site Investigation for the Ruth Mine site performed in 2006.

The components of the HHRE consist of the Problem Formulation and Risk Assessment, as per ODEQ (2000) guidelines:

> ***Problem Formulation*** – The Problem Formulation step describes site information, land and water uses, contamination, including identification of contaminants of potential concern (COPCs) through a screening process, and identification of potentially exposed populations and exposure scenarios.
>
> ***Risk Assessment*** - The Risk Assessment step includes the following components, which are also consistent with risk assessment methodology of USEPA (1989):
>
> - *Exposure Assessment.* Activities through which humans may be exposed to COPCs at the site are identified and quantified. Exposure activities are incorporated with COPC concentration data in environmental media to quantify exposures.
> - *Toxicity Assessment.* The toxicity of the COPCs is quantified for relating human exposures to potential adverse health effects.
> - *Risk Characterization.* Information from the exposure and toxicity assessments is integrated into a quantitative estimate of non-cancer and cancer risks. Uncertainties in the characterization are discussed.

The development of each of these components, and the resultant human health risk estimates, are presented in the following sections.

The evaluation is considered screening-level because it relies on readily available information for exposure modeling, toxicology of metals, and risk modeling. All exposure and risk estimates are based on exposure modeling from data on metals collected from waste rock piles, surface water in the mine adits, and surface water and sediments in Battle Ax Creek and Ruth Creek, which is the tributary that runs past the mine adits and waste rock piles to flow

into Battle Ax Creek. The exposures to metals at the site are based on estimates of reasonable maximum future exposures due to recreational activities directly in the contaminated waste soils and surface waters of the site. The exposures are not documented to presently occur, and any present exposures and health risks would be much less than those estimated in this risk evaluation.

2 PROBLEM FORMULATION

2.1 SITE INFORMATION

The Ruth Mine site is located in the Western Cascades in central Oregon. The mine site is located in the Battle Ax Creek drainage, which flows west to join with Opal Creek to form the Little North Santiam River, which continues west to the Willamette River valley (Figure 2-1). The Western Cascades range is composed almost entirely of volcanic rocks, the remnant of a volcanic range that shifted east to form the High Cascades, which forms the present active Cascade volcanic range. The Western Cascades receive 60 to 100 inches of precipitation annually which causes deep weathering of geologic features.

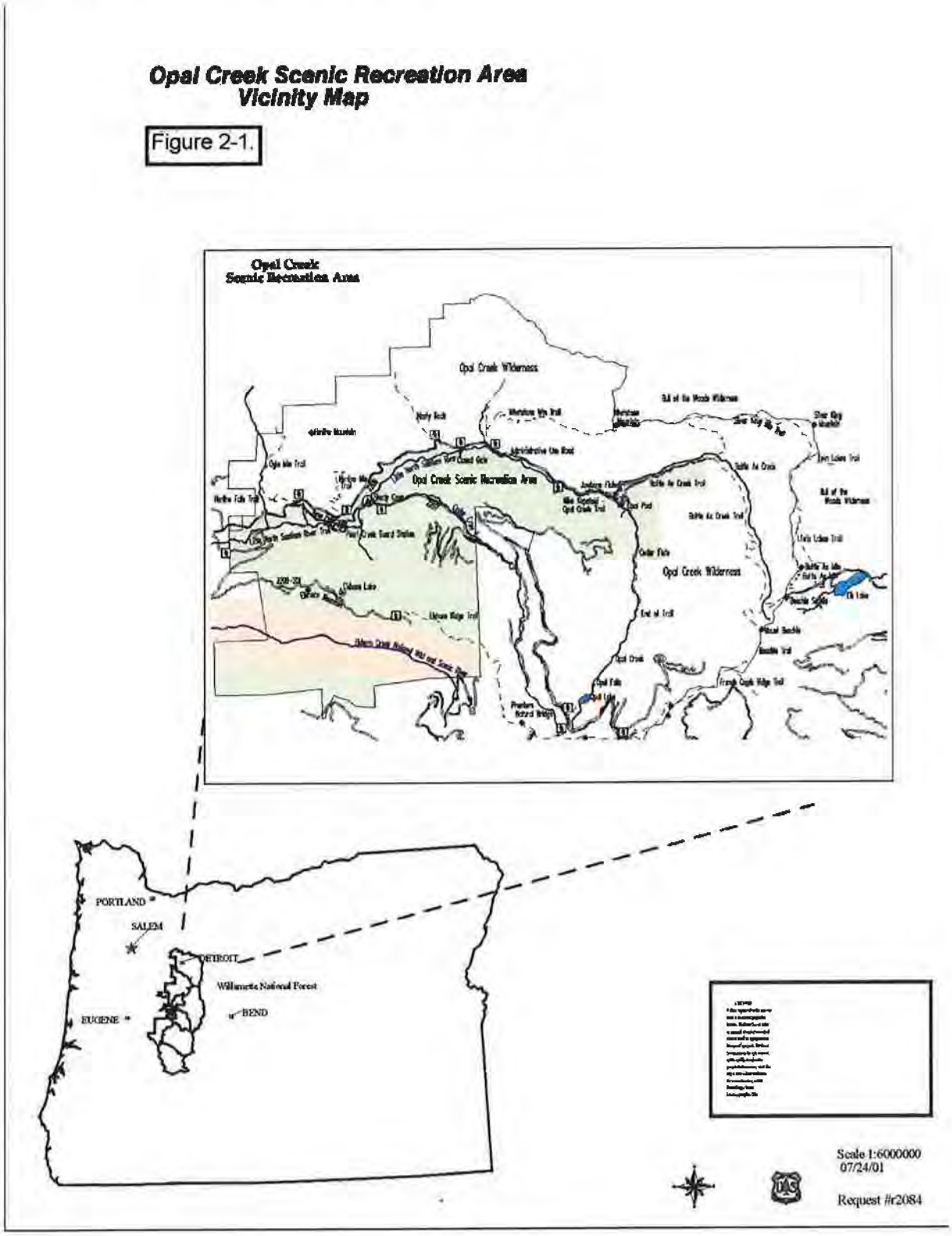
Deposits of gold, silver, lead, and zinc are found in a 25-30 mile wide, north-south belt in the Western Cascades (Orr et al. 1992). Weathering processes have deeply eroded the Western Cascades exposing the ore-bearing rocks near the valley floors. The North Santiam mining district, which includes the Ruth Mine site, contains the most rugged terrain of all the five mining districts of the Cascades. Most of the Ruth Mine ore produced lead and zinc, although small amounts of gold and silver were also recovered.

2.2 LAND USE

The Ruth Mine site is located in an old growth hemlock-dominated forest, with undergrowth characterized by salal, Oregon grape, and shade-tolerant hemlock and red cedar saplings. Open spaces are characterized by red alder, bigleaf maple, and vine maple. The site is contained within the Opal Creek Scenic Recreation Area.

The mine site is located along the Battle Ax Creek trail and a US Forest Service access road approximately 1.5 miles from the Opal Creek Ancient Forest Center at Jawbone Flats, which contains several public accommodations and on-site residences. There are no residences at the mine site. There are no current residents and no allowable future residents at the site due to the designation as a Scenic and Recreation Area. Since the mine is abandoned, there are no on-site workers at the site. Only US Forest Service vehicles and Opal Creek Ancient Forest Center vehicles are allowed to use the access road. There are no residential land uses in the area outside of the caretakers of the Opal Creek Ancient Forest Center, and occupational uses consist of US Forest Service workers and trail guides.

Figure 2-1. Location of Ruth Mine Site



The Ruth Mine site presently consists of two adits, associated waste rock piles, ore cart tracks, and access roads. Adit 4 is located approximately 300 feet up the slope above the Battle Ax Creek trail, alongside Ruth Creek, and adit 5 is located along the access road and trail immediately above Battle Ax Creek. Ruth Creek flows underground part of the way to Battle Ax Creek, including in the areas near adit 4 and its waste rock piles. The access road and trail follow Battle Ax Creek and pass through parts of the historical operations at the mine, at the crossing of Ruth Creek. Recreational uses of the land consist of hiking, fishing, hunting, and horseback riding.

2.3 SOURCES OF CONTAMINATION

The primary sources of contamination at the site are historical mining activities related to operations of the Ruth Mine. Ore was brought up from mines, processed to some extent at the site, and waste rock was deposited in the ravine of Ruth Creek below adit 4 and in the road bed at adit 5, including the bank above Battle Ax Creek.

Waste rock from mine activities at the adits is present in Ruth Creek, which runs past both adits to Battle Ax Creek. Deposits in Ruth Creek may have contributed sedimentary material that washed into Battle Ax Creek. Ruth Creek water may have leached metals from the waste rock into surface water and transported dissolved metals to Battle Ax Creek. Over time, rain and snow melt may have transported dissolved metals or waste rock particles, particularly from the area around the adits, down the Ruth Creek ravine to Battle Ax Creek. Once in the creeks, contaminated sedimentary particles may deposit or transport downstream. Dissolved metals in the surface water may bind to particulates and deposit in the creek or transport downstream.

2.4 IDENTIFICATION OF CONTAMINANTS OF POTENTIAL CONCERN

The available site data are used to identify COPCs for soil, surface water, and sediment. The specific data that are used in the screening are identified in the following section that describes the exposure scenarios that are evaluated. In the first step of the risk assessment, COPCs are identified by screening data on chemicals of interest (COIs) that were analyzed at the site, following the procedure in Section 2.3.2 of ODEQ (2000) guidelines:

- *Frequency of Detection* – COIs detected in less than 5% of the samples of a given medium are excluded from the list of COPCs.
- *Background* – COIs that are at background concentrations are typically not selected as COPCs. Comparison of the maximum concentration of each COI in soil samples against the 90th percentile of background soil data was performed for the background screening.
- *Screening of COIs against PRGs* – The final screening step to select COPCs consists of comparison of maximum concentrations of COIs in soils, surface waters, and sediments with USEPA Preliminary Remediation Goals (PRGs) for residential and industrial exposures. Both soil and sediment concentrations of COIs are compared with soil PRGs, and surface water concentrations of COIs are compared with industrial tap water PRGs. The industrial soil criteria

are designed for evaluating continuous exposures to industrial workers over a standard working time period. Industrial criteria for soils and water are also used to select COPCs for the recreational scenario since recreational screening criteria are not available, and the industrial criteria are considered to be protective of recreational exposures since they are based on exposures that would be higher than those for intermittent exposures under a recreational scenario. For example, the industrial criteria assume full time occupational exposures to environmental media, whereas recreational exposures would entail much less exposure times and less exposure frequencies on an annual basis. Industrial tap water criteria are designed for screening drinking water uses and are conservative for application to surface waters that may be contacted by infrequent recreational activities.

The screening procedures and their results are described in the following sections.

2.4.1 FREQUENCY OF DETECTION

COIs in each environmental medium were first screened on the basis of frequency of detection. If COIs were not detected above a frequency of five percent, they can be eliminated as a COPC (ODEQ 2001). COIs were identified for waste rock soils, surface water, and sediment at the Ruth Mine site. Data showing detected concentrations of COIs in each sample in waste rock soils, surface water, and sediment at the Ruth Mine site are presented in Attachment B to the Screening Ecological Risk Assessment for the Ruth Mine site. Surface water and sediment samples consisted of the surface water from the two adits, and surface water and sediment samples from stations in Ruth Creek and Battle Ax Creek immediately downstream of the confluence with Ruth Creek. Surface water and sediment data from Battle Ax Creek stations located upstream of the confluence with Ruth Creek were not used to identify COIs.

Results of the frequency screen are shown in Table 2-1. COIs that were screened out from further evaluation for waste rock soils on the basis of detection frequency consist of beryllium, thallium, and hexavalent chromium. In surface water, all but barium, cadmium, calcium, chromium, copper, iron, lead, magnesium, manganese, potassium, sodium, and zinc were eliminated from further consideration based on lack of detection in any surface water sample, which included the adit waters, Ruth Creek surface water, and surface water of Battle Ax Creek. In sediment, antimony, beryllium, mercury, selenium, and thallium were never detected in any of the samples, including Ruth Creek and Battle Ax Creek sediments.

Table 2-1. Screening of COIs for Detection Frequency

Chemical of Interest (COI)	Frequency of Detection		
	Waste Rock Soil	Surface Water	Sediment
Aluminum	21/21	0/3	3/3
Antimony	13/21	0/3	0/3
Arsenic	31/31	0/11	8/8

Barium	31/31	3/11	8/8
Beryllium	0/21	0/3	0/3
Cadmium	31/31	2/11	5/8
Calcium	21/21	3/3	3/3
Chromium	31/31	1/11	8/8
Cobalt	21/21	0/3	3/3
Copper	31/31	2/11	8/8
Iron	31/31	5/11	8/8
Lead	31/31	5/11	8/8
Magnesium	21/21	3/3	3/3
Manganese	31/31	4/11	8/8
Mercury	27/31	0/11	0/8
Nickel	31/31	0/11	8/8
Potassium	21/21	2/3	3/3
Selenium	24/31	0/11	0/8
Silver	26/31	0/11	1/8
Sodium	5/21	3/3	3/3
Thallium	0/21	0/3	0/3
Vanadium	21/21	0/3	3/3
Zinc	31/31	11/11	8/8
Hex Chromium	0/10	---	---

Surface water stations = All surface water data from the two adits, Ruth Creek, and Battle Ax Creek immediately downstream of the confluence
Sediment stations = All sediment data from Ruth Creek and Battle Ax Creek immediately downstream of the confluence

2.4.2 BACKGROUND CONCENTRATION SCREENING

Following the screen for frequency of detection, COIs were screened against background concentrations. Background concentrations are set at the 95UCL of the mean concentration of background samples, and the maximum concentration in site soil is compared to this background value, as per ODEQ (2000) guidance. Chemicals with maximum concentrations exceeding the 95 UCL of background samples were retained for further evaluation.

Background concentrations were identified for COIs in soils, surface water, and sediment. The screening for background is presented in tables in Attachment A to the Screening Ecological Risk Assessment for the site. Chemical concentration data for soils, surface water, and sediment data, and the 95 UCL concentrations, are presented in Attachment B to the Screening Ecological Risk Assessment. For soils, background concentrations were determined using data from 20 samples, which were collected from locations around the Morning Star Mine site and the Ruth Mine site that were not impacted by mining-related activities. Locations of the background soil samples can be found in the EE/CA report for the Ruth Mine site (GeoDesign 2009).

Sets of background samples were collected for surface water and for sediment for the Ruth Mine site. Background surface water and sediment samples were collected in Battle Ax Creek upstream of its confluence with Blue Jay Creek, which is the tributary to Battle Ax Creek that flows past the Morning Star Mine site. None of the samples in Battle Ax Creek

located between the Blue Jay Creek confluence and the Ruth Creek confluence were used in the risk evaluation. The sample stations in Battle Ax Creek above the confluence with Blue Jay Creek were identified as locations that are not impacted by discharges from the Morning Star Mine site, Ruth Mine site, or other mining activities. Locations of the surface water and sediment samples are presented on a map of the site in the Screening Ecological Risk Assessment. Background surface water stations are identified as SW-8, SW-MS-14, SW-MS-15, and SW-MS-16. Background sediment stations are identified as SED-MS-14, SED-MS-15, and SED-MS-16. Surface water and sediment data and 95 UCL concentrations are presented in Attachment B to the Screening Ecological Risk Assessment.

Table 2-2 summarizes the chemicals that pass the detection frequency and background comparison screens for soils, surface water, and sediment at the Ruth Mine site.

Table 2-2. Summary of COIs Passing Detection Frequency and Background Screens, Ruth Mine Site

Waste Rock Soils	Surface Water – Site-Related Samples	Surface Water - Battle Ax Creek	Sediment
Antimony	Barium	Barium	Aluminum
Arsenic	Cadmium	Calcium	Arsenic
Cadmium	Calcium	Chromium	Cadmium
Calcium	Chromium	Iron	Calcium
Chromium	Copper	Lead	Cobalt
Cobalt	Iron	Manganese	Copper
Copper	Lead	Sodium	Iron
Iron	Manganese	Zinc	Lead
Lead	Sodium		Magnesium
Magnesium	Zinc		Manganese
Manganese			Nickel
Mercury			Potassium
Nickel			Sodium
Potassium			Vanadium
Selenium			Zinc
Silver			
Zinc			

Surface water site-related samples and sediment samples consist of adits 4 and 5, Ruth Creek, and Battle Ax Creek downstream of confluence with Ruth Creek

2.4.3 SCREENING AGAINST PRGS AND SELECTION OF COPCS

Tables A-1 through A-3 in Attachment A presents the results of the screening against PRGs. Screening against PRGs was performed on those COIs that passed the detection frequency screen and the screen against background. As per ODEQ guidance, the screen against PRGs identified multiple COPCs in multiple media. A summary of the screening results and selection of COPCs in each of the exposure media for the Ruth Mine site is presented in Table 2-3.

Table 2-3. Contaminants of Potential Concern

Exposure Media	Results of Screen
Waste rock soil	Arsenic exceeded the PRG by a factor of 29 Lead exceeded the PRG by a factor of 43
Surface water	Cadmium exceeded the PRG by a factor of 1.2 Lead exceeded the PRG by a factor of 2.5
Sediment	Arsenic exceeded the PRG by a factor of 10

COPCs were selected by screening chemical concentrations against USEPA Consolidated Preliminary Remediation Goals for industrial soil and for tapwater.

2.5 IDENTIFICATION OF POTENTIALLY EXPOSED POPULATIONS AND SCENARIOS

Potentially exposed populations are identified for the site for which risks are estimated. There are no residences at the mine site; the nearest residence is located approximately 1.5 miles down a US Forest Service access road at the Opal Creek Ancient Forest Center in Jawbone Flats, which contains several public accommodations and on-site residences. Because of the remoteness of the mine and the steep grades, there is little likelihood of full-time residents at the site in the future. Since the mine is abandoned, there are no on-site workers at the site. Only US Forest Service vehicles and Opal Creek Ancient Forest Center vehicles are allowed to use the access road. The access road from Jawbone Flats to Ruth Mine encompasses the Battle Ax Creek trail; with the entire mine site and portions of the access road and trail located in the Opal Creek Scenic Recreation Area. The access road and trail pass through the historical mining operations at adit 5. Hence recreational users of the area, primarily for hiking but also fishing, hunting, and horseback riding, are assumed to have the highest potential exposures to COPCs at the mine site.

The estimation of exposure and risk depends on the identification of exposure pathways, scenarios, and exposure routes. Complete exposure pathways consist of four elements: a source of chemical release into the environment, an environmental medium for transport of the chemical (e.g., soil, surface water, and air), a point of potential human exposure, and an exposure route by which the chemical can get into the body.

Potential exposures to recreational users of the site are evaluated through construction of a recreational exposure scenario. The recreational exposure scenario incorporates considerations of the above-mentioned factors, i.e., identification of exposure pathways and exposure routes. The highest exposures to site-related chemicals for recreational users are assumed to be for persons who have hiked into the site and that spend time directly on the waste rock piles and who come in contact with surface water and sediment of the two adits, the tributary Ruth Creek, and Battle Ax Creek. The persons with highest potential exposures would likely be hikers into the area, particularly young children, but would also include hunters and fishers who visit the area. The exposure pathways and routes of exposure to site-related chemicals are evaluated for reasonable maximum, or worst case, exposures. Any persons visiting the site and exposed to waste rock or the surface waters for less time than evaluated under this recreational scenario would have less exposures and less potential health risks. For example, hikers, hunters, and fishers who may visit the site for shorter periods of

time than evaluated under this recreational scenario would have lower potential health risks than estimated in this risk evaluation.

For people who catch and consume fish from Battle Ax Creek, potential exposures to site-related chemicals and associated health risks related to fish consumption are not quantified. Reasonable maximum exposure of fish consumers to site-related chemicals would be related to the catch and consumption of fish from Battle Ax Creek in the reach below the drainage of the Ruth Mine site. The abundance and diversity of fish in Battle Ax Creek are limited, partly due to the fish migration barrier of Salmon Falls on the Little North Santiam River. This barrier is recognized by the Opal Creek Ancient Forest Center (2009) as preventing a diverse fish community, including anadromous salmon species, in Opal Creek and its tributary Battle Ax Creek. US Fish and Wildlife Service identifies the falls as a fish barrier preventing bull trout from migrating to Opal Creek (USWS 2009). Other publications similarly mention a number of natural barriers that prevent salmon and other large fish species from migrating up the Little North Santiam River into Opal Creek (Little 2007).

Although the Ruth Mine site is accessible by trail, there is no trail to Battle Ax Creek itself; access can only be attained from the existing trail over a steep embankment, which is heavily vegetated with moss and emergent trees. Because of the lack of easy access to the creek and the lack of data indicating how much consumable fish might be present in the reach downstream of the Ruth Mine drainage and what the annual consumption rate of those fish might be, the exposures from consumption of fish from the creek cannot be quantified. Also for those reasons, the amount of contaminated fish from the creek that might be consumed by fishers is not considered to be sufficient to present a significant risk. To quantify exposures, any consumed fish would need to reside in the downstream reach of the creek in order to take up metals related to the mine site drainage. Based on the above information, this risk evaluation assumes that there is an insufficient number of fish that reside in the reach downstream of the drainage to present significant exposures to fishers from annual consumption over a 30-year period. Thus, for the identification of significant exposure pathways to site-related chemicals, consumption of fish from Battle Ax Creek is considered to be possible but to present an insignificant health risk.

Based on the above analysis of potential activities and exposure pathways, the following exposure scenarios were developed for complete and significant exposure pathways for recreational exposures to COPCs at the Ruth Mine site.

Adult Recreational Scenario

- Adults who may come in contact with waste rock soil during recreational activities at the mine site, through the following exposure routes:
  - Inadvertent ingestion of dirt particles that consist only of waste rock soil
  - Direct skin contact with waste rock soil
  - Inhalation of dust particles comprised solely of waste rock soil.

- Adults who may contact surface water and sediment at the site, through the following exposure routes:
  - Ingestion of surface water
  - Dermal contact with surface water
  - Ingestion of sediment
  - Dermal contact with sediment.

Child Recreational Scenario

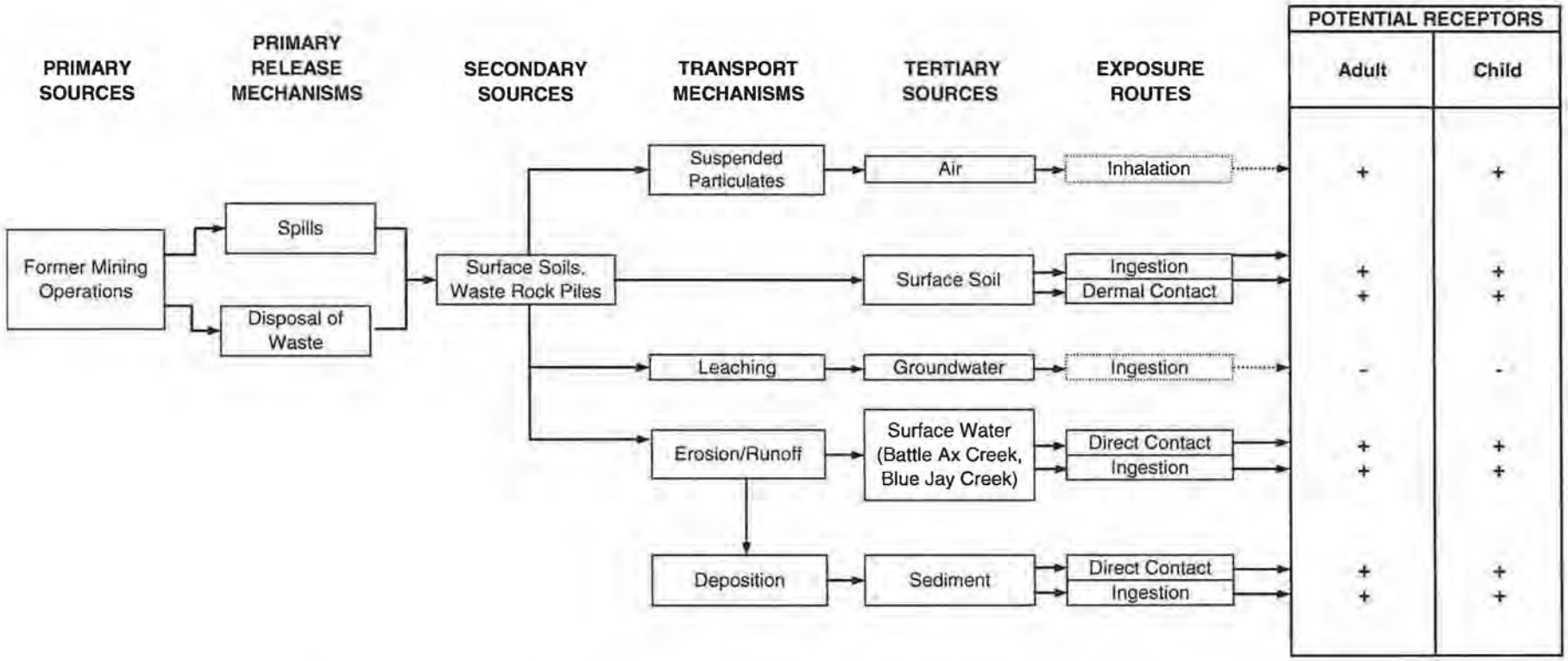
- Children who may come in contact with waste rock soil during recreational activities at the mine site, through the following exposure routes:
  - Inadvertent ingestion of dirt particles that consist only of waste rock soil
  - Direct skin contact with waste rock soil
  - Inhalation of dust particles comprised solely of waste rock soil.
- Children who may play in the surface waters at the site, exposed through the following routes:
  - Ingestion of surface water
  - Dermal contact with surface water
  - Ingestion of sediment
  - Dermal contact with sediment.

For both the adult and child exposure scenarios, risks under reasonable maximum exposure (RME) conditions and central tendency exposure (CTE) conditions are estimated. The RME exposure conditions are designed to estimate a reasonable worst case type of exposure at the site, whereas the CTE conditions represent a more typical exposure.

2.6 CONCEPTUAL EXPOSURE MODEL FOR HUMAN HEALTH

The conceptual exposure model (CEM) for human exposures to COPCs at the Ruth Mine site is presented in Figure 2-2. The CEM depicts the sources of the COPCs, the media to which humans may be exposed, likely exposure pathways, human receptors, and routes of exposure for the scenarios identified in the exposure analysis. The CEM is an integration of the information presented in the above subsections.

Figure 2-2. Conceptual Exposure Model for the Ruth Mine Site



Notes:

+ Complete and potentially significant exposure
- Insignificant or incomplete exposure pathway or medium

3 EXPOSURE ANALYSIS

The Exposure Analysis develops the exposure scenarios and exposure pathways, and quantifies the concentrations of COPCs in the exposure media that humans may contact.

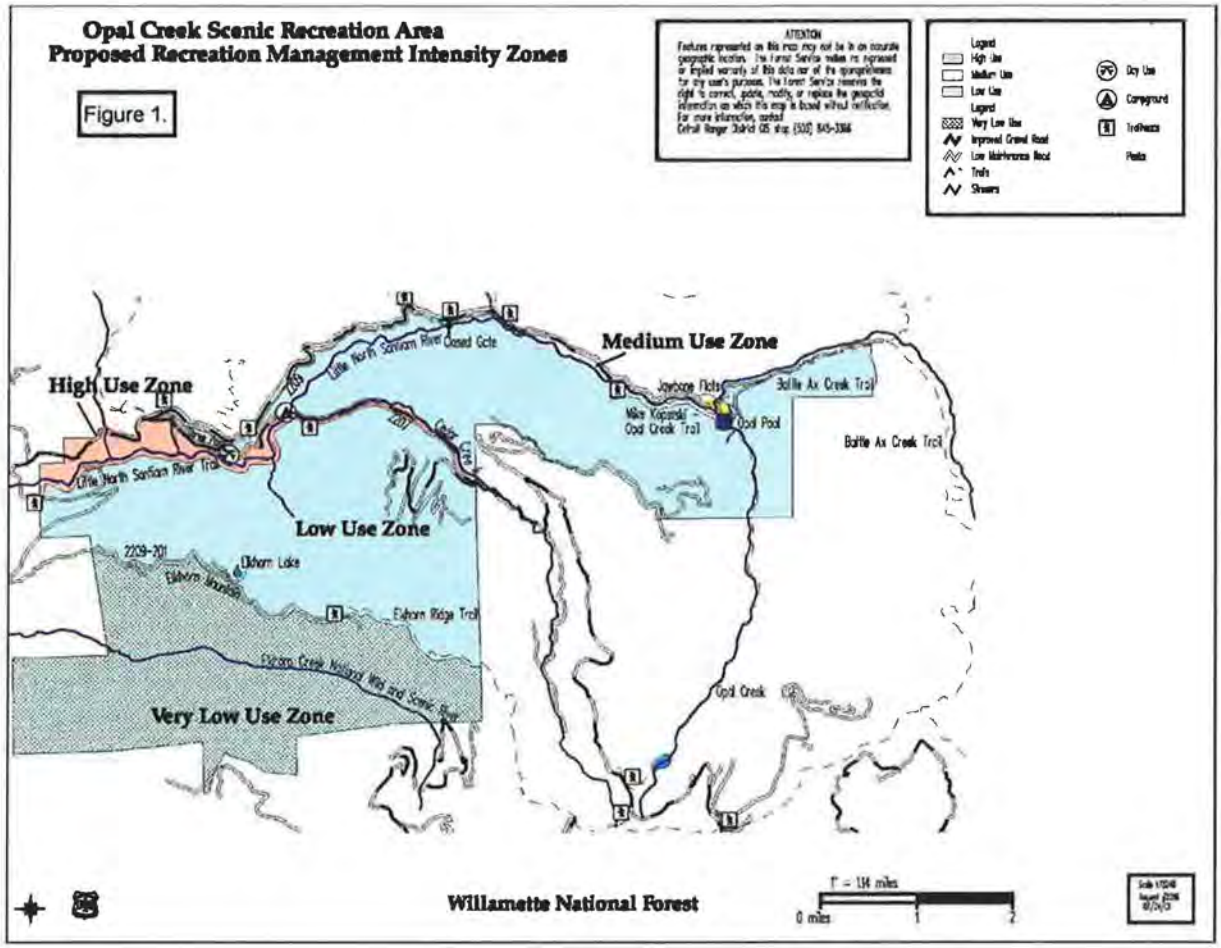
3.1 EXPOSURE ASSUMPTIONS

The parameters that are used to quantify potential exposures for the scenarios described above include many assumptions. Some parameters are quantified following ODEQ (2000) or USEPA (1989) guidance, and some parameters that are specific to the site, such as the amount of time that recreational users may spend at the site, are based on best professional judgment or information from the managers of the Opal Creek Ancient Forest Center at Jawbone Flats. The US Forest Service has identified the Battle Ax Creek portion of the Opal Creek Scenic Recreation Area as a "Low Use" zone in its recreation management plan for the area (Figure 3-1). The durations and frequencies of exposures that are assumed for this risk evaluation are considered reasonably conservative given the current and future anticipated use of the site for recreational purposes.

The following assumptions were made for recreational exposures at the site. Exposure parameters are developed for both the CTE and RME conditions. The parameters and their values are also listed in Table A-4 of Attachment A.

- Body Weight – A body weight of 15 kg for child represents the mean weight of children between the ages of 0 and 6. A body weight of 70 kg for adults is the mean weight of men and women between the ages of 18 and 70. Both values are taken from ODEQ (2000) guidance.
- Exposure Duration – The exposure duration is the number of years over which exposures may occur. For children, values of 2 and 6 years are used for the CTE and RME conditions, respectively. For adults, the values of 9 and 30 years are assumed for CTE and RME conditions, respectively, based on ODEQ (2000) guidance on lengths of residence in a given area.

Figure 3-1. Recreational Zones for the Opal Creek Area



- Exposure Frequency – Exposure frequency is number of days per year that a person may spend at the site, engaged in recreational activities. Frequencies for child exposures are assumed to be 2 weekends in summer, for 2 days each weekend, for a total of 4 days per year for CTE; and 20 days for the RME (i.e., assuming a two-week vacation during summer months when the soils are accessible plus six additional days during the year) for every year over 6 years. For adults, 4 and 20 days per year are also used for the CTE and RME conditions, respectively.
- Exposure Time – It is assumed that young children are accompanied by adults to the mine site, and both children and adults spend 4 hours exposed to waste rock soils during each of the visits to the site. In other words, the exposure time assumes that the child and adult visitors spend all 4 hours actively engaged in activities that result in continuous direct exposure to COPCs in waste rock soils. The time of exposure to contaminated surface water and sediment is assumed to be 0.5 and 1 hour for each daily visit for the CTE and RME exposures, respectively.
- Surface Area – Values for body surface areas for dermal contact for exposures to soil, surface water, and sediment are taken from ODEQ (2000) guidance on soil contact. Swimmable water bodies are not available at the site.
- Pathway Specific Parameters:

  Soil Ingestion – Children are assumed to ingest waste rock pile soils at rates of 25 and 100 mg/day during each 4-hour visit, for CTE and RME conditions, respectively. Adults are assumed to ingest waste rock pile soils at rates of 12 and 25 mg/day during each visit, for CTE and RME conditions, respectively. Ingestion rates are one-quarter the values recommended in ODEQ (2000) and USEPA (1997) for combined ingestion of house dust and soil under continuous exposures in a residential setting. The selected ingestion rates are assumed to be representative of activities that would occur throughout the exposure time of 4 hours per day at the waste rock soils.

  Soil Adherence Factor – Adherence factors for determining the amount of soil and sediment that may stick to skin are taken from USEPA (2004) guidance on dermal risk assessment.

  Inhalation of Fugitive Particulate Dust – Inhalation rates of 1.2 m^3/hr and 1.5 m^3/hr, for children and adults, respectively, for the 4 hours during each visit to the site, are taken from USEPA (1997) guidance.

  Surface Water Ingestion – The rate of surface water ingestion during recreational activities by children and adults is taken from USEPA (1997) guidance, at 0.01 L/hr.

  Sediment Ingestion – Rates of sediment ingestion are assumed to be one-quarter the rates of soil ingestion for the RME.

Slightly different values for some of these parameters, such as exposure duration for children, are assumed by USEPA for evaluating risks from child exposure to lead, as described in the lead risk section (Section 5.3.3).

3.2 EXPOSURE POINT CONCENTRATIONS

Exposure point concentrations (EPCs) are those concentrations of COPCs in environmental media that humans may be exposed to. For the Ruth Mine site, data on concentrations of COIs are available for waste rock soils, and surface waters and sediments of the mine adits 4 and 5, Ruth Creek, and Battle Ax Creek. From those data, EPCs are developed for soils, surface waters, sediments, and air. Air EPCs are developed for particulate dust that is modeled as releases from waste rock soils.

Analytical chemical data to develop EPCs for the site were collected during the November 2005 and the October 2008 site sampling events. The November 2005 data that are used in this risk evaluation for the Ruth Mine site consist of 10 samples of waste rock soils, supplemented with 21 additional samples of waste rock soil collected in October 2008. For surface water, 12 samples including the two adit waters were collected in 2005, and were supplemented with 5 surface water samples collected in Battle Ax Creek in 2008, two of which are upstream of the confluence with Ruth Creek. Sediment data consist of 6 samples collected in 2005, supplemented with 5 additional samples collected in 2008, with two of those located in Battle Ax Creek upstream of the confluence with Ruth Creek. Data from samples collected in Battle Ax Creek upstream of the confluence with Ruth Creek are not used in the calculation of the surface water or sediment EPCs for the Ruth Mine site.

For each environmental medium, EPCs are developed as the upper 90 percent confidence limit (90UCL) on the mean concentration, following ODEQ (2000) guidance. The 90UCL concentration is used to quantify exposure to a chemical with the assumption that it best represents the concentration that a person would contact over chronic time periods, assuming that a person moves randomly throughout the exposure area.

The USEPA ProUCL program was used for statistical analyses and to develop the 90UCL concentrations (USEPA 2007). ProUCL 4.0 contains rigorous parametric and nonparametric (including bootstrap methods) statistical methods (instead of simple ad hoc or substitution methods) that can be used on both full data sets without nondetects and for data sets with non detected concentration (i.e., qualified by the analytical laboratory or data validators as "ND", non-detect). The program uses state-of-the-art parametric (e.g., ROS methods) and nonparametric (Kaplan-Meier method) computation methods for UCLs for data sets with non detected concentrations.

The ProUCL program uses both detected and undetected values, and creates interpolated values for non-detects based on the estimated distribution of the detected concentrations. For chemicals with non-detected values, ProUCL fills in a set of concentrations for nondetects that would result in a better estimate of central tendency than other substitution methods (e.g., use of ½ the detection limit for the non-detected value). ProUCL assumes the distribution of the non-detected values based on the distribution of the detected concentrations, and substitutes values for the non-detects based on that assumed distribution. The full dataset, including the substituted concentrations, is then used by ProUCL to identify the underlying distribution of the data set, to estimate upper confidence limits on the mean concentration for various distribution types, and to recommend the most appropriate 95 UCL based on the data distribution. ProUCL does not provide a recommendation for the 90 UCL, so the same

statistical test basis that was recommended for the 95 UCL was used to identify the most appropriate 90 UCL. Based on the distribution, each COPC in each environmental medium was assigned a normal distribution, a log-normal distribution, a gamma distribution, or an undeterminable distribution by ProUCL, for which ProUCL uses non-parametric statistics in the UCL determination.

The technical guidance document for the software states that the UCL calculated from datasets with very few (i.e., 6 or less) detected concentrations are not reliable enough for deriving EPCs. In this risk evaluation, EPCs for any COPCs with 6 or less detections are not based on the 90 UCL but on the maximum concentration instead. In many instances, particularly for 6 or fewer detected values, the 90UCL was calculated to be higher than the maximum concentration, and the maximum concentration was subsequently used in the risk ratio calculations. Thus, in determining the EPCs, none of the UCLs are based on the use of ½ detection limits, and EPCs are either the ProUCL-derived value for the 90 UCL or the maximum concentration.

EPCs are developed for each COPC in each of the environmental media that receptors may contact.

- *Soils* – Recreational users are assumed to be exposed only to waste rock soils for the duration of their soil exposures at the site. The EPC is based on 21 to 31 waste rock soil samples collected in 2005 and 2008. Exposures to background soils are not included.
- *Surface Water* – Recreational users are assumed to be exposed to surface waters that were sampled at the site. Surface waters consist of a total of 11 samples: two samples of adit waters from adits 4 and 5, one sample in Ruth Creek upstream of adit 4, two samples from Ruth Creek downstream of adit 4, one sample in Battle Ax Creek at the confluence with Ruth Creek, and five samples from Battle Ax Creek downstream of the confluence. The EPC does not include samples from Battle Ax Creek upstream of the confluence with Ruth Creek. It was assumed that visitors to the site could have equal access to all environmental media at the site; e.g., exposures could occur to waters in the two adits, Battle Ax Creek, and Ruth Creek of equal accessibility under future conditions.
- *Sediments* – Recreational users are assumed to be exposed to sediment in the same surface waters as under the surface water exposures. Sediment samples consist of a total of 8 samples: three in Ruth Creek, and five in Battle Ax Creek downstream of the confluence with Ruth Creek. The three sediment samples collected in 2005 and 2008 from Battle Ax Creek immediately upstream of the confluence with Ruth Creek are not used to develop the EPC.
- *Air* – Recreational users are assumed to breathe particulates that have been released only from the waste rock soils. It is assumed that the particulates derive from the waste rock soils and do not include particulates that may derive from nearby background soils.

Metals concentrations in air are modeled from the waste rock soil samples by the following equation:

$$C_{air} = \left(\frac{C_{soil}}{PEF} \times F_c \right)$$

where:

C_{air} = concentration in air (mg/m^3)
C_{soil} = 90UCL in waste rock soil
PEF = Particulate emission factor, set at 1.32E+09 m^3/kg as per ODEQ (2000) guidance
F_c = Fraction of soil that is contaminated; assumed to be 100%.

Air particulate modeling results are displayed in Table A-33 of Attachment A.

Table 3-1 presents the EPCs for the COPCs at the Ruth Mine site.

Table 3-1. Exposure Point Concentrations

Chemical of Potential Concern	Soil CTE/RME (90UCL) (mg/kg)	Surface Water CTE/RME (90UCL) (mg/L)	Sediment CTE/RME (90UCL) (mg/kg)	Air CTE/RME (modeled) (mg/m3)
Arsenic	20.7	NA	11.7	1.57E-08
Cadmium	NA	0.010	NA	NA
Lead	5,987	0.012	NA	4.54E-06

Chemicals of Potential Concern are based on screens for detection frequency, and exceedances of background and USEPA preliminary remediation goals

CTE/RME = central tendency exposures/reasonable maximum exposures

90UCL = 90% upper confidence limit on the mean concentration

NA = Not applicable, not a COPC for that medium based on lack of detections.

3.3 INTAKE ESTIMATION

The final step in the exposure assessment is the estimation of chemical intake and resulting dose for each chemical and each of the pathways considered in the assessment. The extent of potential intake received through the various pathways is dependent on an individual's location and behavior. A series of simplifying assumptions are made to calculate chemical intakes that yield conservatively high estimates of potential exposures. Calculations of intake follow the procedures in ODEQ (2000) guidance.

For long-term (i.e., chronic) exposures to noncarcinogenic chemicals, intakes are averaged over the period of exposure (i.e., the averaging time, AT), and are referred to as the average daily dose (ADD) (USEPA 1989). For carcinogens, intakes are averaged over an entire lifetime and are referred to as the lifetime average daily dose (LADD) (USEPA 1989).

The equations used to estimate intakes for each of the exposure pathways follow those presented in ODEQ (2000) guidance.

3.3.1 INCIDENTAL INGESTION OF SOIL OR SEDIMENT

$$(L)ADD = \frac{C_s \; x \; IR_s \; x \; EF \; x \; ED}{BW \; x \; AT} \; x \; CF$$

where:

(L)ADD	=	(Lifetime) Average Daily Dose (mg/kg-day)
C_s	=	Concentration of chemical in soil or sediment (mg/kg)
IR_s	=	Ingestion Rate of soil or sediment (mg/day)
EF	=	Exposure Frequency (days/year)
ED	=	Exposure Duration (years)
BW	=	Body Weight (kg)
AT	=	Averaging Time (days)
CF	=	Conversion Factor (10^{-6} kg/mg).

For noncarcinogens, intakes are calculated by averaging the daily doses over the averaging time (AT), which is set equal to the exposure duration (ED). For carcinogens, AT is an average upper bound duration of human lifetime, which is assumed by ODEQ (2000) to be 70 years (25,550 days).

3.3.2 DERMAL CONTACT WITH SOIL OR SEDIMENT

$$(L)ADD = \frac{C_s \; x \; SA \; x \; AF \; x \; DAF \; x EF \; x \; ED}{BW \; x \; AT} \; x \; CF$$

where:

(L)ADD	=	(Lifetime) Average Daily Dose (mg/kg-day)
C_s	=	Concentration in soil or sediment (mg/kg)
SA	=	Surface Area of skin contact (cm^2/event)
AF	=	Adherence Factor for soil or sediment to skin (mg/cm^2)
DAF	=	Dermal Absorption Factor (unitless)
EF	=	Exposure Frequency (events/year)
ED	=	Exposure Duration (years)
BW	=	Body Weight (kg)
AT	=	Averaging Time (days)
CF	=	Conversion Factor (10^{-6} kg/mg).

3.3.3 INHALATION OF SOIL PARTICLES

$$(L)ADD = \frac{C_s \; x \; IR_p \; x \; ET \; x \; EF \; x \; ED}{BW \; x \; AT}$$

where:

(L)ADD	=	(Lifetime) Average Daily Dose (mg/kg-day)
C_s	=	Concentration in soil particulates (mg/kg)

IR_p	=	Inhalation Rate of particulates (m^3/hour)
ET	=	Exposure Time (hours/day)
EF	=	Exposure Frequency (days/year)
ED	=	Exposure Duration (years)
BW	=	Body Weight (kg)
AT	=	Averaging Time (days).

3.3.4 INGESTION OF SURFACE WATER

$$(L)ADD = \frac{C_{sw}\ x\ IR_{sw}\ x\ ET\ x\ EF\ x\ ED}{BW\ x\ AT}$$

where:

(L)ADD	=	(Lifetime) Average Daily Dose from ingestion of surface water (mg/kg-day)
C_{sw}	=	Concentration of chemical in surface water (mg/L)
IR_{sw}	=	Ingestion Rate of surface water (L/day)
ET	=	Exposure Time (hours/day)
EF	=	Exposure Frequency (days/year)
ED	=	Exposure Duration (years)
BW	=	Body Weight (kg)
AT	=	Averaging Time (days).

3.3.5 DERMAL CONTACT WITH SURFACE WATER

$$(L)ADD = \frac{C_{sw}\ x\ SA\ x\ PC\ x\ ET\ xEF\ x\ ED}{BW\ x\ AT}\ x\ CF$$

where:

(L)ADD	=	(Lifetime) Average Daily Dose (mg/kg-day)
C_{sw}	=	Concentration in surface water (mg/kg)
SA	=	Surface Area of skin contact (cm^2/event)
PC	=	Permeability Coefficient of chemical (cm/hour)
ET	=	Exposure Time (hours/day)
EF	=	Exposure Frequency (days/year)
ED	=	Exposure Duration (years)
BW	=	Body Weight (kg)
AT	=	Averaging Time (days)
CF	=	Conversion Factor (10^{-3} L/cm^3).

Calculated doses, or intakes, of all COPCs in soil, sediment, and surface water are displayed in the risk calculation tables presented in Tables A-5 through A-32 of Attachment A.

4 TOXICITY ASSESSMENT

The Toxicity Assessment presents the toxicity information and criteria for the COPCs that are used with the exposure intake doses to quantify risks. Toxicity criteria are based on the types of potential adverse health affects associated with exposures to the COPC; the relationship between magnitude of exposure and potential adverse effects; and related uncertainties, such as the weight of evidence of a particular chemical's carcinogenicity in humans. The toxicity criteria rely on existing toxicity information developed for specific chemical constituents. USEPA has evaluated existing toxicity information and characterized the relationship between the dose of the chemical administered or received and the incidence of potentially adverse health effects in the exposed population. From this quantitative dose-response relationship, specific toxicity values have been derived that can be used to estimate the incidence of potentially adverse effects at different exposure levels (USEPA 1989). These toxicity values are called reference doses (RfDs) for non-carcinogens and slope factors (SFs) for potential carcinogens.

All carcinogenicity and non-carcinogenicity toxicity values come from USEPA sources, as per ODEQ guidance. The sources of toxicity values follow the hierarchy of sources as listed in USEPA (2003), with the primary source consisting of the USEPA Integrated Risk Information Systems (IRIS) database, from which toxicity values for all COPCs were available.

4.1 NON-CARCINOGENIC TOXICITY VALUES

Reference doses are expressed in units of milligrams of chemical per kilogram of body weight per day (mg/kg-bw/day). They are derived from either animal laboratory experiments or human epidemiology investigations (usually workplace studies), and include uncertainty factors to account for specific types of uncertainty inherent in extrapolation from the available data, and modifying factors to account for the confidence in the scientific studies. The use of these factors is a conservative approach to the protection of human health and is likely to overestimate the risks associated with chemical exposure.

The primary source for toxicity values for non-carcinogens was the USEPA Integrated Risk Information Systems (IRIS) database. Toxicity values were available for all COPCs in the IRIS database and no alternative sources were necessary.

Toxicity values used for exposures that involve dermal contact with chemicals may require adjustment of the oral toxicity values (oral RfDs) to allow for the difference between the daily intake dose through absorption via dermal contact and the amount that is ingested in the toxicity study used to derive the oral RfD (i.e., the administered dose). Most toxicity values are based on the administered dose, and must be corrected for the percent of chemical-specific absorption that occurs across the gastrointestinal tract prior to their use in dermal contact risk assessment (USEPA 1989, 2004). Ingestion route toxicity values were adjusted by absorption factors in USEPA (2004) guidance to account for the differences between the administered dose and the absorbed dose across the skin. This adjustment lowers the reference doses for use in dermal exposures.

US EPA quantifies non-carcinogenic effects for arsenic and cadmium via ingestion, dermal absorption, and inhalation, for which reference doses are derived (Table 4-1). For lead, US EPA does not recommend the use of a reference dose, but instead provides models to estimate the contribution of the site to blood lead levels in children and fetus through maternal exposures (see Section 5.3)

The toxicity values used for non-carcinogenic chemicals are presented in Table 4-1.

4.2 CARCINOGENIC TOXICITY VALUES

Unlike non-carcinogens, carcinogens are generally assumed to have no threshold, that is, there is presumed to be no level of exposure below which carcinogenic effects will not manifest themselves. This "non-threshold" concept is based on the idea that there are small, finite probabilities of inducing a carcinogenic response associated with every level of exposure to a potential carcinogen. US EPA has quantified cancer toxic potency concentrations, *i.e.*, the slope factor, which reflects the dose-response data for the carcinogenic endpoint (USEPA 1989).

The slope factor is determined by US EPA as the upper 95th percentile confidence limit of the probability of response per unit daily intake of a chemical over a lifetime. Typically, the slope factor is used to estimate the upper-bound lifetime probability of a person developing cancer from exposure to a given concentration of a carcinogen. Slope factors are generally based on experimental animal data, unless suitable epidemiologic studies are available. Due to the difficulty in detecting and measuring carcinogenic endpoints at low exposure concentrations, slope factors are typically developed by using a model to fit the available high-dose, experimental animal data, and then extrapolating downward to the low-dose range to which humans are typically exposed. The models used by US EPA are conservative and provide an upper bound estimate of excess lifetime cancer risk. Thus, the actual risk may be lower and could be zero (USEPA 1989). The toxicity values used for carcinogenic metals are presented in Table 4-1.

Of the COPCs at the site, US EPA has identified arsenic as carcinogenic via ingestion, dermal absorption, and inhalation; and cadmium as carcinogenic via inhalation; for which slope factors have been derived (Table 4-1).

Table 4-1. Toxicity Values

Carcinogenicity					
Chemical of Potential Concern	Cancer Slope Factor			Weight-of-Evidence Classification	Basis of Slope Factor
	Oral (mg/kg-day)-1	Dermal (mg/kg-day)-1	Inhalation (mg/kg-day)-1		
Arsenic	1.5	1.58	15.1	A Known Human Carcinogen	Skin cancer, human epidemiology studies (drinking water)

Cadmium	--	--	6.3	B1 Probable Human Carcinogen	Lung, trachea, human occupational exposure

Non-Carcinogenicity

Chemical of Potential Concern	Reference Dose Oral (mg/kg-day)	Reference Dose Dermal (mg/kg-day)	Reference Dose Inhalation (mg/kg-day)	Basis of RfD	Target Endpoint Effects
Arsenic	0.0003	0.00029	--	Human epidemiology studies, drinking water	Skin, vascular effects
Cadmium	5.0E-04	2.50E-05	--	Model of human renal cortex	Proteinuria
Cadmium	--	--	5.7E-05	NA (USEPA NCEA)	--
Lead	NA	NA	NA	See text	Blood lead

Sources: USEPA IRIS database; USEPA HEAST; USEPA NCEA; USEPA 2004
Dermal RfDs are derived from oral RfDs (USEPA 2004).
NA = not available; lead is evaluated through the USEPA blood lead model.

4.3 CHEMICAL FACTORS

Other chemical factors for calculating exposures include the gastrointestinal absorption factor and the dermal absorption factor. Chemical parameters are listed in Table 4-2. Gastrointestinal and dermal absorption factors were taken from US EPA (1989, 1994b, 2004) guidance.

Table 4-2. Chemical-Specific Parameters

Chemical of Potential Concern	GI Absorption Factor GI ABS	Dermal Absorption Factor DAF	Dermal Permeability Coefficient PC (cm/hr)
Arsenic	0.95	0.03	1.00E-03
Cadmium	0.05	0.001	1.00E-03
Lead	0.3	0.01	1.00E-03

Sources: USEPA 1989, 1994b, 2004

5 RISK CHARACTERIZATION

Risk Characterization is the final step of the risk assessment process. In this step, the toxicity values are combined with the estimated chemical intakes for the receptor populations to quantitatively estimate health risks associated with carcinogen and non-carcinogen exposures. Human health risks are deliberately characterized in a conservative manner in order to determine an upper range of potential risks for exposures to chemicals at the site. The characterization is considered screening level because it is based on limited sampling data and conservative simplifying assumptions about how much a recreational user is exposed to metals in the waste rock and surface waters of the site.

The methodologies used to estimate potential cancer risks and chronic risks for non-carcinogens for conventional chemicals are described below.

5.1 METHOD FOR NONCARCINOGENIC RISKS

The potential human health risks associated with exposures to non-carcinogenic COPCs were estimated by comparing ADDs with established RfDs, as per ODEQ (2000) and US EPA (1989) guidance. A hazard quotient (HQ) was derived for each chemical, as shown in the following equation:

$$HQ = \frac{ADD}{RfD}$$

where:

HQ	=	Hazard Quotient (unitless); ratio of average daily dose or intake level (ADD) to acceptable daily intake level or reference dose (RfD)
ADD	=	Average Daily Dose (mg/kg-day)
RfD	=	Reference Dose (mg/kg-day).

If the ADD exceeds the RfD, the HQ will exceed 1.0 and there may be concern that potential adverse systemic health effects could be observed in the exposed populations. If the ADD does not exceed the RfD, the HQ will not exceed 1.0 and there is no concern that potential adverse systemic health effects will be observed in the exposed populations. However, if the sum of several HQs exceeds 1.0, and the chemicals affect the same target organ, there may be concern that potential adverse systemic health effects will be observed in the exposed populations. In general, the greater the value of the HQ above 1.0, the greater the level of concern. However, the HQ does not represent a statistical probability that an adverse health effect will occur.

For consideration of exposures to more than one chemical causing systemic toxicity via several different pathways, the individual chemical HQs are summed to provide an exposure pathway Hazard Index (HI). If the HI is less than 1.0, then no adverse health effects are likely to be associated with exposures via that pathway at the site. However, if the total HI is greater than 1.0, separate endpoint-specific HIs may be calculated based on a toxic endpoint

of concern or target organ (*e.g.*, HQs for neurotoxins are summed separately from HQs for renal toxins). Only if an endpoint-specific HI is greater than one is there reason for concern about potential health effects for that endpoint.

5.2 METHOD FOR CANCER RISKS

Carcinogenic risk was estimated as the incremental probability of an individual developing cancer over a lifetime as a result of exposure to a potential carcinogen at the site. The numerical estimate of excess lifetime cancer risk was calculated by multiplying the lifetime average daily dose (ADD) by the risk per unit dose (the slope factor), as shown in the following equation:

$$Risk = ADD \times SF$$

where:

Risk	=	The unitless probability of an exposed individual developing cancer
ADD	=	Average Daily Dose over a lifetime (mg/kg-day)
SF	=	Cancer Slope Factor $(mg/kg\text{-}day)^{-1}$.

Because the slope factor is the statistical 95th percent upper confidence limit on the slope of the dose-response curve, this method provides a conservative, upper-bound estimate of risk.

5.3 NON-CANCER AND CANCER RISK ESTIMATES FOR RECREATIONAL USERS

Estimates of potential cancer and noncancer health risks under CTE and RME conditions at the mine site are presented in the following subsections. Estimates are presented for adult and children for each of the exposure pathways.

Noncancer hazard quotients and excess cancer risks under CTE and RME conditions are summarized for adults and children under various exposure scenarios in Tables 5-1 and 5-2. Summary tables of risk estimates are presented for each COPC in Tables A-5 through A-32 in Attachment A. Within each summary table, risks are presented for exposure to waste rock soils, surface waters, sediments, and waste rock soils resuspended as particulates in breathable air.

Table 5-1. Summary of NonCancer Hazard Quotients

Route of Exposure	Children		Adults	
	CTE	RME	CTE	RME
Incidental Ingestion of Surface Soil	0.001	0.03	0.0001	0.001
Dermal Contact with Surface Soil	0.0001	0.01	0.00005	0.0003

Inhalation of Particles from Surface Soil	0.00001	0.00003	0.000002	0.00001
Incidental Ingestion of Surface Water	0.00004	0.0004	0.00001	0.0001
Dermal Contact with Surface Water	0.0003	0.004	0.0001	0.001
Incidental Ingestion of Sediment	0.001	0.014	0.0001	0.001
Dermal Contact with Sediment	0.0001	0.003	0.00003	0.00003

Table 5-2. Summary of Cancer Risks

Route of Exposure	Children		Adults	
	CTE	RME	CTE	RME
Incidental Ingestion of Surface Soil	2E-08	1E-06	8E-09	3E-07
Dermal Contact with Surface Soil	1E-09	2E-07	3E-09	6E-08
Inhalation of Particles from Surface Soil	2E-11	4E-10	3E-11	5E-10
Incidental Ingestion of Surface Water	0E+00	0E+00	0E+00	0E+00
Dermal Contact with Surface Water	0E+00	0E+00	0E+00	0E+00
Incidental Ingestion of Sediment	9E-09	6E-07	4E-09	2E-07
Dermal Contact with Sediment	7E-10	1E-07	2E-09	3E-08

5.3.1 NONCARCINOGENIC RISKS

Calculations of exposures as daily doses, and noncarcinogenic risks for adult and child recreational users, are presented in Attachment A.

Waste rock soils – Arsenic and lead were identified as noncarcinogenic COPCs for waste rock soils. All of the arsenic HQs for ingestion of soil and dermal contact with soil were below 1.0. Risks associated with lead exposures are discussed in a following subsection.

Surface water – Surface water samples consisted of adit water from adit 4 and adit 5, Ruth Creek, and Battle Ax Creek at and down stream of the confluence with Ruth Creek. Cadmium and lead were identified as noncarcinogenic COPCs for surface waters. All of the cadmium HQs for incidental ingestion and dermal contact with surface waters were below 1.0. Risks associated with lead exposures are discussed in a following subsection.

Sediment – Sediment consisted of sediments from the same sources as the surface waters. Arsenic was identified as a noncarcinogenic COPC for sediment. All of the arsenic HQs for ingestion and dermal contact with sediment were below 1.0.

Inhalation of soil particulates – Arsenic and lead were identified as noncarcinogenic COPCs for soil particles. All of the HQs for children and adults were below 1.0.

The risk characterization of noncarcinogenic hazards for recreational exposures at the Ruth Mine site suggests that the potential for noncarcinogenic health effects are negligible.

5.3.2 CARCINOGENIC RISKS

Calculations of exposures as daily doses, and carcinogenic risks for adult and child recreational users, are presented in Attachment A.

Waste rock soils – Arsenic was identified as the only carcinogenic COPC for waste rock soils. The highest excess cancer risk was estimated for the child ingestion of waste rock soil under RME conditions, at 1E-06. The RME conditions for child ingestion of waste rock soil assumes that the child plays on the waste rock for 20 days every year from the ages of 1 through 6, and that they can ingest waste rock soil at the rate of 100 mg during each 4 hour visit on each of those 20 days. The EPC for arsenic in waste rock soil associated with the 1E-06 cancer risk estimate is 20.7 mg/kg. Excess cancer risk estimates for all of the other exposure pathways for child and adult were also below 1E-06.

Surface water – No carcinogenic COPCs were identified for surface water.

Sediment – Arsenic was identified as the only carcinogenic COPC for sediment. Excess cancer risk estimates for all exposure pathways for children and adults were at or below 1E-06.

Inhalation of soil particulates – Arsenic was the only carcinogenic COPC identified for soil particles. All excess cancer risk estimates for children and adults were less than 1E-06.

The risk characterization for cancer risks for recreational exposures at the Ruth Mine site suggests that estimated excess cancer risks for children and adults are negligible.

5.3.3 RISKS FROM LEAD EXPOSURES

Risks from potential exposures to lead in the environment are not evaluated by the methods used for the other COPCs. Regulatory agencies do not provide toxicity criteria for lead, and instead recommend evaluating lead by use of a model to predict blood levels of lead. Lead effects on neurological development of children are best related to blood lead levels rather than to doses or intake levels. USEPA has developed models that predict blood lead levels in children and in the developing fetus from maternal exposures based on multiple sources of lead in the environment. The contribution of lead in site-related media to the total blood lead levels in a child or developing fetus exposed to the site is modeled, and the resultant total blood levels are compared with a health-based criterion for lead in blood.

For the Ruth Mine site, it was assumed that both children and adults are exposed to lead in waste rock soils and air at the site. The mean concentration in waste rock soil (4,643 mg/kg) was used as the exposure point concentration for site-related exposures, as per USEPA (1994a) guidance for the lead model. For the child modeling, the lead level in air was assumed to be the default value in the model, at 0.1 $\mu g/m^3$; the lower concentration of 0.0045 $\mu g/m^3$ that was modeled from the waste rock soils (see Table A-33, Attachment A) was not used. Model parameterization for the child and adult lead models are described separately below.

5.3.3.1 Child Exposures

The model developed for estimating child blood levels is the Integrated Exposure Uptake BioKinetic (IEUBK) model, available as a downloadable model from USEPA (http://www.epa.gov/superfund/programs/lead/products.htm#ieubk). The child model was developed for exposures of young children to lead in a residential environment. The default parameters of the model assume that the child is exposed to lead through multiple environmental media typical of a residential location, including yard soil, house dust, air, food sources, drinking water, and perinatal exposures (i.e., fetal and nursing) from the mother. The ingestion of soil pathway in the model assumes that house dust is comprised partly of outside yard soil that is contaminated with lead. The model assumes that the child is exposed continuously to the above sources from a developing fetus through 7 years of age, with varying rates of exposure to different media for each year of age.

The IEUBK model is designed to predict blood lead levels for residential exposures, rather than recreational exposures that would occur on an intermittent basis. To account for intermittent exposures during recreational activities that would typically occur for a limited frequency each year, the IEUBK model was run by replacing the default soil lead concentration with a time-weighted concentration based on the time spent at the site with exposures to waste rock soils. A time-weighted soil concentration was calculated from the model default concentration of 200 mg/kg for lead in household dust and yard soils by weighting the concentration for 20 days per year at the mean lead concentration in waste rock. The mean concentration of lead in waste rock at the Ruth Mine site is 4,643 mg/kg. Table 5-3 shows the calculation of the time-weighted concentration of 443 mg/kg. The gastrointestinal absorption of lead from the ingested waste rock soil was left at the same absorption that the model uses for soils (i.e., 30 percent).

In addition to this time-weighted average soil lead concentration, alternative values for the lead concentration were developed under differing frequencies of exposure of children to the waste rock soils at the site. The differing frequencies of exposure and resultant alternative time-weighted average soil concentrations of lead that were evaluated are discussed in the Uncertainty Analysis of Section 6. In the Uncertainty Analysis, the frequency that a child would need to visit the site each year for the first 7 years of life that would result in a possible exceedance of the blood lead threshold was explored. The blood lead levels using alternative exposure frequencies were evaluated using the same IEUBK modeling described in this section.

Table 5-3. Development of Child Lead Model Data Input for Ruth Mine Site

Exposure Medium: Soil		
Mean lead concentration in waste rock	4,643	mg/kg dw
Time-weighted average lead concentration based on waste rock and default soil concentrations	443	mg/kg dw

Calculation of time-weighted lead concentration in waste rock + default soil:

Parameter	Description		
EF waste rock	child exposure days	20	
EF waste rock + EF soil	days per year	365	
PB soil	Lead default concentration (mg/kg)	200	
EF soil	Days per year - EF waste rock	351	
(Pbwaste x EF waste rock) + (Pbsoil x EF soil)/(Efwaste rock + EF soil)		**443 mg/kg**	time-weighted lead concentration in soil

Source: Integrated Exposure Uptake Biokinetic Model for Lead in Children (IEUBK) (USEPA 1994a)

The calculation shown in Table 5-3 above incorporates the time exposed to the waste rock soil as 20 out of the 365 days per year. The exposure time of 4 hours per day is not incorporated, but instead the assumption is made that the exposure occurs throughout the day, similar to the exposures to yard and indoor dust lead that is incorporated into the default exposure assumptions of the IEUBK model. Thus, the time-weighted average concentration includes the lead intake associated with recreational activities by the child at the Ruth Mine site based on more conservative assumptions than were used for recreational exposures to other COPCs that were limited to 4 hours a day. With this added exposure incorporated into the time-weighted average, lead intake due to activities while visiting the Ruth Mine site are added under a conservative approach to the exposures included in the IEUBK model as default residential exposures.

In running the model with the time-weighted average concentration for lead in soils, all other exposure pathways and parameters in the IEUBK model were retained at the default values. These include default values for lead levels in food and drinking water, lead in outdoor and indoor air, the relative amounts of yard soil and house dust that a child is assumed to ingest, maternal contribution of lead to the fetus, and absorption of lead from soils and other sources. Within the model, only the daily lead exposure through soil ingestion was altered by the time-weighting procedure to account for added waste rock soil ingestion during each of the seven years of child exposure.

The print-out from the IEUBK model run is presented in Attachment B, using the default residential exposure setting with the RME conditions as described above, and including the time-weighted average daily lead ingestion from soil and waste rock soil, based on 20 days per year exposure. Under this scenario, the highest geometric mean blood lead levels for children between 0.5 and 7 years of age are predicted to be 6.8 μg/dL. This concentration is below the threshold of concern level for child blood lead that USEPA has set at 10 μg/dL. The IEUBK model result is also displayed as a probability density function, which shows the probability of child blood lead levels due to the exposures parameterized in the model. The probability density print out from the model is shown in Attachment B. The probability that a child blood lead level would be below the target level of 10 μg/dL was calculated at 90 percent.

The bioavailability of lead from soil decreases as the amount of lead ingested increases, due to saturation limitations of the uptake from the gastrointestinal tract (USEPA 1994b). The IEUBK model was developed for soil lead concentrations generally around 200 mg/kg; the waste rock soil concentration of 4,643 mg/kg is substantially above that level. Lead in ingested soils that are at concentrations above the model range are absorbed at lower rates than the model assumes (USEPA 1994b). In addition, the absorption efficiency for lead from minerals such as galena, which is found in the Cascades mining districts in which the Ruth Mine site is located, are lower than the absorption assumed in the model (USEPA 1999). For these reasons, the 30 percent absorption efficiency for lead from ingested soil that is assumed in the model is likely an overestimate for the waste rock soils. In addition, the size of particles at hard rock mining sites are generally larger than the sizes of yard and dust particles that formed the basis for skin adherence that is assumed in the model, as recently reviewed for Superfund mining sites (NRC 2005). Thus, the model assumption for the ingestion of soil that adheres to skin is likely overestimated for waste rock soil. Because both of these factors, the percent absorption and soil adherence factor, are conservatively assumed for this modeling, the model result is a very conservative estimate of potential risks from lead exposure.

5.3.3.2 Adult Exposures

A separate model is available from the USEPA web page on estimating lead risks (http://www.epa.gov/superfund/programs/lead/products.htm#ieubk) that can be used to evaluate blood lead levels of a fetus in an exposed adult. The adult exposure model assumes that adults have a baseline level of lead in their blood, and then adds to that a contribution of lead from outside soil and house dust. The model then predicts the blood levels of lead in a fetus of a pregnant adult at those exposures. The predicted blood levels of lead in the fetus are compared to the same criterion as with the IEUBK model.

The adult model was run using 20 days as the RME exposure duration and the average lead concentration of 4,643 mg/kg. The remaining parameters were kept at the default levels, such as blood lead levels from background sources, and used an adult waste rock soil ingestion rate of 25 mg/day under RME conditions. Results of the modeling of fetal blood lead levels from adult exposures predicted 95th percentile fetal blood lead levels to range from 6.0 to 8.1 μg/dL

(Attachment B). These concentrations are below the threshold of concern level for fetal and child blood lead that USEPA has set at 10 μg/dL.

5.4 SUMMARY OF HUMAN HEALTH RISKS

Of the 24 metals and other inorganic COIs analyzed in environmental media at the site, arsenic, cadmium, and lead were identified as COPCs by the screening procedure. These three COPCs were evaluated quantitatively for human health risks following ODEQ guidance. Health risks were evaluated for people who would visit the site for recreational purposes. It was assumed that visitors would be exposed to COPCs in the waste rock soils and in the surface waters of the two mine adits, Ruth Creek that flows past the adits, and in Battle Ax Creek downstream of the confluence with Ruth Creek. The likelihood of exposure to COPCs in the surface waters was assumed to be similar across the site, assuming that both adults and children engaged in recreational activities, both presently and in the future, would have equal access to all contaminated areas. The exposure parameters used in the evaluation were assumed to be health protective for reasonable maximum future recreational exposures at the site. The US Forest Service has identified the Battle Ax Creek portion of the Opal Creek Scenic Recreation Area as a "Low Use" zone in its recreation management plan for the area.

Exposures and risks were evaluated for incidental ingestion of waste rock soil, dermal contact with waste rock soil, inhalation of waste rock soil particulates released to air; and ingestion and dermal contact with both surface water and sediments of the adits, Ruth Creek, and Battle Ax Creek at the site. Risks were not evaluated for potential exposures to background soils or to other creeks in the area.

Results of the risk evaluation indicate that noncarcinogenic risks for all exposure pathways for adults and children are below regulatory levels of concern. Risks to young children for exposure to lead in waste rock soils are at acceptable levels under the assumptions of the RME exposure conditions.

Results of the evaluation of excess cancer risks above background risk levels indicate that the highest cancer risk is associated with child ingestion of waste rock soils, at 1E-06 cancer risk, associated with arsenic levels of 20.7 mg/kg in the waste rock. Excess cancer risks for all other pathways of exposure for both children and adults were estimated to be below 1E-06.

6 UNCERTAINTY ANALYSIS

This section discusses some of the uncertainties in the human health risk evaluation described above. Some uncertainties are specific to the site conditions and some are inherent to the risk assessment process. An analysis of uncertainties provides the risk managers with information on the limitations and interpretation of the risk estimates and potential exposures for use in future decision making.

6.1.1 SAMPLING AND ANALYSIS

The sampling approach for the Ruth Mine site was a focused design, with sampling of waste rock soils and surface waters located in areas of suspected contamination and in areas identified as background to the site. The area was not sampled randomly and the results are not considered representative of average exposures to recreational users of the site. Only samples from the waste rock soils were used for the soil exposure pathways; data on lower contaminated background soils in the area were not used. Average exposures would typically result from varied movement throughout the site, with a mix of exposures to both contaminated and uncontaminated soils and waters, rather than only to contaminated soils as was assumed for this risk evaluation.

Focusing on samples with high levels of contamination, such as soils that appear to consist primarily of waste rock, results in exposure point concentrations and subsequent risks to be overestimated compared to actual exposures encountered by random movement across the area. In other words, since the soil samples collected were mostly biased toward contaminated areas, the measured concentrations and calculated health risks are overestimated.

6.1.2 EXPOSURE POINT CONCENTRATIONS

Estimates of potential exposure to metals at the Ruth Mine site were based on a limited number of samples to represent the various exposure media. For the waste rock soils, 21 - 31 samples were used to develop exposure concentrations; for surface water and sediment only 11 and 8 samples were available, respectively. Typically the use of a low number of samples in the development of exposure concentrations typically results in skewed data sets and high upper confidence limits on the mean values, frequently close to or exceeding the maximum concentration. However, with the use of gamma distribution statistics, a 90UCL was calculable for the EPC for all waste rock soil, surface water, and sediment samples regardless of the skewness of the data. However, due a large number of non-detects in upstream background surface water and sediment samples, 90 UCL and 95 UCL values exceeded maximum concentrations. Therefore, in the evaluation of upstream data for background surface water and sediment, only maximum concentrations were used.

Combining data from different types of environmental sources into a single EPC for an environmental medium may also over-estimate overall risks. For example, the extent of exposure to surface water from adit 4 located up the slope above the access road and trail, and Ruth Creek in the vicinity of adit 4, may differ from exposures to the more accessible Battle

Ax Creek and Ruth Creek near adit 5, which is located nearer to the access road and hiking trail. Combining data from those three sources into the exposure point concentration increases the uncertainty of the exposure estimates. In addition, including adit water data is a conservative estimation of exposures to site surface waters.

6.1.3 EXPOSURE FACTORS

Exposure frequency – The exposure frequency for recreational activities at the mine site was assumed to be 20 days per year for each of 30 years for an adult and for each of the first six years of a child's life. This frequency was based on the best professional judgment following discussions with the Opal Creek Education Center located in Jawbone Flats at the base of the trail leading to the mine site; it was not based on documented visits to the site. The frequency was designed to represent a reasonable maximum exposure for people involved in recreational activities under future conditions who may visit the site.

Because of the lack of documentation of this frequency, there is uncertainty as to its accuracy for potential future conditions. To address this uncertainty, additional risk estimates were calculated under the assumptions of increased exposure frequencies. The exposure frequency of 20 days per year that was used in the risk evaluation resulted in the highest excess cancer risk estimate of 1×10^{-6} for children ingesting waste rock soil while playing on the waste rock piles, which is at the low end of EPA's range of regulatory cancer risk thresholds for hazardous waste sites. The US EPA range of thresholds is from 1×10^{-6} to 1×10^{-4} excess cancer risks. The exposure frequency was increased to determine the days per year of exposure that would result in 1×10^{-5} and 1×10^{-4} excess cancer risks for a young child playing in the waste rock soils. These estimates were performed with all other exposure parameters remaining the same, except for the frequency of days per year.

Results of these risk estimates resulted in the identification of 200 days per year to result in estimated excess cancer risks of 1×10^{-5} for a young child playing in the waste rock soils. At 365 days per year of playing in the waste rock soils, cancer risks for the young child would increase to 2×10^{-5}. Increasing the number of days of exposure of a young child to the waste rock soils from 20 days per year to 30 days per year would increase excess cancer risk estimates to 1.5×10^{-6}, and for 40 days of exposure would increase them to 2×10^{-6}.

Soil ingestion rate - A major source of uncertainty in exposure factors is the selection of the soil ingestion rate for recreational exposures, particularly for children. Soil ingestion for children under the RME scenario was assumed to be 100 mg/day, with all of the ingestion consisting of waste rock soil and all occurring during the 4 hours each day that the child is assumed to be present on the waste rock soil. For lead in waste rock soil, the exposures are assumed to occur throughout the day, rather than limited to 4 hours. This rate of soil ingestion is considered to be conservative and is assumed to not underestimate potential exposures to waste rock soil by ingestion, and thus uncertainty with the soil ingestion rate is high.

Sediment ingestion rate - The sediment ingestion rate was derived from the soil ingestion rate. The sediment ingestion rate is considered sufficiently conservative by this approach.

Gastrointestinal Absorption - A major source of uncertainty for the soil and sediment ingestion pathways is the amount of lead and arsenic that is absorbed from the ingested material. Metals in waste rock are unlikely to be as bioavailable at the fractions recommended for soils by USEPA (1994a, 2004). As noted in the lead modeling section of this risk evaluation, NRC (2005) estimates that lead bioavailability from hard rock mining substrate is less than that associated with more typical sources of lead at hazardous waste sites. Uncertainty with gastrointestinal absorption of metals from hard rock substrate is considered moderate.

Dermal contact - A major source of uncertainty in the direct contact pathway is the absorption of metals across the skin and the resulting toxicity. The dermal absorption factors for the metals used in the modeling were taken from US EPA guidance. The dermal absorption factors are typically based on laboratory studies, and are not specific to the environment in which the metals are found. Specifically, the absorption of arsenic from weathered waste rock is unknown. Uncertainty in the dermal absorption factors is considered high.

Another factor in the dermal contact risk estimates is the adherence factor for soil and sediment adhering to skin. The adherence factor determines how much of the soil or sediment adheres to an area of the skin. The values used are taken from ODEQ and USEPA guidance and are derived from studies with children exposed to dry and wet soil, but not to sediment. The values are not specific to the site. The type of soils used to derive the adherence factors are more typical soil materials that contain organic material, to which metals may desorb from. However, the waste rock soil and sediment at the mine site are very grainy with likely low organic material present.

Also a factor in the dermal contact risk estimates is the frequency of exposures to the sediments. The frequency of exposure was assumed to be 20 days per year, every year, for the RME child recreational user. This value is assumed to be conservatively representative of exposures for an individual who may visit the mine area.

6.1.4 TOXICOLOGY

The toxicity values for metals in any risk assessment are considered uncertain because most of the values are extrapolated from laboratory studies or adult occupational studies performed elsewhere. The toxicity values used in this risk evaluation are not specific to the site or conditions, but they have been generated, reviewed, and accepted by various regulatory agencies. Because resolution of the uncertainty in toxicity of metals to humans is considered difficult, the uncertainty is not considered major.

6.1.5 LEAD EVALUATION

Uncertainties with the use of the IEUBK model to evaluate the potential for child blood lead levels to exceed a health-based threshold due to exposures to soil at the Ruth Mine site are discussed above in Section 5.3.3. As an additional means to address uncertainty in the lead modeling, alternative evaluations of lead exposures and lead modeling were performed. In addition to the IEUBK model run using 20 days per year exposure to the waste rock soils described in Section 5.3.3, the model was also run under alternative exposure frequency

conditions. Alternative exposure frequencies included 30 and 40 days, the annual frequency of exposure to the waste rock soils that would result in the geometric mean blood lead concentration to exceed the USEPA blood lead threshold of 10 μg/dL. For this modeling, the IEUBK model was run exactly the same as in Section 5.3.3, except that the time-weighted average soil concentration of lead was increased until the threshold was reached. All other lead exposures that are mentioned in Section 5.3.3, such as maternal lead concentration, and lead in air, food, house dust, and yard soils, were retained at the default levels.

The IEUBK model outputs for 30 and 40 day exposures of children to the waste rock soils are shown in Attachment B. The highest geometric mean blood lead level for a child between 0.5 and 7 years of age is predicted to be 8.0 μg/dL and 9.1 μg/dL for the 30 day and40 day exposures, respectively. The graphical depictions of the probability distributions for these exposure frequencies are also shown in Attachment B. The percent of children with blood lead levels lower than the threshold decreases with increasing exposure. The 30 day per year exposure would result in 83 percent probability of blood lead lower than 10 μg/dL, compared with 90 percent for the 20 day per year exposure, and the 40 day per year exposure would result in 75 percent probability of blood lead levels below the threshold.

The time-weighted soil concentration of lead in waste rock soil that resulted in the geometric mean for a child between 0.5 and 7 years of age at the blood lead threshold was found to be 800 mg/kg. At that time-weighted concentration, the blood lead level of the 1-2 year old would be 10.1 μg/dL, and the probability of blood lead levels below the threshold decreases to 67 percent. The time-weighted average lead concentration of 800 mg/kg corresponds with 49 days per year exposure to waste rock soils at the Ruth Mine site, meaning that a child would need to be present on the waste rock soils and to consume the waste rock soil all day for 49 days each year. Note that this concentration of 800 mg/kg is the same as the US EPA preliminary remediation goal for industrial soil that was used as the screening level in the initial step of this risk evaluation. The 800 mg/kg screening level was developed by US EPA using the IEUBK model following the same procedure used in the present modeling, which accounts for the similar results.

7 CONCLUSIONS

The human health evaluation was performed for recreational exposures at the Ruth Mine site. The exposures were based on estimates of reasonable maximum future exposures due to recreational activities directly in the contaminated waste soils and surface waters of the site. The exposures are not documented to presently occur, and would be much less than those estimated for this risk evaluation. Exposures were assumed to occur to waste rock soils and to surface waters and sediments of two mine adits, Ruth Creek, and Battle Ax Creek for children and adults who may visit the site for 4 hours a day during 20 days out of each of the first 6 years of a child's life and each of 30 years for an adult. Risks were estimated for chemicals of potential concern that had passed screening tests for detection frequency, elevation above background, and for potential toxicity. The chemicals selected as COPCs consisted of arsenic, cadmium, and lead. Arsenic exposures were evaluated for carcinogenic and noncarcinogenic effects, whereas cadmium was evaluated for noncarcinogenic effects due to exposure to surface waters at the site. Lead was evaluated for noncarcinogenic effects from exposures to waste rock soils by using EPA models for predicting blood lead levels in exposed children (IEUBK model) and in the fetus of an exposed pregnant woman (ALM model). Young children and the developing fetus have been identified as the most sensitive receptors to the effects of lead.

Exposures were estimated for ingestion of arsenic in waste rock soils, surface water, and sediment; inhalation of dusts containing arsenic from waste rock soil; and skin contact with arsenic in waste rock soils, sediment, and surface waters. Exposure to cadmium were evaluated for ingestion and dermal contact with surface waters of the adits and creeks. Exposures to lead were modeled for ingestion of waste rock soils and inhalation of waste rock soil dust. All arsenic exposures were shown to result in estimated cancer risks that did not exceed the threshold of 1×10^{-6}. Noncancer risks for arsenic and cadmium were estimated as hazard quotients well below a threshold of 1 for all routes of exposure. For children playing on the waste rock soils and pregnant women visiting the site, blood lead levels in young children or the developing fetus were modeled to be below the USEPA threshold.

These risk estimates suggest that the metals, particularly arsenic, cadmium, and lead, detected in waste rock soils, sediments, and surface waters of the Ruth Mine site do not pose unacceptable risks under the exposure assumptions for recreational visitors to the site, including young children.

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ATTACHMENT A – RISK CALCULATION TABLES

Table A-1. Waste Rock Soil PRG Screen

Chemical of Interest (COI)	Cancer/ Noncancer	Maximum Detected Concentration (mg/kg)	USEPA Region 6 Industrial Soil PRG (mg/kg)	Individual COI Risk Ratio (Ri)	Individual COPC?	Multiple COIs Ri/Rtotal	Multiple COPC in Soil?
Antimony	NC	1.89	410	0.005	No	0.0001	No
Arsenic	C	46.2	1.6	29	**Yes**	0.39	**Yes**
Cadmium	NC	422	810	0.521	No	0.0071	No
Calcium	-	38,500	NA	NA	No	NA	NA
Chromium	C	37.6	1,400	0.027	No	0.0004	No
Cobalt	NC	34.2	300	0.114	No	0.002	No
Copper	NC	7,600	41,000	0.185	No	0.003	No
Iron	NC	94,600	720,000	0.131	No	0.002	No
Lead	NC	34,000	800	43	**Yes**	0.579	**Yes**
Magnesium	-	18,000	NA	NA	No	NA	NA
Manganese	NC	15,900	23,000	0.691	No	0.01	No
Mercury	NC	1.87	310	0.006	No	0.0001	No
Nickel	NC	40.6	20,000	0.002	No	0.00003	No
Potassium	-	6,770	NA	NA	No	NA	NA
Selenium	NC	16.5	5,100	0.003	No	0.00004	No
Silver	NC	28.6	5,100	0.006	No	0.00008	No
Zinc	NC	98,900	310,000	0.319	No	0.0043	No
			Sum of Risk Ratios (Rtotal)	73.4			
			Number of COIs (N)	14			
			1/N	0.07			

Samples consist of all soil and waste rock samples on-site (N=21-31).

COIs selected by screening for frequency of detection and comparison with background concentrations.

Table A-2. Surface Water PRG Screen

Chemical of Interest (COI)	Cancer/ Noncancer	Maximum Detected Concentration (µg/L)	USEPA Region 6 Tapwater PRG (µg/L)	Individual COI Risk Ratio (Rwater)	Individual COPC?	Multiple COIs Rwater/ Rwtotal	Multiple COPC in Surface Water?
Barium	NC	6.94	7,300	0.001	No	0.0002	No
Cadmium	NC	22.1	18	1.2	**Yes**	0.30	**Yes**
Calcium	--	4120	NA	NA	Yes	NA	NA
Chromium	NC	1.1	55,000	0.00002	No	0.000005	No
Copper	NC	14.8	1,500	0.010	No	0.0024	No
Iron	NC	73.9	26,000	0.003	No	0.00	No
Lead	NC	37.7	15	2.5	**Yes**	0.62	**Yes**
Manganese	NC	30.9	880	0.035	No	0.009	No
Sodium	--	1390	NA	NA	Yes	NA	NA
Zinc	NC	3080	11,000	0.28	No	0.07	No
			Sum of Risk Ratios (Rwtotal)	4			
			Number of COIs (N)	8			
			1/N	0.13			

Surface water samples include all downstream Battle Ax Creek, Ruth Creek, and adit waters on-site (N=11).

PRG is drinking water value.

COIs were selected by screening for frequency of detection and by comparison with Battle Ax Creek upstream concentrations.

Table A-3. Sediment PRG Screen

Chemical of Interest (COI)	Cancer/ Noncancer	Maximum Detected Concentration (mg/kg)	USEPA Region 6 Industrial Soil PRG (mg/kg)	Individual COI Risk Ratio (Rsed)	Individual COPC in Sediment?	Multiple COIs (Rsed/Rsedtotal)	Multiple COPC in Sediment?
Aluminum	NC	30,100	990,000	0.03	No	0.0029	No
Arsenic	C	15.7	1.6	10	**Yes**	0.93	**Yes**
Cadmium	NC	5.6	810	0.007	No	0.00	No
Calcium	-	8,700	NA	NA	Yes	NA	NA
Cobalt	NC	16.1	300	0.05	No	0.0051	No
Copper	NC	465.0	41,000	0.01	No	0.0011	No
Iron	NC	33,400	720,000	0.05	No	0.0044	No
Lead	NC	278	800	0.35	No	0.03	No
Magnesium	-	13,000	NA	NA	Yes	NA	NA
Manganese	NC	4,290	23,000	0.19	No	0.02	No
Nickel	NC	50.2	20,000	0.0025	No	0.0002	No
Potassium	-	1,230	NA	NA	Yes	NA	NA
Sodium	-	572	NA	NA	Yes	NA	NA
Vanadium	NC	66.5	5,200	0.01	No	0.0012	No
Zinc	NC	1,390	310,000	0.0045	No	0.0004	No
			Sum of Risk Ratios (Rsedtotal)	10.5			
			Number of COIs (N)	11			
			1/N	0.09			

Samples consist of sediment samples in downstream Battle Ax Creek and Ruth Creek (N=8).

Table A-4. Exposure Parameters

Variable	Definition	Units	Child Recreational User			Adult Recreational User		
			CTE	RME	REFERENCE	CTE	RME	REFERENCE
	Ingestion of Surface Soil							
IR	Ingestion Rate	mg/day	25	100	ODEQ 1998, BPJ	12	25	ODEQ 1998, BPJ
EF	Exposure Frequency	day/yr	4	20	BPJ	4	20	BPJ
ED	Exposure Duration	yr	2	6	ODEQ 1998	9	30	ODEQ 1998
BW	Body Weight	kg	15	15	ODEQ 1998	70	70	ODEQ 1998
AT-NC	Averaging time - Noncancer	days	730	2,190	ODEQ 1998	3,285	10,950	ODEQ 1998
AT-C	Averaging Time - Cancer	days	25,550	25,550	ODEQ 1998	25,550	25,550	ODEQ 1998
CF	Conversion Factor	kg/mg	1.00E-06	1.00E-06		1.00E-06	1.00E-06	0
	Dermal Contact With Soil							0
SA	Surface Area for Contact	cm2/event	4,500	5,000	ODEQ 1998	5,200	6,900	ODEQ 1998
AF	Adherence Factor	mg/cm2	0.04	0.4	USEPA 2004	0.08	0.08	ODEQ 1998
EF	Exposure Frequency	event/yr	4	20	BPJ	4	20	BPJ
ED	Exposure Duration	yr	2	6	ODEQ 1998	9	30	ODEQ 1998
BW	Body Weight	kg	15	15	ODEQ 1998	70	70	ODEQ 1998
AT-NC	Averaging time - Noncancer	days	730	2,190	ODEQ 1998	3,285	10,950	ODEQ 1998
AT-C	Averaging Time - Cancer	days	25,550	25,550	ODEQ 1998	25,550	25,550	ODEQ 1998
CF	Conversion Factor	kg/mg	1.00E-06	1.00E-06		1.00E-06	1.00E-06	
	Inhalation from Soil							
IR	Inhalation Rate	m3/hr	1.2	1.2	USEPA 1997	1.5	1.5	USEPA 1997
ET	Exposure Time	hr/day	4	4	BPJ	4	4	BPJ
EF	Exposure Frequency	day/yr	4	20	BPJ	4	20	BPJ
ED	Exposure Duration	yr	2	6	ODEQ 1998	9	30	ODEQ 1998
BW	Body Weight	kg	15	15	ODEQ 1998	70	70	ODEQ 1998
AT-NC	Averaging time - Noncancer	days	730	2,190	ODEQ 1998	3,285	10,950	ODEQ 1998
AT-C	Averaging Time - Cancer	days	25,550	25,550	ODEQ 1998	25,550	25,550	ODEQ 1998
	Ingestion of Surface Water							
IR	Ingestion Rate	L/hr	0.01	0.01	USEPA 1997	0.01	0.01	USEPA 1997
ET	Exposure Time	hr/day	0.5	1	ODEQ 1998, BPJ	0.5	1	ODEQ 1998, BPJ
EF	Exposure Frequency	day/yr	4	20	BPJ	4	20	BPJ
ED	Exposure Duration	yr	2	6	ODEQ 1998	9	30	ODEQ 1998
BW	Body Weight	kg	15	15	ODEQ 1998	70	70	ODEQ 1998
AT-NC	Averaging time-Noncancer	days	730	2,190	ODEQ 1998	3,285	10,950	ODEQ 1998

Variable	Definition	Units	Child Recreational User			Adult Recreational User		
AT-C	Averaging Time - Cancer	days	25,550	25,550	ODEQ 1998	25,550	25,550	ODEQ 1998
	Dermal Contact with Surface Water							
SA	Surface Area for Contact	cm2	4,500	5,000	ODEQ 1998	5,200	6,900	ODEQ 1998
ET	Exposure Time	hr/day	0.5	1.0	ODEQ 1998, BPJ	0.5	1.0	ODEQ 1998, BPJ
EF	Exposure Frequency	day/yr	4	20	BPJ	4	20	BPJ
ED	Exposure Duration	yr	2	6	ODEQ 1998	9	30	ODEQ 1998
BW	Body Weight	kg	15	15	ODEQ 1998	70	70	ODEQ 1998
AT-NC	Averaging time - Noncancer	days	730	2,190	ODEQ 1998	3,285	10,950	ODEQ 1998
AT-C	Averaging Time - Cancer	days	25,550	25,550	ODEQ 1998	25,550	25,550	ODEQ 1998
CF	Conversion Factor	L/cm3	1.00E-03	1.00E-03		1.00E-03	1.00E-03	
	Ingestion of Sediment							
IR	Ingestion Rate	mg/day	10	25	BPJ, USEPA 1997	10	25	BPJ, USEPA 1997
EF	Exposure Frequency	day/yr	4	20	BPJ	4	20	BPJ
ED	Exposure Duration	yr	2	6	ODEQ 1998	9	30	ODEQ 1998
BW	Body Weight	kg	15	15	ODEQ 1998	70	70	ODEQ 1998
AT-NC	Averaging time - Noncancer	days	730	2,190	ODEQ 1998	3,285	10,950	ODEQ 1998
AT-C	Averaging Time - Cancer	days	25,550	25,550	ODEQ 1998	25,550	25,550	ODEQ 1998
CF	Conversion Factor	kg/g	1.00E-06	1.00E-06		1.00E-06	1.00E-06	
	Dermal Contact with Sediment							
SA	Surface Area for Contact	cm2	4,500	5,000	ODEQ 1998	5,200	6,900	ODEQ 1998
AF	Adherence Factor	mg/cm2	0.2	1	USEPA 2004; ODEQ 1998	0.08	0.08	ODEQ 1998
EF	Exposure Frequency	day/yr	4	20	BPJ	4	20	BPJ
ED	Exposure Duration	yr	2	6	ODEQ 1998	9	30	ODEQ 1998
BW	Body Weight	kg	15	15	ODEQ 1998	70	70	ODEQ 1998
AT-NC	Averaging time - Noncancer	days	730	2,190	ODEQ 1998	3,285	10,950	ODEQ 1998
AT-C	Averaging Time - Cancer	days	25,550	25,550	ODEQ 1998	25,550	25,550	ODEQ 1998
CF	Conversion Factor	kg/mg	1.00E-06	1.00E-06		1.00E-06	1.00E-06	

Notes:

BPJ = Best Professional Judgment

CTE, RME = Central Tendency Exposure, Reasonable Maximum Exposure

Surface area for contact assumes arms, hands, leg, and feet (ODEQ 1998); for both soil and surface water.

Table A-5. Estimates of Cancer and Noncancer Risks for Child Recreational Users

CTE - Incidental Ingestion of Soil

CTE - Incidental Ingestion of Soil

Ingestion Rate = IR	25	mg/day
Exposure Frequency = EF	4	day/yr
Exposure Duration = ED	2	yr
Body Weight = BW	15	kg
Averaging Time (Noncancer) = AT	730	days
Averaging Time (Cancer) = AT	25,550	days
Conversion Factor = CF	1.00E-06	kg/mg

Intake (mg/kg-day) = Conc * IR * EF * ED *CF / (BW * AT)

NCADD = Average Daily Dose - Noncarcinogens
CADD = Average Daily Dose - Carcinogens
HQ = Hazard Quotient, Noncarcinogens = NCADD/ RfD
Risk = Cancer Risk = CADD * SF

Chemical of Potential Concern	EPC (mg/kg)	NCADD (mg/kg-day)	CADD (mg/kg-day)	Chronic Oral RfD (mg/kg-day)	Oral SF per (mg/kg-day)	HQ	Risk
Arsenic	20.7	3.79E-07	1.08E-08	3.00E-04	1.50E+00	1.26E-03	1.62E-08
Cadmium	NA	–	–	1.00E-03	NA	–	–
Lead	5.987	1.09E-04	3.12E-06	NA	NA	–	–
Cumulative Risk						**1.26E-03**	**1.62E-08**

NA = Not applicable if chemical is not a COPC for the exposure route, or toxicity value is not available

Table A-6. Estimates of Cancer and Noncancer Risks for Child Recreational Users

RME- Incidental Ingestion of Soil

RME- Incidental Ingestion of Soil

Ingestion Rate = IR	100	mg/day
Exposure Frequency = EF	20	day/yr
Exposure Duration = ED	6	yr
Body Weight = BW	15	kg
Averaging Time (Noncancer) = AT	2,190	days
Averaging Time (Cancer) = AT	25,550	days
Conversion Factor = CF	1.00E-06	kg/mg

Intake (mg/kg-day) = Conc * IR * EF * ED *CF / (BW * AT)

NCADD = Average Daily Dose - Noncarcinogens
CADD = Average Daily Dose - Carcinogens
HQ = Hazard Quotient, Noncarcinogens = NCADD/ RfD
Risk = Cancer Risk = CADD * SF

Chemical of Potential Concern	EPC (mg/kg)	NCADD (mg/kg-day)	CADD (mg/kg-day)	Chronic Oral RfD (mg/kg-day)	Oral SF per (mg/kg-day)	HQ	Risk
Arsenic	20.7	7.57E-06	6.49E-07	3.00E-04	1.50E+00	2.52E-02	9.74E-07
Cadmium	NA	--	--	1.00E-03	NA	--	--
Lead	5.987	2.19E-03	1.87E-04	NA	NA	--	--
Cumulative Risk						**2.52E-02**	**9.74E-07**

NA = Not applicable if chemical is not a COPC for the exposure route, or toxicity value is not available

Table A-7. Estimates of Cancer and Noncancer Risks for Child Recreational Users
CTE- Dermal Contact with Soil

CTE- Dermal Contact with Soil

Surface Area for Contact=SA	4,500	cm2/event
Adherence Factor=AF	0.04	mg/cm2
Dermal Absorption Factor=DAF	chemical-specific	
Exposure Frequency = EF	4	event/yr
Exposure Duration = ED	2	yr
Body Weight = BW	15	kg
Averaging Time (Noncancer) = AT	730	days
Averaging Time (Cancer) = AT	25,550	days
Conversion Factor = CF	1.00E-06	kg/mg

Intake (mg/kg-day) = Conc * SA * AF * DAF * EF * ED * CF / (BW * AT)

NCADD = Average Daily Dose - Noncarcinogens
CADD = Average Daily Dose - Carcinogens
HQ = Hazard Quotient, Noncarcinogens = NCADD/ RfD
Risk = Cancer Risk = CADD * SF

Chemical of Potential Concern	EPC (mg/kg)	NCADD (mg/kg-day)	CADD (mg/kg-day)	Dermal RfD (mg/kg-day)	Dermal SF per (mg/kg-day)	HQ	Risk
Arsenic	20.7	2.73E-08	7.79E-10	2.85E-04	1.58E+00	9.57E-05	1.23E-09
Cadmium	NA	–	–	5.00E-05	NA	–	–
Lead	5,987	7.87E-06	2.25E-07	NA	NA	–	–
Cumulative Risk						**9.57E-05**	**1.23E-09**

NA = Not applicable if chemical is not a COPC for the exposure route, or toxicity value is not available

Table A-8. Estimates of Cancer and Noncancer Risks for Child Recreational Users
RME- Dermal Contact with Soil

RME- Dermal Contact with Soil

Surface Area for Contact=SA	5,000	cm2/event
Adherence Factor=AF	0.4	mg/cm2
Dermal Absorption Factor=DAF	chemical-specific	
Exposure Frequency = EF	20	event/yr
Exposure Duration = ED	6	yr
Body Weight = BW	15	kg
Averaging Time (Noncancer) = AT	2,190	days
Averaging Time (Cancer) = AT	25,550	days
Conversion Factor = CF	1.00E-06	kg/mg

Intake (mg/kg-day) = Conc * SA * AF * DAF * EF * ED * CF / (BW * AT)

NCADD = Average Daily Dose - Noncarcinogens
CADD = Average Daily Dose - Carcinogens
HQ = Hazard Quotient, Noncarcinogens = NCADD/ RfD
Risk = Cancer Risk = CADD * SF

Chemical of Potential Concern	EPC (mg/kg)	NCADD (mg/kg-day)	CADD (mg/kg-day)	Dermal RfD (mg/kg-day)	Dermal SF per (mg/kg-day)	HQ	Risk
Arsenic	20.7	1.51E-06	1.30E-07	2.85E-04	1.58E+00	5.31E-03	2.05E-07
Cadmium	NA	--	--	5.00E-05	NA	--	--
Lead	5,987	4.37E-04	3.75E-05	NA	NA	--	--
Cumulative Risk						**5.31E-03**	**2.05E-07**

NA = Not applicable if chemical is not a COPC for the exposure route, or toxicity value is not available

Table A-9. Estimates of Cancer and Noncancer Risks for Child Recreational Users
CTE- Inhalation of Particles from Soil

CTE- Inhalation of Particles from Soil

Inhalation Rate = IR	1.2	m3/hr
Exposure Time = ET	4	hr/day
Exposure Frequency = EF	4	day/yr
Exposure Duration = ED	2	yr
Body Weight = BW	15	kg
Averaging Time (Noncancer) = AT	730	days
Averaging Time (Cancer) = AT	25550	days

Intake (mg/kg-day) = Conc * IR * ET * EF * ED / (BW * AT)

NCADD = Average Daily Dose - Noncarcinogens
CADD = Average Daily Dose - Carcinogens
HQ = Hazard Quotient, Noncarcinogens = NCADD/ RfD
Risk = Cancer Risk = CADD * SF

Chemical of Potential Concern	EPC (mg/m3)	NCADD (mg/kg-day)	CADD (mg/kg-day)	Inhalation RfD (mg/kg-day)	Inhalation SF per (mg/kg-day)	HQ	Risk
Arsenic	1.57E-08	5.51E-11	1.57E-12	8.60E-06	1.51E+01	6.40E-06	2.38E-11
Cadmium	NA	--	--	5.70E-05	6.30E+00	--	--
Lead	4.54E-06	1.59E-08	4.54E-10	NA	NA	--	--
Cumulative Risk						**6.40E-06**	**2.38E-11**

NA = Not applicable if chemical is not a COPC for the exposure route, or toxicity value is not available

Table A-10. Estimates of Cancer and Noncancer Risks for Child Recreational Users
RME- Inhalation of Particles from Soil

RME- Inhalation of Particles from Soil

Inhalation Rate = IR	1.2	m3/hr
Exposure Time = ET	4	hr/day
Exposure Frequency = EF	20	day/yr
Exposure Duration = ED	6	yr
Body Weight = BW	15	kg
Averaging Time (Noncancer) = AT	2190	days
Averaging Time (Cancer) = AT	25550	days

Intake (mg/kg-day) = Conc * IR * ET * EF * ED / (BW * AT)

NCADD = Average Daily Dose - Noncarcinogens
CADD = Average Daily Dose - Carcinogens
HQ = Hazard Quotient, Noncarcinogens = NCADD/ RfD
Risk = Cancer Risk = CADD * SF

Chemical of Potential Concern	EPC (mg/m3)	NCADD (mg/kg-day)	CADD (mg/kg-day)	Inhalation RfD (mg/kg-day)	Inhalation SF per (mg/kg-day)	HQ	Risk
Arsenic	1.57E-08	2.75E-10	2.36E-11	8.60E-06	1.51E+01	3.20E-05	3.56E-10
Cadmium	NA	--	--	5.70E-05	6.30E+00	--	--
Lead	4.54E-06	7.95E-08	6.82E-09	NA	NA	--	--
Cumulative Risk						**3.20E-05**	**3.56E-10**

NA = Not applicable if chemical is not a COPC for the exposure route, or toxicity value is not available

Table A-11. Estimates of Cancer and Noncancer Risks for Adult Recreational Users
CTE- Incidental Ingestion of Soil

CTE- Incidental Ingestion of Soil

Ingestion Rate = IR	12 mg/day
Exposure Frequency = EF	4 day/yr
Exposure Duration = ED	9 yr
Body Weight = BW	70 kg
Averaging Time (Noncancer) = AT	3,285 days
Averaging Time (Cancer) = AT	25,550 days
Conversion Factor = CF	1.00E-06 kg/mg

Intake (mg/kg-day) = Conc * IR * EF * ED *CF / (BW * AT)

NCADD = Average Daily Dose - Noncarcinogens
CADD = Average Daily Dose - Carcinogens
HQ = Hazard Quotient, Noncarcinogens = NCADD/ RfD
Risk = Cancer Risk = CADD * SF

Chemical of Potential Concern	EPC (mg/kg)	NCADD (mg/kg-day)	CADD (mg/kg-day)	Chronic Oral RfD (mg/kg-day)	Oral SF per (mg/kg-day)	HQ	Risk
Arsenic	20.7	3.89E-08	5.01E-09	3.00E-04	1.50E+00	1.30E-04	7.51E-09
Cadmium	NA	—	—	1.00E-03	NA	—	—
Lead	5,987	1.12E-05	1.45E-06	NA	NA	—	—
Cumulative Risk						**1.30E-04**	**7.51E-09**

NA = Not applicable if chemical is not a COPC for the exposure route, or toxicity value is not available

Table A-12. Estimates of Cancer and Noncancer Risks for Adult Recreational Users
RME- Incidental Ingestion of Soil

RME- Incidental Ingestion of Soil

Ingestion Rate = IR	25 mg/day
Exposure Frequency = EF	20 day/yr
Exposure Duration = ED	30 yr
Body Weight = BW	70 kg
Averaging Time (Noncancer) = AT	10,950 days
Averaging Time (Cancer) = AT	25,550 days
Conversion Factor = CF	1.00E-06 kg/mg

Intake (mg/kg-day) = Conc * IR * EF * ED *CF / (BW * AT)

NCADD = Average Daily Dose - Noncarcinogens
CADD = Average Daily Dose - Carcinogens
HQ = Hazard Quotient, Noncarcinogens = NCADD/ RfD
Risk = Cancer Risk = CADD * SF

Chemical of Potential Concern	EPC (mg/kg)	NCADD (mg/kg-day)	CADD (mg/kg-day)	Chronic Oral RfD (mg/kg-day)	Oral SF per (mg/kg-day)	HQ	Risk
Arsenic	20.7	4.06E-07	1.74E-07	3.00E-04	1.50E+00	1.35E-03	2.61E-07
Cadmium	NA	—	—	1.00E-03	NA	—	—
Lead	5.987	1.17E-04	5.02E-05	NA	NA	—	—
Cumulative Risk						**1.35E-03**	**2.61E-07**

NA = Not applicable if chemical is not a COPC for the exposure route, or toxicity value is not available

Table A-13. Estimates of Cancer and Noncancer Risks for Adult Recreational Users

CTE- Dermal Contact with Soil

CTE- Dermal Contact with Soil

Surface Area for Contact=SA	5,200 cm2/event
Adherence Factor=AF	0.08 mg/cm2
Dermal Absorption Factor=DAF	chemical specific
Exposure Frequency = EF	4 event/yr
Exposure Duration = ED	9 yr
Body Weight = BW	70 kg
Averaging Time (Noncancer) = AT	3,285 days
Averaging Time (Cancer) = AT	25,550 days
Conversion Factor = CF	1.00E-06 kg/mg

Intake (mg/kg-day) = Conc * SA * AF * DAF * EF * ED * CF / (BW * AT)

NCADD = Average Daily Dose - Noncarcinogens

CADD = Average Daily Dose - Carcinogens

HQ = Hazard Quotient, Noncarcinogens = NCADD/ RfD

Risk = Cancer Risk = CADD * SF

Chemical of Potential Concern	EPC (mg/kg)	NCADD (mg/kg-day)	CADD (mg/kg-day)	Dermal RfD (mg/kg-day)	Dermal SF per (mg/kg-day)	HQ	Risk
Arsenic	20.7	1.35E-08	1.74E-09	2.85E-04	1.58E+00	4.74E-05	2.74E-09
Cadmium	NA	--	--	5.00E-05	NA	--	--
Lead	5.987	3.90E-06	5.01E-07	NA	NA	--	--
Cumulative Risk						**4.74E-05**	**2.74E-09**

NA = Not applicable if chemical is not a COPC for the exposure route, or toxicity value is not available

Table A-14. Estimates of Cancer and Noncancer Risks for Adult Recreational Users

RME- Dermal Contact with Soil

RME- Dermal Contact with Soil

Surface Area for Contact=SA	6,900 cm2/event
Adherence Factor=AF	0.08 mg/cm2
Dermal Absorption Factor=DAF	chemical specific
Exposure Frequency = EF	20 event/yr
Exposure Duration = ED	30 yr
Body Weight = BW	70 kg
Averaging Time (Noncancer) = AT	10,950 days
Averaging Time (Cancer) = AT	25,550 days
Conversion Factor = CF	1.00E-06 kg/mg

Intake (mg/kg-day) = Conc * SA * AF * DAF * EF * ED * CF / (BW * AT)

NCADD = Average Daily Dose - Noncarcinogens
CADD = Average Daily Dose - Carcinogens
HQ = Hazard Quotient, Noncarcinogens = NCADD/ RfD
Risk = Cancer Risk = CADD * SF

Chemical of Potential Concern	EPC (mg/kg)	NCADD (mg/kg-day)	CADD (mg/kg-day)	Dermal RfD (mg/kg-day)	Dermal SF per (mg/kg-day)	HQ	Risk
Arsenic	20.7	8.96E-08	3.84E-08	2.85E-04	1.58E+00	3.14E-04	6.06E-08
Cadmium	NA	--	--	5.00E-05	NA	--	--
Lead	5,987	2.59E-05	1.11E-05	NA	NA	--	--
Cumulative Risk						**3.14E-04**	**6.06E-08**

NA = Not applicable if chemical is not a COPC for the exposure route, or toxicity value is not available

Table A-15. Estimates of Cancer and Noncancer Risks for Adult Recreational Users

CTE- Inhalation of Particles from Soil

CTE- Inhalation of Particles from Soil

Inhalation Rate = IR	1.5 m3/hr
Exposure Time = ET	4 hr/day
Exposure Frequency = EF	4 day/yr
Exposure Duration = ED	9 yr
Body Weight = BW	70 kg
Averaging Time (Noncancer) = AT	3285 days
Averaging Time (Cancer) = AT	25550 days

Intake (mg/kg-day) = Conc * IR * ET * EF * ED / (BW * AT)

NCADD = Average Daily Dose - Noncarcinogens
CADD = Average Daily Dose - Carcinogens
HQ = Hazard Quotient, Noncarcinogens = NCADD/ RfD
Risk = Cancer Risk = CADD * SF

Chemical of Potential Concern	EPC (mg/m3)	NCADD (mg/kg-day)	CADD (mg/kg-day)	Inhalation RfD (mg/kg-day)	Inhalation SF per (mg/kg-day)	HQ	Risk
Arsenic	1.57E-08	1.48E-11	1.90E-12	8.60E-06	1.51E+01	1.72E-06	2.86E-11
Cadmium	NA	--	--	5.70E-05	6.30E+00	--	--
Lead	4.54E-06	4.26E-09	5.48E-10	NA	NA	--	--
Cumulative Risk						**1.72E-06**	**2.86E-11**

NA = Not applicable if chemical is not a COPC for the exposure route, or toxicity value is not available

Table A-16. Estimates of Cancer and Noncancer Risks for Adult Recreational Users

RME- Inhalation of Particles from Soil

RME- Inhalation of Particles from Soil

Inhalation Rate = IR	1.5 m3/hr
Exposure Time = ET	4 hr/day
Exposure Frequency = EF	20 day/yr
Exposure Duration = ED	30 yr
Body Weight = BW	70 kg
Averaging Time (Noncancer) = AT	10950 days
Averaging Time (Cancer) = AT	25550 days

Intake (mg/kg-day) = Conc * IR * ET * EF * ED / (BW * AT)

NCADD = Average Daily Dose - Noncarcinogens
CADD = Average Daily Dose - Carcinogens
HQ = Hazard Quotient, Noncarcinogens = NCADD/ RfD
Risk = Cancer Risk = CADD * SF

Chemical of Potential Concern	EPC (mg/L)	NCADD (mg/kg-day)	CADD (mg/kg-day)	Inhalation RfD (mg/kg-day)	Inhalation SF per (mg/kg-day)	HQ	Risk
Arsenic	1.57E-08	7.38E-11	3.16E-11	8.60E-06	1.51E+01	8.58E-06	4.77E-10
Cadmium	NA	--	--	5.70E-05	6.30E+00	--	--
Lead	4.54E-06	2.13E-08	9.13E-09	NA	NA	--	--
Cumulative Risk						**8.58E-06**	**4.77E-10**

NA = Not applicable if chemical is not a COPC for the exposure route, or toxicity value is not available

Table A-17. Estimates of Cancer and Noncancer Risks for Child Recreational Users
CTE - Ingestion of Surface Water

CTE - Ingestion of Surface Water

Ingestion Rate = IR	0.01 L/hr
Exposure Time = ET	0.5 hr/day
Exposure Frequency = EF	4 day/yr
Exposure Duration = ED	2 yr
Body Weight = BW	15 kg
Averaging Time (Noncancer) = AT	730 days
Averaging Time (Cancer) = AT	25,550 days

Intake (mg/kg-day) = Conc * IR * ET * EF * ED / (BW * AT)

NCADD = Average Daily Dose - Noncarcinogens
CADD = Average Daily Dose - Carcinogens
HQ = Hazard Quotient, Noncarcinogens = NCADD/ RfD
Risk = Cancer Risk = CADD * SF

Chemical of Potential Concern	EPC (mg/L)	NCADD (mg/kg-day)	CADD (mg/kg-day)	Chronic Oral RfD (mg/kg-day)	Oral SF per (mg/kg-day)	HQ	Risk
Arsenic	NA	—	—	3.00E-04	1.50E+00	—	—
Cadmium	9.72E-03	3.55E-08	1.01E-09	1.00E-03	NA	3.55E-05	—
Lead	1.22E-02	4.46E-08	1.27E-09	NA	NA	—	—
Cumulative Risk						**3.55E-05**	**0.00E+00**

NA = Not applicable if chemical is not a COPC for the exposure route, or toxicity value is not available

Table A-18. Estimates of Cancer and Noncancer Risks for Child Recreational Users
RME- Ingestion of Surface Water

RME- Ingestion of Surface Water

Ingestion Rate = IR	0.01 L/hr
Exposure Time = ET	1 hr/day
Exposure Frequency = EF	20 day/yr
Exposure Duration = ED	6 yr
Body Weight = BW	15 kg
Averaging Time (Noncancer) = AT	2,190 days
Averaging Time (Cancer) = AT	25,550 days

0

Intake (mg/kg-day) = Conc * IR * ET * EF * ED / (BW * AT)

NCADD = Average Daily Dose - Noncarcinogens
CADD = Average Daily Dose - Carcinogens
HQ = Hazard Quotient, Noncarcinogens = NCADD/ RfD
Risk = Cancer Risk = CADD * SF

Chemical of Potential Concern	EPC (mg/L)	NCADD (mg/kg-day)	CADD (mg/kg-day)	Chronic Oral RfD (mg/kg-day)	Oral SF per (mg/kg-day)	HQ	Risk
Arsenic	NA	--	--	3.00E-04	1.50E+00	--	--
Cadmium	9.72E-03	3.55E-07	3.04E-08	1.00E-03	NA	3.55E-04	--
Lead	1.22E-02	4.46E-07	3.82E-08	NA	NA	--	--
Cumulative Risk						**3.55E-04**	**0.00E+00**

NA = Not applicable if chemical is not a COPC for the exposure route, or toxicity value is not available

Table A-19. Estimates of Cancer and Noncancer Risks for Child Recreational Users

CTE- Dermal Contact with Surface Water

CTE- Dermal Contact with Surface Water

Surface Area Available for Contact = SA	4,500 cm2
Event Time = ET	1 hr/day
Permeability Coefficient = PC	chemical-specific cm/hr
Exposure Frequency = EF	4 day/yr
Exposure Duration = ED	2 yr
Body Weight = BW	15 kg
Averaging Time (Noncancer) = AT	730 days
Averaging Time (Cancer) = AT	25,550 days
Conversion Factor = CF	1.0E-03 L/cm3

Intake (mg/kg-day) = Conc * SA * PC * ET * EF * ED * CF / (BW * AT)

NCADD = Average Daily Dose - Noncarcinogens
CADD = Average Daily Dose - Carcinogens
HQ = Hazard Quotient, Noncarcinogens = NCADD/ RfD
Risk = Cancer Risk = CADD * SF

Chemical of Potential Concern	EPC (mg/L)	NCADD (mg/kg-day)	CADD (mg/kg-day)	Dermal RfD (mg/kg-day)	Dermal SF per (mg/kg-day)	HQ	Risk
Arsenic	NA	--	--	2.85E-04	1.58E+00	--	--
Cadmium	9.72E-03	1.60E-08	4.57E-10	5.00E-05	NA	3.20E-04	--
Lead	1.22E-02	2.01E-08	5.73E-10	NA	NA	--	--
Cumulative Risk						**3.20E-04**	**0.00E+00**

NA = Not applicable if chemical is not a COPC for the exposure route, or toxicity value is not available

Table A-20. Estimates of Cancer and Noncancer Risks for Child Recreational Users
RME- Dermal Contact with Surface Water

RME- Dermal Contact with Surface Water

Surface Area Available for Contact = SA	5,000 cm2
Event Time = ET	1 hr/day
Permeability Coefficient = PC	chemical-specific cm/hr
Exposure Frequency = EF	20 day/yr
Exposure Duration = ED	6 yr
Body Weight = BW	15 kg
Averaging Time (Noncancer) = AT	2,190 days
Averaging Time (Cancer) = AT	25,550 days
Conversion Factor = CF	1.0E-03 L/cm3

Intake (mg/kg-day) = Conc * SA * PC * ET * EF * ED * CF / (BW * AT)

NCADD = Average Daily Dose - Noncarcinogens
CADD = Average Daily Dose - Carcinogens
HQ = Hazard Quotient, Noncarcinogens = NCADD/ RfD
Risk = Cancer Risk = CADD * SF

Chemical of Potential Concern	EPC (mg/L)	NCADD (mg/kg-day)	CADD (mg/kg-day)	Dermal RfD (mg/kg-day)	Dermal SF per (mg/kg-day)	HQ	Risk
Arsenic	NA	–	–	2.85E-04	1.58E+00	–	–
Cadmium	9.72E-03	1.78E-07	1.52E-08	5.00E-05	NA	3.55E-03	–
Lead	1.22E-02	2.23E-07	1.91E-08	NA	NA	–	–
Cumulative Risk						**3.55E-03**	**0.00E+00**

NA = Not applicable if chemical is not a COPC for the exposure route, or toxicity value is not available

Table A-21. Estimates of Cancer and Noncancer Risks for Adult Recreational Users
CTE - Ingestion of Surface Water

CTE - Ingestion of Surface Water

Ingestion Rate = IR	0.01 L/hr
Exposure Time = ET	0.5 hr/day
Exposure Frequency = EF	4 day/yr
Exposure Duration = ED	9 yr
Body Weight = BW	70 kg
Averaging Time (Noncancer) = AT	3,285 days
Averaging Time (Cancer) = AT	25,550 days

Intake (mg/kg-day) = Conc * IR * ET * EF * ED / (BW * AT)

NCADD = Average Daily Dose - Noncarcinogens
CADD = Average Daily Dose - Carcinogens
HQ = Hazard Quotient, Noncarcinogens = NCADD/ RfD
Risk = Cancer Risk = CADD * SF

Chemical of Potential Concern	EPC (mg/L)	NCADD (mg/kg-day)	CADD (mg/kg-day)	Chronic Oral RfD (mg/kg-day)	Oral SF per (mg/kg-day)	HQ	Risk
Arsenic	NA	–	–	3.00E-04	1.50E+00	–	–
Cadmium	9.72E-03	7.61E-09	9.78E-10	1.00E-03	NA	7.61E-06	–
Lead	1.22E-02	9.55E-09	1.23E-09	NA	NA	–	–
Cumulative Risk						**7.61E-06**	**0.00E+00**

NA = Not applicable if chemical is not a COPC for the exposure route, or toxicity value is not available

Table A-22. Estimates of Cancer and Noncancer Risks for Adult Recreational Users
RME - Ingestion of Surface Water

RME - Ingestion of Surface Water

Ingestion Rate = IR	0.01 L/hr
Exposure Time = ET	1 hr/day
Exposure Frequency = EF	20 day/yr
Exposure Duration = ED	30 yr
Body Weight = BW	70 kg
Averaging Time (Noncancer) = AT	10,950 days
Averaging Time (Cancer) = AT	25,550 days

Intake (mg/kg-day) = Conc * IR * ET * EF * ED / (BW * AT)

NCADD = Average Daily Dose - Noncarcinogens
CADD = Average Daily Dose - Carcinogens
HQ = Hazard Quotient, Noncarcinogens = NCADD/ RfD
Risk = Cancer Risk = CADD * SF

Chemical of Potential Concern	EPC (mg/L)	NCADD (mg/kg-day)	CADD (mg/kg-day)	Chronic Oral RfD (mg/kg-day)	Oral SF per (mg/kg-day)	HQ	Risk
Arsenic	NA	--	--	3.00E-04	1.50E+00	--	--
Cadmium	9.72E-03	7.61E-08	3.26E-08	1.00E-03	NA	7.61E-05	--
Lead	1.22E-02	9.55E-08	4.09E-08	NA	NA	--	--
Cumulative Risk						**7.61E-05**	**0.00E+00**

NA = Not applicable if chemical is not a COPC for the exposure route, or toxicity value is not available

Table A-23. Estimates of Cancer and Noncancer Risks for Adult Recreational Users
CTE- Dermal Contact with Surface Water

CTE- Dermal Contact with Surface Water

Surface Area Available for Contact = SA	5,200 cm2
Event Time = ET	1 hr/day
Permeability Coefficient = PC	chemical-specific
Exposure Frequency = EF	4 day/yr
Exposure Duration = ED	9 yr
Body Weight = BW	70 kg
Averaging Time (Noncancer) = AT	3,285 days
Averaging Time (Cancer) = AT	25,550 days
Conversion Factor = CF	1.0E-03 L/cm3

Intake (mg/kg-day) = Conc * SA * PC * ET * EF * ED * CF / (BW * AT)

NCADD = Average Daily Dose - Noncarcinogens
CADD = Average Daily Dose - Carcinogens
HQ = Hazard Quotient, Noncarcinogens = NCADD/ RfD
Risk = Cancer Risk = CADD * SF

Chemical of Potential Concern	EPC (mg/L)	NCADD (mg/kg-day)	CADD (mg/kg-day)	Dermal RfD (mg/kg-day)	Dermal SF per (mg/kg-day)	HQ	Risk
Arsenic	NA	--	--	2.85E-04	1.58E+00	--	--
Cadmium	9.72E-03	3.96E-09	5.09E-10	5.00E-05	NA	7.91E-05	--
Lead	1.22E-02	4.97E-09	6.38E-10	NA	NA	--	--
Cumulative Risk						**7.91E-05**	**0.00E+00**

NA = Not applicable if chemical is not a COPC for the exposure route, or toxicity value is not available

Table A-24. Estimates of Cancer and Noncancer Risks for Adult Recreational Users
RME- Dermal Contact with Surface Water

RME- Dermal Contact with Surface Water

Surface Area Available for Contact = SA	6,900 cm2
Event Time = ET	1 hr/day
Permeability Coefficient = PC	chemical-specific
Exposure Frequency = EF	20 day/yr
Exposure Duration = ED	30 yr
Body Weight = BW	70 kg
Averaging Time (Noncancer) = AT	10,950 days
Averaging Time (Cancer) = AT	25,550 days
Conversion Factor = CF	1.0E-03 L/cm3

Intake (mg/kg-day) = Conc * SA * PC * ET * EF * ED * CF / (BW * AT)

NCADD = Average Daily Dose - Noncarcinogens
CADD = Average Daily Dose - Carcinogens
HQ = Hazard Quotient, Noncarcinogens = NCADD/ RfD
Risk = Cancer Risk = CADD * SF

Chemical of Potential Concern	EPC (mg/L)	NCADD (mg/kg-day)	CADD (mg/kg-day)	Dermal RfD (mg/kg-day)	Dermal SF per (mg/kg-day)	HQ	Risk
Arsenic	NA	–	–	2.85E-04	1.58E+00	–	–
Cadmium	9.72E-03	5.25E-08	2.25E-08	5.00E-05	NA	1.05E-03	–
Lead	1.22E-02	6.59E-08	2.82E-08	NA	NA	–	–
Cumulative Risk						**1.05E-03**	**0.00E+00**

NA = Not applicable if chemical is not a COPC for the exposure route, or toxicity value is not available

Table A-25. Estimates of Cancer and Noncancer Risks for Child Recreational Users
CTE - Incidental Ingestion of Sediment

CTE - Incidental Ingestion of Sediment

Ingestion Rate = IR	25 mg/day
Exposure Frequency = EF	4 day/yr
Exposure Duration = ED	2 yr
Body Weight = BW	15 kg
Averaging Time (Noncancer) = AT	730 days
Averaging Time (Cancer) = AT	25,550 days
Conversion Factor = CF	1.00E-06 kg/g

Intake (mg/kg-day) = Conc * IR * EF * ED *CF / (BW * AT)

NCADD = Average Daily Dose - Noncarcinogens
CADD = Average Daily Dose - Carcinogens
HQ = Hazard Quotient, Noncarcinogens = NCADD/ RfD
Risk = Cancer Risk = CADD * SF

Chemical of Potential Concern	EPC (mg/kg)	NCADD (mg/kg-day)	CADD (mg/kg-day)	Chronic Oral RfD (mg/kg-day)	Oral SF per (mg/kg-day)	HQ	Risk
Arsenic	11.7	2.14E-07	6.13E-09	3.00E-04	1.50E+00	7.15E-04	9.19E-09
Cadmium	NA	--	--	1.00E-03	NA	--	--
Lead	NA	--	--	NA	NA	--	--
Cumulative Risk						**7.15E-04**	**9.19E-09**

NA = Not applicable if chemical is not a COPC for the exposure route, or toxicity value is not available

Table A-26. Estimates of Cancer and Noncancer Risks for Child Recreational Users
RME- Incidental Ingestion of Sediment

RME- Incidental Ingestion of Sediment

Ingestion Rate = IR	100 mg/day
Exposure Frequency = EF	20 day/yr
Exposure Duration = ED	6 yr
Body Weight = BW	15 kg
Averaging Time (Noncancer) = AT	2,190 days
Averaging Time (Cancer) = AT	25,550 days
Conversion Factor = CF	1.00E-06 kg/g

Intake (mg/kg-day) = Conc * IR * EF * ED *CF / (BW * AT)

NCADD = Average Daily Dose - Noncarcinogens
CADD = Average Daily Dose - Carcinogens
HQ = Hazard Quotient, Noncarcinogens = NCADD/ RfD
Risk = Cancer Risk = CADD * SF

Chemical of Potential Concern	EPC (mg/kg)	NCADD (mg/kg-day)	CADD (mg/kg-day)	Chronic Oral RfD (mg/kg-day)	Oral SF per (mg/kg-day)	HQ	Risk
Arsenic	11.7	4.29E-06	3.68E-07	3.00E-04	1.50E+00	1.43E-02	5.51E-07
Cadmium	NA	--	--	1.00E-03	NA	--	--
Lead	NA	--	--	NA	NA	--	--
Cumulative Risk						**1.43E-02**	**5.51E-07**

NA = Not applicable if chemical is not a COPC for the exposure route, or toxicity value is not available

Table A-27. Estimates of Cancer and Noncancer Risks for Child Recreational Users
CTE- Dermal Contact with Sediment

CTE- Dermal Contact with Sediment

Surface Area for Contact=SA	4,500 cm2
Adherence Factor=AF	0.04 mg/cm2
Dermal Absorption Factor=DAF	chemical-specific
Exposure Frequency = EF	4 day/yr
Exposure Duration = ED	2 yr
Body Weight = BW	15 kg
Averaging Time (Noncancer) = AT	730 days
Averaging Time (Cancer) = AT	25,550 days
Conversion Factor = CF	1.00E-06 kg/mg

Intake (mg/kg-day) = Conc * SA * AF * DAF * EF * ED * CF / (BW * AT)

NCADD = Average Daily Dose - Noncarcinogens
CADD = Average Daily Dose - Carcinogens
HQ = Hazard Quotient, Noncarcinogens = NCADD/ RfD
Risk = Cancer Risk = CADD * SF

Chemical of Potential Concern	EPC (mg/kg)	NCADD (mg/kg-day)	CADD (mg/kg-day)	Dermal RfD (mg/kg-day)	Dermal SF per (mg/kg-day)	HQ	Risk
Arsenic	11.7	1.54E-08	4.41E-10	2.85E-04	1.58E+00	5.42E-05	6.96E-10
Cadmium	NA	--	--	5.00E-05	NA	--	--
Lead	NA	--	--	NA	NA	--	--
Cumulative Risk						**5.42E-05**	**6.96E-10**

NA = Not applicable if chemical is not a COPC for the exposure route, or toxicity value is not available

Table A-28. Estimates of Cancer and Noncancer Risks for Child Recreational Users
RME- Dermal Contact with Sediment

RME- Dermal Contact with Sediment

Surface Area for Contact=SA	5,000 cm2
Adherence Factor=AF	0.4 mg/cm2
Dermal Absorption Factor=DAF	chemical-specific
Exposure Frequency = EF	20 day/yr
Exposure Duration = ED	6 yr
Body Weight = BW	15 kg
Averaging Time (Noncancer) = AT	2,190 days
Averaging Time (Cancer) = AT	25,550 days
Conversion Factor = CF	1.00E-06 kg/mg

Intake (mg/kg-day) = Conc * SA * AF * DAF * EF * ED * CF / (BW * AT)

NCADD = Average Daily Dose - Noncarcinogens
CADD = Average Daily Dose - Carcinogens
HQ = Hazard Quotient, Noncarcinogens = NCADD/ RfD
Risk = Cancer Risk = CADD * SF

Chemical of Potential Concern	EPC (mg/kg)	NCADD (mg/kg-day)	CADD (mg/kg-day)	Dermal RfD (mg/kg-day)	Dermal SF per (mg/kg-day)	HQ	Risk
Arsenic	11.7	8.58E-07	7.35E-08	2.85E-04	1.58E+00	3.01E-03	1.16E-07
Cadmium	NA	--	--	5.00E-05	NA	--	--
Lead	NA	--	--	NA	NA	--	--
Cumulative Risk						**3.01E-03**	**1.16E-07**

NA = Not applicable if chemical is not a COPC for the exposure route, or toxicity value is not available

Table A-29. Estimates of Cancer and Noncancer Risks for Adult Recreational Users
CTE - Incidental Ingestion of Sediment

CTE - Incidental Ingestion of Sediment

Ingestion Rate = IR	12 mg/day
Exposure Frequency = EF	4 day/yr
Exposure Duration = ED	9 yr
Body Weight = BW	70 kg
Averaging Time (Noncancer) = AT	3,285 days
Averaging Time (Cancer) = AT	25,550 days
Conversion Factor = CF	1.00E-06 kg/g

Intake (mg/kg-day) = Conc * IR * EF * ED *CF / (BW * AT)

NCADD = Average Daily Dose - Noncarcinogens
CADD = Average Daily Dose - Carcinogens
HQ = Hazard Quotient, Noncarcinogens = NCADD/ RfD
Risk = Cancer Risk = CADD * SF

Chemical of Potential Concern	EPC (mg/kg)	NCADD (mg/kg-day)	CADD (mg/kg-day)	Chronic Oral RfD (mg/kg-day)	Oral SF per (mg/kg-day)	HQ	Risk
Arsenic	11.7	2.21E-08	2.84E-09	3.00E-04	1.50E+00	7.35E-05	4.25E-09
Cadmium	NA	--	--	1.00E-03	NA	--	--
Lead	NA	--	--	NA	NA	--	--
Cumulative Risk						**7.35E-05**	**4.25E-09**

NA = Not applicable if chemical is not a COPC for the exposure route, or toxicity value is not available

Table A-30. Estimates of Cancer and Noncancer Risks for Adult Recreational Users
RME- Incidental Ingestion of Sediment

RME- Incidental Ingestion of Sediment

Ingestion Rate = IR	25 mg/day
Exposure Frequency = EF	20 day/yr
Exposure Duration = ED	30 yr
Body Weight = BW	70 kg
Averaging Time (Noncancer) = AT	10,950 days
Averaging Time (Cancer) = AT	25,550 days
Conversion Factor = CF	1.00E-06 kg/g

Intake (mg/kg-day) = Conc * IR * EF * ED *CF / (BW * AT)

NCADD = Average Daily Dose - Noncarcinogens
CADD = Average Daily Dose - Carcinogens
HQ = Hazard Quotient, Noncarcinogens = NCADD/ RfD
Risk = Cancer Risk = CADD * SF

Chemical of Potential Concern	EPC (mg/kg)	NCADD (mg/kg-day)	CADD (mg/kg-day)	Chronic Oral RfD (mg/kg-day)	Oral SF per (mg/kg-day)	HQ	Risk
Arsenic	11.7	2.30E-07	9.85E-08	3.00E-04	1.50E+00	7.66E-04	1.48E-07
Cadmium	NA	–	–	1.00E-03	NA	–	–
Lead	NA	–	–	NA	NA	–	–
Cumulative Risk						**7.66E-04**	**1.48E-07**

NA = Not applicable if chemical is not a COPC for the exposure route, or toxicity value is not available

Table A-31. Estimates of Cancer and Noncancer Risks for Adult Recreational Users
CTE- Dermal Contact with Sediment

CTE- Dermal Contact with Sediment

Surface Area for Contact=SA	5,200 cm2
Adherence Factor=AF	0.08 mg/cm2
Dermal Absorption Factor=DAF	chemical specific
Exposure Frequency = EF	4 day/yr
Exposure Duration = ED	9 yr
Body Weight = BW	70 kg
Averaging Time (Noncancer) = AT	3,285 days
Averaging Time (Cancer) = AT	25,550 days
Conversion Factor = CF	1.00E-06 kg/mg

Intake (mg/kg-day) = Conc * SA * AF * DAF * EF * ED * CF / (BW * AT)

NCADD = Average Daily Dose - Noncarcinogens
CADD = Average Daily Dose - Carcinogens
HQ = Hazard Quotient, Noncarcinogens = NCADD/ RfD
Risk = Cancer Risk = CADD * SF

Chemical of Potential Concern	EPC (mg/kg)	NCADD (mg/kg-day)	CADD (mg/kg-day)	Dermal RfD (mg/kg-day)	Dermal SF per (mg/kg-day)	HQ	Risk
Arsenic	11.7	7.65E-09	9.83E-10	2.85E-04	1.58E+00	2.68E-05	1.55E-09
Cadmium	NA	--	--	5.00E-05	NA	--	--
Lead	NA	--	--	NA	NA	--	--
Cumulative Risk						**2.68E-05**	**1.55E-09**

NA = Not applicable if chemical is not a COPC for the exposure route, or toxicity value is not available

Table A-32. Estimates of Cancer and Noncancer Risks for Adult Recreational Users
RME- Dermal Contact with Sediment

RME- Dermal Contact with Sediment

Surface Area for Contact=SA	6,900 cm2
Adherence Factor=AF	0.08 mg/cm2
Dermal Absorption Factor=DAF	chemical specific
Exposure Frequency = EF	20 day/yr
Exposure Duration = ED	30 yr
Body Weight = BW	70 kg
Averaging Time (Noncancer) = AT	10,950 days
Averaging Time (Cancer) = AT	25,550 days
Conversion Factor = CF	1.00E-06 kg/mg

Intake (mg/kg-day) = Conc * SA * AF * DAF * EF * ED * CF / (BW * AT)

NCADD = Average Daily Dose - Noncarcinogens
CADD = Average Daily Dose - Carcinogens
HQ = Hazard Quotient, Noncarcinogens = NCADD/ RfD
Risk = Cancer Risk = CADD * SF

Chemical of Potential Concern	EPC (mg/kg)	NCADD (mg/kg-day)	CADD (mg/kg-day)	Dermal RfD (mg/kg-day)	Dermal SF per (mg/kg-day)	HQ	Risk
Arsenic	11.7	5.07E-08	2.17E-08	2.85E-04	1.58E+00	1.78E-04	3.43E-08
Cadmium	NA	–	–	5.00E-05	NA	–	–
Lead	NA	–	–	NA	NA	–	–
Cumulative Risk						**1.78E-04**	**3.43E-08**

NA = Not applicable if chemical is not a COPC for the exposure route, or toxicity value is not available

Table A-33. Air Particulate Modeling

Chemical	C_{soil}	PEF	Fraction Contaminated	C_{air}, Particulate	
	mg/kg	m3/kg	100%	g/cm3	mg/m3
			(ODEQ 1998)		
Arsenic	20.7	1.32E+09	100%	1.57E-17	1.57E-08
Cadmium	NA	1.32E+09	100%	--	NA
Lead	5,987	1.32E+09	100%	4.54E-15	4.54E-06

C_{soil} = Exposure Point Concentration (90UCL) in waste rock soil

PEF = Particulate Emission Factor; default value from ODEQ (1998)

Cair = Csoil/PEF * Fraction contaminated

NA = not a COPC for soil

ATTACHMENT B – PRINTOUTS OF CHILD AND ADULT LEAD MODEL RUNS

Model Results for 20 days per year exposure frequency - child

LEAD MODEL FOR WINDOWS Version 1.0

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Model Version: 1.0 Build 264
User Name:
Date:
Site Name:
Operable Unit:
Run Mode: Research

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The time step used in this model run: 1 - Every 4 Hours (6 times a day).

****** Air ******

Indoor Air Pb Concentration: 30.000 percent of outdoor.
Other Air Parameters:

Age	Time Outdoors (hours)	Ventilation Rate (m^3/day)	Lung Absorption (%)	Outdoor Air Pb Conc (ug Pb/m^3)
.5-1	1.000	2.000	32.000	0.100
1-2	2.000	3.000	32.000	0.100
2-3	3.000	5.000	32.000	0.100
3-4	4.000	5.000	32.000	0.100
4-5	4.000	5.000	32.000	0.100
5-6	4.000	7.000	32.000	0.100
6-7	4.000	7.000	32.000	0.100

****** Diet ******

Age	Diet Intake(ug/day)
.5-1	5.530
1-2	5.780
2-3	6.490
3-4	6.240
4-5	6.010
5-6	6.340
6-7	7.000

****** Drinking Water ******

Water Consumption:

Age	Water (L/day)

.5-1	0.200
1-2	0.500
2-3	0.520
3-4	0.530
4-5	0.550
5-6	0.580
6-7	0.590

Drinking Water Concentration: 4.000 ug Pb/L

****** Soil & Dust ******

Multiple Source Analysis Used
Average multiple source concentration: 320.100 ug/g

Mass fraction of outdoor soil to indoor dust conversion factor: 0.700
Outdoor airborne lead to indoor household dust lead concentration: 100.000
Use alternate indoor dust Pb sources? No

Age	Soil (ug Pb/g)	House Dust (ug Pb/g)
.5-1	443.000	320.100
1-2	443.000	320.100
2-3	443.000	320.100
3-4	443.000	320.100
4-5	443.000	320.100
5-6	443.000	320.100
6-7	443.000	320.100

****** Alternate Intake ******

Age	Alternate (ug Pb/day)
.5-1	0.000
1-2	0.000
2-3	0.000
3-4	0.000
4-5	0.000
5-6	0.000
6-7	0.000

****** Maternal Contribution: Infant Model ******

Maternal Blood Concentration: 2.500 ug Pb/dL

****
CALCULATED BLOOD LEAD AND LEAD UPTAKES:
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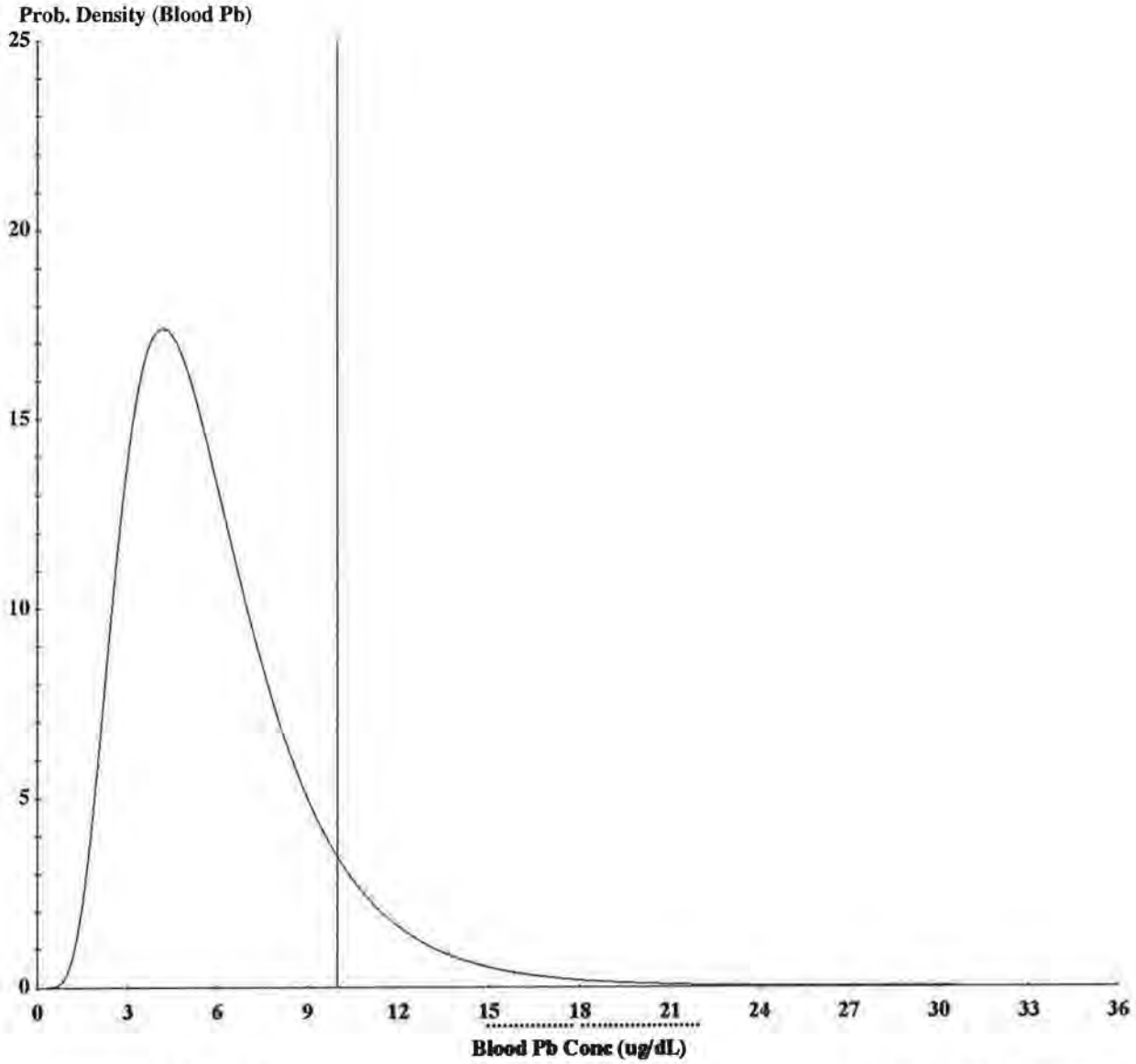
Year	Air (ug/day)	Diet (ug/day)	Alternate (ug/day)	Water (ug/day)
.5-1	0.021	2.430	0.000	0.352
1-2	0.034	2.495	0.000	0.863
2-3	0.062	2.851	0.000	0.914
3-4	0.067	2.791	0.000	0.948
4-5	0.067	2.778	0.000	1.017
5-6	0.093	2.967	0.000	1.086
6-7	0.093	3.296	0.000	1.111

Year	Soil+Dust (ug/day)	Total (ug/day)	Blood (ug/dL)
.5-1	8.413	11.215	6.0
1-2	13.126	16.519	6.8
2-3	13.359	17.186	6.4
3-4	13.599	17.405	6.1
4-5	10.413	14.275	5.1
5-6	9.487	13.634	4.3
6-7	9.015	13.515	3.9



Cutoff = 10.000 ug/dl
Geo Mean = 5.440
GSD = 1.600 %
Above = 9.761 %
Below = 90.239

Age Range = 0 to 84 months
Time Step = Every 4 Hours
Run Mode = Research

Probability Density Curve for 20 Days per Year Exposure Frequency

Adult Lead Model for 20 days per year Exposure Frequency

Calculations of Blood Lead Concentrations (PbBs)

U.S. EPA Technical Review Workgroup for Lead, Adult Lead Committee

Version date 05/19/05

Exposure Variable	Description of Exposure Variable	Units	Region OR Ethnic GSDi and PbBo Data from NHANES III Analysis							
			All/All	All/ White	All/ Black	All/ Mexican	Northe ast/All	Midw est/All	South/ All	West/ All
PbS	Soil lead concentration	µg/g or ppm	4643	4643	4643	4643	4643	4643	4643	4643
$R_{fetal/maternal}$	Fetal/maternal PbB ratio	--	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
BKSF	Biokinetic Slope Factor	µg/dL per µg/day	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
GSD_i	Geometric standard deviation PbB	--	2.1	2.1	2.2	2.3	2.0	2.2	2.1	2.1
PbB_0	Baseline PbB	µg/dL	1.5	1.5	1.8	1.7	2.0	1.5	1.4	1.4
IR_S	Soil ingestion rate (including soil-derived indoor dust)	g/day	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
IR_{S+D}	Total ingestion rate of outdoor soil and indoor dust	g/day	--	--	--	--	--	--	--	--
W_S	Weighting factor; fraction of IR_{S+D} ingested as outdoor soil	--	--	--	--	--	--	--	--	--
K_{SD}	Mass fraction of soil in dust	--	--	--	--	--	--	--	--	--
$AF_{S,D}$	Absorption fraction (same for soil and dust)	--	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
$EF_{S,D}$	Exposure frequency (same for soil and dust)	days/yr	20	20	20	20	20	20	20	20
$AT_{S,D}$	Averaging time (same for soil and dust)	days/yr	365	365	365	365	365	365	365	365
PbB_{adult}	**PbB of adult worker, geometric mean**	**ug/dL**	**2.1**	**2.1**	**2.4**	**2.3**	**2.6**	**2.1**	**2.0**	**2.0**
$PbB_{fetal,0.95}$	95th percentile PbB among fetuses of adult workers	µg/dL	6.6	6.2	7.6	8.1	7.3	6.9	6.0	6.2
PbB_t	Target PbB level of concern (e.g., 10 µg/dL)	µg/dL	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
$P(PbB_{fetal} > PbB_t)$	**Probability that fetal PbB > PbB_t, assuming lognormal distribution**	**%**	**1.4%**	**1.1%**	**2.3%**	**2.9%**	**1.8%**	**1.7%**	**0.9%**	**1.1%**

[1] Equation 1 does not apportion exposure between soil and dust ingestion (excludes W_S, K_{SD}).

When $IR_S = IR_{S+D}$ and $W_S = 1.0$, the equations yield the same $PbB_{fetal,0.95}$.

Model Results for 30 days per year exposure frequency

LEAD MODEL FOR WINDOWS Version 1.0

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Model Version: 1.0 Build 264
User Name:
Date:
Site Name:
Operable Unit:
Run Mode: Research

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The time step used in this model run: 1 - Every 4 Hours (6 times a day).

****** Air ******

Indoor Air Pb Concentration: 30.000 percent of outdoor.
Other Air Parameters:

Age	Time Outdoors (hours)	Ventilation Rate (m^3/day)	Lung Absorption (%)	Outdoor Air Pb Conc (ug Pb/m^3)
.5-1	1.000	2.000	32.000	0.100
1-2	2.000	3.000	32.000	0.100
2-3	3.000	5.000	32.000	0.100
3-4	4.000	5.000	32.000	0.100
4-5	4.000	5.000	32.000	0.100
5-6	4.000	7.000	32.000	0.100
6-7	4.000	7.000	32.000	0.100

****** Diet ******

Age	Diet Intake(ug/day)
.5-1	5.530
1-2	5.780
2-3	6.490
3-4	6.240
4-5	6.010
5-6	6.340
6-7	7.000

****** Drinking Water ******

Water Consumption:

Age	Water (L/day)

.5-1	0.200
1-2	0.500
2-3	0.520
3-4	0.530
4-5	0.550
5-6	0.580
6-7	0.590

Drinking Water Concentration: 4.000 ug Pb/L

****** Soil & Dust ******

Multiple Source Analysis Used
Average multiple source concentration: 405.500 ug/g

Mass fraction of outdoor soil to indoor dust conversion factor: 0.700
Outdoor airborne lead to indoor household dust lead concentration: 100.000
Use alternate indoor dust Pb sources? No

Age	Soil (ug Pb/g)	House Dust (ug Pb/g)
.5-1	565.000	405.500
1-2	565.000	405.500
2-3	565.000	405.500
3-4	565.000	405.500
4-5	565.000	405.500
5-6	565.000	405.500
6-7	565.000	405.500

****** Alternate Intake ******

Age	Alternate (ug Pb/day)
.5-1	0.000
1-2	0.000
2-3	0.000
3-4	0.000
4-5	0.000
5-6	0.000
6-7	0.000

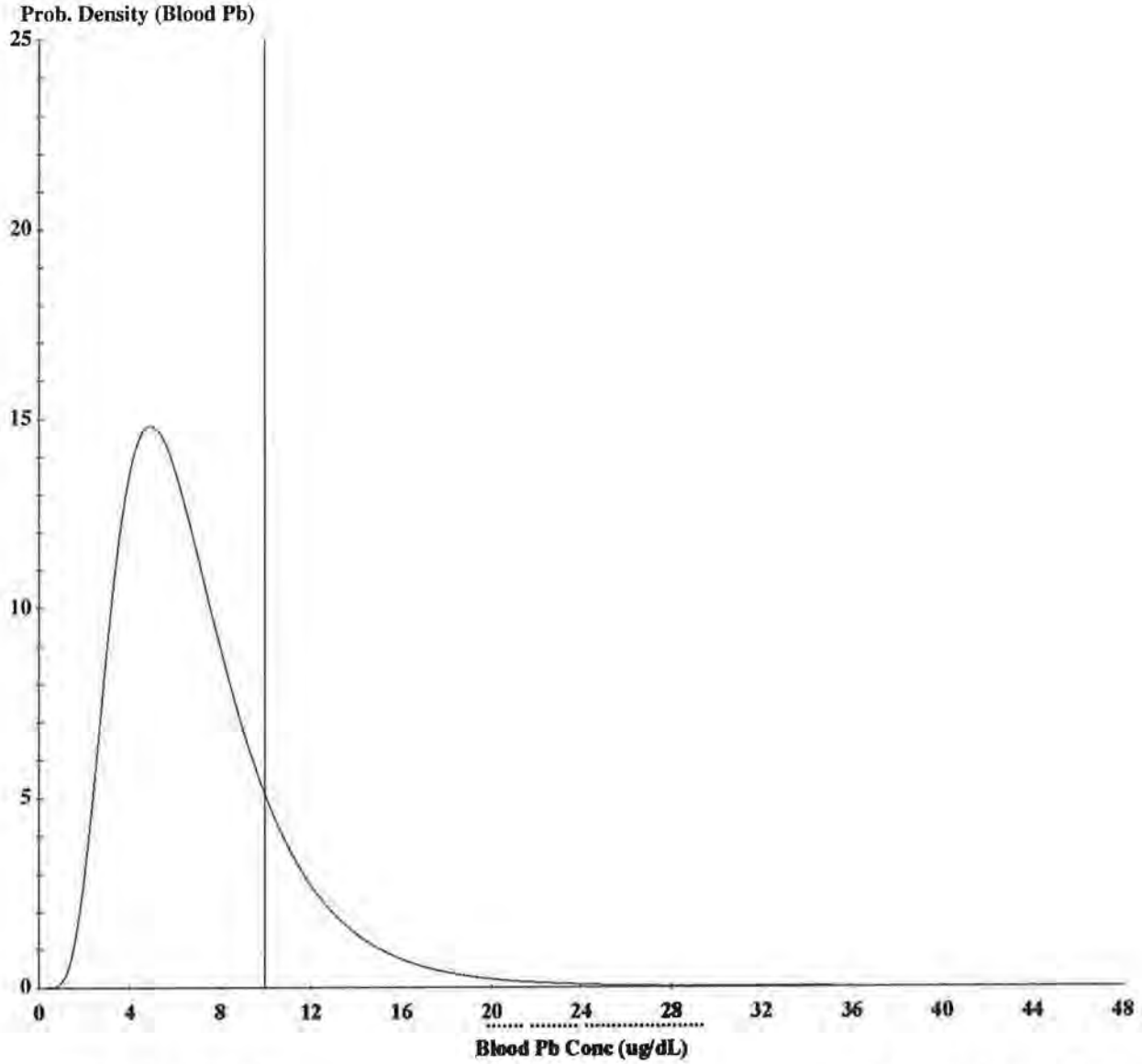
****** Maternal Contribution: Infant Model ******

Maternal Blood Concentration: 2.500 ug Pb/dL

****
CALCULATED BLOOD LEAD AND LEAD UPTAKES:
****

Year	Air (ug/day)	Diet (ug/day)	Alternate (ug/day)	Water (ug/day)
.5-1	0.021	2.374	0.000	0.343
1-2	0.034	2.427	0.000	0.840
2-3	0.062	2.783	0.000	0.892
3-4	0.067	2.732	0.000	0.928
4-5	0.067	2.738	0.000	1.002
5-6	0.093	2.932	0.000	1.073
6-7	0.093	3.262	0.000	1.100

Year	Soil+Dust (ug/day)	Total (ug/day)	Blood (ug/dL)
.5-1	10.448	13.187	7.0
1-2	16.232	19.533	8.0
2-3	16.576	20.313	7.5
3-4	16.923	20.649	7.2
4-5	13.048	16.855	6.0
5-6	11.920	16.018	5.1
6-7	11.343	15.798	4.5



Cutoff = 10.000 ug/dl
Geo Mean = 6.389
GSD = 1.600 %
Above = 17.020 %
Below = 82.980

Age Range = 0 to 84 months
Time Step = Every 4 Hours
Run Mode = Research

Probability Density Curve for 30 Days per Year Exposure Frequency

Model Results for 40 days per year exposure frequency

LEAD MODEL FOR WINDOWS Version 1.0

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Model Version: 1.0 Build 264
User Name:
Date:
Site Name:
Operable Unit:
Run Mode: Research

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The time step used in this model run: 1 - Every 4 Hours (6 times a day).

****** Air ******

Indoor Air Pb Concentration: 30.000 percent of outdoor.
Other Air Parameters:

Age	Time Outdoors (hours)	Ventilation Rate (m^3/day)	Lung Absorption (%)	Outdoor Air Pb Conc (ug Pb/m^3)
.5-1	1.000	2.000	32.000	0.100
1-2	2.000	3.000	32.000	0.100
2-3	3.000	5.000	32.000	0.100
3-4	4.000	5.000	32.000	0.100
4-5	4.000	5.000	32.000	0.100
5-6	4.000	7.000	32.000	0.100
6-7	4.000	7.000	32.000	0.100

****** Diet ******

Age	Diet Intake(ug/day)
.5-1	5.530
1-2	5.780
2-3	6.490
3-4	6.240
4-5	6.010
5-6	6.340
6-7	7.000

****** Drinking Water ******

Water Consumption:

Age	Water (L/day)

.5-1	0.200
1-2	0.500
2-3	0.520
3-4	0.530
4-5	0.550
5-6	0.580
6-7	0.590

Drinking Water Concentration: 4.000 ug Pb/L

****** Soil & Dust ******

Multiple Source Analysis Used
Average multiple source concentration: 490.900 ug/g

Mass fraction of outdoor soil to indoor dust conversion factor: 0.700
Outdoor airborne lead to indoor household dust lead concentration: 100.000
Use alternate indoor dust Pb sources? No

Age	Soil (ug Pb/g)	House Dust (ug Pb/g)
.5-1	687.000	490.900
1-2	687.000	490.900
2-3	687.000	490.900
3-4	687.000	490.900
4-5	687.000	490.900
5-6	687.000	490.900
6-7	687.000	490.900

****** Alternate Intake ******

Age	Alternate (ug Pb/day)
.5-1	0.000
1-2	0.000
2-3	0.000
3-4	0.000
4-5	0.000
5-6	0.000
6-7	0.000

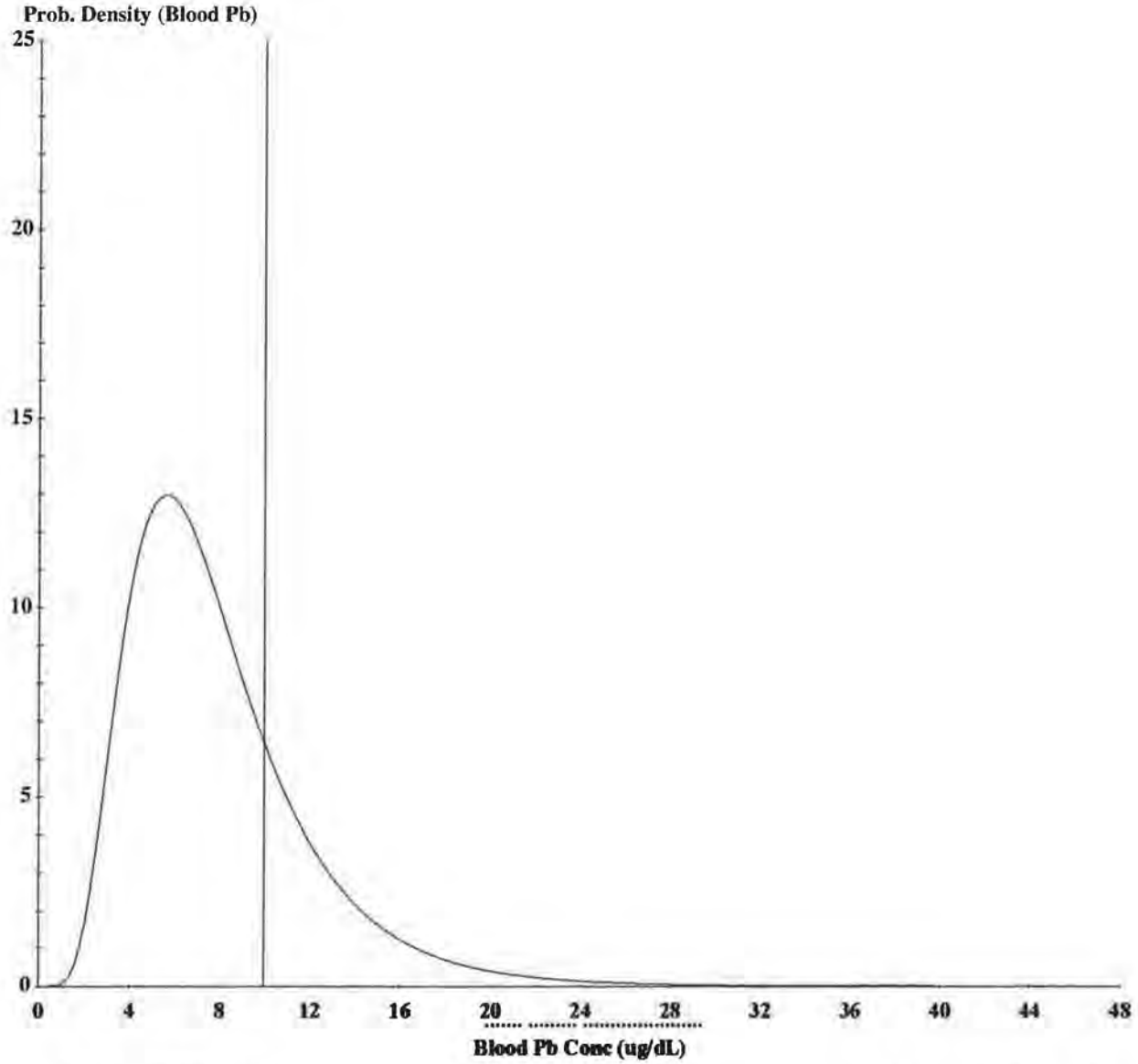
****** Maternal Contribution: Infant Model ******

Maternal Blood Concentration: 2.500 ug Pb/dL

****
CALCULATED BLOOD LEAD AND LEAD UPTAKES:
****

Year	Air (ug/day)	Diet (ug/day)	Alternate (ug/day)	Water (ug/day)
.5-1	0.021	2.321	0.000	0.336
1-2	0.034	2.363	0.000	0.818
2-3	0.062	2.718	0.000	0.871
3-4	0.067	2.676	0.000	0.909
4-5	0.067	2.700	0.000	0.988
5-6	0.093	2.898	0.000	1.061
6-7	0.093	3.229	0.000	1.089

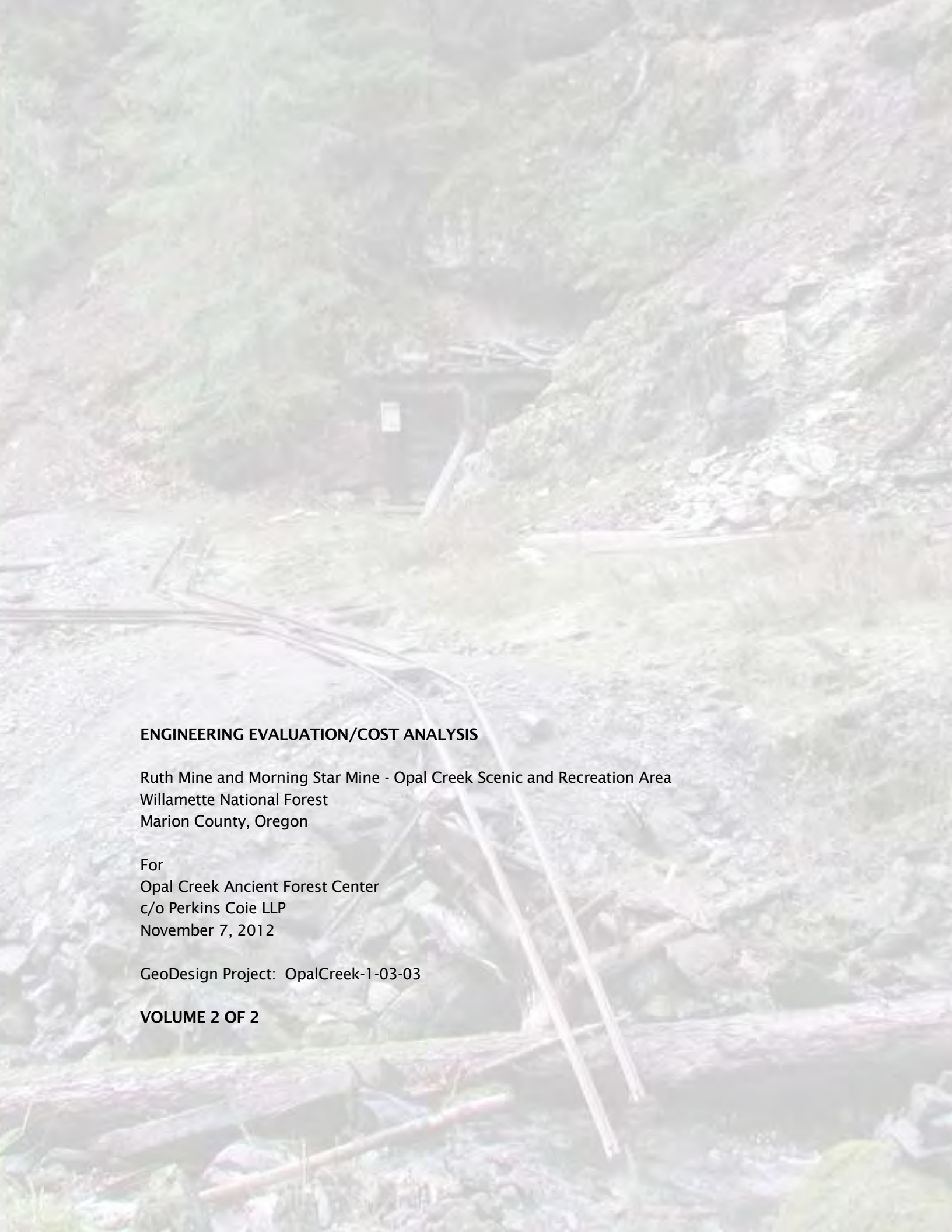
Year	Soil+Dust (ug/day)	Total (ug/day)	Blood (ug/dL)
.5-1	12.396	15.074	8.0
1-2	19.181	22.396	9.1
2-3	19.649	23.301	8.6
3-4	20.114	23.765	8.2
4-5	15.610	19.364	6.8
5-6	14.297	18.349	5.8
6-7	13.624	18.034	5.2



Cutoff = 10.000 ug/dl
Geo Mean = 7.295
GSD = 1.600 %
Above = 25.110 %
Below = 74.890

Age Range = 0 to 84 months
Time Step = Every 4 Hours
Run Mode = Research

Probability Density Curve for 40 Days per Year Exposure Frequency



ENGINEERING EVALUATION/COST ANALYSIS

Ruth Mine and Morning Star Mine - Opal Creek Scenic and Recreation Area
Willamette National Forest
Marion County, Oregon

For
Opal Creek Ancient Forest Center
c/o Perkins Coie LLP
November 7, 2012

GeoDesign Project: OpalCreek-1-03-03

VOLUME 2 OF 2

APPENDIX B

PASCOE environmental consulting

Screening Ecological Risk Assessment

Ruth Mine Site
Willamette National Forest, Oregon

FINAL

December 2009

Prepared for

GeoDesign, Inc.
Portland, Oregon

210 Taylor Street, Room 15 ▲ Port Townsend ▲ WA 98368

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1 INTRODUCTION

A screening-level ecological risk assessment was performed for the Ruth Mine Site, Willamette National Forest, Marion County, Oregon. This document constitutes Appendix B to the Engineering Evaluation/Cost Analysis for the Ruth Mine site (GeoDesign 2009). The ecological risk assessment analyzes the potential for adverse effects to local ecological receptors and communities that may be exposed to chemicals at the mine site. The risk assessment follows Oregon Department of Environmental Quality (ODEQ) guidance on performing a Level II screening ecological risk assessment (ODEQ 2001). In addition, impacts to macroinvertebrate communities in the sediment habitat of Battle Ax Creek are evaluated using the macroinvertebrate bioassessment protocol of the Oregon Plan for Salmon and Watersheds (OPSW 1999). Macroinvertebrate data and their evaluation are presented in Attachment C, and results are integrated into the screening ecological risk assessment following discussions of potential ecological risks related to sediment chemical concentrations. The ecological risk assessment is also consistent with USEPA guidance (1998) on performing screening level ecological risk assessments and with the general report format in USEPA guidance while presenting the information requested in ODEQ guidance for Level II ecological risk assessment.

The components of this assessment consist of the following:

- Description of the ecological elements and habitats of the site.
- Identification of site-specific ecological receptors, potential exposure pathways, and chemicals of interest (COIs).
- Identification of assessment and measurement endpoints for the ecological receptors, and risk-based screening criteria consistent with those endpoints.
- Selection of contaminants of potential ecological concern (CPECs) based on screening against risk-based ecological criteria.
- Description of potential links between the CPECs and ecological receptors at the site.
- Evaluation of macroinvertebrate communities in Battle Ax Creek.
- Evaluation of the potential for site-related ecological risk.

The assessment is considered screening-level because it relies on readily available information for exposure assessment, toxicology of metals, and screening against risk-based criteria. All potential exposures are based on metals data from samples collected of waste rock soils, background soils, surface water in mine adits, and surface water and sediments in Battle Ax Creek and Ruth Creek, which is a tributary that runs through the Ruth Mine site to Battle Ax Creek. The site was visited in November 2005 and again in October 2008 for the collection of sample data. Description of the site ecology is based on publically available information and on the site visit.

2 PROBLEM FORMULATION

The Problem Formulation step presents a description of the site and the ecological habitats, ecological receptors, and contamination. This information is used to construct a conceptual ecological exposure model, which describes the potential exposures of ecological receptors to contaminants of interest (COIs) at the site.

2.1 ECOLOGICAL SETTING

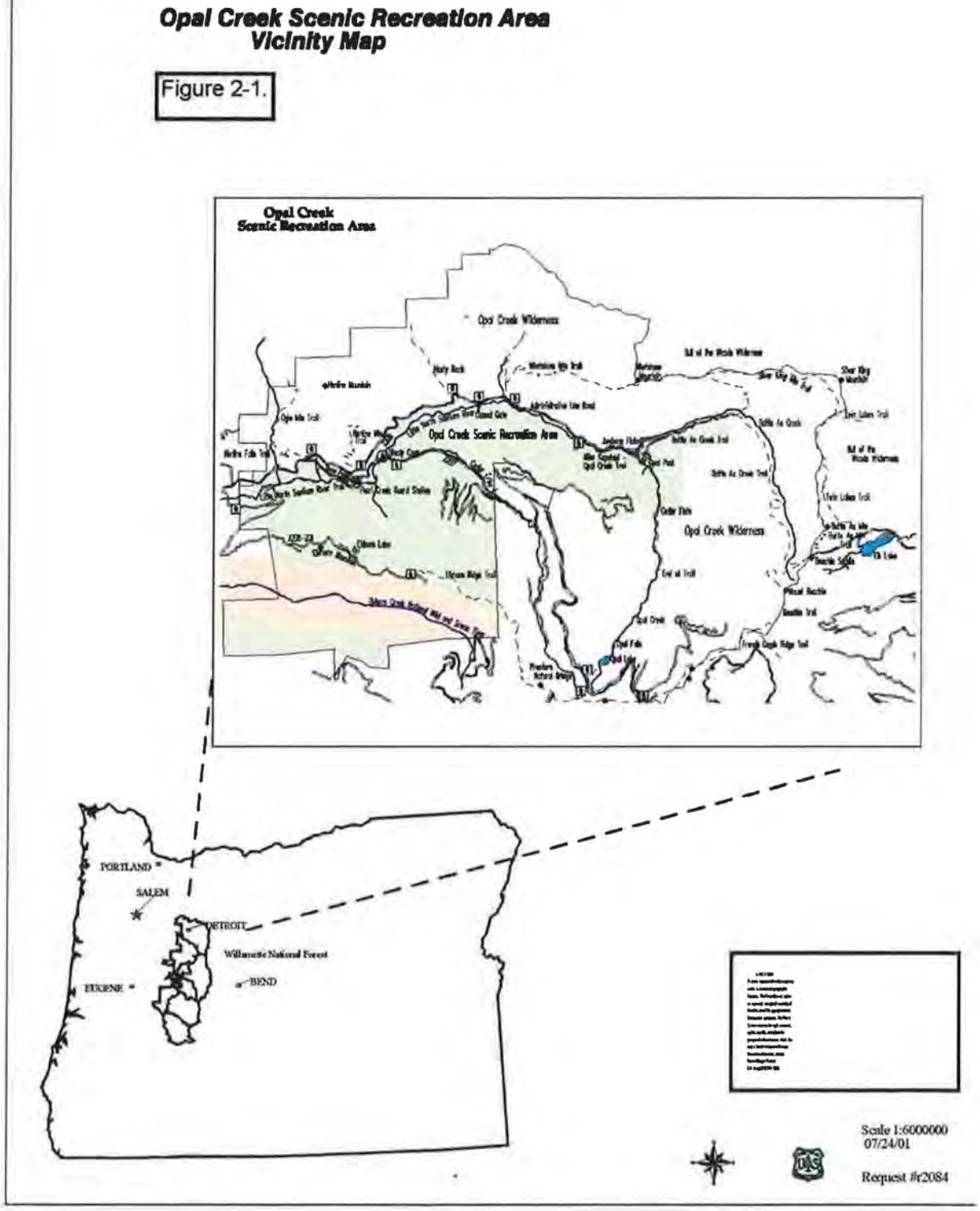
Information on regional and site-specific ecology is summarized to provide an understanding of the environment and the wildlife, fish, plants, invertebrates, and birds that may be exposed at the site. In general, an ecological risk assessment assumes that local species are resident on the site or use the site in sufficient abundance such that exposure to site contaminants could potentially affect the species population. Species populations and communities of populations are the critical ecological components that are evaluated for risks, with the understanding that impacts to individual organisms do not necessarily indicate that populations are at risk.

2.1.1 LOCATION AND GEOLOGY

The Ruth Mine site is located in the Western Cascades in central Oregon (Figure 2-1). The mine site is located in the Battle Ax Creek drainage, which flows west to join with Opal Creek to form the Little North Santiam River, which continues west to the Willamette River valley. The site is located in the Opal Creek Scenic and Recreation Area, adjacent to the Opal Creek Wilderness. Most of the valleys in the higher elevations, including the Battle Ax Creek/Opal Creek valleys, were formed during the last glacial period 15,000 years ago.

The Western Cascades range is composed almost entirely of volcanic rocks, the remnant of a volcanic range that shifted east to form the High Cascades, which forms the present active Cascade volcanic range. The Western Cascades range is a low elevation eroded volcanic range that runs north-south, parallel to the Pacific coast. The Western Cascades receive 60 to 100 inches of precipitation annually which causes deep weathering of geologic features.

Figure 2-1. Location of the Ruth Mine Site



Gold and silver deposits have been found to exist in a 25-30 mile wide, north-south belt in the Western Cascades (Orr et al. 1992). Deposits of lead, zinc, and copper in the forms of galena, sphalerite, and chalcopyrite, in addition to gold and silver, are found in this region. These ores are found in either veins or porphyry deposits formed when fractured areas of volcanic rock were invaded by mineral rich hydrothermal solutions at temperatures of 250 to 350 degrees F.

Weathering processes have deeply eroded the Western Cascades exposing the ore-bearing rocks near the valley floors. The North Santiam mining district, which includes the Ruth Mine site, contains the most rugged terrain of all the five mining districts of the Cascades. Most of the Ruth Mine ore produced lead and zinc, although small amounts of gold and silver were also recovered.

2.1.2 HABITAT

A thorough study of the site ecology is not available. Information on the ecological setting is taken from available sources and observations during the 2005 sampling event. The mine site is located in an old growth hemlock-dominated montane habitat transitioning into a higher elevation Pacific Silver Fir-dominated habitat (Figure 2-2). Typical vegetation in the western hemlock habitat (NPS 1998) consists of western hemlock (*Tsuga heterophylla*), with a mix of Douglas-fir (*Pseudotsuga menziesii*), western red cedar (*Thuja plicata*), and Pacific yew (*Taxus brevifolius*). Undergrowth is characterized by salal, Oregon grape, and shade-tolerant hemlock and red cedar saplings. Open spaces are characterized by red alder (*Alnus rubra*), bigleaf maple (*Acer macrophylum*), and vine maple (*Acer circinatum*). Small mammals in the hemlock-dominant forest typically include Douglas squirrel (*Tamiasciurus douglasii*) and red tree voles (*Phenacomys longicaudus*).

The Opal Creek Ancient Forest Center, located in Jaw Bone Flats in the Opal Creek Scenic Recreation Area, maintains a list of plant, fish, amphibian, mammal, and invertebrate species in the area (http://www.opalcreek.org/eco/all-list.html). The abundance and diversity of fish in Battle Ax Creek are limited, partly due to the fish migration barrier of Salmon Falls on the Little North Santiam River. This barrier is recognized by the Opal Creek Ancient Forest Center (2009) as preventing a diverse fish community, including anadromous salmon species, in Opal Creek and its tributary Battle Ax Creek. US Fish and Wildlife Service identifies the falls as a fish barrier preventing bull trout from migrating to Opal Creek (USWS 2009). Other publications similarly mention a number of natural barriers that prevent salmon and other large fish species from migrating up the Little North Santiam River into Opal Creek (Little 2007).

Threatened and endangered species in the West Cascades are identified by the Oregon Natural Heritage Center (2007). Threatened and endangered species that may be present in the habitat of the Opal Creek area are presented in Table 2-1. Threatened and endangered species include the northern spotted owl, lynx, grey wolf, and two species of salmon.

Identification of chemicals of concern and potential risks related to surface water and sediment exposures addresses threatened and endangered species. For exposures to soil, specific considerations for the presence of threatened and endangered species are included in

the estimation of the potential for ecological risks. For mammals, potential risks from soil exposures are considered for the North American lynx (*Lynx Canadensis*) and gray wolf (*Canis lupus*), and for the northern spotted owl (*Strix occidentalis* caurina). Lynx depend on snowshoe hare (*Lepus americanus*) populations for both survival and reproduction, and tend to favor mid-successional forests that result from wildfires and timber harvesting because of the abundance of hare. Their second preferred prey is red squirrels. Female lynx in the northern Cascades are reported to have a home range of over 9,000 acres (Koehler 1990). Northern spotted owls generally inhabit older forested habitats because they contain the structural characteristics required for nesting, roosting, and foraging (North et al. 1999). Foraging area varies, and depends on density and size of trees and snags, open clearings, and water sources. Specifically, northern spotted owls require a multi-layered, multi-species canopy with moderate to high canopy closure. The stands typically contain a high incidence of trees with large cavities and other types of deformities; large snags (standing dead trees); an abundance of large, dead wood on the ground; and open space within and below the upper canopy for spotted owls to fly. In general, foraging area ranges up to tens of acres, with northern flying squirrels (*Glaucomys sabrinus*) and woodrats (*Neotoma* spp.) the predominant prey. Other prey species such as the red tree vole (*Arborimus longicaudus*), red-backed voles (*Clethrionomys gapperi*), mice, rabbits and hares, birds, and insects may be seasonally or locally important.

Battle Ax Creek provides habitat for aquatic receptors and for organisms that may use the surface water and sediments for foraging. Ruth Creek is smaller in size and flows down a steep gradient, and is intermittent in areas near the waste rock piles. The lack of continuous flow in areas of the creek result in a lack of suitable sediment for biological habitat, and the steep gradient may result in high flows that inhibit deposition or scour deposits.

Figure 2-2. Plant Association Groups at the Ruth Mine Site

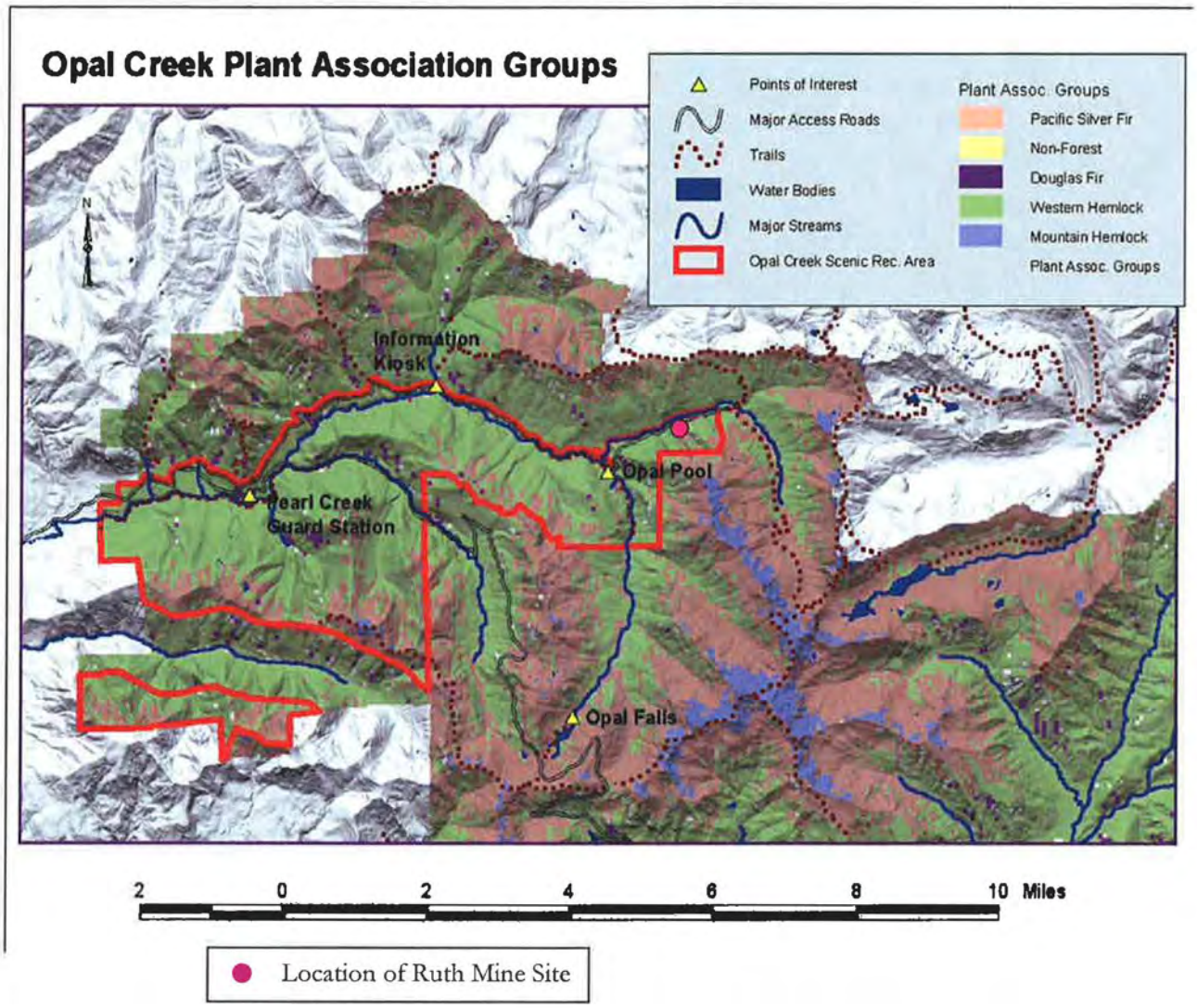


Table 2-1. Threatened and Endangered Species at Opal Creek

AMPHIBIANS			
Common Name	**Scientific Name**	**Federal Status**	**OR State Status**
Salamander, Cascade torrent	Rhyacotriton cascadae		Sensitive
Salamander, Clouded	Aneides ferreus		Sensitive
Salamander, Oregon slender	Batrachoseps wrighti		Sensitive
Frog, Tailed	Ascaphus truei	Species of Concern	Sensitive
Frog, Cascades	Rana cascadae	Species of Concern	Sensitive
Toad, Western	Bufo boreas		Sensitive
BIRDS			
Common Name	**Scientific Name**	**Federal Status**	**OR State Status**
Goshawk, Northern	Accipiter gentilis	Species of Concern	Sensitive
Woodpecker, Black-backed	Picoides arcticus		Sensitive
Nighthawk, Common	Chordeiles minor		Sensitive
Duck, Harlequin	Histrionicus histrionicus	Species of Concern	Sensitive
Quail, Mountain	Oreortyx pictus		Sensitive
Owl, Northern pygmy	Glaucidium gnoma		Sensitive
Owl, Northern spotted	Strix occidentalis caurina	Threatened	Threatened
Woodpecker, Pileated	Dryocopus pileatus		Sensitive
Bluebird, Western	Sialia mexicana		Sensitive
MAMMALS			
Common Name	**Scientific Name**	**Federal Status**	**OR State Status**
Marten, American	Martes americana		Sensitive
Long-eared Bat	Myotis evotis	Species of Concern	Sensitive
Lynx, North American	Lynx canadensis	Threatened	
Wolf, Gray	Canis lupus	Endangered	Endangered
Wolverine	Gulo gulo	Species of Concern	Threatened
FISH			
Common Name	**Scientific Name**	**Federal Status**	**OR State Status**
Salmon, Chinook	Oncorhynchus tshawytscha	Endangered & Threatened	Threatened
Salmon, Steelhead	Oncorhynchus mykiss	Endangered & Threatened	
Trout, Westslope cutthroat	Oncorhynchus clarki lewisi	Species of Concern	
PLANTS			
No plants on the Opal Creek list were found on the Federal or Oregon T&E list			

Lists of species observed at Opal Creek Ancient Forest Center were matched with the federal and Oregon T&E lists.

Sources:

Threatened and Endangered Species List: http://www.pacificbio.org/ESIN/Infopages/Oregonlist.html

Species List for Opal Creek: http://www.opalcreek.org/eco/all-list.html

2.2 CONTAMINANTS OF INTEREST (COI)

Chemicals that may adversely affect ecological receptors, including populations of individual organisms and communities, are defined as chemical stressors on the environment. Stressors may also be biological, such as pathogens, or physical. Physical stressors at the mine site include alterations in the habitat such as mine and road construction, waste rock accumulation, removal of canopy cover, stream diversions and bed alterations, and physical blockages to fish movement. Physical barriers to fish movement are present in the Upper North Santiam River, and may impact fish populations in Battle Ax Creek. This risk assessment does not evaluate risk of impacts to ecological receptors due to biological or physical stressors.

The COIs are identified as those metals that were analyzed and detected in environmental media at the site:

- Aluminum
- Antimony
- Arsenic
- Barium
- Beryllium
- Cadmium
- Calcium
- Chromium
- Cobalt
- Copper
- Iron
- Lead
- Magnesium
- Manganese
- Mercury
- Nickel
- Potassium
- Selenium
- Silver
- Sodium
- Thallium
- Vanadium
- Zinc.

2.3 CONCEPTUAL ECOLOGICAL EXPOSURE MODEL

The conceptual ecological exposure model (CEEM) depicts the sources of contamination, contaminant release and possible transport mechanisms, impacted exposure media, and exposure routes for ecological receptors at the site. A graphical presentation of the CEEM is presented in Figure 2-3.

2.3.1 SOURCES OF CONTAMINATION

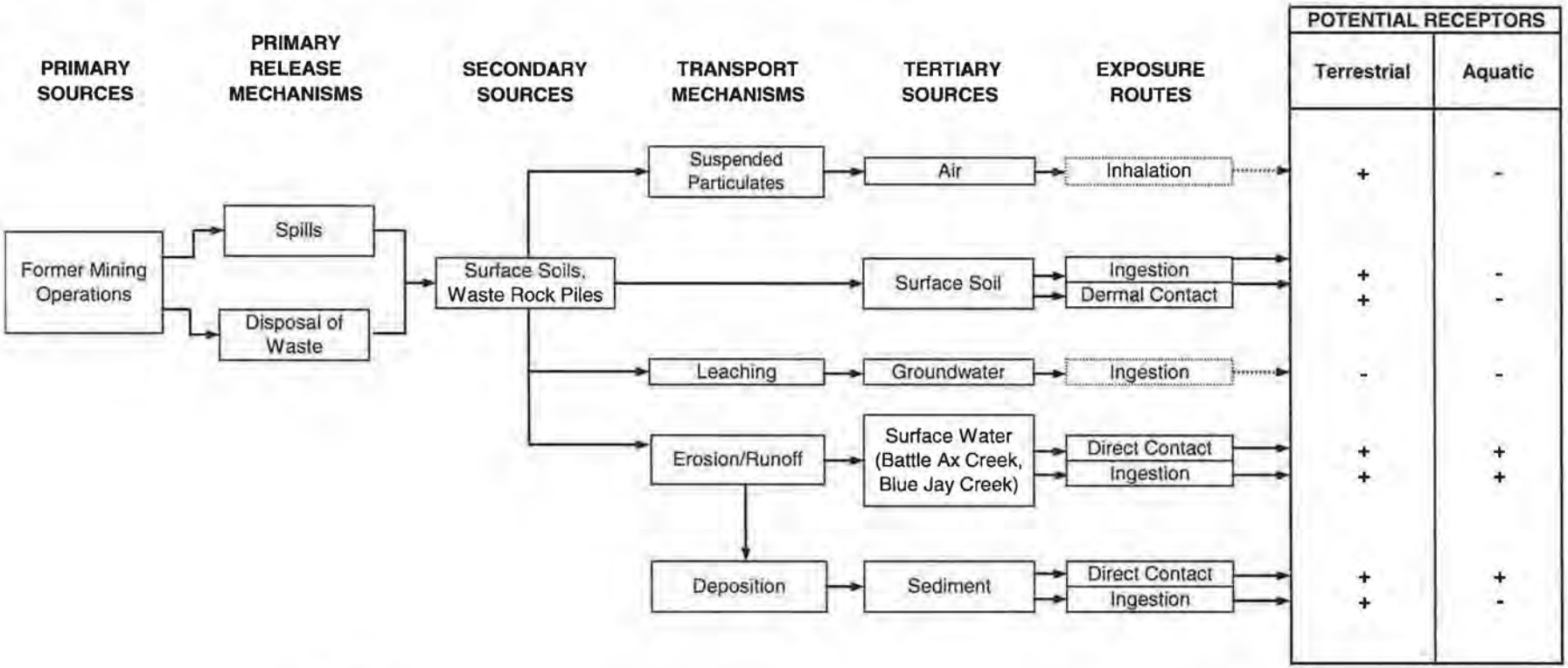
The primary sources of contamination at the site are historical mining activities related to operations of the Ruth Mine. Ore was brought up from mines, with the adits located near access roads and serving as the primary source of ore wastes, processed to some extent at the site, and waste rock was deposited in and adjacent to the ravine of Ruth Creek below adit 4 and around adit 5, including in the bed and bank of the access road to adit 5 above Battle Ax Creek.

Waste rock from mine activities is present in Ruth Creek, which runs from adit 4 to Battle Ax Creek. Deposits in Ruth Creek may have contributed sedimentary material that washed into Battle Ax Creek. Ruth Creek water may have leached metals from the waste rock into surface water and transported dissolved metals to Battle Ax Creek. Waste rock in the vicinity of adit 5 may also have contributed sedimentary material to Battle Ax Creek. Over time, rain and snow melt may have transported dissolved metals or waste rock particles down the Ruth Creek ravine to Battle Ax Creek, or served as a source of runoff from the area around adit 5. Once in the creeks, contaminated sedimentary particles may deposit or transport downstream. Dissolved metals in the surface water may bind to particulates and deposit in the creek or transport downstream.

2.3.2 ECOLOGICAL RECEPTORS AND EXPOSURE PATHWAYS

Based on the habitat types at the Ruth Mine site, expected wildlife in that habitat, and the species of wildlife that have been observed at the Opal Creek Ancient Forest Center, ecological receptors of potential concern and their possible site-related exposures are identified in Table 2-2.

Figure 2-3. Conceptual Ecological Exposure Model for the Ruth Mine Site



Notes:

+ Complete and potentially significant exposure
- Insignificant or incomplete exposure pathway or medium

Table 2-2. Ecological Receptors of Concern and Exposures

Ecological Receptor of Concern	Exposure Media and Pathway
Small mammals	Direct exposure to COIs in waste rock soils, surface water, sediments
	Ingestion of COIs in surface water
	Ingestion of COIs in waste rock soil is considered unlikely since the locations are primarily on existing access road bed or in piles of hard rock and not suitable habitat for small mammals nesting or burrowing.
Terrestrial forbs and grasses	Direct contact and root uptake of waste rock COIs is considered a marginal possibility since most of the waste rock is located on existing access road bed or in piles of hard rock and not suitable habitat for most plants.
Terrestrial trees and shrubs	Root uptake of COIs in waste rock soil may be considered an exposure pathway for trees located near the road bed.
Terrestrial invertebrates	Direct exposure to waste rock soil is considered not of ecological significance since the road bed and hard rock piles are not ideal habitat for soil invertebrates.
Wildlife (birds, mammals)	Birds and mammals may be exposed to COIs in waste rock soil through direct contact, and to COIs in surface water through ingestion. However, because of the extensive habitat in the surrounding landscape for birds and large mammals, the relatively limited amount of site soil habitat that is impacted by waste rock is considered to contribute negligible exposures to wildlife.
	Birds and large mammals may be exposed to bioaccumulative COIs through the ingestion of contaminated food sources, such as plants, invertebrates, or small mammals at the site.
Amphibians	Direct contact with COIs in surface water is considered a likely exposure pathway for Battle Ax Creek. Most of Ruth Creek is not considered suitable aquatic habitat due to the steep gradient, high flow rate, intermittent flows, and apparent lack of organic material in much of the sediment that would provide substrate for adequate food sources.
Fish	Fish may be exposed to COIs in surface water and sediment of Battle Ax Creek. Fish barriers are present that prevent fish migration; rainbow trout may be present. Ruth Creek is not considered suitable habitat for fish due to the steep gradient, high flow rate, and intermittent flows.
Aquatic invertebrates (benthic and water column)	Aquatic invertebrates may be exposed to COIs in surface water and sediment of Battle Ax Creek. Most of Ruth Creek is not considered suitable aquatic habitat due to the steep gradient, high flow rate, intermittent flows, and apparent lack of organic material in much of the sediment.

3 ASSESSMENT ENDPOINTS AND MEASURES OF EFFECT

Assessment endpoints are defined as the explicit expression of an ecological value deemed important to protect, operationally defined by a receptor and one or more of that receptor's measurable attributes (ODEQ 2001). Assessment endpoints link the ecological risk assessment and risk management by highlighting ecological processes that are important to risk managers. Unless an ecological receptor is listed as a Threatened and Endangered (T&E) species, assessment endpoints are selected that are relevant to population-level rather than individual effects. For T&E species, risks to individuals are important to the evaluation.

Assessment endpoints are listed for each receptor of concern in Table 3-1, along with measures of effects and exposures used in the risk assessment. Survival, growth, and reproduction are the key endpoints for ecological receptors in this assessment. Measures of effect and exposure for the screening level II ecological risk assessment under ODEQ (2001) guidelines consist of comparison of the exposure concentrations in various environmental media with the appropriate screening level value (SLV). The SLVs are intended to be protective of the key assessment endpoints. For chemicals for which SLVs are unavailable, surrogate risk-based screening criteria were identified. Ecological receptors, the assessment endpoints, and the environmental media and appropriate SLV types are identified in Table 3-1.

Table 3-1. Assessment Endpoints and Measures of Effect and Exposure

Ecological Receptor of Concern	Assessment Endpoint	Measures of Effect and Exposure
Small mammals	Survival, growth, reproduction	Comparison of waste rock soil exposure concentrations to soil screening criteria for mammals[a]
Terrestrial forbs and grasses	Survival, growth, development	Comparison of waste rock soil exposure concentrations to soil screening criteria for plants
Terrestrial trees and shrubs	Survival, growth, development	Comparison of waste rock soil exposure concentrations to soil screening criteria for plants
Terrestrial invertebrates	Survival, growth, reproduction	Comparison of waste rock soil exposure concentrations to soil screening criteria for invertebrates
Wildlife (birds, large mammals)	Survival, growth, reproduction	Comparison of waste rock soil exposure concentrations to soil screening criteria for birds and mammals Comparison of surface water exposure concentrations to surface water screening criteria for birds and mammals Comparison of sediment exposure concentrations to sediment screening criteria for bioaccumulation in

Ecological Receptor of Concern	Assessment Endpoint	Measures of Effect and Exposure
		wildlife
Amphibians	Survival, growth, reproduction	Comparison of surface water exposure concentrations to surface water screening criteria for aquatic organisms
Fish	Survival, growth, reproduction	Comparison of surface water exposure concentrations to surface water screening criteria for aquatic organisms
Aquatic invertebrates (benthic and water column)	Survival, growth, reproduction	Comparison of surface water exposure concentrations to surface water screening criteria for aquatic organisms Comparison of sediment exposure concentrations to sediment screening criteria for benthic organisms

a. Screening criteria are the SLVs provided by ODEQ (2001).

4 IDENTIFICATION OF CONTAMINANTS OF POTENTIAL ECOLOGICAL CONCERN

Contaminants of potential ecological concern (CPECs) are identified by screening of COIs on the basis of physiochemical properties and their toxicity and bioaccumulation potential (ODEQ 2001). The screening based on physiochemical properties of a COI is performed by consideration of frequency of detection and background concentrations. Screening does not include whether the COI is an essential nutrient.

4.1 INITIAL SCREENING

4.1.1 FREQUENCY OF DETECTION

COIs in each environmental medium were first screened on the basis of frequency of detection. If COIs were not detected above a frequency of five percent, they can be eliminated as a CPEC (ODEQ 2001). Data showing detected concentrations of COIs in each sample in waste rock soils, surface waters, and sediment at the Ruth Mine site are presented in Attachment B. Soil samples consist of waste rock soils in the vicinity of adits 4 and 5 and from the road bed near adit 5. Surface water and sediment samples consisted of the surface waters from adits 4 & 5, and surface water and sediment samples from stations in Ruth Creek and in Battle Ax Creek immediately downstream of the confluence with Ruth Creek. Surface water and sediment data from Battle Ax Creek stations located upstream of the confluence with Ruth Creek were not used in this screen.

Results of the frequency screen are shown in Table 4-1. COIs that were screened out from further evaluation for waste rock soils on the basis of detection frequency consist of beryllium, thallium, and hexavalent chromium. In surface water, all but barium, cadmium, calcium, chromium, copper, iron, lead, magnesium, manganese, potassium, sodium, and zinc were eliminated from further consideration based on lack of detection in any surface water sample, which included the adit waters, Ruth Creek surface water, and surface water of Battle Ax Creek. In sediment, antimony, beryllium, mercury, selenium, and thallium were never detected in any of the samples, including Ruth Creek and Battle Ax Creek sediments.

Table 4-1. Screening of COIs for Detection Frequency

Chemical of Interest (COI)	Frequency of Detection		
	Waste Rock Soil	Surface Water	Sediment
Aluminum	21/21	0/3	3/3
Antimony	13/21	0/3	0/3
Arsenic	31/31	0/11	8/8
Barium	31/31	3/11	8/8
Beryllium	0/21	0/3	0/3
Cadmium	31/31	2/11	5/8
Calcium	21/21	3/3	3/3
Chromium	31/31	1/11	8/8
Cobalt	21/21	0/3	3/3
Copper	31/31	2/11	8/8
Iron	31/31	5/11	8/8
Lead	31/31	5/11	8/8
Magnesium	21/21	3/3	3/3
Manganese	31/31	4/11	8/8
Mercury	27/31	0/11	0/8
Nickel	31/31	0/11	8/8
Potassium	21/21	2/3	3/3
Selenium	24/31	0/11	0/8
Silver	26/31	0/11	1/8
Sodium	5/21	3/3	3/3
Thallium	0/21	0/3	0/3
Vanadium	21/21	0/3	3/3
Zinc	31/31	11/11	8/8
Hex Chromium	0/10	---	---

Surface water stations = All surface water data from adits 4 and 5, Ruth Creek, and Battle Ax Creek immediately downstream of confluence
Sediment stations = All sediment data from Ruth Creek and Battle Ax Creek immediately downstream of confluence

4.1.2 BACKGROUND CONCENTRATION SCREENING

Following the screen for frequency of detection, COIs were screened against background concentrations. Background concentrations are set at the 95UCL of the mean concentration of background samples, and the maximum concentration in site soil is compared to this background value, as per ODEQ (2001) guidance. Chemicals with maximum concentrations exceeding the 95 UCL of background samples were retained as CPECs for further evaluation.

Background concentrations were identified for COIs in soils, surface water, and sediment. For soils, background concentrations were determined using data from 20 samples, labeled BG-1 through BG-20 in Table B-1 of Attachment B, which were collected from locations around both the Ruth Mine site and the Morning Star Mine site that were not impacted by mining-related activities. Locations of the background soil samples can be found in the

EE/CA report for the Ruth Mine site. Data and 95 UCL concentrations for the background soil screen are presented in Table B-1, Attachment B, with results of the screen presented below in Table 4-2. Note that although the maximum waste rock soil concentrations of barium and vanadium exceed their 95 UCL background concentrations, the 95 UCLs and ranges of values for these COIs in waste rock soils do not exceed those of background samples, suggesting that barium and vanadium concentrations in waste rock soil are not elevated, and they are not selected as CPECs in soil.

Table 4-2. Waste Rock Comparison to Soils Background

Chemical of Interest (COI)	Background (95UCL mg/kg)	Maximum Waste Rock (mg/kg)	95 UCL Waste Rock (mg/kg)	Detected > 5% and Exceeds Background?
Aluminum	39,635	43,000	33,169	No
Antimony	1.50	1.89	1.538	**Yes**
Arsenic	9.35	46.2	21.38	**Yes**
Barium	82.1	124	55.96	No
Beryllium	---	ND	---	No
Cadmium	16.8	422	139.5	**Yes**
Calcium	2,246	38,500	20,979	**Yes**
Chromium	22.8	37.6	29.21	**Yes**
Cobalt	11.5	34.2	24.73	**Yes**
Copper	256	7,600	2,791	**Yes**
Iron	31,706	94,600	60,562	**Yes**
Lead	914	34,000	6,438	**Yes**
Magnesium	5,437	18,000	14,582	**Yes**
Manganese	3,282	15,900	7,957	**Yes**
Mercury	0.12	1.87	0.503	**Yes**
Nickel	22.4	40.6	27.26	**Yes**
Potassium	1,128	6,770	3,827	**Yes**
Selenium	1.55	16.5	5	**Yes**
Silver	3.47	28.6	11	**Yes**
Sodium	200.5	184	148.4	No
Thallium	---	ND	---	No
Vanadium	77.7	80.7	53.52	No
Zinc	13,960	98,900	32,756	**Yes**
Hex Chromium	<1.27	<1.17	---	No

Soil background samples = BG1 through BG20
--- = not calculable due to lack of detections

Sets of background samples were collected for surface water and sediment for the Ruth Mine site. Background surface water and sediment samples were collected in Battle Ax Creek upstream of its confluence with Blue Jay Creek. These sample stations were identified as locations that are not impacted by discharges from the Morning Star Mine site that is located upstream of the Ruth Mine drainage, or from other mining activities. Locations of the surface water and sediment samples are shown in Figure 4-1. Background surface water stations are identified as SW-8, SW-MS-14, SW-MS-15, and SW-MS-16. Background sediment stations

are identified as SED-MS-14, SED-MS-15, and SED-MS-16. Surface water and sediment data and 95 UCL concentrations are presented in Tables B-2 and B-3 of Attachment B.

Comparison of surface water maximum concentrations of COIs passing the detection frequency screen with the background 95UCL concentrations identified barium, cadmium, calcium, chromium, copper, iron, lead, manganese, sodium, and zinc as exceeding background for surface water (Table 4-3). In addition, separate comparisons were made for metals detected in Battle Ax Creek alone, where maximum concentrations of barium, calcium, chromium, iron, lead, manganese, sodium, and zinc were found to exceed upstream background (Table 4-4).

For sediment in Battle Ax Creek and Ruth Creek, the screen against background identified aluminum, arsenic, cadmium, calcium, cobalt, copper, iron, lead, magnesium, manganese, nickel, potassium, sodium, vanadium, and zinc as exceeding background (Table 4-5). Although maximum concentrations of barium and chromium in site-related samples slightly exceeded the maximum concentrations in upstream background sediments, the 90 UCL concentrations were substantially lower than maximum concentrations in upstream sediments, suggesting that barium and chromium are not elevated in Battle Ax Creek. Barium and chromium were not selected as CPECs for sediment.

Table 4-6 summarizes the chemicals that pass the detection frequency and background comparison screens for soils, surface water, and sediment at the Ruth Mine site.

Figure 4-1. Locations of Surface Water and Sediment Samples

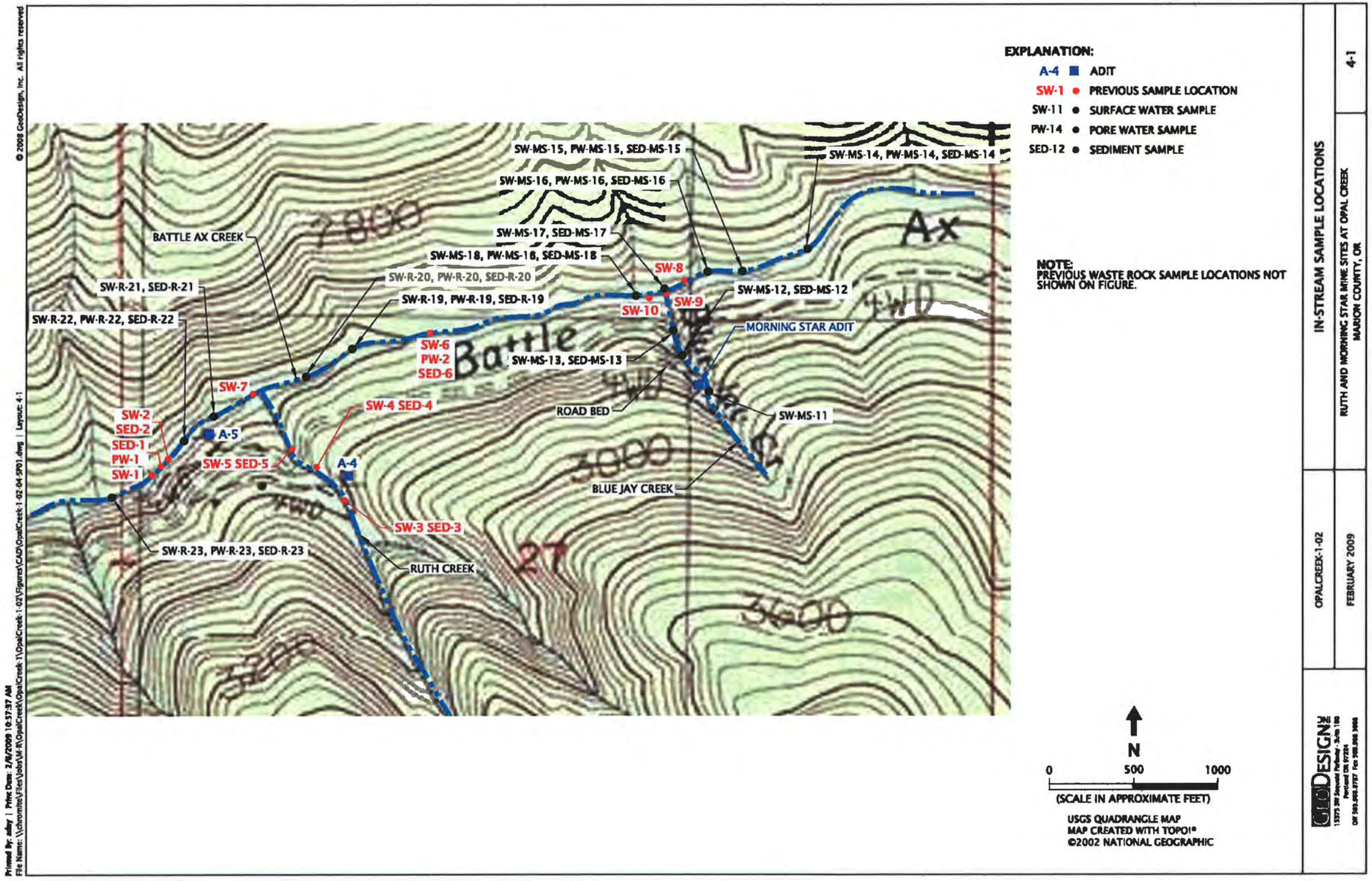


Table 4-3. Site-Related Surface Water Comparison to Upstream Background

Chemical of Interest (COI)	Maximum Upstream (mg/L)	Maximum Site-Related (mg/L)	Detected > 5% and Exceeds Background?
Aluminum	ND<0.1	ND<0.1	No
Antimony	ND<0.001	ND<0.001	No
Arsenic	ND<0.001	ND<0.001	No
Barium	ND<0.001	0.0069	**Yes**
Beryllium	ND<0.001	ND<0.001	No
Cadmium	ND<0.001	0.0221	**Yes**
Calcium	4.05	4.12	**Yes**
Chromium	ND<0.001	0.0011	**Yes**
Cobalt	ND<0.002	ND<0.002	No
Copper	ND<0.004	0.0148	**Yes**
Iron	ND<0.1	0.0739	**Yes**
Lead	ND<0.001	0.0377	**Yes**
Magnesium	0.48	0.48	No
Manganese	ND<0.001	0.0309	**Yes**
Mercury	ND<0.0001	ND<0.001	No
Nickel	ND<0.001	ND<0.001	No
Potassium	0.117	0.108	No
Selenium	ND<0.001	ND<0.001	No
Silver	ND<0.002	ND<0.002	No
Sodium	1.32	1.39	**Yes**
Thallium	ND<0.001	ND<0.001	No
Vanadium	ND<0.002	ND<0.002	No
Zinc	0.011	3.08	**Yes**

Upstream background = Battle Ax Creek upstream of confluence with Blue Jay Creek (n=3-4)

Site-Related = Adits 4 & 5, Ruth Creek, and Battle Ax Creek at and immediately downstream of confluence (n=3-11)

Table 4-4. Battle Ax Creek Surface Water Comparison to Upstream Background

Chemical of Interest (COI)	Maximum Upstream Background (mg/L)	Maximum Downstream Battle Ax Creek (mg/L)	Detected > 5% and Exceeds Upstream?
Aluminum	ND<0.1	ND<0.1	No
Antimony	ND<0.001	ND<0.001	No
Arsenic	ND<0.001	ND<0.001	No
Barium	ND<0.001	0.0010	**Yes**
Beryllium	ND<0.001	ND<0.001	No
Cadmium	ND<0.001	ND<0.001	No
Calcium	4.05	4.12	**Yes**
Chromium	ND<0.001	0.0011	**Yes**
Cobalt	ND<0.002	ND<0.002	No
Copper	ND<0.004	ND<0.004	No
Iron	ND<0.1	0.0258	**Yes**
Lead	ND<0.001	0.0030	**Yes**

Chemical of Interest (COI)	Maximum Upstream Background (mg/L)	Maximum Downstream Battle Ax Creek (mg/L)	Detected > 5% and Exceeds Upstream?
Magnesium	0.483	0.480	No
Manganese	ND<0.001	0.0014	**Yes**
Mercury	ND<0.0001	ND<0.001	No
Nickel	ND<0.001	ND<0.001	No
Potassium	0.117	0.108	No
Selenium	ND<0.001	ND<0.001	No
Silver	ND<0.002	ND<0.002	No
Sodium	1.32	1.39	**Yes**
Thallium	ND<0.001	ND<0.001	No
Vanadium	ND<0.002	ND<0.002	No
Zinc	0.011	0.019	**Yes**

Upstream background = Battle Ax Creek upstream of confluence with Blue Jay Creek (n=3-4)

Downstream = Battle Ax Creek samples at and immediately downstream of confluence with Ruth Creek (n=3)

Table 4-5. Site-Related Sediment Comparison to Background

Chemical of Interest (COI)	Background Upstream of Blue Jay Creek (maximum, mg/kg)	Site-Related Maximum (mg/kg)	Site-Related 90UCL (mg/kg)	Detected > 5% and Exceeds Upstream?
Aluminum	24,100	30,100	30,080	**Yes**
Antimony	ND<1.32	ND<1.43	--	No
Arsenic	1.42	15.7	11.7	**Yes**
Barium	51.6	59.2	43.3	No
Beryllium	ND<2.63	ND<2.86	--	No
Cadmium	ND<1.32	5.59	2.44	**Yes**
Calcium	7,490	8,700	8,700	**Yes**
Chromium	22.3	22.6	17.5	No
Cobalt	12.5	16.1	16.1	**Yes**
Copper	24.3	465	195	**Yes**
Iron	25,000	33,400	26,060	**Yes**
Lead	3.44	278	220	**Yes**
Magnesium	10,600	13,000	13,000	**Yes**
Manganese	466	4,290	2,238	**Yes**
Mercury	ND<0.105	ND<0.115	--	No
Nickel	28.7	50.2	34.4	**Yes**
Potassium	844	1,230	1,230	**Yes**
Selenium	ND<1.32	ND<1.43	--	No
Silver	ND<2.63	0.75	--	No
Sodium	445	572	572	**Yes**
Thallium	ND<1.32	ND<1.43	--	No
Vanadium	43.4	66.5	66.8	**Yes**
Zinc	50.5	1,390	783	**Yes**

Background Upstream = Battle Ax Creek upstream of confluence with Blue Jay Creek (n=3); 95UCL values for all COIs exceeded maximum values.

Site-Related = All data from Ruth Creek and Battle Ax Creek at and immediately downstream of confluence (n=3-8)

Table 4-6. Summary of COIs Passing Detection Frequency and Background Screens, Ruth Mine Site

Waste Rock Soils	Surface Water – Site-Related Samples	Surface Water - Battle Ax Creek	Sediment
Antimony	Barium	Barium	Aluminum
Arsenic	Cadmium	Calcium	Arsenic
Cadmium	Calcium	Chromium	Cadmium
Calcium	Chromium	Iron	Calcium
Chromium	Copper	Lead	Cobalt
Cobalt	Iron	Manganese	Copper
Copper	Lead	Sodium	Iron
Iron	Manganese	Zinc	Lead
Lead	Sodium		Magnesium
Magnesium	Zinc		Manganese
Manganese			Nickel
Mercury			Potassium
Nickel			Sodium
Potassium			Vanadium
Selenium			Zinc
Silver			
Zinc			

Surface water site-related samples and sediment samples consist of Adits 4 & 5, Ruth Creek, and Battle Ax Creek at and downstream of the confluence with Ruth Creek

4.2 ENVIRONMENTAL CONCENTRATIONS

Environmental concentrations (ECs) are those concentrations of chemicals in environmental media to which ecological receptors may be exposed. For the Ruth Mine site, data on concentrations of COIs are available for waste rock soils, and surface waters and sediments of Adits 4 and 5, Ruth Creek, and Battle Ax Creek. From those data, ECs are developed for soils, surface waters, sediments, and air. Analytical chemical data to develop ECs for the site were collected during the November 2005 and the October 2008 site sampling events. The November 2005 data consisted of 10 samples of waste rock soils, supplemented with 21 additional samples of waste rock soil collected in October 2008. For surface water, 12 samples including the two adit waters were collected in 2005, supplemented by 5 additional surface water samples in Battle Ax Creek in 2008, two of which are upstream of the confluence with Ruth Creek. Sediment data consist of 6 samples collected in 2005, supplemented with 5 additional samples collected in 2008, with two of those from Battle Ax Creek upstream of the confluence with Ruth Creek. Data from samples collected in Battle Ax Creek upstream of the confluence with Ruth Creek are not used in the calculation of ECs for the Ruth Mine site.

For each environmental medium, ECs are developed as the upper 90 percent confidence limit (90UCL) on the mean concentration for each chemical in the site-related samples, following

ODEQ (2001) guidance. The 90UCL concentrations are used to quantify exposures with the assumption that they best represent an upper bound of concentrations of COIs that an ecological receptor would contact. 90UCL concentrations are developed for the COIs that passed the detection frequency and background screens, as summarized above in Table 4-6. Concentration data for each sample and 90UCL concentrations for waste rock soils, surface water, and sediment are presented in Attachment B.

The USEPA ProUCL program was used for statistical analyses and to develop the 90UCL concentrations (USEPA 2007). ProUCL 4.0 contains rigorous parametric and nonparametric (including bootstrap methods) statistical methods (instead of simple ad hoc or substitution methods) that can be used on both full data sets without nondetects and for data sets with non detected concentration (i.e., qualified by the analytical laboratory or data validators as "ND", non-detect). The program uses state-of-the-art parametric (e.g., ROS methods) and nonparametric (Kaplan-Meier method) computation methods for upper confidence limits (UCL) for data sets with non detected concentrations.

The ProUCL program uses both detected and undetected values, and creates interpolated values for non-detects based on the estimated distribution of the detected concentrations. For chemicals with non-detected values, ProUCL fills in a set of concentrations for nondetects that would result in a better estimate of central tendency than other substitution methods (e.g., use of ½ the detection limit for the non-detected value). ProUCL assumes the distribution of the non-detected values based on the distribution of the detected concentrations, and substitutes values for the non-detects based on that assumed distribution. The full dataset, including the substituted concentrations, is then used by ProUCL to identify the underlying distribution of the data set, to estimate upper confidence limits on the mean concentration for various distribution types, and to recommend the most appropriate 95 UCL based on the data distribution. ProUCL does not provide a recommendation for the 90 UCL, so the same statistical test basis that was recommended for the 95 UCL was used to identify the most appropriate 90 UCL. Based on the distribution, each COI in each environmental medium was assigned a normal distribution, a log-normal distribution, a gamma distribution, or an undeterminable distribution by ProUCL, for which non-parametric statistics were used in the UCL determination.

The technical guidance document for the software states that the UCL calculated from datasets with very few (i.e., 6 or less) detected concentrations are not reliable enough for deriving ECs. In this screening ecological risk assessment, ECs for any COPCs with 6 or less detections are not based on the 90 UCL but on the maximum concentration instead. In many instances, particularly for 6 or fewer detected values, the 90UCL was calculated to be higher than the maximum concentration, and the maximum concentration was subsequently used in the risk ratio calculations. Thus, in determining the ECs, none of the UCLs are based on the use of ½ detection limits, and ECs are either the ProUCL-derived value for the 90 UCL or the maximum concentration.

ECs are developed for each COI in each of the environmental media that receptors may contact.

- *Waste Rock Soils* – The ECs are based on 21 to 31 waste rock soil samples collected in 2005 and 2008. Terrestrial plants, invertebrates, birds, and mammals

are assumed to be exposed only to waste rock soils for the duration of their soil exposures at the site. Exposures to background soils are not included.

- *Surface Water* – Aquatic organisms, birds, and mammals are assumed to be exposed to all surface waters that were sampled at the site. Surface waters consist of a total of 11 samples: two samples of adit waters from adits 4 and 5, one sample in Ruth Creek upstream of adit 4, two samples from Ruth Creek downstream of adit 4, one sample in Battle Ax Creek at the confluence with Ruth Creek, and five samples from Battle Ax Creek downstream of the confluence. The ECs do not include samples from Battle Ax Creek upstream of the confluence with Ruth Creek. The ECs also do not include samples from Battle Ax Creek upstream of Blue Jay Creek, which consists of four samples that are used as upstream background locations, three of them collected in 2008 and one in 2005. It was assumed that receptors could have equal access to all environmental media at the site; e.g., exposures could occur to surface waters in Battle Ax Creek downstream of the confluence and with Ruth Creek and in the adits with equal accessibility.
- *Sediments* – Benthic invertebrates and wildlife are assumed to be exposed to sediment in the same surface waters as for the surface water exposures. Sediment samples consist of a total of 8 samples: three in Ruth Creek, and five in Battle Ax Creek downstream of the confluence with Ruth Creek. The three sediment samples collected in 2005 and 2008 from Battle Ax Creek immediately upstream of the confluence with Ruth Creek are not used to develop the ECs.

ECs are developed in Attachment B for all chemicals that passed the screening for frequency of detection and for comparison with background. Table 4-7 summarizes the ECs for the COIs at the Ruth Mine site.

Table 4-7. Environmental Concentrations, Ruth Mine Site

Chemical of Interest (COI)	Waste Rock Soil 90 UCL Concentration (mg/kg)	Surface Water 90 UCL Concentration (mg/L)	Sediment 90 UCL Concentration (mg/kg)
Aluminum	NA	NA	30,080
Antimony	1.5	NA	NA
Arsenic	20.7	NA	11.7
Barium	NA	0.003	NA
Cadmium	129.4	0.010	2.4
Calcium	20,180	4.12	8,700
Chromium	28.8	0.001	NA
Cobalt	24.1	NA	17.0
Copper	2,336	0.007	194.5
Iron	59,016	0.039	26,060
Lead	5,987	0.012	220
Magnesium	14,354	NA	13,297
Manganese	7,703	0.011	2,238
Mercury	0.47	NA	NA
Nickel	26.9	NA	34.4
Potassium	3,710	NA	1,230
Selenium	4.3	NA	NA

Silver	10.3	NA	NA
Sodium	NA	1.39	572
Vanadium	NA	NA	66.8
Zinc	30,391	1.29	783

NA = not applicable, chemical was either not detected or did not exceed background.
90 UCL = 90% upper confidence limit on the mean concentration

4.3 RISK-BASED SCREENING

Ecological risk-based screening consists of a comparison of ECs with risk-based screening criteria. ECs are identified for each COI in the previous section. Screening criteria are defined by ODEQ (2001) as the SLVs for each environmental medium at the site. The comparison of the ECs with the SLVs comprises a screening based on chemistry and toxicity. The result of the screening is a list of CPECs for each medium at the site that have the potential to pose risks to ecological receptors. The screening accounts for exposure to individual COIs, exposures to multiple COIs within a given media, and exposure to individual or multiple COIs within different media. The SLVs that are used in the comparison are considered applicable to the types of ecological receptors that may be present at the site.

4.3.1 RISK-BASED SCREENING CRITERIA

Screening criteria are provided by ODEQ (2001) as SLVs for soils, surface water, and sediment. SLVs are available for exposures of terrestrial plants, invertebrates, birds, and mammals to soils; aquatic organisms, birds, and mammals to surface waters; and benthic invertebrates to sediments and wildlife that may bioaccumulate COIs from sediments. SLVs are not available from ODEQ for a few COIs, such as antimony, iron, and silver for birds and mammals exposed to soil, and exposure of invertebrates to cobalt in sediment, but also for calcium, magnesium, potassium, and sodium for all environmental media. For those COIs, various sources of criteria were searched in order to identify surrogate values for the missing SLVs. Sources included soil (EcoSSLs) and water screening benchmarks for wildlife developed by USEPA (2005, 2008) and Oak Ridge National Laboratory (Efroymson et al., 1997; Suter and Tsao, 1996; Jones et al., 1997; Sample et al., 1996), and NOAA and Washington Department of Ecology benchmarks for freshwater sediment (MacDonald et al., 2000; Ecology 2003). Surrogate screening values for soil were found as USEPA (2008) EcoSSLs for cobalt and silver for birds, and antimony for soil invertebrates; a surrogate value for cobalt for freshwater sediments was taken from USEPA (2005) Region 5 screening criteria. No other surrogate screening criteria were found for other COIs for which ODEQ SLVs are unavailable.

4.3.2 SCREENING PROCEDURE

The screening procedure consists of the comparison of the ECs for each COI in each environmental medium with their respective SLVs or surrogate criteria for that medium. Results of each step of the screening calculations are displayed in the tables in Attachment A, which follow the format provided in the ODEQ (2001) guidance on Level II screening ecological risk assessment.

For each COI *i* in each medium *j*, a chemical-specific risk ratio is calculated (T_{ij}) as the ratio of the EC to the SLV or surrogate criterion, as per the following equation:

$$T_{ij} = \frac{C_{ij}}{SLV_{ij}}$$

where:

T_{ij}	=	Risk ratio
C_{ij}	=	90UCL in given medium
SLV	=	Screening level value or risk-based criterion.

The individual risk ratio T_{ij} is compared with the receptor designator *Q*, which for soils is defined as Q=1 for listed threatened and endangered species, and Q=5 for non-T&E species, whereas for surface water and sediment, Q=1. The following relationships identify the COI as a CPEC:

- If the individual risk ratio T_{ij} is greater than 5 for soils or greater than 1 for surface water or sediment, the COI is selected as a CPEC
- If T&E species are present and T_{ij} is greater than 1, the COI is selected as a CPEC
- For benthic invertebrates, if T_{ij} is greater than 1, the COI is selected as a CPEC.

Thus, for soil, a risk ratio greater than 5 indicates a potential for ecological risk to that non-T&E receptor type; whereas a risk ratio greater than 1 indicates a potential for ecological risk to the T&E receptor type. For surface water and sediment, a risk ratio greater than 1 indicates a potential for ecological risk to the either T&E receptors or non-T&E receptors. Those COIs for which ecological risks are indicated become the CPECs for that medium at the site. The predicted risks for those CPECs are discussed further in the risk characterization section.

Overall risk (T_j) for each medium *j* was calculated as the sum of the individual chemical risk ratio T_{ij} values. To account for the cumulative risk from multiple COIs in a medium, ODEQ (2001) provides the following equation, whereby if this relationship holds true, the COI is identified as a CPEC, for those receptors and media where $T_{ij} > Q$:

$$T_{ij} / T_j \geq \frac{1}{N_{ij}} xQ$$

where:

T_{ij} = Risk ratio for the individual chemical *i* in medium *j*
T_j = Sum of risk ratios for medium *j*
N_{ij} = Total number of COIs for medium *j*
Q = Value of 1 for T&E species for soil and for surface water and sediment, value of 5 for non-T&E species in soil.

To account for COIs detected in multiple media, those detected COIs are selected as CPECs if the sum of the T_{ij} values is greater than Q. To account for potential bioaccumulation through aquatic food chains, ODEQ (2001) provides bioaccumulative SLVs for sediment, in addition to SLVs for freshwater benthos in sediment, for comparison with sediment concentrations.

4.3.3 SCREENING RESULTS

Surface Soil – The waste rock soil screen is shown in Tables A-1a through A-1e of Attachment A. The results of the screen and identification of CPECs for waste rock soil are summarized in Table 4-8 below. Most of the COIs detected in waste rock soils were elevated above background and exceeded one or more of the soil SLVs: cadmium, chromium, copper, iron, lead, manganese, silver, and zinc. Of the COIs detected above background soil levels, antimony, calcium, cobalt, magnesium, mercury, nickel, and potassium were not selected as CPECs based on the screen. Risks were predicted to terrestrial plants for cadmium, chromium, copper, iron, lead, manganese, silver, and zinc; to soil invertebrates for cadmium, chromium, copper, iron, lead, manganese, and zinc; to birds for cadmium, chromium, copper, lead, and zinc; to protected birds for arsenic, cadmium, chromium, copper, lead, manganese, selenium, silver, and zinc; to protected mammals for cadmium, copper, lead, and zinc; and copper for non-protected mammals.

Table 4-8. Waste Rock Soils CPECs, Ruth Mine Site

Chemical of Interest (COI)	Selected as CPEC?					
	Plants	Invertebrates	Non-Protected Birds	Non-Protected Mammals	Protected Birds	Protected Mammals
Antimony	No	No	No	No	No	No
Arsenic	No	No	No	No	**Yes**	No
Cadmium	**Yes**	**Yes**	**Yes**	No	**Yes**	**Yes**
Calcium	No	No	No	No	No	No
Chromium	**Yes**	**Yes**	**Yes**	No	**Yes**	No
Cobalt	No	No	No	No	No	No
Copper	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
Iron	**Yes**	**Yes**	No	No	No	No
Lead	**Yes**	**Yes**	**Yes**	No	**Yes**	**Yes**
Magnesium	No	No	No	No	No	No
Manganese	**Yes**	**Yes**	No	No	**Yes**	No
Mercury	No	No	No	No	No	No
Nickel	No	No	No	No	No	No
Potassium	No	No	No	No	No	No
Selenium	No	No	No	No	**Yes**	No
Silver	**Yes**	No	No	No	**Yes**	No
Zinc	**Yes**	**Yes**	**Yes**	No	**Yes**	**Yes**

Habitat suitability is not accounted for in the screening.

Surface Water - The surface water screen for CPECs is shown in Tables A-2 a through A-2e in Attachment A; results of the CPEC selection for surface water are summarized in Table 4-9 below. Cadmium, lead, and zinc were identified as CPECs in surface water, based on the exceedances of SLV for aquatic receptors. Potential risks are not predicted to birds or mammals for surface water exposures to any COIs at the Ruth Mine site.

Table 4-9. Surface Water CPECs, Ruth Mine Site

Chemical of Interest (COI)	Selected as CPEC?			
	Aquatic	Birds	Non-Protected Mammals	Protected Mammals
Barium	No	No	No	No
Cadmium	**Yes**	No	No	No
Calcium	No	No	No	No
Chromium	No	No	No	No
Copper	No	No	No	No
Iron	No	No	No	No
Lead	**Yes**	No	No	No
Manganese	No	No	No	No
Sodium	No	No	No	No
Zinc	**Yes**	No	No	No

Note: Habitat suitability is not accounted for in the screening.

Sediment - The sediment screen for CPECs is shown in Tables A-3a and A-3b in Attachment A; results of the CPEC selection for sediment are summarized in Table 4-10 below. Many COIs were detected in sediment and selected as CPECs for sediment benthos: aluminum, arsenic, cadmium, copper, lead, manganese, nickel, and zinc; and arsenic, cadmium, copper, lead, and zinc based on potential bioaccumulation in wildlife.

Table 4-10. Sediment CPECs, Ruth Mine Site

Chemical of Interest (COI)	Selected as CPEC for sediment?	
	Freshwater Sediment Benthos	Wildlife Bioaccumulation
Aluminum	**Yes**	No
Arsenic	**Yes**	**Yes**
Cadmium	**Yes**	**Yes**
Calcium	No	No
Cobalt	No	No
Copper	**Yes**	**Yes**
Iron	No	No
Lead	**Yes**	**Yes**
Magnesium	No	No
Manganese	**Yes**	No
Nickel	**Yes**	No
Potassium	No	No
Sodium	No	No

Vanadium	No	No
Zinc	**Yes**	**Yes**

Many of the CPECs showed only slight exceedances of their SLVs whereas others showed much higher elevations, as can be seen with the individual risk ratios in the tables of Attachment A. Those CPECs showing the highest exceedances for each of the environmental media are identified as the chemicals with the highest potential for ecological risks at the site. In summary, the following CPECs showed the highest potential risks to ecological receptors at the Ruth Mine Site, based on individual risk ratios:

Waste rock soils

- *Plants* - iron, lead, and zinc
- *Invertebrates* - iron and zinc
- *Birds* - lead and zinc
- *Mammals* - cadmium, copper, lead, and zinc.

Surface waters – cadmium, lead, and zinc for aquatic species; no CPECs and no risks are predicted for birds or mammals.

Sediment – cadmium, lead, and zinc for freshwater benthos and potential risks to wildlife through bioaccumulation.

5 RISK CHARACTERIZATION

Risk characterization is the step that describes the screening risk results that were calculated in the previous section, and includes an uncertainty analysis. The predicted risks are described in context of the exposure media, the receptor types present at the site, and the conservativeness of the risk screening procedure, and gives a general idea of the likelihood of actual risk. Uncertainties in parameter values and assumptions associated with the screening process are discussed, including their impact on whether risks may be under-estimated or over-estimated.

5.1 RISK DESCRIPTION

5.1.1 WASTE ROCK SOIL

Numerous metals are identified as CPECs for potential risks to plants, invertebrates, and birds that may be exposed to waste rock soil at the site. Most of the metals in waste rock soil exceeded the background levels, as determined by comparison of the waste rock soil maximum concentrations with the 95 UCL for the 20 background soil samples that were located in areas removed from impacts of activities at the mine site or other known local anthropogenic influences. Note that almost all of the background concentrations of metals in soils also exceed the lowest of the four soil SLVs, as listed in Table 5-1. The exceedance of soil screening criteria by background concentrations suggests that a simple exceedance of a Level II SLV by a waste rock soil chemical may not necessarily indicate a high level of risk to ecological receptors, since they are exposed to levels of metals in the background soils of the site that may also indicate a risk. This comparison indicates that many of the Level II SLVs are lower than the natural levels of these metals in the soils of the environs where the Ruth Mine is located.

The ranges of background soil concentrations for most metals were very wide, and particularly for lead and zinc, they spanned two to three orders of magnitude (see Table B.1, Attachment B). The high concentrations of metals in background soils relative to soil SLVs and the wide range of concentrations reflect discrete locations of highly mineralized soils in the general area where the site is located. This characteristic may be considered typical of the enriched veins of metals found in the Western Cascade mining districts. The highest elevated concentrations in waste rock soils, and consequent highest risk ratios, are consistently associated with lead and zinc, which were the primary metals mined at the site. How much of a risk the elevated metals in the waste rock soils pose to receptors that may also be exposed to naturally high levels of metals in the surrounding environment is unknown. Nonetheless, the concentrations of many waste rock soil metals are substantially higher than the background soils, up to 10-times higher for cadmium, copper, and lead based on maximum concentrations. These high concentrations are identified as posing potential ecological risks to soil receptors based on their individual risk ratios.

Table 5-1. Background Soil Exceedances of Lowest Level II SLV

Metals in Waste Rock Soil	Maximum Background Concentration Exceed Level II SLV?	95 UCL Background Concentration Exceed Level II SLV?
Arsenic	**Yes**	No
Barium	**Yes**	No
Cadmium	**Yes**	**Yes**
Chromium	**Yes**	**Yes**
Copper	**Yes**	**Yes**
Iron	**Yes**	**Yes**
Lead	**Yes**	**Yes**
Manganese	**Yes**	**Yes**
Mercury	**Yes**	**Yes**
Nickel	**Yes**	No
Selenium	**Yes**	**Yes**
Silver	**Yes**	**Yes**
Vanadium	**Yes**	**Yes**
Zinc	**Yes**	**Yes**

The locations of the waste rock soil samples were selected to characterize the areas of the site where waste rock was deposited, which consisted of areas in the vicinity and downgradient of the mine shaft area of operation. As discussed in Section 5.2.4 below, the potential for risks to animals and birds at the site based on the risk ratios alone, particularly for larger T&E species, is highly uncertain, either because they tend to forage over areas larger than the size of the waste rock soils, or because the waste rock soils provide poor habitat. In general, the bioavailability of the waste rock metals to small mammals and birds is uncertain but likely less than 100 percent, and the lack of vegetation and food resources in the waste rock piles would limit exposures to waste rock metals. Consequently, risks to these receptors are uncertain and would likely be less than the risk ratios suggest.

5.1.2 SURFACE WATER

5.1.2.1 Risk Ratios

Cadmium, lead, and zinc were the metals in surface water found to pose potential ecological risks to aquatic receptors based on risk ratios; no potential risks were predicted for plants or animals due to exposure to surface water. Cadmium was found to exceed the SLV only in the adit waters; no exceedances were found for surface waters of Ruth Creek or Battle Ax Creek (see Table B-2). Lead concentrations showed the highest exceedances in adit waters, primarily adit 4; exceedances in Ruth Creek were less. A single exceedance of lead SLV was found in Battle Ax Creek downstream of the adit 5 drainage only during the 2005 sampling; lead exceedances were not observed in Battle Ax Creek during the 2008 resampling. Zinc exceedances were found only in the waters of the two adits, similar to that found with cadmium; none of the zinc concentrations in surface water of Ruth Creek or Battle Ax Creek exceeded the SLV. No other metals exceeded SLVs in any water body.

Because the exceedances of the cadmium and zinc SLVs were limited to the adit waters, which provide limited habitat for aquatic organisms, the potential risks from cadmium or zinc

to aquatic receptors at the site are highly uncertain and most likely very low, lower than the risk ratios suggest. Similarly, the exceedance of the lead SLV in the adit waters and Ruth Creek present very low risks to aquatic receptors in those waters because of the low quality or absence of suitable habitat to support aquatic communities, based on the ephemeral flow of Ruth Creek and the primarily hard rock substrate. Amphibians could be exposed to surface water in the adits; however, the size of available exposure area of the adit water is very small and the water at adit 4 represents a trickle emerging from the adit. Exposures over a small area such as the adit water would not be expected to impact an amphibian population.

The exceedance of the lead SLV in the single station of Battle Ax Creek was not reproducible during subsequent resampling; thus whether lead concentrations are continually elevated in Battle Ax Creek appears unlikely. The potential for risks from lead to aquatic receptors in Battle Ax Creek are highly uncertain because of this finding.

5.1.2.2 Dissolved Metals in Surface Waters

The environmental concentration data used in the risk ratio calculations for surface water were derived from data on total metals collected in 2005 and 2008 (see Table B-2); dissolved metals data were not collected during those sampling events. However, the Oregon SLVs for surface water as well as Oregon freshwater chronic water quality criteria (WQC) are based on concentrations of dissolved metals in surface water, not on concentrations of total metals. The comparisons of environmental data with these criteria are meant to be performed using dissolved fractions of the metals. Dissolved metals concentrations may be lower than the concentrations of total metals, which include particle-bound metals as well as dissolved forms such as salts or bound to soluble organic carbon.

The purpose of the surface water sampling performed in 2009 was to collect data on dissolved metals and total metals in various locations of surface water at the Ruth Mine site. The data were intended to determine the proportions of total metals made up by dissolved forms. These proportions could then be used to evaluate the assumption that the 2005 and 2008 surface water data used in this risk assessment are representative of dissolved metals, and are appropriate for the purpose of comparison with the Oregon surface water SLVs. The dissolved metals concentrations were collected after performance of the risk assessment, and were not intended for recalculation of exposure point concentrations for surface water or to recalculate risk ratios. The 2009 surface water data are provided in Table D-1 of Attachment D, which includes the Oregon SLVs and freshwater WQC.

The methods for sampling and analysis, and the locations of sample collection, are presented in the revised final EE/CA for the Ruth Mine site (GeoDesign 2009). Samples consisted of single samples from reoccupied stations in surface waters at adit 4 and adit 5, and one sample from a new station (SW-R-24) located in Battle Ax Creek, at the point where the discharge from adit 5 enters the creek. Adit 5 is located on the embankment approximately 20-ft above Battle Ax Creek and the adit discharge flows down the embankment to discharge into the creek.

5.1.3 SEDIMENT

Cadmium, lead, and zinc showed the highest exceedances of the sediment freshwater benthos SLVs in site-related sediment. These same metals were found to exceed surface water SLVs. Because sediment benthos would generally be exposed to localized concentrations of CPECs, they are also evaluated on a single station basis. For cadmium, Ruth Creek and Battle Ax Creek showed exceedances of both the sediment benthos and the wildlife bioaccumulation SLV. For lead, all stations in Ruth Creek and Battle Ax Creek exceeded the freshwater benthos SLV, but only stations in Ruth Creek exceeded the wildlife bioaccumulation SLV (see Table B-3). For zinc, all stations in Ruth Creek and Battle Ax Creek exceeded both the freshwater benthos SLV and the wildlife bioaccumulation SLV. The highest exceedances of SLVs were found for cadmium and zinc exceedances of the wildlife bioaccumulation SLV in Battle Ax Creek downstream of the Ruth Creek confluence.

The exceedances of the bioaccumulation SLVs for cadmium, lead, and zinc suggest that the sediment could pose risks to organisms if they used it for food sources. For Ruth Creek, the habitat is of poor quality as a food source because of the lack of sufficient sedimentary material and organic material over the hard rock substrate, and the intermittent flow. For Battle Ax Creek, macroinvertebrates would be expected to be present as food sources for the potential uptake of sediment metals if they are sufficiently bioavailable. The evaluation of macroinvertebrates in sediment of Battle Ax Creek at the Ruth Mine site, summarized below, suggest that the potential risk to macroinvertebrates is highly uncertain.

5.1.4 MACROINVERTEBRATE EVALUATION

An evaluation of macroinvertebrates in Battle Ax Creek was performed with data collected during the October 2008 site visit. The evaluation of stream bed macroinvertebrates in Battle Ax Creek provides a more direct assessment of the biological community in the creek sediments than does a comparison of sediment chemical concentrations with screening criteria such as the SLVs. The use of SLVs in the screening procedure is designed partly to determine a potential for risk based on potential toxicity to macroinvertebrates and consequent effects on the community or population of the macroinvertebrates. The evaluation of the macroinvertebrate community provides a more direct evaluation of the impacts of sediment chemicals on that community. Macroinvertebrates are fairly stationary, easy to collect, and are responsive to human disturbance. In addition, the relative sensitivity or tolerance of many macroinvertebrates to stream conditions is well known. For these reasons, USEPA (1990) recommends their evaluation in an assessment of ecological integrity of streams.

The evaluation of stream macroinvertebrates in Battle Ax Creek followed the macroinvertebrate bioassessment protocol of the Oregon Plan for Salmon and Watersheds (OPSW 1999). The protocol was adapted from the USEPA Rapid Bioassessment Protocols (Barbour 1999) for use in the state of Oregon. The OPSW protocol provides three levels of evaluation; for Battle Ax Creek, Level 3 was followed. The evaluation is described in detail in Attachment C. The results of the evaluation are summarized herein.

A summary of the dissolved metals data and total metals data from the three surface water stations is presented in Table 5-2. The data in Table 5-2 shows that dissolved metals concentrations in surface waters of the adits and in Battle Ax Creek were not substantially different from the total metals concentrations. Some dissolved metals levels were slightly higher and some slightly lower than the total metals levels. The finding that all or almost all of the concentrations of the metals in surface waters were in dissolved forms suggests that particle-bound metals were very low in the surface water samples.

The concentrations of dissolved and total forms of all the metals in the Battle Ax Creek water sample are very close to the concentrations observed for the adit 5 water sample. The sample in Battle Ax Creek was collected at the point of the adit 5 water discharge to the creek, and the similarities in the concentrations suggests that the Battle Ax Creek sample was not diluted with Battle Ax Creek water, but rather the collection may have sampled mostly or only adit 5 drainage water prior to its mixing with Battle Ax Creek water.

There is no reason to suspect that the proportions of dissolved metals in surface waters at the Ruth Mine site would change over the course of a few years. Thus, the finding that the metals in surface waters were essentially all in dissolved forms in the 2009 sampling suggests that previous analyses of surface water samples (i.e., samples collected in 2005 and 2008) would also be primarily in dissolved forms. In other words, if it is assumed that the general relationship between dissolved and total metals in the 2009 samples can be considered representative of relationships in past sampling efforts, then the past analytical data can be assumed to consist almost entirely of dissolved metals. Thus, the metals concentrations that were used as exposure point concentrations for the purpose of calculating risk ratios for surface water can be assumed to represent dissolved metals concentrations.

The data collected in 2009 on total metals concentrations were also compared with the previous total metals data collected in 2005. Comparable data are available for the adit waters, and are shown in Table 5-3. The comparison shows that adit water concentrations of metals are not substantially different between the 2005 and 2008 sampling events; concentrations for some metals are slightly lower and some are slightly higher. Since the data are limited to single samples from each of the two adits, the slight differences cannot be tested statistically and are assumed to represent typical variability in field sample collection methods and laboratory measurements.

The conclusion that the previous metals data collected in 2005 and 2008 represent concentrations of dissolved metals indicates that the risk ratios for surface water calculated in the previous section can be considered to be based on dissolved metals. This conclusion is considered to be sufficiently conservative for risk assessment since it assumes that all metals are in dissolved form at their measured concentrations in both the 2005 and 2008 data; no changes or re-evaluation of potential ecological risks to surface water receptors are indicated. The dissolved metals data that were collected in 2009 are used solely to evaluate the assumption that previous metals data can represent dissolved forms of the metals, or whether the concentrations of dissolved forms might be less than the total metals concentrations. The evaluation demonstrates that the assumption that all previous metals data in surface water are in dissolved form is not overly conservative.

Table 5-2. Comparison of Dissolved and Total Metals in Surface Waters

Metal	Adit 4		Adit 5		Battle Ax Creek at confluence with Adit 5 drainage water	
	Dissolved Metals	Total Metals	Dissolved Metals	Total Metals	Dissolved Metals	Total Metals
	(mg/L)					
Arsenic	ND <0.001	ND <0.001	ND <0.001	ND <0.001	ND <0.001	ND <0.001
Barium	0.011	0.011	0.0045	0.0041	0.0048	0.0045
Cadmium	0.036	0.035	0.005	0.005	0.005	0.005
Calcium	67.2	69	41.8	42.9	41.5	43.2
Copper	0.00518	0.00727	ND <0.004	ND <0.004	ND <0.004	ND <0.004
Lead	0.0223	0.0271	ND <0.001	ND <0.001	ND <0.001	ND <0.001
Magnesium	1.36	1.35	1.01	1.02	1	1
Zinc	6.44	6.67	1.51	1.55	1.43	1.52

Data are single values, collected in 2009.

Table 5-3. Comparison of 2009 Total Metals Data with Previous Data

Metal	Adit 4 Total Metals (mg/L)		Adit 5 Total Metals (mg/L)	
	2005	2009	2005	2009
Arsenic	ND<0.001	ND<0.001	ND<0.001	ND<0.001
Barium	0.007	0.011	0.0032	0.0045
Cadmium	0.022	0.035	0.0054	0.005
Calcium	--	69	--	43.2
Copper	0.015	0.007	0.0046	ND<0.004
Lead	0.038	0.027	0.0026	ND<0.001
Magnesium	--	1.35	--	1
Zinc	3.08	6.67	1.27	1.52

Data are single values, collected in 2005 and 2009.

Macroinvertebrate stations were selected in Battle Ax Creek to characterize the sediment biological integrity upstream and downstream of the Ruth Mine drainage, which is carried by Ruth Creek as it flows past the two Ruth Mine adits. Stations BI-MS-14 Pool, BI-MS-15 Riffle, BI-MS-16 Pool are located in Battle Ax Creek upstream of the confluence with Blue Jay Creek, which drains the Morning Star Mine site, and are used as upstream background stations, similar to the use of the upstream sediment stations at those locations. Macroinvertebrate stations in Battle Ax Creek immediately upstream of the confluence with Ruth Creek and drainage from Adits 4 and 5 are Stations BI-R-19 Pool, and BI-R-20 Riffle; and located immediately downstream of Ruth Creek and the mine adits drainage are BI-R-22 Pool, and BI-R-23 Riffle. These latter two stations are identified as the downstream stations that would be expected to receive maximum impact from the Ruth Mine drainage. Macroinvertebrate collection stations are shown on a map in Figure C-1.

The OPSW scores provide an indication of the level of impairment of the macroinvertebrate community. Impairment levels are identified as *No Impairment, Slight Impairment, Moderate Impairment, and Severe Impairment.* Total abundances and species diversities of macroinvertebrate communities in all four of the Battle Ax Creek stations were similar. For the two upstream and two downstream stations, results of the OPSW scoring were *No Impairment* (see Attachment C). Results of the scoring suggest that the macroinvertebrate communities of the two downstream stations are not impaired and are similar in benthic macroinvertebrate community structure to the two upstream stations.

Each of the macroinvertebrate stations was also evaluated relative to metals concentrations in the sediment of the station. Concentrations of metals in sediments of the two upstream stations were very similar (see stations SED-R-19 and SED-R-20 in Table B-3 of Attachment B). Of the downstream stations, station SED-R-22 shows the highest metals concentrations, with SED-R-23 somewhat lower but elevated above the upstream stations SED-R-19 and SED-R-20. The relationships between the OPSW scores and the metals concentrations of sediments of the two upstream stations and the two downstream stations were examined by graphically comparing the scores with sediment metals data for each station (Figure C-8, Attachment C). The evaluation demonstrates the lack of influence of the sediment metals on the OPSW scores, despite the elevated metals concentrations and exceedances of SLVs in the downstream stations, particularly station SED-R-22.

The lack of impacts to the benthic community in the downstream stations despite elevated concentrations of sediment metals suggests that the metals are very limited in bioavailability to the benthic organisms. The Level II SLVs do not account for the bioavailability of metals such as lead or zinc in the hard rock particles that make up the sediments of Battle Ax Creek, and their application to predicting potential risks to sediment macroinvertebrates in Battle Ax Creek entails high uncertainty, with a tendency to overpredict rather than underpredict potential ecological risks. Thus, actual risks to macroinvertebrate ecology in Battle Ax Creek from these metals are expected to be lower than the risk ratios suggest.

5.2 UNCERTAINTY ANALYSIS

This section discusses some of the uncertainties in the Level II screening ecological risk assessment described above. Some uncertainties are specific to the site conditions and some

are inherent to the risk assessment process. An analysis of uncertainties provides the risk managers with information on the limitations and interpretation of the risk estimates and potential exposures for use in future decision making.

5.2.1 SAMPLING AND ANALYSIS

The sampling approach for the Ruth Mine site was a focused design, with sampling of waste rock soils and surface waters located in areas of suspected contamination and in areas identified as background to the site. The data used to quantify exposures consist of the focused sample locations and are not considered representative of average exposures to ecological receptors or wildlife that may reside or forage at the site. For example, only samples from the waste rock soils were used to quantify the soil exposure pathways; data on lower contaminated soils in the area were not used. For wildlife such as birds and large mammals, foraging areas would be larger than the focused sampling of waste rock soils, and average exposures would typically result from movement throughout the site, with a mix of exposures to both contaminated and uncontaminated soils and waters.

Focusing on samples with high contamination, such as soils that consist of waste rock, results in exposure concentrations and subsequent risk ratios to be overestimated compared to actual exposures encountered by random movement of mobile ecological receptors through the area.

5.2.2 EXPOSURE CONCENTRATIONS

Estimates of exposure to metals at the mine site were based on a limited number of samples to represent the various exposure media. Although a suitable number of samples were available for waste rock soils, 21 to 31 samples, to develop exposure concentrations, for surface water and sediment only three to eight and three to eleven samples were available, respectively. Use of a low number of samples in the development of exposure concentrations typically results in highly skewed data sets and high upper confidence limits on the mean values, frequently close to or exceeding the maximum concentration. With the use of gamma distribution statistics, a 90UCL was calculable for the EC for all waste rock soil, surface water, and sediment samples regardless of the low number or the skewness of the data. However, due a large number of non-detects in upstream background surface water and sediment samples, 90UCL values exceeded maximum concentrations for all of the COIs that have ODEQ screening levels. Maximum concentrations were used for evaluation of surface waters, which would over-estimate actual long term average exposures to ecological receptors that may be exposed to the surface water.

Combining data from different types of environmental sources into a single EC for an environmental medium may also over-estimate overall risks. For example, combining surface water data from Ruth Creek, which may not present suitable habitat for aquatic organisms, with data from Battle Ax Creek that does present suitable habitat, may lead to imprecision in the risk ratios for aquatic organisms. Evaluation of the specific locations where exceedances of SLVs were observed, particularly for Ruth Creek, helps to place these exceedances in perspective with actual habitats and receptor types that may be exposed.

Cadmium and zinc in surface water at the site were identified as possibly posing a risk to aquatic receptors, but not to plants or animals that may use the surface water. However, both cadmium and zinc concentrations exceed the surface water SLV only for the samples from the two adits; no samples from Ruth Creek or Battle Ax Creek exceeded SLVs. The adits do not provide suitable habitat for aquatic communities at the site. These results suggest that cadmium and zinc in surface waters of Ruth Creek or Battle Ax Creek do not pose risks to aquatic receptors, and that the potential risks to aquatic receptors associated with the elevated cadmium and zinc concentrations entail high uncertainty.

The exceedance of the lead SLV in the adit waters and Ruth Creek are similarly highly uncertain because of the low quality or absence of suitable habitat to support aquatic communities. The potential risk of lead to aquatic communities in Battle Ax Creek is uncertain because of the lack of reproducibility of the exceedance of the lead SLV during subsequent resampling.

5.2.3 TOXICOLOGY

The Level II SLVs are derived from a mix of sources identified in ODEQ (2001). The various sources present a variety of criteria that have been developed following differing methodologies. Many of the criteria are based on observed no-effect-levels in laboratory studies on organisms and do not present levels where low frequency of effects might occur. Low frequency of effects on reproduction and survival of organisms in a laboratory-based test system may be adequately protective of populations and communities of the organisms in the field. For this reason, the Level II SLVs as based on no-effects levels are considered to be substantially conservative for the protection of populations and communities.

The Level II SLVs are also not based on toxicity data or effects that are specific to the site or to the conditions at the site, although they have been generated, reviewed, and accepted by various regulatory agencies. As befitting their use to screen for potential ecological risks, the SLVs are considered to be conservative and to not under-protect ecological receptors in contaminated environments. The resultant risk ratios are best used to identify potential ecological risks, as per ODEQ guidance, rather than to represent site-specific estimates of risk or impacted ecological communities or populations. The use of site-specific toxicity tests with media collected from the site and organisms that are ecologically relevant for the site habitat would reduce uncertainties in the risk estimates. The performance of macroinvertebrate community analyses also provides a more site-specific evaluation of whether sediment benthic organisms display impacts of exposure to toxic chemicals in the sediment.

The SLVs for bioaccumulative compounds and for wildlife are based on the assumption that a certain amount of chemical in the soil, water, or sediment will be transferred to relevant food sources at the site. The SLVs do not take into account the differences between the conditions under which the bioaccumulation tests and screening values were developed and the conditions of the site that may govern site-specific bioaccumulation. These differences entail uncertainty, and the bioaccumulation assumed in the SLVs likely over-estimates actual bioaccumulation of site-related metals.

5.2.4 RISK CHARACTERIZATION FOR WASTE ROCK SOILS

The area of the waste rock soils is not large, and not larger than foraging ranges of small mammals and birds that may frequent the site (assumed to be about one acre for shrews and two acres for robin fledglings [USEPA 1993], for which the Level II SLVs for mammals and birds are applicable). For the northern spotted owl, a protected species that may be found in the area, the foraging range is much larger than the area for the robin, and at tens of acres (North et al. 1999) is substantially larger than the area of the waste rock soils. Small mammals and birds would not be expected to spend a substantial amount of foraging time on the waste rocks due to lack of food resources or suitable burrowing material. Protected mammal and bird species, such as the lynx, gray wolf, and northern spotted owl, would forage over much larger areas with preferable habitat and food resources than available at the waste rock soils. For these reasons, although the risk ratios suggest the potential for risks, actual risks to the T&E species associated with the waste rock soils would be highly uncertain and would be lower than the risk ratios suggest. The risk ratios do not account for availability or conditions of the habitat, nor the size of foraging area relative to the contaminated area. At the Ruth Mine site, the waste rock piles do not provide high quality foraging habitat since they are comprised primarily of hard rock surrounded by an abundance of high quality forage area. Similarly, the hard rock of the waste piles would also likely minimize the quality of habitat for plants or invertebrates, including their use as food sources.

Waste rock piles do not present high quality habitat for plants or invertebrates due to the presence of hard surface and minimal organic material. Small mammals could use rock piles as habitat and could be at risk from exposure at the piles; however, as mentioned above, the bioavailability of the waste rock metals to small mammals is uncertain, and the extent of exposure to site-related chemicals would be limited to the area of the pile. The lack of vegetation and food resources in the waste rock piles would limit exposures of small mammals to waste rock metals, and consequently the risk ratios for these receptors would be uncertain and likely overestimate ecological risks to small mammal populations.

5.2.5 MACROINVERTEBRATE EVALUATION

The macroinvertebrate analysis was performed for two sediment stations located in Battle Ax Creek downstream of the confluence with Ruth Creek, which were compared with results from two stations located upstream of the confluence. Use of the results of two upstream and two downstream stations to evaluate potential ecological risks to a local population follows the Oregon guidance (OPSW 1999) for macroinvertebrate evaluations. Insufficient sediment material at the sample locations prevented a more thorough macroinvertebrate evaluation of Battle Ax Creek. Because the macroinvertebrate evaluation protocol was developed for Coastal Oregon Streams rather than Cascade streams, the interpretation of resulting metrics entails uncertainty. However, the lack of significant shifts in the metrics between upstream and downstream stations, and the lack of impacts on the metrics despite elevated metals concentrations in downstream sediments, suggests that there are minimal impacts of the mine discharges on the macroinvertebrate communities of Battle Ax Creek. Although sediment stations in Ruth Creek had the highest lead concentrations at the site, sedimentary material was insufficient for collection for macroinvertebrate analyses.

The sediment station with the highest metals concentration in Battle Ax Creek was located downstream of the confluence with Ruth Creek and Adit 5 (SED-R-23). However, the lack of impacts to the benthic community in the downstream station despite elevated concentrations of lead and zinc (Attachment C) suggests that the metals are very limited in bioavailability to the benthic organisms. The Level II SLVs do not account for the bioavailability of lead or zinc in the hard rock particles that make up the sediments of Battle Ax Creek. Thus, the risk ratios that predict potential risks to sediment macroinvertebrates in Battle Ax Creek entail high uncertainty, and actual ecological risks would be lower than the risk ratios suggest.

The low bioavailability of metals from the hard rock sedimentary material is further evidenced by the porewater data. Porewater data are available for four sediment stations in Battle Ax Creek downstream of adit 5, and the three upstream background stations. Porewater data are presented in a table at the end of Attachment B. The data show detections of lead and zinc in only one or two of the porewater samples of the four downstream stations. The single detected lead concentration is barely above the detection limits for the remaining stations both upstream and downstream of adit 5, suggesting that lead in porewater is not elevated in downstream stations. Zinc concentrations in downstream porewater samples are elevated compared with upstream stations; however, the relative levels in porewater among the stations do not appear to relate to the relative levels in the respective sediment samples from the same locations. The highest concentration of zinc was found in Station PW-1 collected during 2005, which exceed the surface water SLV for aquatic receptors; re-sampling of downstream porewater in 2008 did not find a similar elevated porewater concentration (Stations PW-R-22 and PW-R-23). The lack of detection of the lead in porewater, and the apparent lack of relationship between sediment and porewater zinc concentrations, is consistent with low releases of metals from the sedimentary material. Such low releases would result in low availability of dissolved metals in porewater for uptake by biological organisms present in the sediment.

6 CONCLUSIONS

Based on the Level II screening ecological risk assessment for the Ruth Mine site, waste rock soils are identified to pose a potential risk to plants and invertebrates that grow or reside in the soils due to the elevated levels of metals, particularly cadmium, chromium, copper, iron, lead, and zinc. However, the waste rock soils do not present high quality habitat for plants or invertebrates due to their substrate condition as hard rock piles. Potential risks are also identified for birds and protected mammals, however, due to the lack of suitable habitat, mammals are unlikely to use the waste rock soils in the road bed for burrowing or for much food resource. The hard rock piles could present habitat for small mammals but the surrounding terrain presents much higher quality habitat and reliable food sources than the hard rock piles. It would be expected that small mammals would not use the waste rock soils to much extent. The hard rock piles also present poor quality habitat or food sources to birds or larger mammals, such as the federally protected lynx and spotted owl species, and they would be expected to have minimal exposures to the CPECs in the waste rock soils.

Cadmium, lead, and zinc were identified as CPECs for surface waters at the site, however, the exceedances of the cadmium and zinc SLVs were found only for the two adit water samples. None of the surface water concentrations of cadmium or zinc in either Ruth Creek or Battle Ax Creek exceeded Level II screening values, and potential ecological risks are not predicted for those surface waters. Lead was also identified as a CPEC. Exceedance of the lead SLV in suitable aquatic habitat of Battle Ax Creek was low and was not reproducible in subsequent resampling. Thus, the potential for aquatic risk from lead based on risk ratios is uncertain, and actual risk is likely lower than the risk ratios suggest.

Eight CPECs were identified for sediment in Ruth Creek and Battle Ax Creek, with the highest exceedances of benthos SLVs found for cadmium, copper, lead, and zinc in the tributary Ruth Creek. Lesser exceedances were found in Battle Ax Creek, except for zinc which showed the highest exceedance for the benthos SLV in the Battle Ax Creek station immediately downstream of the confluence with Ruth Creek and adit 5 drainage. High exceedances of the bioaccumulation SLV were also found for cadmium and zinc in Ruth Creek and Battle Ax Creek sediments. However, Ruth Creek sediment is unlikely to present a suitable habitat for invertebrates, which would limit them as potential food sources for higher trophic organisms, due to the very small amount of sediment observed in the creek and the intermittent flow.

The exceedances of sediment SLVs by cadmium, copper, lead, and zinc in Battle Ax Creek sediments downstream of the confluence with Ruth Creek suggest a potential risk to sediment invertebrates of Battle Ax Creek. However, the macroinvertebrate evaluation demonstrated that sediments in Battle Ax Creek downstream of the confluence with Ruth Creek did not show any community impairment, despite the levels of exceedances of the metals SLVs. These results suggest that the sediment metals are not sufficiently bioavailable to result in impacts or risks to ecological receptors at the Ruth Mine site. The lack of bioavailability of metals in sediments at the site may be related to the hard rock matrix and natural source of the sedimentary material in which the metals are contained.

Evaluation of the slope stability at adits 4 and 5 found that future mass wasting of the waste rock pile may be a possibility only at adit 4. Although the risk assessment was performed under current conditions and assumptions about future conditions, the risk results are not applicable under possible future conditions of mass wasting. Assumptions about current and future conditions include continuous erosion of the waste rock piles that has been ongoing for decades. The evaluation of slope stability at the Ruth Mine site found a potential for ongoing bank erosion at the waste rock pile at adit 4 to impact the long-term stability of the waste rock pile. Sudden disruption of the stability of the waste rock pile could present higher risks to aquatic receptors in Battle Ax Creek should substantial waste rock material transport to the creek. Mitigation activities are recommended. At adit 5, the steep bank on the south side of Battle Ax Creek is underlain by rock, and large-scale landsliding of this slope is unlikely. Mass wasting at adit 5 is not a concern for future risks to aquatic receptors. Also, because the slope is underlain by rock, rapid erosion of this bank by Battle Ax Creek is unlikely.

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ATTACHMENT A – RISK RATIO CALCULATION TABLES

Table A-1a. Waste Rock Soil Screen, Ruth Mine Site

Chemical of Interest (COI)	90 UCL Concentration (mg/kg)	Maximum Detected Concentration (mg/kg)	Screening Level Value			
			Plants (mg/kg)	Invertebrates (mg/kg)	Birds (mg/kg)	Mammals (mg/kg)
Antimony	1.5	1.9	5	78	NA	15
Arsenic	20.7	46.2	10	60	10	29
Cadmium	129.4	422	4	20	6	125
Calcium	20,180	38,500	NA	NA	NA	NA
Chromium	28.8	37.6	1	0.4	4	340000
Cobalt	24.1	34.2	20	1000	120	150
Copper	2,336	7,600	100	50	190	390
Iron	59,016	94,600	10	200	NA	NA
Lead	5,987	34,000	50	500	16	4000
Magnesium	14,354	18,000	NA	NA	NA	NA
Manganese	7,703	15,900	500	100	4125	11000
Mercury	0.47	1.87	0.3	0.1	1.5	73
Nickel	26.9	40.6	30	200	320	625
Potassium	3,710	6,770	NA	NA	NA	NA
Selenium	4.3	16.5	1	70	2	25
Silver	10.3	28.6	2	50	4.2	NA
Zinc	30,391	98,900	50	200	60	20000

Samples consist of all waste rock samples on-site (N=21-31).

90 UCL concentrations determined with ProUCL program (USEPA 2007)

COIs selected by screening for frequency of detection and comparison with site-related background.

Antimony screening criterion for invertebrates = EcoSSL (USEPA 2008)

Cobalt screening criterion for birds = EcoSSL (USEPA 2008)

Silver screening criterion for birds = EcoSSL (USEPA 2008)

Table A-1b. Waste Rock Soil Screen, Ruth Mine Site

Chemical of Interest (COI)	COI Risk Ratio			
	Plants (Tij)	Invertebrates (Tij)	Birds (Tij)	Mammals (Tij)
Antimony	0.3	0.019	NA	0.1
Arsenic	2.1	0.3	2.1	0.7
Cadmium	32	6.5	22	1.0
Calcium	NA	NA	NA	NA
Chromium	29	72	7	0.0001
Cobalt	1.2	0.024	0	0.2
Copper	23	47	12	6.0
Iron	5,902	295	NA	NA
Lead	120	12	374	1.5
Magnesium	NA	NA	NA	NA
Manganese	15	77.0	2	0.7
Mercury	1.6	5	0.3	0.01
Nickel	0.9	0.1	0.1	0.04
Potassium	NA	NA	NA	NA
Selenium	4.3	0.1	2.2	0.2
Silver	5.1	0.2	2	NA
Zinc	608	152	507	1.5
Sum of Risk Ratios (Tj)	6,744	667	931	11.8
Number of COIs (Nij)	13	13	12	11
1/Nij	0.08	0.08	0.08	0.09

Risk Ratio (Tij) = (COI concentration)/SLV

Table A-1c. Waste Rock Soil Screen, Ruth Mine Site

Chemical of Interest (COI)	Potential Risk to Non-Protected Species?				Potential Risk to Protected Birds? (Tij>1)	Potential Risk to Protected Mammals? (Tij>1)
	Plants (Tij>5)	Invertebrates (Tij>5)	Birds (Tij>5)	Mammals (Tij>5)		
Antimony	No	No	NA	No	NA	No
Arsenic	No	No	No	No	**Yes**	No
Cadmium	**Yes**	**Yes**	**Yes**	No	**Yes**	**Yes**
Calcium	NA	NA	NA	NA	NA	NA
Chromium	**Yes**	**Yes**	**Yes**	No	**Yes**	No
Cobalt	No	No	No	No	No	No
Copper	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
Iron	**Yes**	**Yes**	NA	NA	NA	NA
Lead	**Yes**	**Yes**	**Yes**	No	**Yes**	**Yes**
Magnesium	NA	NA	NA	NA	NA	NA
Manganese	**Yes**	**Yes**	No	No	**Yes**	No
Mercury	No	No	No	No	No	No
Nickel	No	No	No	No	No	No
Potassium	NA	NA	NA	NA	NA	NA
Selenium	No	No	No	No	**Yes**	No
Silver	**Yes**	No	No	NA	**Yes**	NA
Zinc	**Yes**	**Yes**	**Yes**	No	**Yes**	**Yes**

Potential Risk = Tij > Q

Q = 5 for non-T&E species

Q = 1 for T&E species

Table A-1d. Waste Rock Soil Screen, Ruth Mine Site

	Risks to Non-Protected Species Due to Multiple Contaminants? (Tij/Tj>(1/Nij)*Q)				Risks to Protected Species Due to Multiple Contaminants? (Tij/Tj>(1/Nij)*Q)	
Chemical of Interest (COI)	**Plants**	**Invertebrates**	**Birds**	**Mammals**	**Birds**	**Mammals**
Antimony	No	No	NA	No	NA	No
Arsenic	No	No	No	No	No	No
Cadmium	No	No	No	No	No	No
Calcium	NA	NA	NA	NA	NA	NA
Chromium	No	No	No	No	No	No
Cobalt	No	No	No	No	No	No
Copper	No	No	No	**Yes**	No	**Yes**
Iron	**Yes**	**Yes**	NA	NA	NA	NA
Lead	No	No	No	No	**Yes**	**Yes**
Magnesium	NA	NA	NA	NA	NA	NA
Manganese	No	No	No	No	No	No
Mercury	No	No	No	No	No	No
Nickel	No	No	No	No	No	No
Potassium	NA	NA	NA	NA	NA	NA
Selenium	No	No	No	No	No	No
Silver	No	No	No	NA	No	NA
Zinc	No	No	**Yes**	No	**Yes**	**Yes**
		Q=5			Q=1	

Table A-1e. Waste Rock Soil Screen, Ruth Mine Site

Chemical of Interest (COI)	Selected as CPEC?					
	Plants	Invertebrates	Non-Protected Birds	Non-Protected Mammals	Protected Birds	Protected Mammals
Antimony	No	No	No	No	No	No
Arsenic	No	No	No	No	**Yes**	No
Cadmium	**Yes**	**Yes**	**Yes**	No	**Yes**	**Yes**
Calcium	No	No	No	No	No	No
Chromium	**Yes**	**Yes**	**Yes**	No	**Yes**	No
Cobalt	No	No	No	No	No	No
Copper	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
Iron	**Yes**	**Yes**	No	No	No	No
Lead	**Yes**	**Yes**	**Yes**	No	**Yes**	**Yes**
Magnesium	No	No	No	No	No	No
Manganese	**Yes**	**Yes**	No	No	**Yes**	No
Mercury	No	No	No	No	No	No
Nickel	No	No	No	No	No	No
Potassium	No	No	No	No	No	No
Selenium	No	No	No	No	**Yes**	No
Silver	**Yes**	No	No	No	**Yes**	No
Zinc	**Yes**	**Yes**	**Yes**	No	**Yes**	**Yes**

Habitat suitability is not accounted for in the screening.

Table A-2a. Surface Water SLV Screen, Ruth Mine Site

Chemical of Interest (COI)	90 UCL or Maximum Concentration (mg/L)	Screening Level Value		
		Aquatic (mg/L)	Birds (mg/L)	Mammals (mg/L)
Barium	0.003	0.004	150	39
Cadmium	0.010	0.0022	10	8
Calcium	4.12	116	NA	NA
Chromium	0.001	0.074	7.2	21,000
Copper	0.007	0.009	341	53
Iron	0.039	1000	NA	NA
Lead	0.012	0.0025	28	323
Manganese	0.011	0.12	7242	676
Sodium	1.39	680	NA	NA
Zinc	1.29	0.12	105	1230

Surface water samples include Ruth Creek, Battle Ax Creek, and waters from Adits 4 & 5 (N=11).
90 UCL concentrations determined with ProUCL program (USEPA 2007); max values used where UCL not calculable.
COIs selected by screening for frequency of detection and comparison with upstream concentrations.

Table A-2b. Surface Water SLV Screen, Ruth Mine Site

Chemical of Interest (COI)	COI Risk Ratio		
	Aquatic (Tij)	Birds (Tij)	Mammals (Tij)
Barium	0.7	0.00002	0.00007
Cadmium	4.4	0.00097	0.0012
Calcium	0.036	NA	NA
Chromium	0.015	0.0002	0.0000001
Copper	0.8	0.00002	0.00014
Iron	0.00004	NA	NA
Lead	4.9	0.00044	0.00004
Manganese	0.1	0.000002	0.00002
Sodium	0.002	NA	NA
Zinc	10.7	0.01	0.001
Sum of Risk Ratios (Tj)	22	0.01	0.0025
Number of COIs (Nij)	10	7	7
1/Nij	0.10	0.14	0.14

Risk Ratio (Tij) = (COI concentration)/SLV

Table A-2c. Surface Water SLV Screen, Ruth Mine Site

Chemical of Interest (COI)	Potential Risk to Non-Protected Species?			Potential Risk to Protected Mammals? (Tij>1)
	Aquatic (Tij>1)	Birds (Tij>1)	Mammals (Tij>1)	
Barium	No	No	No	No
Cadmium	**Yes**	No	No	No
Calcium	No	NA	NA	NA
Chromium	No	No	No	No
Copper	No	No	No	No
Iron	No	NA	NA	NA
Lead	**Yes**	No	No	No
Manganese	No	No	No	No
Sodium	No	NA	NA	NA
Zinc	**Yes**	No	No	No

Potential Risk = Tij > Q

Q = 1 for non-T&E and for T&E species

Table A-2d. Surface Water SLV Screen, Ruth Mine Site

Chemical of Interest (COI)	Risks to Non-Protected Species Due to Multiple Contaminants? (Tij/Tj>(1/Nij)*Q)			Risks to Protected Mammals Due to Multiple Contaminants? (Tij/Tj>(1/Nij)*Q)
	Aquatic	Birds	Mammals	
Barium	No	No	No	No
Cadmium	**Yes**	No	No	No
Calcium	No	NA	NA	NA
Chromium	No	No	No	No
Copper	No	No	No	No
Iron	No	NA	NA	NA
Lead	**Yes**	No	No	No
Manganese	No	No	No	No
Sodium	No	NA	NA	NA
Zinc	**Yes**	No	No	No

Q = 1 for non-T&E and for T&E species

Table A-2e. Surface Water SLV Screen, Ruth Mine Site

Chemical of Interest (COI)	Selected as CPEC?			
	Aquatic	Birds	Non-Protected Mammals	Protected Mammals
Barium	No	No	No	No
Cadmium	**Yes**	No	No	No
Calcium	No	No	No	No
Chromium	No	No	No	No
Copper	No	No	No	No
Iron	No	No	No	No
Lead	**Yes**	No	No	No
Manganese	No	No	No	No
Sodium	No	No	No	No
Zinc	**Yes**	No	No	No

Habitat suitability is not accounted for in the screening.

Table A-3a. Sediment Screen, Ruth Mine Site

Chemical of Interest (COI)	90 UCL or Maximum Concentration (mg/kg)	Screening Level Value: Freshwater Sediment Benthos (mg/kg)	Screening Level Value: Wildlife Bioaccumulation (mg/kg)	COI Risk Ratio: Freshwater Sediment Benthos (Tij)	COI Risk Ratio: Wildlife Bioaccumulation (Tij)
Aluminum	30,080	25,500	NA	1.2	NA
Arsenic	11.7	6	4	2.0	2.9
Cadmium	2.4	0.6	0.003	4.1	814
Calcium	8,700	NA	NA	NA	NA
Cobalt	17.0	50	NA	0	NA
Copper	194.5	36	10	5.4	19
Iron	26,060	188,400	NA	0.1	NA
Lead	220	35	128	6	1.7
Magnesium	13,297	NA	NA	NA	NA
Manganese	2,238	1100	NA	2.0	NA
Nickel	34.4	18	316	1.9	0.1
Potassium	1,230	NA	NA	NA	NA
Sodium	572	NA	NA	NA	NA
Vanadium	66.8	NA	NA	NA	NA
Zinc	783	123	3	6.4	261
			Sum of Risk Ratios (Tj):	28.5	1,099
			Number of COIs (Nij):	9	6
			1/Nij:	0.11	0.17

Risk Ratio (Tij) = (90UCL COI concentration)/SLV

Samples consist of sediment samples in downstream Battle Ax Creek and Ruth Creek (N=3-8).

90 UCL concentrations determined with ProUCL program (USEPA 2007)

Source of SLVs for aluminum, lead = NOAA (2004) SQuiRT

Source of SLV for iron = NOAA (2004) SQuiRT

Source of SLV for cobalt = USEPA (2005) Region 5 Eco screening criteria

Table A-3b. Sediment Screen, Ruth Mine Site

Chemical of Interest (COI)	Potential Risk to Sediment-Exposed Species?		Risks Due to Multiple Contaminants? (Tij/Tj>(1/Nij)*Q)		Selected as CPEC?	
	Freshwater Sediment Benthos (Tij>1)	Wildlife Bioaccumulation (Tij>1)	Freshwater Sediment Benthos	Wildlife Bioaccumulation	Freshwater Sediment Benthos	Wildlife Bioaccumulation
Aluminum	**Yes**	NA	No	NA	**Yes**	No
Arsenic	**Yes**	**Yes**	No	No	**Yes**	**Yes**
Cadmium	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
Calcium	NA	NA	NA	NA	No	No
Cobalt	No	NA	No	NA	No	No
Copper	**Yes**	**Yes**	**Yes**	No	**Yes**	**Yes**
Iron	No	NA	No	NA	No	No
Lead	**Yes**	**Yes**	**Yes**	No	**Yes**	**Yes**
Magnesium	NA	NA	NA	NA	No	No
Manganese	**Yes**	NA	No	NA	**Yes**	No
Nickel	**Yes**	No	No	No	**Yes**	No
Potassium	NA	NA	NA	NA	No	No
Sodium	NA	NA	NA	NA	No	No
Vanadium	NA	NA	NA	NA	No	No
Zinc	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**

Potential Risk = Tij > Q

Q = 1 for all sediment species (ODEQ 1998)

Table A-5a. Battle Ax Creek Surface Water SLV Screen, Ruth Mine Site

Chemical of Interest (COI)	Maximum Concentration (mg/L)	Screening Level Value		
		Aquatic (mg/L)	Birds (mg/L)	Mammals (mg/L)
Barium	0.0010	0.004	150	39
Calcium	4.12	116	NA	NA
Chromium	0.0011	0.074	7.2	21,000
Iron	0.0258	1000	NA	NA
Lead	0.0021	0.0025	28	323
Manganese	0.0014	0.12	7242	676
Sodium	1.39	680	NA	NA
Zinc	0.018	0.12	105	1230

Surface water samples consist of Battle Ax Creek (N=6).
90 UCL concentrations determined with ProUCL program (USEPA 2007); max values used where UCL not calculable.
COIs selected by screening for frequency of detection and comparison with upstream concentrations.

Table A-5b. Battle Ax Creek Surface Water SLV Screen, Ruth Mine Site

Chemical of Interest (COI)	COI Risk Ratio		
	Aquatic (Tij)	Birds (Tij)	Mammals (Tij)
Barium	0.26	0.00001	0.00003
Calcium	0.04	NA	NA
Chromium	0.015	0.0002	0.0000001
Iron	0.00003	NA	NA
Lead	0.85	0.0001	0.00001
Manganese	0.011	0.0000002	0.000002
Sodium	0.002	NA	NA
Zinc	0.15	0.0002	0.00001
Sum of Risk Ratios (Tj)	0.15	0.0002	0.00001
Number of COIs (Nij)	1	1	1
1/Nij	1.00	1.00	1.00

Risk Ratio (Tij) = (COI concentration)/SLV

Table A-5c. Battle Ax Creek Surface Water SLV Screen, Ruth Mine Site

Chemical of Interest (COI)	Potential Risk to Non-Protected Species?			Potential Risk to Protected Mammals? (Tij>1)
	Aquatic (Tij>1)	Birds (Tij>1)	Mammals (Tij>1)	
Barium	No	No	No	No
Calcium	No	NA	NA	NA
Chromium	No	No	No	No
Iron	No	NA	NA	NA
Lead	No	No	No	No
Manganese	No	No	No	No
Sodium	No	NA	NA	NA
Zinc	No	No	No	No

Potential Risk = Tij > Q
Q = 1 for non-T&E and for T&E species

Table A-5d. Battle Ax Creek Surface Water SLV Screen, Ruth Mine Site

Chemical of Interest (COI)	Risks to Non-Protected Species Due to Multiple Contaminants? (Tij/Tj>(1/Nij)*Q)			Risks to Protected Mammals Due to Multiple Contaminants? (Tij/Tj>(1/Nij)*Q)
	Aquatic	Birds	Mammals	
Barium	No	No	No	No
Calcium	No	NA	NA	NA
Chromium	No	No	No	No
Iron	No	NA	NA	NA
Lead	No	No	No	No
Manganese	No	No	No	No
Sodium	No	NA	NA	NA
Zinc	No	No	No	No

Q = 1 for non-T&E and for T&E species

Table A-5e. Battle Ax Creek Surface Water SLV Screen, Ruth Mine Site

Chemical of Interest (COI)	Selected as CPEC?			
	Aquatic	Birds	Non-Protected Mammals	Protected Mammals
Barium	No	No	No	No
Calcium	No	No	No	No
Chromium	No	No	No	No
Iron	No	No	No	No
Lead	No	No	No	No
Manganese	No	No	No	No
Sodium	No	No	No	No
Zinc	No	No	No	No

ATTACHMENT B - STATISTICAL TABLES

TABLE B-1. Soil Samples Statistics, Ruth Mine Site

Background Soils

Sample I.D.	Total Metals (mg/kg)																							
	Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chrom.	Cobalt	Copper	Iron	Lead	Magnes-ium	Mangan-ese	Mercury	Nickel	Potas-sium	Selenium	Silver	Sodium	Thallium	Vanadium	Zinc	Hexavalent Chromium
BG-1	---	---	2.55	92.3	---	ND<0.657	---	17.0	---	42.9	17,700	26.0	---	516	ND<0.0876	22.2	---	ND<0.657	ND<0.657	---	---	---	126	ND<1.27
BG-2	---	---	2.41	40.7	---	ND<0.570	---	18.4	---	48.7	16,200	25.1	---	807	ND<0.0891	24.2	---	ND<0.570	ND<0.570	---	---	---	469	ND<1.16
BG-3	---	---	3.23	75.7	---	ND<0.595	---	18.8	---	57.4	19,100	2.9	---	450	ND<0.0972	25.6	---	ND<0.595	ND<0.595	---	---	---	86.7	442
BG-4	---	---	30.5	21.4	---	98.4	---	20.5	---	868	47,700	5450	---	7700	ND<0.0593	23.8	---	3.56	9.09	---	---	---	24600	ND<1.15
BG-5	---	---	17.3	66.7	---	3.28	---	38.5	---	365	29,200	2020	---	5340	0.121	30.9	---	1.3	3.33	---	---	---	1700	ND<1.21
BG-6	---	---	2.48	42.1	---	ND<0.608	---	18.0	---	40.0	16,700	16.7	---	722	ND<0.0627	25.4	---	ND<0.608	ND<0.608	---	---	---	83.0	ND<1.24
BG-7	---	---	12.0	22.2	---	23.5	---	28.3	---	506	24,000	936	---	3620	0.123	31.0	---	1.18	2.39	---	---	---	4160	ND<1.12
BG-8	---	---	2.54	63.3	---	ND<0.581	---	14.9	---	51.9	17,600	27.3	---	648	ND<0.103	23.8	---	ND<0.581	ND<0.581	---	---	---	107	ND<1.19
BG-9	---	---	3.43	69.6	---	1.16	---	21.4	---	196	15,400	146	---	893	ND<0.0879	27.7	---	ND<0.586	ND<0.586	---	---	---	2470	ND<1.19
BG-10	---	---	8.45	110	---	ND<0.599	---	16.7	---	73.5	16,900	68.2	---	959	ND<0.0659	21.9	---	ND<0.599	ND<0.599	---	---	---	268	ND<1.16
BG-11	33,200	ND<1.55	7.37	55.2	ND<3.11	ND<1.55	2,690	22.8	7.03	25.3	33,800	13.5	4,270	234	0.14	14.1	944	ND<1.55	ND<3.11	ND<155	ND<1.55	81.8	52.4	---
BG-12	28,800	1.53	4.97	121	ND<2.55	ND<1.27	2,170	11.1	11.3	15	32,800	8.53	4,680	1,050	ND<0.102	7.49	1,300	ND<1.27	ND<2.55	295	ND<1.27	73.6	69.5	---
BG-13	35,500	ND<1.43	5.86	92.9	ND<2.86	ND<1.43	2,090	12.2	13.7	21.7	32,400	8.38	6,440	1,270	ND<0.144	11.7	834	ND<1.43	ND<2.86	196	ND<1.43	69.8	77.5	---
BG-14	19,700	ND<1.50	5.1	48.2	ND<3.01	ND<1.50	727	19.2	4.54	14.5	34,100	15.8	2,270	169	ND<0.120	7.96	533	ND<1.50	ND<3.01	ND<150	ND<1.50	88	42.9	---
BG_15	31,700	ND<1.72	3.88	78.7	ND<3.44	ND<1.72	1,280	19.9	7.4	23.5	29,700	22.1	3,340	367	ND<0.137	12.1	780	ND<1.72	ND<3.44	ND<172	ND<1.72	63.4	69.2	---
BG-16	40,400	ND<1.21	4.86	123	ND<2.42	ND<1.21	2,130	24.7	12.9	50.6	39,300	160	6,470	773	0.121	20	1,480	ND<1.21	ND<2.42	138	ND<1.21	76.4	352	---
BG-17	45,300	ND<1.17	5.8	75.3	ND<2.34	ND<1.17	983	19.7	8.45	30.8	33,600	105	2,630	641	0.117	12.7	708	ND<1.17	ND<2.34	201	ND<1.17	68.2	520	---
BG-18	49,900	1.48	5.68	103	ND<2.49	ND<1.25	1,180	29	13.3	48	42,700	66.4	6,320	742	ND<0.0996	21.1	1,260	ND<1.25	ND<2.49	139	ND<1.25	78.1	392	---
BG-19	34,800	ND<1.53	5.47	67.6	ND<3.07	ND<1.53	2,080	23.5	11.1	38.4	31,700	80.9	5,670	750	0.138	18.9	1,030	ND<1.53	ND<3.07	ND<153	ND<1.53	64.8	264	---
BG-20	12,700	ND<1.36	1.97	42	ND<2.72	ND<1.36	2,880	12	3.69	5.78	15,300	8.31	1,890	437	0.109	5.78	459	ND<1.36	ND<2.72	171	ND<1.36	47	33.8	---
Maximum detected	49,900	1.53	30.5	123	ND	98.4	2,880	38.5	13.7	868	47,700	5,450	6,470	7,700	0.140	31.0	1,480	3.56	9.09	295	ND	88.0	24,600	442
95 UCL	39,635	1.50	9.35	82.1	---	16.8	2,246	22.8	11.5	256	31,706	914	5,437	3,282	0.12	22.4	1,128	1.55	3.47	201	---	77.7	13,960	<1.27
Distribution	N	NonPara	Log	N	---	N	N	N	N	Log	Gamma A	Log	N	NonPara	N	N	N	N	N	N	---	N	NonPara	---

Waste Rock Soils

WRS-1	---	---	7.88	56.6	---	3.95	---	23.1	---	94.5	30300	346	---	1220	0.135	19.2	---	ND<0.545	ND<0.545	---	---	---	918	ND<1.12
WRS-2	---	---	46.2	7.94	---	307	---	16.6	---	7600	77000	2050	---	10200	1.87	17.6	---	9.98	9.19	---	---	---	64900	ND<1.09
WRS-3	---	---	22.8	10.2	---	171	---	37.6	---	1120	68200	14000	---	15900	0.548	23.7	---	6.56	7.62	---	---	---	43600	ND<1.06
WRS-4	---	---	23.7	10.0	---	422	---	19.6	---	2780	77000	34000	---	12900	0.431	18.7	---	16.5	7.1	---	---	---	98900	ND<1.05
WRS-5	---	---	22.0	11.5	---	227	---	23.2	---	5480	74000	10800	---	13000	0.378	22.9	---	6.67	9.66	---	---	---	54800	ND<1.17
WRS-6	---	---	26.9	17.5	---	76.8	---	18.0	---	541	35100	4030	---	5480	1.11	23.1	---	3.03	10.0	---	---	---	17100	ND<0.758
WRS-7	---	---	10.8	28.1	---	17.2	---	26.5	---	134	26800	2440	---	5300	ND<0.0880	31.6	---	2.97	4.98	---	---	---	4370	ND<0.689
WRS-8	---	---	15.4	34.7	---	66.1	---	32.9	---	363	33500	2670	---	7730	0.126	40.6	---	2.05	5.51	---	---	---	14800	ND<0.637
WRS-9	---	---	17.9	16.3	---	33.3	---	34.6	---	202	36800	1480	---	6360	0.37	35.7	---	1.02	3.63	---	---	---	7630	ND<0.671
WRS-10	---	---	26.9	28.2	---	68.4	---	13.8	---	462	24200	2410	---	4640	0.341	22.7	---	2.06	6.49	---	---	---	15200	ND<0.715
WRS-R-11	29,200	1.52	13.8	40.7	ND<2.63	33.9	4,350	24.6	20.1	409	51,500	937	9,790	1,890	0.25	26.6	1,340	ND<1.32	ND<2.63	168	ND<1.32	56.5	8,590	---
WRS-R-12	43,000	ND<1.23	11.8	62.5	ND<2.45	29.3	1,770	33.3	21.5	318	58,000	2,160	11,100	3,610	0.429	27.7	1,640	1.51	6.51	ND<123	ND<1.23	80.7	7,080	---
WRS-R-13	30,200	1.71	19.6	66.1	ND<2.28	132	17,300	26.7	25.2	688	64,500	5,550	14,300	7,100	0.387	26.4	3,540	3.13	11.2	ND<114	ND<1.14	53.4	29,900	---
WRS-R-14	34,300	1.53	18.0	56.0	ND<2.29	80	34,400	33	25.7	1,050	71,700	4,460	16,900	9,340	0.217	27.5	4,280	4.07	14.7	ND<114	ND<1.14	53	19,200	---
WRS-R-15	34,600	1.85	23	48	ND<2.24	156	27,200	27.4	31.4	6,330	80,400	5,760	16,400	8,910	0.516	24.2	3,970	7.37	27	ND<112	ND<1.12	52.6	35,800	---
WRS-R-16	38,300	1.78	21.9	38.8	ND<2.40	212	16,800	28.4	31	1,790	94,400	8,830	18,000	11,500	0.467	27.7	4,020	4.96	18.8	ND<120	ND<1.20	54.9	51,400	---
WRS-R-17	41,800	1.64	11.2	72.6	ND<2.69	39	5,540	29.8	19	336	48,200	1,260	10,300	2,520	0.175	27.9	1,660	1.51	3.31	184	ND<1.34	69	8,940	---
WRS-R-18	34,500	1.72	19.6	35.6	ND<2.23	255	21,600	30	34.2	6,500	87,000	8,330	16,000	9,280	0.592	26.5	2,970	7.03	28.6	ND<112	ND<1.12	54.1	60,300	---
WRS-R-19	31,900	1.75	20.8	39.5	ND<2.42	89.1	16,800	33	25.5	824	72,900	4,540	15,300	8,120	0.314	27.1	3,380	2.66	10.5	138	ND<1.21	50.7	22,200	---
WRS-R-20	36,400	1.89	24.9	53.6	ND<2.35	226	16,100	30.3	31.9	2,170	81,800	7,460	15,900	9,130	0.446	26.7	5,280	4.86	17.8	ND<117	ND<1.17	53.5	54,200	---
WRS-R-21	38,400	1.75	23.5	59	ND<2.23	188	17,200	28.4	32.6	1,470	94,600	6,400	17,400	12,500	0.357	27.2	5,490	4.86	17.5	ND<111	ND<1.11	50.3	46,000	---
WRS-R-22	21,200	ND<1.13	16.8	50.5	ND<2.26	19.3	11,800	29.8	13.4	152	31,400	1,190	12,400	4,020	0.0902	24.3	3,500	ND<1.13	2.49	ND<113	ND<1.13	30	5,000	---
WRS-R-23	19,500	ND<1.12	8.16	59.6	ND<2.25	16.9	16,500	31.5	14.4	102	29,100	682	10,100	3,270	ND<0.0899	27.9	2,750	ND<1.12	ND<2.25	ND<112	ND<1.12	31.2	4,170	---
WRS-R-24	24,700	ND<1.19	5.39	42.5	ND<2.38	16.4	14,200	25.6	16.9	1,190	39,100	1,130	13,300	3,480	0.131	24.7	2,140	ND<1.19	5.16	150	ND<1.19	47.4	3,510	---
WRS-R-25	23,400	1.36	10.7	95.3	ND<2.28	32.2	23,300	33.5	14.8	128	34,700	1,450	8,870	5,040	0.388	28.5	3,000	ND<1.14	3.13	ND<114	ND<1.14	37.8	7,510	---
WRS-R-26	34,600	ND<1.23	9.14	124	ND<2.47	8.02	5,510	32.3	21.5	198	42,700	1,130	13,600	3,890	0.111	25.8	2,610	ND<1.23	ND<2.47	161	ND<1.23	65.7	2,020	---
WRS-R-27	25,300	ND<1.21	37.2	42.8	ND<2.43	43.5	18,500	26.9	24.3	272	59,700	1,850	13,600	6,700	0.911	26.9	3,570	2.73	7.84	ND<121	ND<1.21	30.3	10,500	---
WRS-R-28	23,200	ND<1.10	13.2	61.2	ND<2.21	17.6	18,300	31.4	15.7	155	36,900	1,230	13,400	4,460	0.132	26.1	2,750	1.44	4.15	ND<110	ND<1.10	35.5	4,690	---
WRS-R-29	23,100	1.13	11.6	40.2	ND<2.14	47.5	17,500	24.3	16.7	437	35,400	1,210	13,100	5,270	ND<0.0854	22.1	2,320	2.07	5.5	ND<107	ND<1.07	33.5	10,600	---
WRS-R-DUP	27,200	1.23	3.87	102	ND<2.14	12.8	38,500	21.5	13.6	100	31,500	905	13,500	4,640	ND<0.0856	19.3	2,780	1.34	ND<2.14	ND<107	ND<1.07	42.1	2,730	---
WRS-R-30	27,000	ND<1.11	30.3	66.3	ND<2.23	34	24,900	24.4	14.5	223	38,700	3,230	12,300	4,670	0.145	22.4	6,770	2.03	7.4	ND<111	ND<1.11	34	8,100	---
Frequency of Detection	21/21	13/21	31/31	31/31	0/21	31/31	21/21	31/31	21/21	31/31	31/31	31/31	21/21	31/31	27/31	31/31	21/21	24/31	26/31	5/21	0/21	21/21	31/31	0/10
Max concentration	43,000	1.89	46.2	124	ND	422	38,500	37.6	34.2	7,600	94,600	34,000	18,000	15,900	1.87	40.6	6,770	16.5	28.6	184	ND	80.7	98,900	<1.17
90 UCL	32,565	1.51	20.7	54.1	---	129	20,180	28.8	24.1	2,336	59,016	5,987	14,354	7,703	0.47	26.9	3,710	4.3	10.3	147	---	52.3	30,391	---
95 UCL	33,169	1.54	21.4	56.0	---	140	20,979	29.2	24.7	2,791	60,562	6,438	14,582	7,957	0.5	27.3	3,827	5	11	148	---	53.5	32,756	---
Distribution	N	N	N	N	---	Gamma	N	N	N	Log	NonPara	Gamma A	N	N	Gamma	Log	N	Gamma	Gamma	N	---	N	Gamma	

UCL determined with ProUCL (USEPA 2007). UCLs for all COIs with ND are determined by Kaplan-Meier method of data substitution; distribution is for detected values only

Background determined as 95 UCL of the mean of all BG samples

Gamma A = Approximate gamma

Gamma = gamma

Log = Lognormal

N = normal

NonPara = Nonparametric

Table B-2. Surface Water Samples Statistics, Ruth Mine Site

Sample I.D.	Location	Total Metals (mg/L)																						
		Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead	Magnes-ium	Manga-nese	Mercury	Nickel	Potas-sium	Selenium	Silver	Sodium	Thallium	Vanadium	Zinc
AW-4	Adit 4	---	---	ND<0.001	0.00694	---	0.0221	---	ND<0.001	---	0.0148	0.0475	0.0377	---	0.0235	ND <0.0002	ND <0.002	---	ND<0.002	ND <0.001	---	---	---	3.08
AW-5	Adit 5	---	---	ND<0.001	0.00322	---	0.00539	---	ND<0.001	---	0.0046	0.0739	0.00262	---	0.0309	ND <0.0002	ND <0.002	---	ND<0.002	ND <0.001	---	---	---	1.27
SW-3	Tributary, above Adit 4	---	---	ND<0.001	ND <0.001	---	ND<0.001	---	ND<0.001	---	ND <0.002	ND<0.01	ND <0.001	---	ND <0.002	ND <0.0002	ND <0.002	---	ND<0.002	ND <0.001	---	---	---	0.0186
SW-4	Tributary, below Adit 4	---	---	ND<0.001	ND <0.001	---	ND<0.001	---	ND<0.001	---	ND <0.002	0.0434	0.00392	---	0.004	ND <0.0002	ND <0.002	---	ND<0.002	ND <0.001	---	---	---	0.0516
SW-5	Tributary, below Adit 4	---	---	ND<0.001	ND <0.001	---	ND<0.001	---	ND<0.001	---	ND <0.002	ND<0.01	0.00444	---	ND <0.002	ND <0.0002	ND <0.002	---	ND<0.002	ND <0.001	---	---	---	0.0856
SW-1	Battle Ax Cr., downstream of Adit 5	---	---	ND<0.001	ND <0.001	---	ND<0.001	---	ND<0.001	---	ND <0.002	0.0117	0.00295	---	ND <0.002	ND <0.0002	ND <0.002	---	ND<0.002	ND <0.001	---	---	---	0.0193
SW-2	Battle Ax Cr., downstream of Adit 5	---	---	ND<0.001	0.00104	---	ND<0.001	---	ND<0.001	---	ND <0.002	0.0258	ND <0.001	---	ND <0.002	ND <0.0002	ND <0.002	---	ND<0.002	ND <0.001	---	---	---	0.00775
SW-7	Battle Ax Cr., confluence of tributary	---	---	ND<0.001	ND <0.001	---	ND<0.001	---	ND<0.001	---	ND <0.002	ND<0.01	ND <0.001	---	ND <0.002	ND <0.0002	ND <0.002	---	ND<0.002	ND <0.001	---	---	---	0.0174
SW-R-21	Battle Ax Cr., downstream of Adit 5	ND<0.1	ND<0.001	ND<0.001	ND <0.001	ND<0.001	ND<0.001	4.01	ND<0.001	ND <0.002	ND <0.004	ND<0.10	ND <0.001	0.467	ND <0.001	ND <0.001	ND <0.001	ND <0.100	ND<0.001	ND <0.002	1.31	ND<0.001	ND<0.002	0.0148
SW-R-22	Battle Ax Cr., downstream of Adit 5	ND<0.1	ND<0.001	ND<0.001	ND <0.001	ND<0.001	ND<0.001	4.12	ND<0.001	ND <0.002	ND <0.004	ND<0.10	ND <0.001	0.48	0.00136	ND <0.001	ND <0.001	0.105	ND<0.001	ND <0.002	1.39	ND<0.001	ND<0.002	0.0187
SW-R-23	Battle Ax Cr., downstream of Adit 5	ND<0.1	ND<0.001	ND<0.001	ND <0.001	ND<0.001	ND<0.001	4.11	0.0011	ND <0.002	ND <0.004	ND <0.001	ND <0.001	0.467	ND <0.001	ND <0.001	ND <0.001	0.108	ND<0.001	ND <0.002	1.33	ND<0.001	ND<0.002	0.0167
Frequency of Detection		0/3	0/3	0/11	3/11	0/3	2/11	3/3	1/11	0/3	2/11	5/11	5/11	3/3	4/11	0/11	0/11	2/3	0/11	0/11	3/3	0/3	0/3	11/11
Maximum detected		ND<0.1	ND<0.001	ND<0.001	0.00694	ND<0.001	0.0221	4.12	0.0011	ND <0.002	0.0148	0.0739	0.0377	0.48	0.0309	ND <0.001	ND <0.001	0.108	ND<0.001	ND <0.002	1.39	ND<0.001	ND<0.002	3.08
90 UCL		---	---	---	0.003	---	0.010	4.12	0.0011	---	0.007	0.039	0.012	0.48	0.011	---	---	---	---	---	1.39	---	---	1.285
Distribution		---	---	---	N	---	NonPara		---	---	NonPara	N	NonPara	---	N	---	---		---	---		---	---	NonPara
Battle Ax downstream																								
Battle Ax Maximum		ND<0.1	ND<0.001	ND<0.001	0.00104	ND<0.001	ND<0.001	4.12	0.0011	ND <0.002	ND <0.004	0.0258	0.00295	0.48	0.00136	ND <0.001	ND <0.001	0.108	ND<0.001	ND <0.002	1.39	ND<0.001	ND<0.002	0.0193
Battle Ax 90 UCL		---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

Sample I.D.	Location	Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead	Magnes-ium	Manga-nese	Mercury	Nickel	Potas-sium	Selenium	Silver	Sodium	Thallium	Vanadium	Zinc
Upstream of Ruth Mine																								
SW-6	Battle Ax Cr., upstream of Adit 5	---	---	ND<0.001	ND <0.001	---	ND<0.001	---	ND<0.001	---	ND <0.002	ND<0.01	ND <0.001	---	ND <0.002	ND <0.0002	ND <0.002	---	ND<0.002	ND <0.001	---	---	---	ND <0.005
SW-R-19	Battle Ax Cr., upstream of Adit 5	0.375	ND<0.001	ND<0.001	0.00208	ND<0.001	ND<0.001	4.29	0.00103	ND <0.002	ND <0.004	0.187	ND <0.001	0.559	0.00682	ND <0.001	ND <0.001	0.167	ND<0.001	ND <0.002	1.42	ND<0.001	ND<0.002	0.00861
SW-R-20	Battle Ax Cr., upstream of Adit 5	ND<0.1	ND<0.001	ND<0.001	ND <0.001	ND<0.001	ND<0.001	4.08	ND<0.001	ND <0.002	ND <0.004	ND<0.1	ND <0.001	0.482	ND <0.001	ND <0.001	ND <0.001	0.113	ND<0.001	ND <0.002	1.37	ND<0.001	ND<0.002	0.00667
Maximum detected		0.375	ND<0.001	ND<0.001	0.00208	ND<0.001	ND<0.001	4.29	0.00103	ND <0.002	ND <0.004	0.187	ND <0.001	0.559	0.00682	ND <0.001	ND <0.001	0.167	ND<0.001	ND <0.002	1.42	ND<0.001	ND<0.002	0.00861
Upstream Background																								
SW-8	Battle Ax Cr., upstream of Blue Jay Cr.	---	---	ND<0.001	ND <0.001	---	ND<0.001	---	ND<0.001	---	ND <0.002	ND<0.01	ND <0.001	---	ND <0.002	ND <0.0002	ND <0.002	---	ND<0.002	ND <0.001	---	---	---	ND <0.005
SW-MS-14	Battle Ax Cr., upstream of Blue Jay Cr.	ND<0.1	ND<0.001	ND<0.001	ND <0.001	ND<0.001	ND<0.001	4.05	ND<0.001	ND <0.002	ND <0.004	ND<0.1	ND <0.001	0.483	ND <0.001	ND <0.0001	ND <0.001	0.11	ND<0.001	ND <0.002	1.32	ND<0.001	ND<0.002	0.00689
SW-MS-15	Battle Ax Cr., upstream of Blue Jay Cr.	ND<0.1	ND<0.001	ND<0.001	ND <0.001	ND<0.001	ND<0.001	4.03	ND<0.001	ND <0.002	ND <0.004	ND<0.1	ND <0.001	0.473	ND <0.001	ND <0.0001	ND <0.001	0.108	ND<0.001	ND <0.002	1.29	ND<0.001	ND<0.002	0.0107
SW-MS-16	Battle Ax Cr., upstream of Blue Jay Cr.	ND<0.1	ND<0.001	ND<0.001	ND <0.001	ND<0.001	ND<0.001	3.91	ND<0.001	ND <0.002	ND <0.004	ND<0.1	ND <0.001	0.466	ND <0.001	ND <0.0001	ND <0.001	0.117	ND<0.001	ND <0.002	1.3	ND<0.001	ND<0.002	0.00978
Maximum detected		ND<0.1	ND<0.001	ND<0.001	ND <0.001	ND<0.001	ND<0.001	4.05	ND<0.001	ND <0.002	ND <0.004	ND<0.1	ND <0.001	0.483	ND <0.001	ND <0.0001	ND <0.001	0.117	ND<0.001	ND <0.002	1.32	ND<0.001	ND<0.002	0.0107
95 UCL		---	---	---	---	---	---	4.05	---	---	---	---	---	0.483	---	---	---	0.117	---	---	1.32	---	---	

Table B-3. Sediment Samples Statistics, Ruth Mine Site

Sample I.D.	Location	Total Metals(mg/kg)																						
		Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead	Magnes-ium	Manga-nese	Mercury	Nickel	Potas-sium	Selenium	Silver	Sodium	Thallium	Vanadium	Zinc
SED-1	Battle Ax Cr., downstream of Adit 5	---	---	1.08	22.9	---	0.66	---	12.9	---	29.1	11700	35.6	---	339	ND <0.0927	27.9	---	ND<0.588	ND<0.588	---	---	---	246
SED-2	Battle Ax Cr., downstream of Adit 5	---	---	1.95	30.4	---	ND<0.657	---	11.2	---	20.4	13100	38.1	---	948	ND <0.107	23.7	---	ND<0.657	ND<0.657	---	---	---	290
SED-3	Tributary, above Adit 4	---	---	2.00	35.7	---	1.06	---	14.6	---	63.9	16500	244	---	1440	ND <0.0643	15.7	---	ND<0.618	ND<0.618	---	---	---	648
SED-4	Tributary, below Adit 4	---	---	3.68	34.6	---	1.87	---	13.8	---	465	20800	265	---	2280	ND <0.0633	18.8	---	ND<0.652	0.745	---	---	---	953
SED-5	Tributary, below Adit 4	---	---	11.7	12.2	---	0.989	---	9.86	---	39.6	23100	278	---	4290	ND <0.102	17.4	---	ND<0.706	ND<0.706	---	---	---	577
SED-R-21	Battle Ax Cr., downstream of Adit 5	19,500	ND<1.33	1.53	35.9	ND<2.67	ND<1.33	6,060	16.5	12.6	30.8	25,300	55.5	10,300	728	ND <0.107	23.8	715	ND<1.33	ND<2.67	372	ND<1.33	48.2	174
SED-R-22	Battle Ax Cr., downstream of Adit 5	23,000	ND<1.43	15.70	54	ND<2.86	5.59	6,700	20.8	16.1	34.6	33,400	83.2	13,000	2,110	ND <0.115	50.2	973	ND<1.43	ND<2.86	354	ND<1.43	55.6	1,390
SED-R-23	Battle Ax Cr., downstream of Adit 5	30,100	ND<1.32	1.85	59.2	ND<2.64	ND<1.32	8,700	22.6	15.8	109	32,100	43.8	12,100	567	ND <0.106	45.5	1,230	ND<1.32	ND<2.64	572	ND<1.32	66.5	299
Frequency of Detection		3/3	0/3	8/8	8/8	0/3	5/8	3/3	8/8	3/3	8/8	8/8	8/8	3/3	8/8	0/8	8/8	3/3	0/8	1/8	3/3	0/3	3/3	8/8
Maximum detected		30,100	ND<1.43	15.7	59.2	ND<2.86	5.59	8,700	22.6	16.1	465	33,400	278	13,000	4,290	ND <0.115	50.2	1,230	ND<1.43	0.75	572	ND<1.43	66.5	1,390
	90 UCL	30,080	--	11.7	43.3	--	2.44	8,700	17.5	17.0	195	26,060	220	13,297	2,238	--	34.4	1,230	--	--	572	--	66.8	783
	Distribution	N	--	Log	N	--	Gamma	N	N	N	Gamma	N	Gamma	N	N	--	N		--			--	N	N
Upstream of Ruth Mine																								
SED-6	Battle Ax Cr., upstream of Adit 5	---	---	2.60	82.3	---	ND<0.661	---	14.0	---	35.9	15200	12.8	---	768	ND <0.0748	30.6	---	ND<0.661	ND<0.661	---	---	---	119
SED-R-19	Battle Ax Cr., upstream of Adit 5	17,300	ND<1.42	ND<1.42	30.4	ND<2.84	ND<1.42	5,010	13.1	10.0	21.5	20,500	8.58	8,480	383	ND <0.114	26.9	630	ND<1.42	ND<2.84	283	ND<1.42	36.7	67.9
SED-R-20	Battle Ax Cr., upstream of Adit 5	22,400	ND<1.34	2.39	27.2	ND<2.68	ND<1.34	7,170	11.6	11.2	29.9	25,000	4.75	9,060	439	ND <0.107	17.5	643	ND<1.34	ND<2.68	167	ND<1.34	38.9	62.2
Maximum detected		22,400	ND<1.42	2.60	82.3	ND<2.84	ND<1.42	7,170	14.0	11.2	35.9	25,000	12.8	9,060	768	ND <0.114	30.6	643.0	ND<1.42	ND<2.84	283	ND<1.42	38.9	119
	95 UCL	--	--	--	98.8	--	--	7,170	14.9	--	41.3	28,503	15.5	--	881	--	36.4	--	--	--	--	--	--	136
	Distribution	--	--	--	N	--	--	N	N	--	N	N	N	--	N	--	N	--	--	--	--	--	--	N
Upstream Background																								
SED-MS-14	Battle Ax Cr., upstream of Blue Jay Cr.	17,900	ND<1.32	1.42	32.8	ND<2.63	ND<1.32	7,490	11.4	9.6	15.5	16,000	2.97	7,330	424	ND <0.105	16.3	844	ND<1.32	ND<2.63	267	ND<1.32	28.8	36.1
SED-MS-15	Battle Ax Cr., upstream of Blue Jay Cr.	24,100	ND<1.20	1.25	51.6	ND<2.4	ND<1.2	6,460	22.3	12.5	24.3	25,000	3.44	10,600	466	ND <0.0962	28.7	843	ND<1.2	ND<2.4	396	ND<1.2	43.4	50.5
SED-MS-16	Battle Ax Cr., upstream of Blue Jay Cr.	19,600	ND<1.31	ND<1.31	39.9	ND<2.61	ND<1.31	6,090	10.7	10.3	20.8	19,100	2.27	9,640	359	ND <0.105	21.2	547	ND<1.31	ND<2.61	445	ND<1.31	36.3	39.6
Maximum detected		24,100	ND<1.32	1.42	51.6	ND<2.63	ND<1.32	7,490	22.3	12.5	24.3	25,000	3.44	10,600	466	ND<0.105	28.7	844	ND<1.32	ND<2.63	445	ND<1.32	43.4	50.5
	95 UCL	25,934	--	--	57.4	--	--	7,903	25.8	13.4	27.7	27,741	3.89	12,024	507	--	32.6	1,033	--	--	524	--	48.5	54.7
	Distribution	N	--		N	--	--	N	N	N	N	N	N	N	N	--	N	N	--	--	N	--	N	N

Porewater

Sample I.D.	Location	Dissolved Metals (mg/L)																							
		Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead	Magnes-ium	Manga-nese	Mercury	Nickel	Potas-sium	Selenium	Silver	Sodium	Thallium	Vanadium	Zinc
PW-1	Battle Ax Cr., downstream of Adit 5	---	---	ND <0.001	0.00201	---	0.00149	---	ND<0.001	---	ND <0.002	ND<0.01	ND <0.001	---	ND<0.002	ND <0.0002	ND<0.002	---	ND<0.002	ND <0.001	---	---	---	0.277
PW-2	Battle Ax Cr., downstream of Adit 5	---	---	ND <0.001	ND <0.0010	---	ND<0.001	---	ND<0.001	---	ND <0.002	ND<0.01	ND <0.001	---	ND<0.002	ND <0.0002	ND<0.002	---	ND<0.002	ND <0.001	---	---	---	ND <0.005
PW-R-22	Battle Ax Cr., downstream of Adit 5	ND<0.1	ND<0.001	ND <0.001	0.00136	ND<0.001	ND<0.001	4.05	ND<0.001	ND <0.002	ND <0.005	ND<0.1	0.00153	0.452	0.00434	ND <0.0001	ND<0.001	0.144	ND<0.001	ND <0.002	1.37	ND <0.001	ND<0.002	0.103
PW-R-23	Battle Ax Cr., downstream of Adit 5	ND<0.1	ND<0.001	ND <0.001	0.00236	ND<0.001	ND<0.001	8.41	ND<0.001	ND <0.002	ND <0.005	ND<0.1	ND <0.001	0.648	0.00484	ND <0.0001	ND<0.001	0.159	ND<0.001	ND <0.002	1.95	ND <0.001	ND<0.002	0.078
Maximum detected		ND<0.1	ND<0.001	ND <0.001	0.0024	ND<0.001	0.0015	8.41	ND<0.001	ND <0.002	ND <0.005	ND<0.1	0.0015	0.648	0.0048	ND <0.0001	ND<0.001	0.159	ND<0.001	ND <0.002	1.95	ND <0.001	ND<0.002	0.277
Upstream of Ruth Mine																									
PW-R-19	Battle Ax Cr., upstream of Adit 5	ND<0.1	ND<0.001	ND <0.001	0.00104	ND<0.001	ND<0.001	3.7	ND<0.001	ND <0.002	ND <0.005	ND<0.1	ND <0.001	0.465	0.00191	ND <0.0001	ND<0.001	0.111	ND<0.001	ND <0.002	1.41	ND <0.001	ND<0.002	0.0071
PW-R-20	Battle Ax Cr., upstream of Adit 5	ND<0.1	ND<0.001	ND <0.001	0.00117	ND<0.001	ND<0.001	4.4	ND<0.001	ND <0.002	ND <0.005	ND<0.1	ND <0.001	0.491	0.0041	ND <0.0001	ND<0.001	0.138	ND<0.001	ND <0.002	1.41	ND <0.001	ND<0.002	0.0059
Maximum detected		ND<0.1	ND<0.001	ND <0.001	0.0012	ND<0.001	ND<0.001	4.4	ND<0.001	ND <0.002	ND <0.005	ND<0.1	ND <0.001	0.491	0.0041	ND <0.0001	ND<0.001	0.138	ND<0.001	ND <0.002	1.4	ND <0.001	ND<0.002	0.0071
Upstream of Morning Star (Background)																									
PW-MS-14	Battle Ax Cr., upstream of Blue Jay Cr.	ND<0.1	ND<0.001	ND <0.001	0.0015	ND<0.001	ND<0.001	3.9	ND<0.001	ND <0.002	ND <0.005	ND<0.1	ND <0.001	0.502	0.00521	ND <0.0001	0.00227	0.175	ND<0.001	ND <0.002	1.52	ND <0.001	ND<0.002	0.0055
PW-MS-15	Battle Ax Cr., upstream of Blue Jay Cr.	ND<0.1	ND<0.001	ND <0.001	0.00106	ND<0.001	ND<0.001	3.83	ND<0.001	ND <0.002	ND <0.005	ND<0.1	ND <0.001	0.494	0.00447	ND <0.0001	0.00213	0.138	ND<0.001	ND <0.002	1.37	ND <0.001	ND<0.002	0.0051
PW-MS-16	Battle Ax Cr., upstream of Blue Jay Cr.	ND<0.1	ND<0.001	ND <0.001	ND <0.001	ND<0.001	ND<0.001	3.8	ND<0.001	ND <0.002	ND <0.005	ND<0.1	ND <0.001	0.478	0.00191	ND <0.0001	ND<0.001	0.101	ND<0.001	ND <0.002	1.35	ND <0.001	ND<0.002	ND <0.004
Maximum detected		ND<0.1	ND<0.001	ND <0.001	0.0015	ND<0.001	ND<0.001	3.9	ND<0.001	ND <0.002	ND <0.005	ND<0.1	ND <0.001	0.502	0.0052	ND <0.0001	ND<0.001	0.175	ND<0.001	ND <0.002	1.520	ND <0.001	ND<0.002	0.0055

Table B-4. Sediment Samples Statistics for Battle Ax Creek, Ruth Mine Site

Sample I.D.	Location	Aluminum	Arsenic	Barium	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead	Magnes-ium	Manga-nese	Nickel	Potas-sium	Sodium	Vanadium	Zinc
SED-1	Battle Ax Cr., downstream of Adit 5	---	1.08	22.9	0.66	---	12.9	---	29.1	11700	35.6	---	339	27.9	---	---	---	246
SED-2	Battle Ax Cr., downstream of Adit 5	---	1.95	30.4	ND<0.657	---	11.2	---	20.4	13100	38.1	---	948	23.7	---	---	---	290
SED-R-21	Battle Ax Cr., downstream of Adit 5	19,500	1.53	35.9	ND<1.33	6,060	16.5	12.6	30.8	25,300	55.5	10,300	728	23.8	715	372	48.2	174
SED-R-22	Battle Ax Cr., downstream of Adit 5	23,000	15.70	54	5.59	6,700	20.8	16.1	34.6	33,400	83.2	13,000	2,110	50.2	973	354	55.6	1,390
SED-R-23	Battle Ax Cr., downstream of Adit 5	30,100	1.85	59.2	ND<1.32	8,700	22.6	15.8	109	32,100	43.8	12,100	567	45.5	1,230	572	66.5	299
	Maximum detected	30,100	15.7	59.2	5.59	8,700	22.6	16.1	109	33,400	83.2	13,000	2,110	50.2	1,230	572	66.5	1,390
	90 UCL	30,080	12.9	51.1	5.39	8,653	20.2	17.0	89.7	30,162	64.6	13,297	1,413	42.9	1,253	564	66.8	1,316
	Distribution	N	NonPara	N	NonPara	N	N	N	Log	N	N	N	N	N	N	N	N	Log
Upstream of Ruth Mine																		
SED-6	Battle Ax Cr., upstream of Adit 5	---	2.60	82.3	ND<0.661	---	14.0	---	35.9	15200	12.8	---	768	30.6	---	---	---	119
SED-R-19	Battle Ax Cr., upstream of Adit 5	17,300	ND<1.42	30.4	ND<1.42	5,010	13.1	10.0	21.5	20,500	8.58	8,480	383	26.9	630	283	36.7	67.9
SED-R-20	Battle Ax Cr., upstream of Adit 5	22,400	2.39	27.2	ND<1.34	7,170	11.6	11.2	29.9	25,000	4.75	9,060	439	17.5	643	167	38.9	62.2
	Maximum detected	22,400	2.60	82.3	ND<1.42	7,170	14.0	11.2	35.9	25,000	12.8	9,060	768	30.6	643.0	283	38.9	119
	95 UCL	--	--	98.8	--	--	14.9	--	41.3	28,503	15.5	--	881	36.4	--	--	--	136
	Distribution	--	--	N	--	--	N	--	N	N	N	--	N	N	--	--	--	N
Upstream Background																		
SED-MS-14	Battle Ax Cr., upstream of Blue Jay Cr.	17,900	1.42	32.8	ND<1.32	7,490	11.4	9.6	15.5	16,000	2.97	7,330	424	16.3	844	267	28.8	36.1
SED-MS-15	Battle Ax Cr., upstream of Blue Jay Cr.	24,100	1.25	51.6	ND<1.2	6,460	22.3	12.5	24.3	25,000	3.44	10,600	466	28.7	843	396	43.4	50.5
SED-MS-16	Battle Ax Cr., upstream of Blue Jay Cr.	19,600	ND<1.31	39.9	ND<1.31	6,090	10.7	10.3	20.8	19,100	2.27	9,640	359	21.2	547	445	36.3	39.6
	Maximum detected	24,100	1.42	51.6	ND<1.32	7,490	22.3	12.5	24.3	25,000	3.44	10,600	466	28.7	844	445	43.4	50.5
	95 UCL	25,934	--	57.4	--	7,903	25.8	13.4	27.7	27,741	3.89	12,024	507	32.6	1,033	524	48.5	54.7
	Distribution	N		N	--	N	N	N	N	N	N	N	N	N	N	N	N	N

ATTACHMENT C - MACROINVERTEBRATE EVALUATION

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INTRODUCTION

An evaluation of macroinvertebrates in Battle Ax Creek was performed as part of the screening ecological risk assessment for the Ruth Mine Site, Opal Creek Recreation Area, Oregon. Concentrations of metals in surface water and sediment of the creek are evaluated in the Level II screening ecological risk assessment for their potential risk to ecological receptors in the creek. The evaluation of stream bed macroinvertebrates, described in this attachment to the screening ecological risk assessment, provides a more direct assessment of the biological community in the creek sediments. Macroinvertebrates are fairly stationary, easy to collect, and are responsive to human disturbance. In addition, the relative sensitivity or tolerance of many macroinvertebrates to stream conditions is well known. For these reasons, USEPA (1990) recommends their evaluation in an assessment of ecological integrity of streams.

The evaluation of stream macroinvertebrates in Battle Ax Creek followed the macroinvertebrate bioassessment protocol of the Oregon Plan for Salmon and Watersheds (OPSW 1999). The protocol was adapted from the USEPA Rapid Bioassessment Protocols (Barbour 1999) for use in the state of Oregon. Because the protocol was developed for Coastal Oregon streams, principally for riffle habitats, the interpretation of results for Oregon Cascade streams such as Battle Ax Creek bears some uncertainty. The OPSW protocol provides three levels of evaluation; for Battle Ax Creek, Level 3 was followed.

METHODS FOR DATA COLLECTION AND ANALYSIS

The following summarizes the procedures for sample collection and laboratory analyses. Descriptions of stream habitat and reaches for three sediment stations, and results of the macroinvertebrate evaluations at those stations, are presented in the following section.

SAMPLE COLLECTION

The Level 3 macroinvertebrate collection procedure followed the method provided in OPSW (1999), with some minor modifications. Because of the limited amount of riffle and pool habitats in the stream, a random selection of sample locations within each identified reach of the stream was not possible. Instead, all accessible riffles and pools were sampled within each reach. Stations were selected based on distance from the confluence of Battle Ax Creek and Ruth Creek, where the Ruth Mine shaft, adits, and waste rocks are located. As a tributary to Battle Ax Creek, Ruth Creek serves as a source of drainage from the two adits to Battle Ax Creek. Stations were identified as short reaches, at approximately 30 m length.

Riffle and pool samples were collected by the kick method. For the riffle sample from each station, all accessible riffles were disturbed by the kick method and macroinvertebrates were collected by flat net. Large substrate was rubbed by hand to dislodge organisms, and the substrate was discarded to the stream. Depth of disturbance of sediment was from two to five centimeters. Three kick dislodgings were collected for each sample. Each kick collection covered approximately 1.5 ft^2, for a total of

approximately 4.5 ft^2 of coverage per sample. After each riffle sample collection, contents of the net were placed in a sieve bucket. All samples from the riffle areas of each station were combined in the sieve bucket, washed with river water and sieved, and removed from the net by hand and placed into labeled sample jars. Samples were covered with 90% ethanol, placed on ice for two days, and then shipped to the enumeration laboratory for sorting and analysis.

SAMPLE ANALYSIS

Samples were shipped from GeoDesign and received by the lab with no deviations from the Level 3 protocol. All samples were analyzed at the laboratory following the OPSW (1999) Level 3 protocol. Sorting, species identification, and enumeration of all samples were performed by EcoAnalysts, Moscow, ID.

Sample results are provided by the lab as raw data and as various metrics, including those used in the OSPW protocol to characterize stream sediment macroinvertebrates. All data and metrics received from the lab are included in tables in this attachment.

RESULTS

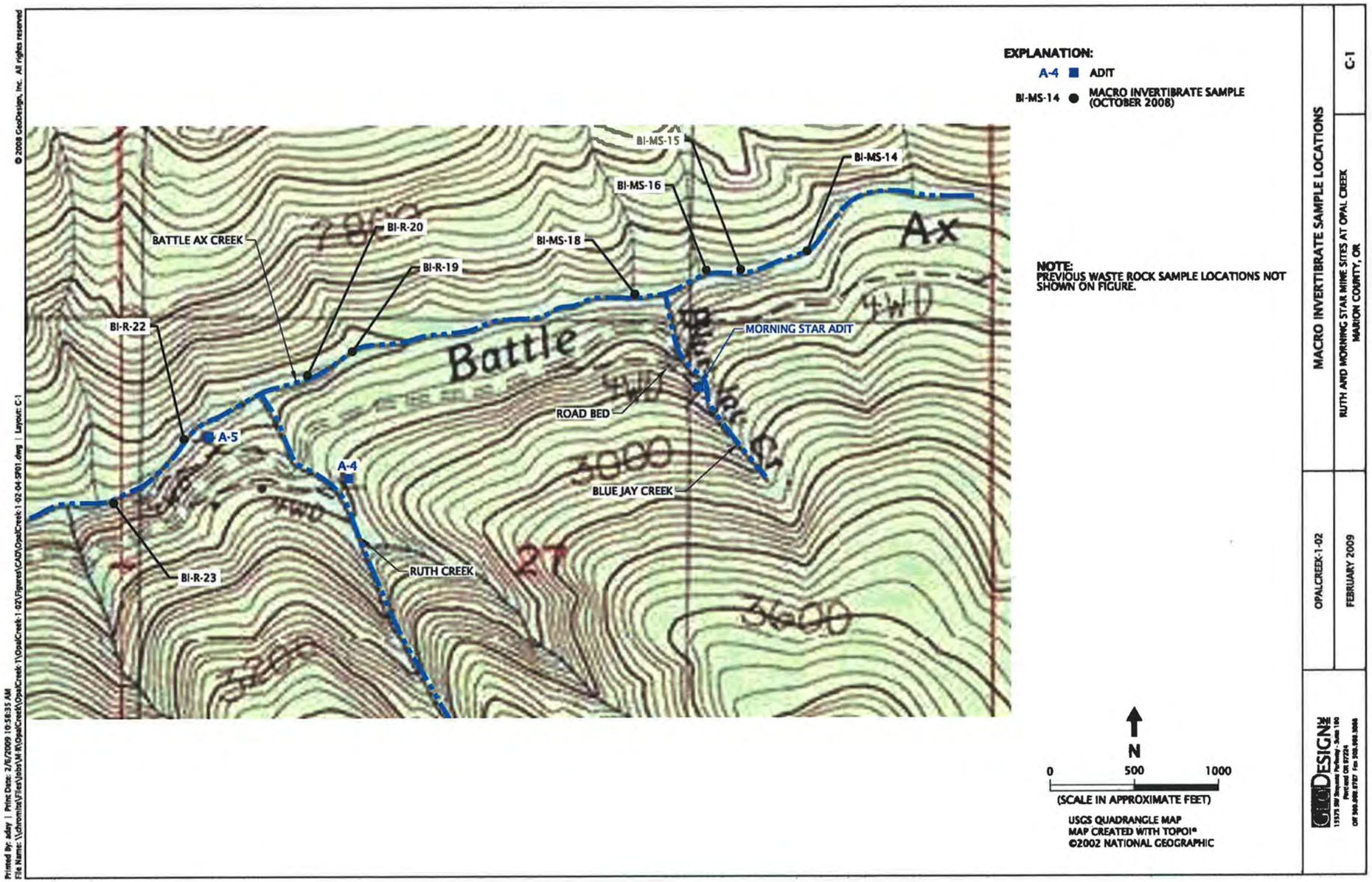
The locations of sediment stations for the collection of macroinvertebrates are identified, and the station reaches are described. Results of the enumeration of macroinvertebrates at each station are presented, with original data and laboratory metrics presented in the attached tables. Results of the metric scores are presented in a summary table, and characteristic metrics for the stations are presented graphically.

DESCRIPTIONS OF STATIONS AND HABITAT

Macroinvertebrate stations were selected in Battle Ax Creek to characterize the sediment biological integrity upstream and downstream of the Ruth Mine drainage, which is carried by Ruth Creek as it flows past the two Ruth Mine adits. Stations selected for macroinvertebrate collection were matched with locations from which sediment and surface water samples were collected in Battle Ax Creek. Stations for macroinvertebrate collection for the Ruth Mine site are labeled BI-R-19 Pool, BI-R-20 Riffle, BI-R-22 Pool, and BI-R-23 Riffle. Stations BI-R-19 Pool and BI-R-20 Riffle are located in Battle Ax Creek upstream of the confluence with Ruth Creek, and stations BI-R-22 Pool and BI-R-23 Riffle are located downstream of the confluence. Macroinvertebrate collection stations are shown on a map in Figure C-1.

All stations were located in Battle Ax Creek. The creek is about 6 m across in these reaches. The reaches are characterized by steep, heavily vegetated banks. Water flow was rapid; sampling occurred in mid-October after start of the rain season. Depth in the middle of the reach was two to three feet. Because of the rapid flow and depth, samples were collected from riffles and pools located in the nearshore area of the reach in water depths of less than three feet.

Figure C-1. Locations of Macroinvertebrate Sample Collection



The riparian zone is undisturbed from the creek shoreline up the slope over 20 m to the mine access road. Riparian vegetation is characterized as an advanced growth, hemlock dominant forest. Understory along the banks was heavily vegetated with various young trees, thick brush, and moss. The presence of downed trees, snags, large boulders, and extensive canopy provides high quality habitat for aquatic organisms.

Substrates of all reaches were dominated by boulders and large cobble, with very little gravel or sediment. The few areas where gravel and small cobble were present were sampled for the riffle sample. Little gravel or sediment was available in pools, with bare hard rock substrate or 1-2 cm of sandy-gravel material overlay. All accessible pools were sampled for the pool sample; available pools were located in depositional areas near shore.

MACROINVERTEBRATE COMMUNITY METRICS

OPDW Level 3 assessments are based on genus/species level identifications. A variety of metrics are used for comparison with the genus/species makeup of the macroinvertebrate community. The full suite of community metrics and metrics used in the OPSW procedure that were developed for each station are provided in the attached data tables, and are followed by the OPSW metric scoring procedure for that station.

Community Metrics

Pools

Pools were available for sample collection at two stations, BI-R-19 Pool and BI-R-22 Pool, located upstream and downstream of the confluence with Ruth Creek, respectively. Data on invertebrate abundance showed fairly high abundance for these two stations, at 544 and 312 in samples from BI-R-19 Pool and BI-R-22 Pool, respectively (Table C-1).

Riffles

Macroinvertebrates were successfully collected from riffles at two sediment stations: BI-R-20 Riffle and BI-R-23 Riffle, located upstream and downstream of the confluence with Ruth Creek, respectively. As shown in Table C-1, the abundances of the riffle samples were sufficient for enumeration, with abundance at BI-R-20 Riffle at 494, and BI-R-23 Riffle at 213. Although the abundances of the downstream stations are lower than those of the upstream stations, abundance was sufficient for enumeration, and the results described indicate no apparent differences among the four stations.

OPSW Metric Scores

Level 3 of the OPSW (1999) protocol provides a sensitive measure of stream condition using macroinvertebrate communities as the primary indicator. The protocol uses a set of metrics that are considered the most reliable indicators of macroinvertebrate community conditions for streams in the Oregon coastal range. These metrics are a subset of the community metrics presented for each station in the attached tables. The metrics are used to generate a score that relates to the overall condition of the macroinvertebrate community at that station. Four classes of stream disturbance can be determined from the scores: *no impairment, slight impairment, moderate impairment,* and *severe impairment.*

The following metrics are used in the scoring system by OPSW:

Taxa Richness – total number of invertebrate taxa

Mayfly (Ephemeroptera) Richness – total number of mayfly taxa

Stonefly (Plecoptera) Richness – total number of stonefly taxa

Caddisfly (Trichoptera) Richness – total number of caddisfly taxa

Sensitive Taxa – Number of taxa known to be sensitive to human disturbance

Sediment Sensitive Taxa – Number of taxa known to be sensitive to fine sediment

Modified HBI – Hilsenhof Biotic Index, index of sensitivity to organic enrichment

% Tolerant Taxa – Percent of total invertebrates that belong to taxa tolerant to disturbance

% Sediment Tolerant Taxa – Percent of total invertebrates that belong to taxa sensitive to fine sediment

% Dominant (single taxa) – Percent to total invertebrates that are comprised of the single most abundant taxon.

Data on genus/species identifications at each station in Battle Ax Creek are presented in the following tables. Assignment of scores for each OPSW metric at each station, and results of the total metric score for each station are also provided in the following data tables. Because of the similarity in results in community metrics between pool and riffle stations, they are discussed together. A summary of the metric scoring for all stations is provided in Table C-1, and discussed below.

Table C-1. Summary of Macroinvertebrate Scoring for Battle Ax Creek, Ruth Mine

	Station			
Metric	**BI-R-19 Pool**	**BI-R-20 Riffle**	**BI-R-22 Pool**	**BI-R-23 Riffle**
Corrected Abundance	544	494	312	213
Taxa Richness	5	5	5	5
Mayfly Richness	5	3	3	3
Stonefly Richness	5	5	5	5
Caddisfly Richness	3	5	5	5
Sensitive Taxa	5	5	5	5

Sediment sens. Taxa	3	5	5	5
Modified HBI	5	5	5	5
% Tolerant Taxa	5	5	3	3
% Sed Tol Taxa	5	5	3	3
% Dominant (single taxa)	1	3	5	5
Total Score	**42**	**46**	**44**	**44**

Score Range	**Stream Condition**
>39	No Impairment: passes level 3 assessment. Indicates good diversity of invertebrates and stream conditions with little or no disturbance.
30-39	Slight Impairment: evidence of some impairment exists.
20-29	Moderate Impairment: clear evidence of disturbance exists.
<20	Severe Impairment: conditions indicate a high level of disturbance.

Upstream Stations

Upstream stations BI-R-19 Pool and BI-R-20 Riffle are located in Battle Ax Creek upstream of the confluence with Ruth Creek, which is assumed to be a source of metals from drainage of the Ruth Mine adits and waste rock soils to Battle Ax Creek. The upstream stations are assumed to represent background conditions for benthic communities; they are believed to be located sufficiently downstream of the drainage from Morning Star Mine, located at the confluence with Blue Jay Creek. Results of the OPSW scoring of the upstream stations BI-R-19 Pool and BI-R-20 Riffle supports their identification as unimpacted by mine drainage that may occur from the Morning Star Mine site further upstream.

In addition to the upstream stations BI-R-19 Pool and BI-R-20 Riffle, three macroinvertebrate sampling stations were located in Battle Ax Creek upstream of the confluence with Blue Jay Creek. Those stations are used as background for the macroinvertebrate analysis of the Morning Star Mine site, which is drained by Blue Jay Creek. The OPSW scores of the stations selected as background for the Morning Star Mine site are similar to those selected as background for the Ruth Mine site, providing further support for use of stations BI-R-19 Pool and BI-R-20 Riffle as background for the Ruth Mine site macroinvertebrate analysis.

The OPSW scores for the upstream stations BI-R-19 Pool and BI-R-20 Riffle were both *No Impairment* (Table C-1). Total abundances and species diversities of macroinvertebrate communities in the upstream stations BI-R-19 Pool and BI-R-20 Riffle were very similar (see Figures C-2 through C-5), consistent with the similar results of the OPSW scoring for these stations.

Downstream Station

The two downstream stations BI-R-22 Pool and BI-R-23 Riffle are located in Battle Ax Creek downstream of the confluence with Ruth Creek, and therefore downstream of the potential source of metals from the two Ruth Mine adits and waste rock piles to Battle Ax

Creek. The downstream stations showed no differences from the upstream stations with regards to the OPSW scores (Table C-1), with scores of *No Impairment*. Results of the scoring suggest that the macroinvertebrate communities of the downstream stations BI-R-22 Pool and BI-R-23 Riffle are not impaired and are similar in benthic macroinvertebrate community structures to the upstream stations.

Relationship of Metric Scores with Potential Sources and Metals Concentrations

The relationship between the OPSW scores and the locations of the sample locations with respect to the potential sources of metals to the downstream station locations was examined by graphically plotting the scores on a schematic of the reaches. Figure C-7 depicts the upstream and downstream stations by OPSW scores and location in Battle Ax Creek with respect to the drainage from Ruth Mine. The schematic provides further illustration of the lack of impacts to the benthic communities of the downstream stations BI-R-22 Pool and BI-R-23 Riffle.

The relationships between the OPSW scores and the metals concentrations of sediments of the upstream and downstream stations were examined by graphically comparing the station scores with sediment metals data. Note that sediment samples for metals concentration data were collected from available sedimentation areas at each station location, consisting mostly of sediments in pools, whereas the OPSW scores were developed separately for the two different types of sedimentation (i.e., riffles and pools) within each station location. Thus, the metals concentrations that come from a mix of primarily pool with some riffle sediments may not adequately represent community conditions in specifically riffle or pool environments.

For depicting the relationship between OPSW scores and metals concentrations, the concentrations of the metals with the highest exceedances of Level II screening criteria are plotted against the OPSW scores. Plots of metals concentrations and OPSW metric scores for the riffle and pool stations are depicted in Figure C-8. The concentrations and Level II SLVs for arsenic, copper, lead, nickel, and zinc are shown on this graphic. The graphic of Figure C-8 shows the lack of a relationship between OPSW scores and the concentrations of metals in sediments of the Battle Ax Creek stations. Sediments with concentrations of lead and zinc, and to a lesser extent nickel, exceeding their Level II screening criteria are all associated with OPSW scores of *No Impairment* to the benthic community.

The lack of impacts to benthic communities despite elevated concentrations of sediment metals suggests that the metals are very limited in bioavailability to the benthic organisms. The Level II SLVs assume that the chemicals are bioavailable at the levels inherent in the studies from which the screening values are derived. The DEQ Level II SLVs for lead and zinc are taken from the TEL values in NOAA (1999) SQuiRT, which in turn are taken from the TELs in USEPA and USFWS reports that developed sediment screening values for the Great Lakes program (Fox and Tuchman 1996, Ingersoll et al 1996, USEPA 1996). The TELs developed in these reports are based on field-collected samples of sediment from the Great Lakes and toxicity tests for *Hyallela azteca*, and are generally identified as the concentrations presenting the fifth percentiles of the response

values. The sediment samples from the Great Lakes were contaminated with metals from sources other than hard rock mining, primarily from industrial liquid effluent discharges. Liquid discharges likely contained metals in dissolved form that subsequently bound to the surfaces of suspended particles and settled out as sediments in the Great Lakes. The bioavailability of these surface-bound metals would be much greater than the bioavailability of metals contained within the mineral matrix of hard rock particles, which would characterize the sediments of Battle Ax Creek.

Because these TELs do not account for the low bioavailability of lead or zinc in the hard rock particles that make up the sediments of Battle Ax Creek, their application to predicting potential risks to sediment macroinvertebrates in Battle Ax Creek entails high uncertainty. The lack of accounting for the differences in bioaccumulation between the studies that form the basis of the SLVs and hard rock substrate found at the site may explain the lack of measurable macroinvertebrate impacts in Battle Ax Creek sediments with elevated metals concentrations.

CONCLUSIONS OF MACROINVERTEBRATE EVALUATION

Comparable data on macroinvertebrate community metrics were collected at stations in Battle Ax Creek located upstream (two stations) and downstream (two stations) of the confluence with Ruth Creek, which drains the adits and waste rock piles of the abandoned Ruth Mine. The abundance of macroinvertebrates at both the upstream background stations and the stations downstream of the confluence indicated no impairment. Comparison of the community metric scores with metals concentrations in sediment samples showed no relationships, despite the concentrations of lead and zinc in downstream stations elevated above Level II SLVs. Because the macroinvertebrate evaluation protocol was developed for Coastal Oregon Streams rather than Cascade streams, the interpretation of metrics results entails uncertainty. However, the lack of significant shifts in the metrics between riffle stations suggests minimal impact of the mines or of sediment chemistry on the macroinvertebrate community of Battle Ax Creek. In summary, the results of the macroinvertebrate evaluation suggest that the Ruth Mine drainage through Ruth Creek to Battle Ax Creek, and runoff from the road bed and waste rock soils around adit 5, do not result in impacts to the macroinvertebrate communities in downstream sediments of Battle Ax Creek.

REFERENCES FOR ATTACHMENT C

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MACROINVERTEBRATE EVALUATION FIGURES

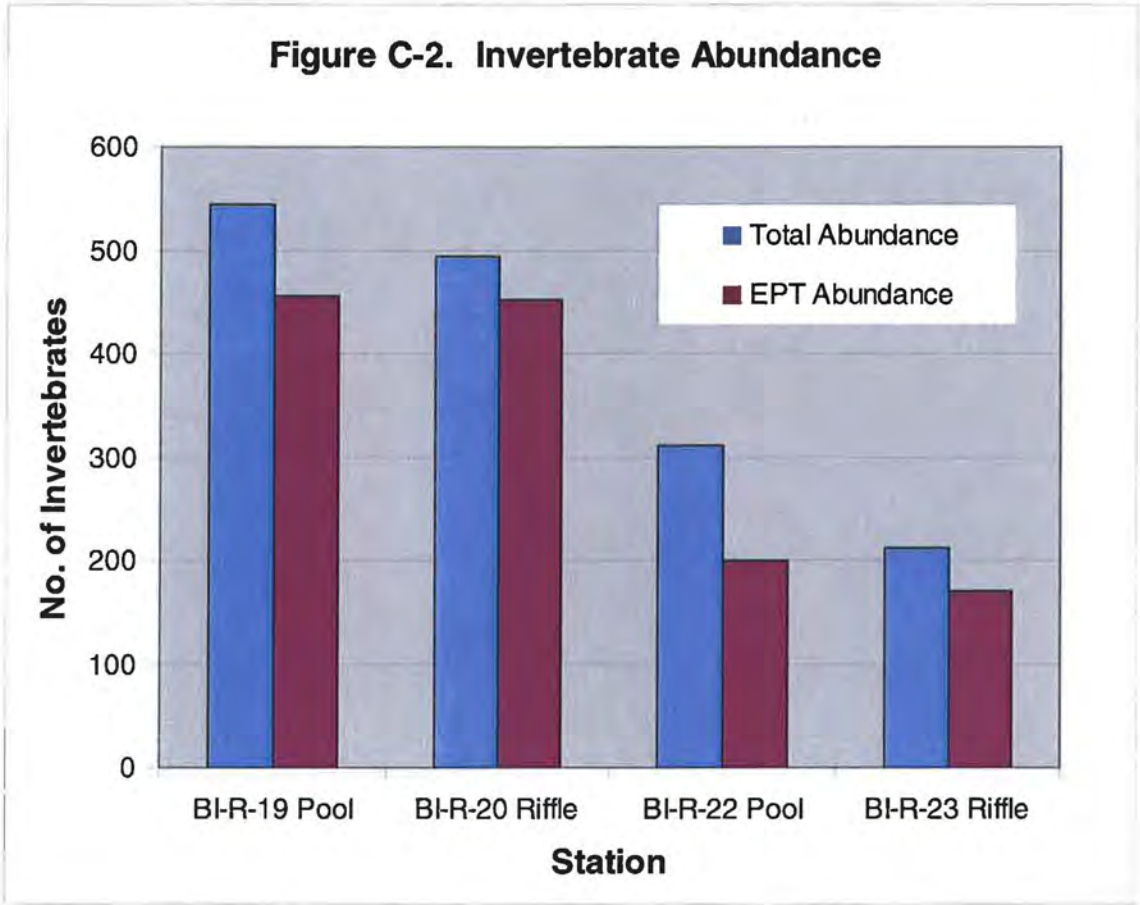


Figure C-2. Invertebrate Abundance
600
500
400
300
200
100
0
No. of Invertebrates
Total Abundance
EPT Abundance
BI-R-19 Pool
BI-R-20 Riffle
BI-R-22 Pool
BI-R-23 Riffle
Station

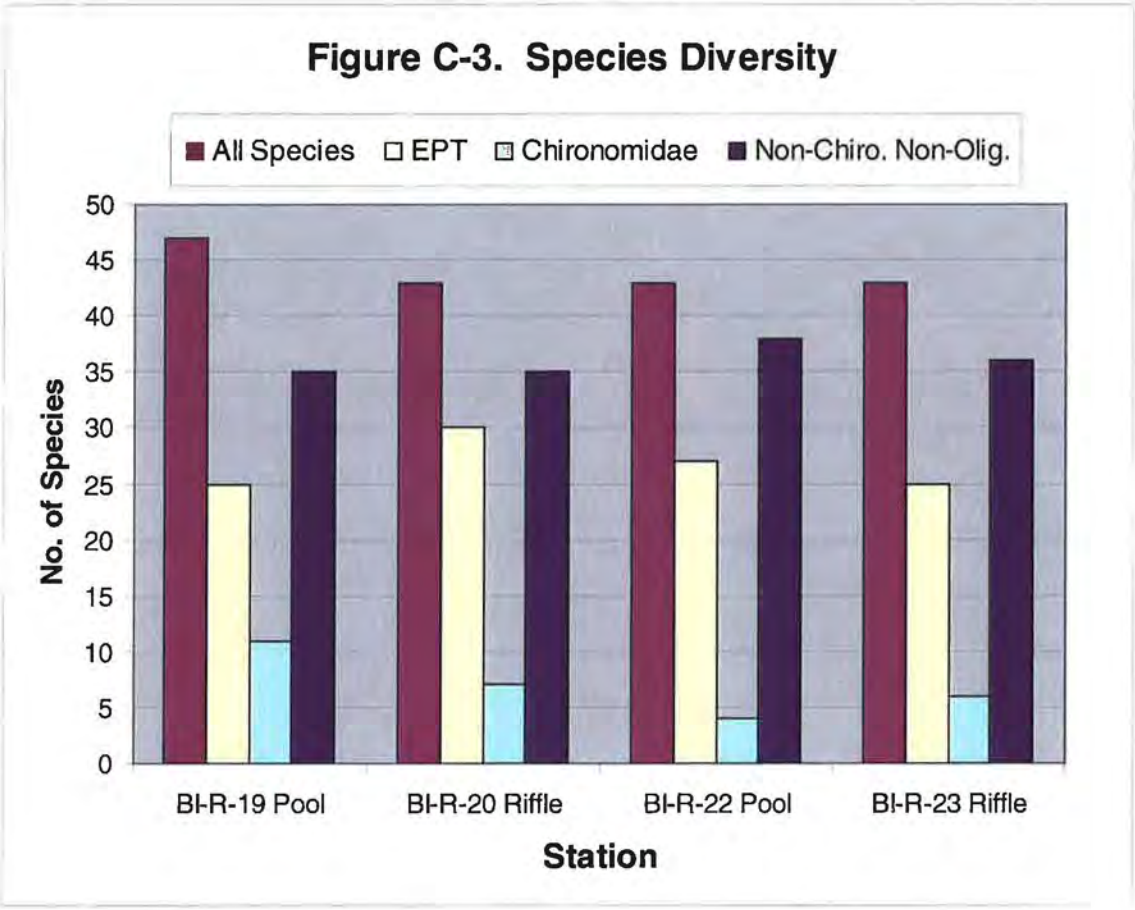


Figure C-3. Species Diversity
All Species
EPT
Chironomidae
Non-Chiro. Non-Olig.
No. of Species
50
45
40
35
30
25
20
15
10
5
0
BI-R-19 Pool
BI-R-20 Riffle
BI-R-22 Pool
BI-R-23 Riffle
Station

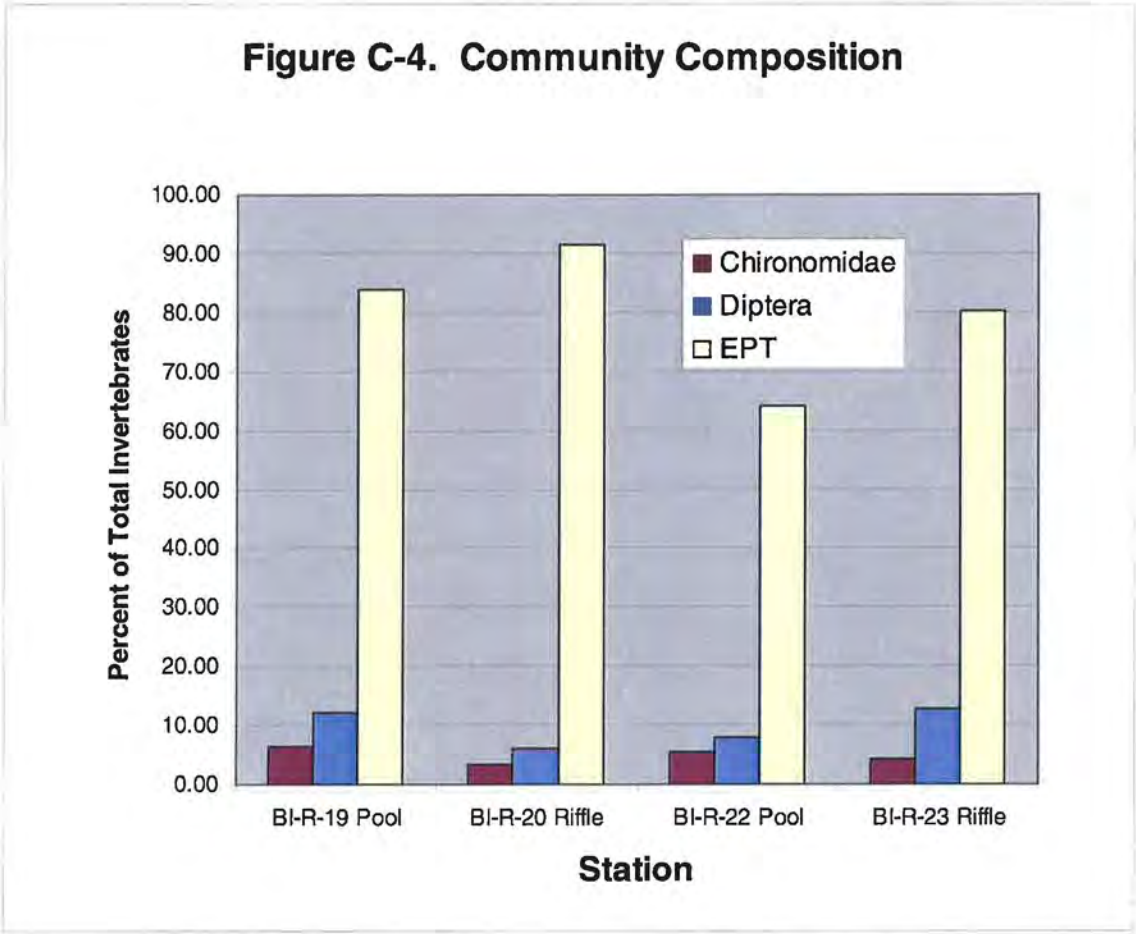
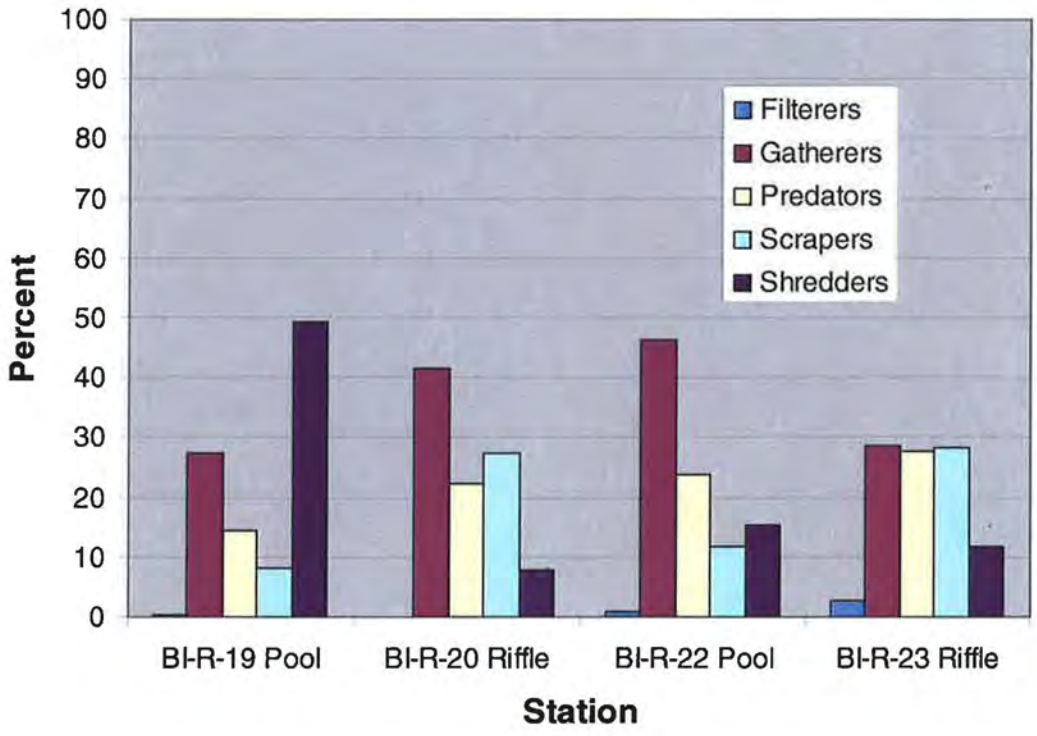


Figure C-4. Community Composition
100.00
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
Percent of Total Invertebrates
Chironomidae
Diptera
EPT
BI-R-19 Pool
BI-R-20 Riffle
BI-R-22 Pool
BI-R-23 Riffle
Station

Figure C-5. Functional Feeding Group Composition



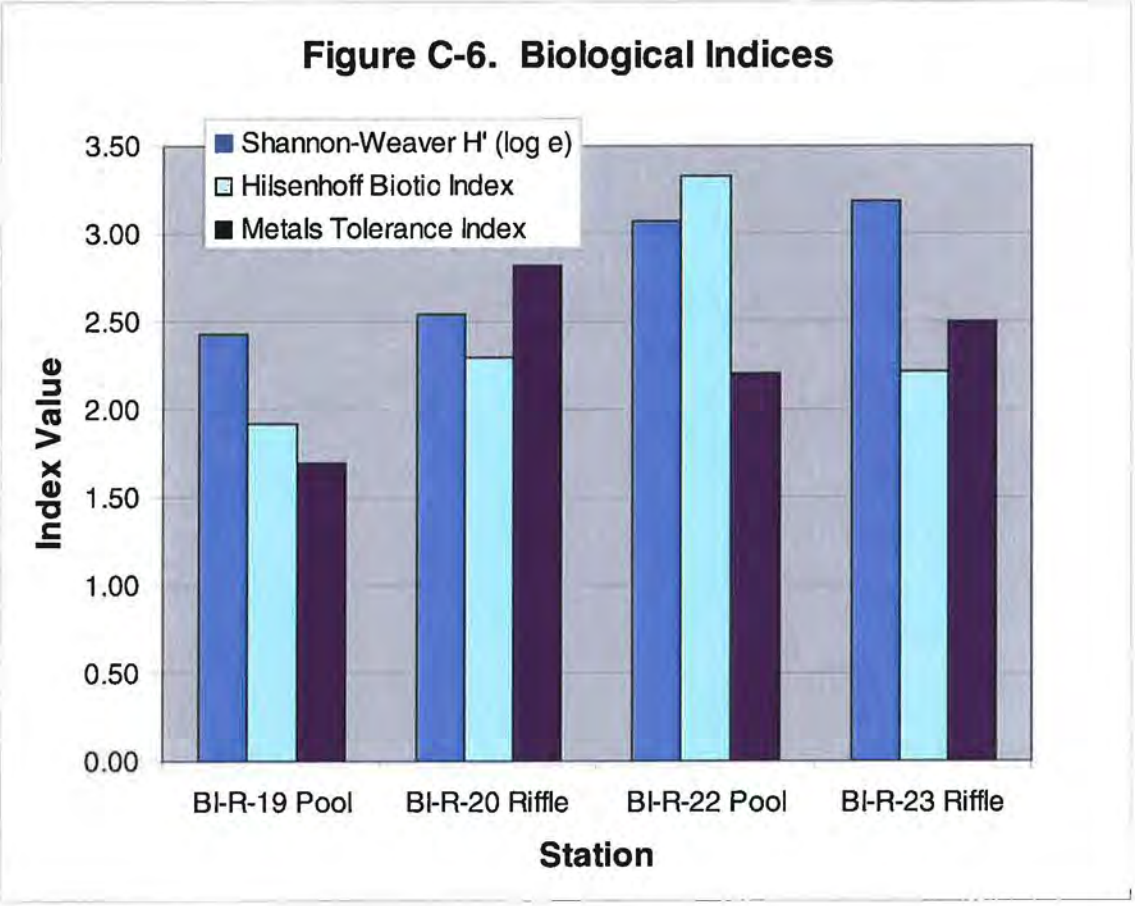
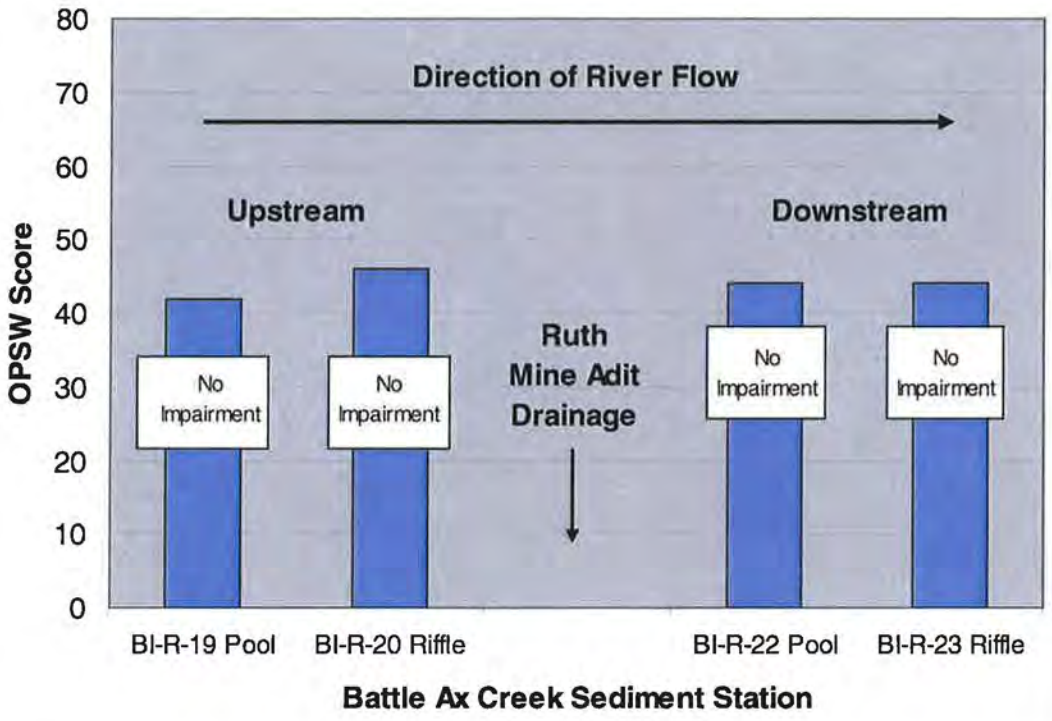


Figure C-6. Biological Indices
Shannon-Weaver H' (log e)
Hilsenhoff Biotic Index
Metals Tolerance Index
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
Index Value
BI-R-19 Pool
BI-R-20 Riffle
BI-R-22 Pool
BI-R-23 Riffle
Station

Figure C-7. OPSW Scores for Sediment Stations Relative to Mine Drainage



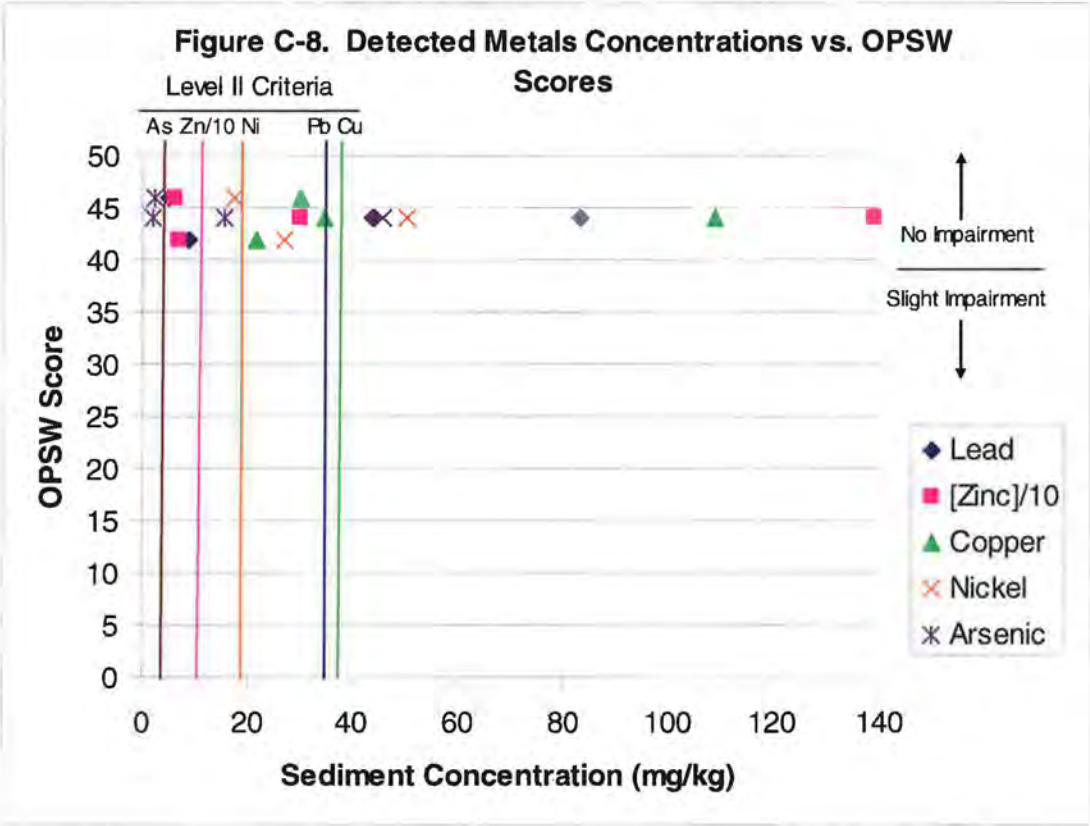


Figure C-8. Detected Metals Concentrations vs. OPSW Scores
Level II Criteria
As Zn/10 Ni
Pb Cu
OPSW Score
50
45
40
35
30
25
20
15
10
5
0
0
20
40
60
80
100
120
140
Sediment Concentration (mg/kg)
No Impairment
Slight Impairment
Lead
[Zinc]/10
Copper
Nickel
Arsenic

MACROINVERTEBRATE EVALUATION DATA TABLES AND METRIC SCORES

GeoDesign Opal Creek Benthos 2008
Data are NOT adjusted for subsampling

	Stream	Battle Ax				
	Site	BI-R-19				
	Date		10-08-2008			
	Device	kick net				
	Habitat	pool				
	Percent Subsampled	96.15				
	EcoAnalysts Sample ID	5242.1-5	Sediment Tolerant to Fines Taxa (SDTOL)	Sediment Sensitive to Fines Taxa (SEDINTOL)	Tolerant to Disturbance (TOL)	Sensitive to Disturbance (SENS)
Ephemeroptera	Ameletus sp.	29				
	Baetis sp.	0				
	Baetis tricaudatus	50				
	Caudatella hystrix	0				Y
	Cinygmula sp.	10				
	Diphetor hageni	1				
	Drunella doddsi	21				21
	Drunella spinifera	7				7
	Epeorus grandis	0				Y
	Epeorus sp.	0				
	Ephemerella sp.	2				
	Ironodes sp.	0				
	Leptophlebiidae	8				
	Rhithrogena sp.	4				
Plecoptera	Calineuria californica	13				
	Chloroperlidae	0				
	Kathroperla sp.	0				Y
	Kogotus/Rickera sp.	2				
	Leuctridae	0				Y
	Megarcys sp.	0				Y
	Moselia infuscata	0				Y
	Paraleuctra sp.	2				2
	Pteronarcys sp.	0				
	Skwala sp.	5				
	Sweltsa sp.	11				
	Visoka cataractae	1				1
	Yoraperla sp.	6				6
	Zapada cinctipes	13				
	Zapada columbiana	0				Y
	Zapada frigida	0				Y
Coleoptera	Heterlimnius sp.	8				
	Narpus sp.	0				
	Optioservus sp.	1			1	
Megaloptera	Orohermes crepusculus	1		1		
Diptera-Chironomidae	Boreochlus sp.	0				
	Brillia sp.	1				
	Chaetocladius sp.	0				
	Corynoneura sp.	1				
	Cricotopus (Nostoc.) nostocicola	0				
	Diamesa sp.	0				
	Dicrotendipes sp.	0				
	Eukiefferiella sp.	1				
	Limnophyes sp.	0	Y			
	Micropsectra sp.	15				
	Orthocladius (Symp.) lignicola	0				

	Orthocladius Complex	0				
	Parametriocnemus sp.	1				
	Parorthocladius sp.	5				
	Polypedilum sp.	0				
	Reomyia sp.	1				
	Rheocricotopus sp.	1				
	Smittia sp.	0				
	Tanytarsus sp.	0				
	Thienemanniella sp.	1				
	Thienemannimyia gr. sp.	2				
	Tvetenia bavarica gr.	4				
Diptera	Bezzia/Palpomyia sp.	2				
	Dicranota sp.	21	21			
	Hesperoconopa sp.	0				Y
	Hexatoma sp.	4	4			
	Oreogeton sp.	2				2
	Pericoma/Telmatoscopus sp.	1				
	Simulium sp.	1				
	Tipula sp.	0	Y			
Trichoptera	Anagapetus sp.	0		Y		Y
	Arctopsyche grandis	0		Y		
	Ecclisomyia sp.	7				7
	Glossosoma sp.	0		Y		
	Hydatophylax sp.	1				
	Lepidostoma sp.	235				
	Limnephilidae	0				
	Micrasema sp.	0				
	Neophylax occidentis	0				
	Parapsyche elsis	0		Y		Y
	Polycentropodidae	0				
	Polycentropus sp.	2				
	Rhyacophila arnaudi	0				
	Rhyacophila betteni gr.	2				
	Rhyacophila brunnea gr.	1				
	Rhyacophila hyalinata gr.	1				
	Rhyacophila narvae	4				
Gastropoda	Menetus opercularis	0				
	Pristinicola hemphilli	0				
Annelida	Oligochaeta	8	8		8	
Acari	Oribatei	0				
	Protzia sp.	0				
Other Organisms	Polycelis sp.	3				
	TOTAL	**523**				
		No. of Taxa:	3	1	2	7
		Abundance:	33	1	9	46

GeoDesign Opal Creek Benthos 2008

Stream	**Battle Ax**
Site	**BI-R-19**
Date	**10-08-2008**
Device	**kick net**
Habitat	**pool**
Percent Subsampled	**96.15**
EcoAnalysts Sample ID	**5242.1-5**
Abundance Measures	
Corrected Abundance	543.92
EPT Abundance	455.52
Dominance Measures	
Dominant Taxon	Lepidostoma sp.
Dominant Abundance	244.4
2nd Dominant Taxon	Baetis tricaudatus
2nd Dominant Abundance	52
3rd Dominant Taxon	Ameletus sp.
3rd Dominant Abundance	30.16
% Dominant Taxon	44.93
% 2 Dominant Taxa	54.49
% 3 Dominant Taxa	60.04
Richness Measures	
Species Richness	47
EPT Richness	25
Ephemeroptera Richness	9
Plecoptera Richness	8
Trichoptera Richness	8
Chironomidae Richness	11
Oligochaeta Richness	1
Non-Chiro. Non-Olig. Richness	35
Rhyacophila Richness	4
Community Composition	
% Ephemeroptera	25.24
% Plecoptera	10.13
% Trichoptera	48.37
% EPT	83.75
% Coleoptera	1.72
% Diptera	12.24
% Oligochaeta	1.53
% Baetidae	9.75
% Brachycentridae	0
% Chironomidae	6.31
% Ephemerellidae	5.74
% Hydropsychidae	0
% Odonata	0

% Perlidae	2.49
% Pteronarcyidae	0
% Simuliidae	0.19
Functional Group Composition	
% Filterers	0.19
% Gatherers	27.34
% Predators	14.53
% Scrapers	8.22
% Shredders	49.52
% Piercer-Herbivores	0
% Unclassified	0.19
Filterer Richness	1
Gatherer Richness	17
Predator Richness	16
Scraper Richness	5
Shredder Richness	7
Piercer-Herbivore Richness	0
Unclassified	1
Diversity/Evenness Measures	
Shannon-Weaver H' (log 10)	1.06
Shannon-Weaver H' (log 2)	3.51
Shannon-Weaver H' (log e)	2.43
Margalef's Richness	7.3
Pielou's J'	0.63
Simpson's Heterogeneity	0.78
Biotic Indices	
% Indiv. w/ HBI Value	99.24
Hilsenhoff Biotic Index	1.92
% Indiv. w/ MTI Value	90.82
Metals Tolerance Index	1.69
% Indiv. w/ FSBI Value	42.83
Fine Sediment Biotic Index	120
FSBI - average	2.55
FSBI - weighted average	4.75
% Indiv. w/ TPM Value	84.32
Temp. Pref. Metric - average	4.11
TPM - weighted average	5.49
Karr BIBI Metrics	
Long-Lived Taxa Richness	8
Clinger Richness	25
% Clingers	41.49
Intolerant Taxa Richness	22
% Tolerant Individuals	1.48
% Tolerant Taxa	2.13
Coleoptera Richness	2

Ruth Mine Site
BI-R-19 Pool
Genus/Species Level Metrics and Scoring Criteria.

Metric	Raw Value	Scoring Criteria 5	3	1	Score
Taxa Richness	47	>35	19-35	<19	5
Mayfly Richness	9	>8	4-8	<4	5
Stonefly Richness	8	>5	3-5	<3	5
Caddisfly Richness	8	>8	4-8	<4	3
Sensitive Taxa	7	>4	2-4	<2	5
Sediment sens. Taxa	1	>2	1	0	3
Modified HBI	1.92	<4.0	4-5	>5.0	5
% Tolerant Taxa	1.72	<15	15-45	>45	5
% Sed Tol Taxa	6.31	<10	10-25	>25	5
% Dominant (single taxa)	44.93	<20	20-40	>40	1
				Total score	**42**

Score Range	Stream Condition
>39	No Impairment: passes level 3 assessment. Indicates good diversity of invertebrates and stream conditions with little or no disturbance.
30-39	Slight Impairment: evidence of some impairment exists.
20-29	Moderate Impairment: clear evidence of disturbance exists.
<20	Severe Impairment: conditions indicate a high level of disturbance.

GeoDesign Opal Creek Benthos 2008
Data are NOT adjusted for subsampling

	Stream	**Battle Ax**				
	Site	**BI-R-20**				
	Date		**10-08-2008**			
	Device	**kick net**				
	Habitat	**riffle**				
	Percent Subsampled	**100.00**				
	EcoAnalysts Sample ID	**5242.1-6**	**Sediment Tolerant to Fines Taxa (SDTOL)**	**Sediment Sensitive to Fines Taxa (SEDINTOL)**	**Tolerant to Disturbance (TOL)**	**Sensitive to Disturbance (SENS)**
Ephemeroptera	Ameletus sp.	7				
	Baetis sp.	0				
	Baetis tricaudatus	178				
	Caudatella hystrix	0				Y
	Cinygmula sp.	4				
	Diphetor hageni	0				
	Drunella doddsi	84				84
	Drunella spinifera	4				4
	Epeorus grandis	5				5
	Epeorus sp.	0				
	Ephemerella sp.	0				
	Ironodes sp.	0				
	Leptophlebiidae	4				
	Rhithrogena sp.	25				
Plecoptera	Calineuria californica	34				
	Chloroperlidae	0				
	Kathroperla sp.	1				1
	Kogotus/Rickera sp.	5				
	Leuctridae	2				2
	Megarcys sp.	3				3
	Moselia infuscata	1				1
	Paraleuctra sp.	0				Y
	Pteronarcys sp.	0				
	Skwala sp.	9				
	Sweltsa sp.	21				
	Visoka cataractae	3				3
	Yoraperla sp.	6				6
	Zapada cinctipes	2				
	Zapada columbiana	0				Y
	Zapada frigida	0				Y
Coleoptera	Heterlimnius sp.	0				
	Narpus sp.	0				
	Optioservus sp.	0			Y	
Megaloptera	Orohermes crepusculus	4		4		
Diptera-Chironomidae	Boreochlus sp.	0				
	Brillia sp.	0				
	Chaetocladius sp.	0				
	Corynoneura sp.	0				
	Cricotopus (Nostoc.) nostocicola	1				
	Diamesa sp.	0				
	Dicrotendipes sp.	0				
	Eukiefferiella sp.	1				
	Limnophyes sp.	0	Y			
	Micropsectra sp.	5				

	Orthocladius (Symp.) lignicola	0				
	Orthocladius Complex	0				
	Parametriocnemus sp.	2				
	Parorthocladius sp.	1				
	Polypedilum sp.	0				
	Reomyia sp.	0				
	Rheocricotopus sp.	0				
	Smittia sp.	0				
	Tanytarsus sp.	0				
	Thienemanniella sp.	0				
	Thienemannimyia gr. sp.	1				
	Tvetenia bavarica gr.	5				
Diptera	Bezzia/Palpomyia sp.	2				
	Dicranota sp.	9	9			
	Hesperoconopa sp.	0				Y
	Hexatoma sp.	3	3			
	Oreogeton sp.	0				Y
	Pericoma/Telmatoscopus sp.	0				
	Simulium sp.	0				
	Tipula sp.	0	Y			
Trichoptera	Anagapetus sp.	6		6		6
	Arctopsyche grandis	0		Y		
	Ecclisomyia sp.	0				Y
	Glossosoma sp.	2		2		
	Hydatophylax sp.	0				
	Lepidostoma sp.	17				
	Limnephilidae	0				
	Micrasema sp.	7				
	Neophylax occidentis	5				
	Parapsyche elsis	1		1		1
	Polycentropodidae	0				
	Polycentropus sp.	2				
	Rhyacophila arnaudi	0				
	Rhyacophila betteni gr.	4				
	Rhyacophila brunnea gr.	1				
	Rhyacophila hyalinata gr.	4				
	Rhyacophila narvae	5				
Gastropoda	Menetus opercularis	0				
	Pristinicola hemphilli	0				
Annelida	Oligochaeta	2	2		2	
Acari	Oribatei	0				
	Protzia sp.	0				
Other Organisms	Polycelis sp.	6				
	TOTAL	**494**				
		No. of Taxa:	3	4	1	11
		Abundance:	14	13	2	116

GeoDesign Opal Creek Benthos 2008
Data are adjusted for subsampling

Stream	**Battle Ax**
Site	**BI-R-20**
Date	**10-08-2008**
Device	**kick net**
Habitat	**riffle**
Percent Subsampled	**100.00**
EcoAnalysts Sample ID	**5242.1-6**
Abundance Measures	
Corrected Abundance	494
EPT Abundance	452
Dominance Measures	
Dominant Taxon	Baetis tricaudatus
Dominant Abundance	178
2nd Dominant Taxon	Drunella doddsi
2nd Dominant Abundance	84
3rd Dominant Taxon	Calineuria californica
3rd Dominant Abundance	34
% Dominant Taxon	36.03
% 2 Dominant Taxa	53.04
% 3 Dominant Taxa	59.92
Richness Measures	
Species Richness	43
EPT Richness	30
Ephemeroptera Richness	8
Plecoptera Richness	11
Trichoptera Richness	11
Chironomidae Richness	7
Oligochaeta Richness	1
Non-Chiro. Non-Olig. Richness	35
Rhyacophila Richness	4
Community Composition	
% Ephemeroptera	62.96
% Plecoptera	17.61
% Trichoptera	10.93
% EPT	91.5
% Coleoptera	0
% Diptera	6.07
% Oligochaeta	0.4
% Baetidae	36.03
% Brachycentridae	1.42
% Chironomidae	3.24
% Ephemerellidae	17.81
% Hydropsychidae	0.2
% Odonata	0

% Perlidae	6.88
% Pteronarcyidae	0
% Simuliidae	0
Functional Group Composition	
% Filterers	0
% Gatherers	41.7
% Predators	22.27
% Scrapers	27.33
% Shredders	7.89
% Piercer-Herbivores	0
% Unclassified	0.81
Filterer Richness	0
Gatherer Richness	10
Predator Richness	16
Scraper Richness	8
Shredder Richness	8
Piercer-Herbivore Richness	0
Unclassified	1
Diversity/Evenness Measures	
Shannon-Weaver H' (log 10)	1.1
Shannon-Weaver H' (log 2)	3.67
Shannon-Weaver H' (log e)	2.54
Margalef's Richness	6.77
Pielou's J'	0.68
Simpson's Heterogeneity	0.83
Biotic Indices	
% Indiv. w/ HBI Value	98.79
Hilsenhoff Biotic Index	2.3
% Indiv. w/ MTI Value	87.65
Metals Tolerance Index	2.82
% Indiv. w/ FSBI Value	86.23
Fine Sediment Biotic Index	124
FSBI - average	2.88
FSBI - weighted average	5.39
% Indiv. w/ TPM Value	91.5
Temp. Pref. Metric - average	4.79
TPM - weighted average	5.94
Karr BIBI Metrics	
Long-Lived Taxa Richness	10
Clinger Richness	26
% Clingers	86.03
Intolerant Taxa Richness	27
% Tolerant Individuals	0.41
% Tolerant Taxa	2.33
Coleoptera Richness	0

Ruth Mine Site
BI-R-20 Riffle
Genus/Species Level Metrics and Scoring Criteria.

Metric	Raw Value	Scoring Criteria 5	3	1	Score
Taxa Richness	43	>35	19-35	<19	5
Mayfly Richness	8	>8	4-8	<4	3
Stonefly Richness	11	>5	3-5	<3	5
Caddisfly Richness	11	>8	4-8	<4	5
Sensitive Taxa	11	>4	2-4	<2	5
Sediment sens. Taxa	4	>2	1	0	5
Modified HBI	2.30	<4.0	4-5	>5.0	5
% Tolerant Taxa	0.40	<15	15-45	>45	5
% Sed Tol Taxa	2.83	<10	10-25	>25	5
% Dominant (single taxa)	36.03	<20	20-40	>40	3
				Total score	**46**

Score Range	Stream Condition
>39	No Impairment: passes level 3 assessment. Indicates good diversity of invertebrates and stream conditions with little or no disturbance.
30-39	Slight Impairment: evidence of some impairment exists.
20-29	Moderate Impairment: clear evidence of disturbance exists.
<20	Severe Impairment: conditions indicate a high level of disturbance.

GeoDesign Opal Creek Benthos 2008
Data are NOT adjusted for subsampling

	Stream	**Battle Ax**				
	Site	**BI-R-22**				
	Date		**10-09-2008**			
	Device	**kick net**				
	Habitat	**pool**				
	Percent Subsampled	**100.00**				
	EcoAnalysts Sample ID	**5242.1-7**	**Sediment Tolerant to Fines Taxa (SDTOL)**	**Sediment Sensitive to Fines Taxa (SEDINTOL)**	**Tolerant to Disturbance (TOL)**	**Sensitive to Disturbance (SENS)**
Ephemeroptera	Ameletus sp.	27				
	Baetis sp.	0				
	Baetis tricaudatus	36				
	Caudatella hystrix	0				Y
	Cinygmula sp.	5				
	Diphetor hageni	0				
	Drunella doddsi	9				9
	Drunella spinifera	2				2
	Epeorus grandis	3				3
	Epeorus sp.	0				
	Ephemerella sp.	0				
	Ironodes sp.	0				
	Leptophlebiidae	3				
	Rhithrogena sp.	8				
Plecoptera	Calineuria californica	20				
	Chloroperlidae	0				
	Kathroperla sp.	0				Y
	Kogotus/Rickera sp.	1				
	Leuctridae	0				Y
	Megarcys sp.	0				Y
	Moselia infuscata	0				Y
	Paraleuctra sp.	2				2
	Pteronarcys sp.	0				
	Skwala sp.	8				
	Sweltsa sp.	12				
	Visoka cataractae	3				3
	Yoraperla sp.	7				7
	Zapada cinctipes	7				
	Zapada columbiana	1				1
	Zapada frigida	1				1
Coleoptera	Heterlimnius sp.	6				
	Narpus sp.	2				
	Optioservus sp.	0			Y	
Megaloptera	Orohermes crepusculus	4		4		
Diptera-Chironomidae	Boreochlus sp.	0				
	Brillia sp.	1				
	Chaetocladius sp.	0				
	Corynoneura sp.	0				
	Cricotopus (Nostoc.) nostocicola	0				
	Diamesa sp.	0				
	Dicrotendipes sp.	0				
	Eukiefferiella sp.	0				
	Limnophyes sp.	0	Y			
	Micropsectra sp.	13				

	Orthocladius (Symp.) lignicola	0				
	Orthocladius Complex	0				
	Parametriocnemus sp.	0				
	Parorthocladius sp.	0				
	Polypedilum sp.	0				
	Reomyia sp.	0				
	Rheocricotopus sp.	0				
	Smittia sp.	0				
	Tanytarsus sp.	0				
	Thienemanniella sp.	0				
	Thienemannimyia gr. sp.	2				
	Tvetenia bavarica gr.	1				
Diptera	Bezzia/Palpomyia sp.	4				
	Dicranota sp.	2	2			
	Hesperoconopa sp.	0				Y
	Hexatoma sp.	0	Y			
	Oreogeton sp.	2				2
	Pericoma/Telmatoscopus sp.	0				
	Simulium sp.	0				
	Tipula sp.	0	Y			
Trichoptera	Anagapetus sp.	1		1		1
	Arctopsyche grandis	0		Y		
	Ecclisomyia sp.	0				Y
	Glossosoma sp.	3		3		
	Hydatophylax sp.	0				
	Lepidostoma sp.	24				
	Limnephilidae	0				
	Micrasema sp.	2				
	Neophylax occidentis	4				
	Parapsyche elsis	1		1		1
	Polycentropodidae	3				
	Polycentropus sp.	0				
	Rhyacophila arnaudi	0				
	Rhyacophila betteni gr.	0				
	Rhyacophila brunnea gr.	1				
	Rhyacophila hyalinata gr.	0				
	Rhyacophila narvae	6				
Gastropoda	Menetus opercularis	2				
	Pristinicola hemphilli	1				
Annelida	Oligochaeta	57	57		57	
Acari	Oribatei	1				
	Protzia sp.	1				
Other Organisms	Polycelis sp.	13				
	TOTAL	**312**				
		No. of Taxa:	2	4	1	11
		Abundance:	59	9	57	32

GeoDesign Opal Creek Benthos 2008
Data are adjusted for subsampling

Stream	**Battle Ax**
Site	**BI-R-22**
Date	**10-09-2008**
Device	**kick net**
Habitat	**pool**
Percent Subsampled	**100.00**
EcoAnalysts Sample ID	**5242.1-7**
Abundance Measures	
Corrected Abundance	312
EPT Abundance	200
Dominance Measures	
Dominant Taxon	Oligochaeta
Dominant Abundance	57
2nd Dominant Taxon	Baetis tricaudatus
2nd Dominant Abundance	36
3rd Dominant Taxon	Ameletus sp.
3rd Dominant Abundance	27
% Dominant Taxon	18.27
% 2 Dominant Taxa	29.81
% 3 Dominant Taxa	38.46
Richness Measures	
Species Richness	43
EPT Richness	27
Ephemeroptera Richness	8
Plecoptera Richness	10
Trichoptera Richness	9
Chironomidae Richness	4
Oligochaeta Richness	1
Non-Chiro. Non-Olig. Richness	38
Rhyacophila Richness	2
Community Composition	
% Ephemeroptera	29.81
% Plecoptera	19.87
% Trichoptera	14.42
% EPT	64.1
% Coleoptera	2.56
% Diptera	8.01
% Oligochaeta	18.27
% Baetidae	11.54
% Brachycentridae	0.64
% Chironomidae	5.45
% Ephemerellidae	3.53
% Hydropsychidae	0.32
% Odonata	0

% Perlidae	6.41
% Pteronarcyidae	0
% Simuliidae	0
Functional Group Composition	
% Filterers	0.96
% Gatherers	46.47
% Predators	23.72
% Scrapers	11.86
% Shredders	15.38
% Piercer-Herbivores	0
% Unclassified	1.6
Filterer Richness	1
Gatherer Richness	8
Predator Richness	14
Scraper Richness	9
Shredder Richness	9
Piercer-Herbivore Richness	0
Unclassified	2
Diversity/Evenness Measures	
Shannon-Weaver H' (log 10)	1.33
Shannon-Weaver H' (log 2)	4.42
Shannon-Weaver H' (log e)	3.07
Margalef's Richness	7.31
Pielou's J'	0.82
Simpson's Heterogeneity	0.93
Biotic Indices	
% Indiv. w/ HBI Value	96.47
Hilsenhoff Biotic Index	3.33
% Indiv. w/ MTI Value	62.82
Metals Tolerance Index	2.2
% Indiv. w/ FSBI Value	56.41
Fine Sediment Biotic Index	117
FSBI - average	2.72
FSBI - weighted average	4.85
% Indiv. w/ TPM Value	65.71
Temp. Pref. Metric - average	4.51
TPM - weighted average	5.8
Karr BIBI Metrics	
Long-Lived Taxa Richness	10
Clinger Richness	26
% Clingers	60.9
Intolerant Taxa Richness	23
% Tolerant Individuals	18.94
% Tolerant Taxa	2.33
Coleoptera Richness	2

Ruth Mine Site
BI-R-22 Pool
Genus/Species Level Metrics and Scoring Criteria.

Metric	Raw Value	Scoring Criteria 5	3	1	Score
Taxa Richness	43	>35	19-35	<19	5
Mayfly Richness	8	>8	4-8	<4	3
Stonefly Richness	10	>5	3-5	<3	5
Caddisfly Richness	9	>8	4-8	<4	5
Sensitive Taxa	11	>4	2-4	<2	5
Sediment sens. Taxa	4	>2	1	0	5
Modified HBI	3.33	<4.0	4-5	>5.0	5
% Tolerant Taxa	18.27	<15	15-45	>45	3
% Sed Tol Taxa	18.91	<10	10-25	>25	3
% Dominant (single taxa)	18.27	<20	20-40	>40	5
				Total score	**44**

Score Range	Stream Condition
>39	No Impairment: passes level 3 assessment. Indicates good diversity of invertebrates and stream conditions with little or no disturbance.
30-39	Slight Impairment: evidence of some impairment exists.
20-29	Moderate Impairment: clear evidence of disturbance exists.
<20	Severe Impairment: conditions indicate a high level of disturbance.

GeoDesign Opal Creek Benthos 2008
Data are NOT adjusted for subsampling

	Stream	**Battle Ax**				
	Site	**BI-R-23**				
	Date		**10-09-2008**			
	Device	**kick net**				
	Habitat	**riffle**				
	Percent Subsampled	**100.00**				
	EcoAnalysts Sample ID	**5242.1-8**	**Sediment Tolerant to Fines Taxa (SDTOL)**	**Sediment Sensitive to Fines Taxa (SEDINTOL)**	**Tolerant to Disturbance (TOL)**	**Sensitive to Disturbance (SENS)**
Ephemeroptera	Ameletus sp.	10				
	Baetis sp.	0				
	Baetis tricaudatus	35				
	Caudatella hystrix	0				Y
	Cinygmula sp.	6				
	Diphetor hageni	0				
	Drunella doddsi	17				17
	Drunella spinifera	2				2
	Epeorus grandis	0				Y
	Epeorus sp.	0				
	Ephemerella sp.	0				
	Ironodes sp.	0				
	Leptophlebiidae	3				
	Rhithrogena sp.	19				
Plecoptera	Calineuria californica	16				
	Chloroperlidae	0				
	Kathroperla sp.	1				1
	Kogotus/Rickera sp.	2				
	Leuctridae	0				Y
	Megarcys sp.	2				2
	Moselia infuscata	0				Y
	Paraleuctra sp.	0				Y
	Pteronarcys sp.	0				
	Skwala sp.	2				
	Sweltsa sp.	9				
	Visoka cataractae	0				Y
	Yoraperla sp.	4				4
	Zapada cinctipes	5				
	Zapada columbiana	0				Y
	Zapada frigida	1				1
Coleoptera	Heterlimnius sp.	3				
	Narpus sp.	0				
	Optioservus sp.	1			1	
Megaloptera	Orohermes crepusculus	1		1		
Diptera-Chironomidae	Boreochlus sp.	0				
	Brillia sp.	1				
	Chaetocladius sp.	0				
	Corynoneura sp.	0				
	Cricotopus (Nostoc.) nostocicola	0				
	Diamesa sp.	0				
	Dicrotendipes sp.	0				
	Eukiefferiella sp.	0				
	Limnophyes sp.	0	Y			
	Micropsectra sp.	2				

	Orthocladius (Symp.) lignicola	0				
	Orthocladius Complex	1				
	Parametriocnemus sp.	0				
	Parorthocladius sp.	1				
	Polypedilum sp.	0				
	Reomyia sp.	0				
	Rheocricotopus sp.	2				
	Smittia sp.	0				
	Tanytarsus sp.	0				
	Thienemanniella sp.	0				
	Thienemannimyia gr. sp.	0				
	Tvetenia bavarica gr.	2				
Diptera	Bezzia/Palpomyia sp.	3				
	Dicranota sp.	7	7			
	Hesperoconopa sp.	0				Y
	Hexatoma sp.	2	2			
	Oreogeton sp.	1				1
	Pericoma/Telmatoscopus sp.	0				
	Simulium sp.	5				
	Tipula sp.	0	Y			
Trichoptera	Anagapetus sp.	3		3		3
	Arctopsyche grandis	1		1		
	Ecclisomyia sp.	0				Y
	Glossosoma sp.	0		Y		
	Hydatophylax sp.	0				
	Lepidostoma sp.	11				
	Limnephilidae	0				
	Micrasema sp.	3				
	Neophylax occidentis	11				
	Parapsyche elsis	0		Y		Y
	Polycentropodidae	0				
	Polycentropus sp.	1				
	Rhyacophila arnaudi	1				
	Rhyacophila betteni gr.	0				
	Rhyacophila brunnea gr.	1				
	Rhyacophila hyalinata gr.	0				
	Rhyacophila narvae	5				
Gastropoda	Menetus opercularis	1				
	Pristinicola hemphilli	1				
Annelida	Oligochaeta	1	1		1	
Acari	Oribatei	0				
	Protzia sp.	0				
Other Organisms	Polycelis sp.	7				
	TOTAL	**213**				
		No. of Taxa:	3	3	2	8
		Abundance:	10	5	2	31

GeoDesign Opal Creek Benthos 2008
Data are adjusted for subsampling

Stream	**Battle Ax**
Site	**BI-R-23**
Date	**10-09-2008**
Device	**kick net**
Habitat	**riffle**
Percent Subsampled	**100.00**
EcoAnalysts Sample ID	**5242.1-8**
Abundance Measures	
Corrected Abundance	213
EPT Abundance	171
Dominance Measures	
Dominant Taxon	Baetis tricaudatus
Dominant Abundance	35
2nd Dominant Taxon	Rhithrogena sp.
2nd Dominant Abundance	19
3rd Dominant Taxon	Drunella doddsi
3rd Dominant Abundance	17
% Dominant Taxon	16.43
% 2 Dominant Taxa	25.35
% 3 Dominant Taxa	33.33
Richness Measures	
Species Richness	43
EPT Richness	25
Ephemeroptera Richness	7
Plecoptera Richness	9
Trichoptera Richness	9
Chironomidae Richness	6
Oligochaeta Richness	1
Non-Chiro. Non-Olig. Richness	36
Rhyacophila Richness	3
Community Composition	
% Ephemeroptera	43.19
% Plecoptera	19.72
% Trichoptera	17.37
% EPT	80.28
% Coleoptera	1.88
% Diptera	12.68
% Oligochaeta	0.47
% Baetidae	16.43
% Brachycentridae	1.41
% Chironomidae	4.23
% Ephemerellidae	8.92
% Hydropsychidae	0.47
% Odonata	0

% Perlidae	7.51
% Pteronarcyidae	0
% Simuliidae	2.35
Functional Group Composition	
% Filterers	2.82
% Gatherers	28.64
% Predators	27.7
% Scrapers	28.17
% Shredders	11.74
% Piercer-Herbivores	0
% Unclassified	0.94
Filterer Richness	2
Gatherer Richness	11
Predator Richness	14
Scraper Richness	8
Shredder Richness	6
Piercer-Herbivore Richness	0
Unclassified	2
Diversity/Evenness Measures	
Shannon-Weaver H' (log 10)	1.38
Shannon-Weaver H' (log 2)	4.59
Shannon-Weaver H' (log e)	3.18
Margalef's Richness	7.83
Pielou's J'	0.85
Simpson's Heterogeneity	0.94
Biotic Indices	
% Indiv. w/ HBI Value	97.65
Hilsenhoff Biotic Index	2.21
% Indiv. w/ MTI Value	77.46
Metals Tolerance Index	2.5
% Indiv. w/ FSBI Value	78.87
Fine Sediment Biotic Index	116
FSBI - average	2.7
FSBI - weighted average	5.02
% Indiv. w/ TPM Value	84.04
Temp. Pref. Metric - average	4.19
TPM - weighted average	6.06
Karr BIBI Metrics	
Long-Lived Taxa Richness	8
Clinger Richness	25
% Clingers	77.46
Intolerant Taxa Richness	22
% Tolerant Individuals	0.48
% Tolerant Taxa	2.33
Coleoptera Richness	2

Ruth Mine Site
BI-R-23 Riffle
Genus/Species Level Metrics and Scoring Criteria.

Metric	Raw Value	Scoring Criteria 5	3	1	Score
Taxa Richness	43	>35	19-35	<19	5
Mayfly Richness	7	>8	4-8	<4	3
Stonefly Richness	9	>5	3-5	<3	5
Caddisfly Richness	9	>8	4-8	<4	5
Sensitive Taxa	11	>4	2-4	<2	5
Sediment sens. Taxa	4	>2	1	0	5
Modified HBI	2.21	<4.0	4-5	>5.0	5
% Tolerant Taxa	18.27	<15	15-45	>45	3
% Sed Tol Taxa	18.91	<10	10-25	>25	3
% Dominant (single taxa)	16.43	<20	20-40	>40	5
				Total score	**44**

Score Range	Stream Condition
>39	No Impairment: passes level 3 assessment. Indicates good diversity of invertebrates and stream conditions with little or no disturbance.
30-39	Slight Impairment: evidence of some impairment exists.
20-29	Moderate Impairment: clear evidence of disturbance exists.
<20	Severe Impairment: conditions indicate a high level of disturbance.

ATTACHMENT D – SUPPLEMENTAL SURFACE WATER METALS DATA

Data on dissolved and total metals collected in 2009.

Table D-1 Supplemental Surface Water Metals Data for Ruth Mine Site

Sample I.D.	Location	Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead	Magnesium	Manganese	Mercury	Nickel	Potassium	Selenium	Silver	Sodium	Thallium	Vanadium	Zinc
		Total Metals (mg/L)																						
AW-4-2	Adit 4	---	---	ND <0.0010	0.0106	---	0.035	69	---	---	0.00727	---	0.0271	1.35	---	---	---	---	---	---	---	---	---	6.67
AW-5-2	Adit 5	---	---	ND <0.0010	0.00411	---	0.00499	42.9	---	---	ND <0.0040	---	ND <0.0010	1.02	---	---	---	---	---	---	---	---	---	1.55
SW-R-24	Battle Ax Creek at confluence with Adit 5 drainage water	---	---	ND <0.0010	0.00447	---	0.005	43.2	---	---	ND <0.0040	---	ND <0.0010	1	---	---	---	---	---	---	---	---	---	1.52
		Dissolved Metals (mg/L)																						
AW-4-2-DISS	Adit 4	---	---	ND <0.0010	0.011	---	0.0363	67.2	---	---	0.00518	---	0.0223	1.36	---	---	---	---	---	---	---	---	---	6.44
AW-5-2-DISS	Adit 5	---	---	ND <0.0010	0.0045	---	0.00538	41.8	---	---	ND <0.004	---	ND <0.0010	1.01	---	---	---	---	---	---	---	---	---	1.51
SW-R-24-DISS	Battle Ax Creek at confluence with Adit 5 drainage water	---	---	ND <0.0010	0.00483	---	0.0052	41.5	---	---	ND <0.004	---	ND <0.0010	1	---	---	---	---	---	---	---	---	---	1.43
Surface Water Level II SLV[a]		0.087	1	0.15	0.004	0.0053	0.0022	116	0.00021	0.023	0.009	1	0.0025	82	0.120	0.00077	0.052	53	0.005	0.00012	680	0.04	0.02	0.12
Oregon Water Quality Criteria (freshwater chronic)[b]		NA	NA	0.19	NA	NA	0.0011[c]	NA	0.011(hex) 0.21(tri)[c]	NA	0.012[c]	1	0.0032[c]	NA	NA	0.000012	0.16[c]	NA	0.035	0.00012[c]	NA	NA	NA	0.11[c]

a. The lowest of the Level II SLVs for surface water are presented (three sets of SLVs are available, for aquatic organisms, birds, and mammals)
b. DEQ Water Quality Criteria converted to mg/L for ease of comparison with data and with SLVs.
c. Hardness dependent; criterion assumes 100mg/L. Actual hardness values were 178 mg/L (AW-4-2), 111 mg/L (AW-5-2), and 112 mg/L (SW-R-24). Hardness values greater than 100 mg/L would result in higher, less conservative WQC than those presented here.
NA = not available
ND = not detected
Data collected July 2009.

APPENDIX C

PASCOE environmental consulting

Human Health Risk Assessment

Morning Star Mine Site
Willamette National Forest, Oregon

May 2009

Prepared for

GeoDesign, Inc.
Portland, Oregon

210 Taylor Street, Room 15 ▲ Port Townsend ▲ WA 98368

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1 INTRODUCTION

A screening-level human health risk assessment was performed for the Morning Star Mine Site, Willamette National Forest, Marion County, Oregon. The human health risk assessment analyzes the potential for health risks associated with recreational activities at the mine site that might occur by members of the public. The assessment addresses present and future health risks due to the presence of metals at the site, in the absence of any changes in site conditions. The assessment does not address other types of risks that may be associated with the mine.

The assessment incorporates analytical data collected from environmental media at the mine with information on potential exposure pathways to provide an understanding of the potential human health risks.

The components of the HHRA consist of the Problem Formulation and Risk Assessment, as per ODEQ (2000) guidelines:

> ***Problem Formulation*** – The Problem Formulation step describes site information, land and water uses, contamination, including identification of contaminants of potential concern (COPCs) through a screening process, and identification of potentially exposed populations and exposure scenarios.
>
> ***Risk Assessment*** - The Risk Assessment step includes the following components, which are also consistent with the HHRA methodology of USEPA (1989):
>
> - *Exposure Assessment.* Activities through which humans may be exposed to COPCs at the site are identified and quantified. Exposure activities are incorporated with COPC concentration data in environmental media to quantify exposures.
> - *Toxicity Assessment.* The toxicity of the COPCs is quantified for relating human exposures to potential adverse health effects.
> - *Risk Characterization.* Information from the exposure and toxicity assessments is integrated into a quantitative estimate of non-cancer and cancer risks. Uncertainties in the characterization are discussed.

The development of each of these components, and the resultant human health risk estimates, are presented in the following sections.

The assessment is considered screening-level because it relies on readily available information for exposure modeling, toxicology of metals, and risk modeling. All exposure and risk estimates are based on exposure modeling from data on metals collected from waste rock piles, surface water in the mine adit, and surface water and sediments in Battle Ax Creek and Blue Jay Creek, which is the tributary that runs past the mine adit and waste rock piles to flow into Battle Ax Creek. The exposures to metals at the site are based on estimates of reasonable maximum future exposures due to recreational activities directly in the waste soils and surface waters of the site. The exposures are not documented to presently occur, and any

present exposures and health risks would be much less than those estimated in this risk assessment.

2 PROBLEM FORMULATION

2.1 SITE INFORMATION

The Morning Star Mine site is located in the Western Cascades in central Oregon. The mine site is located in the Battle Ax Creek drainage, which flows west to join with Opal Creek to form the Little North Santiam River, which continues west to the Willamette River valley (Figure 2-1). The Western Cascades range is composed almost entirely of volcanic rocks, the remnant of a volcanic range that shifted east to form the High Cascades, which forms the present active Cascade volcanic range. The Western Cascades receive 60 to 100 inches of precipitation annually which causes deep weathering of geologic features.

Deposits of gold, silver, lead, and zinc are found in a 25-30 mile wide, north-south belt in the Western Cascades (Orr et al. 1992). Weathering processes have deeply eroded the Western Cascades exposing the ore-bearing rocks near the valley floors. The North Santiam mining district, which includes the Morning Star Mine site, contains the most rugged terrain of all the five mining districts of the Cascades. Most of the Morning Star Mine ore produced lead and zinc, although small amounts of gold and silver were also recovered.

2.2 LAND USE

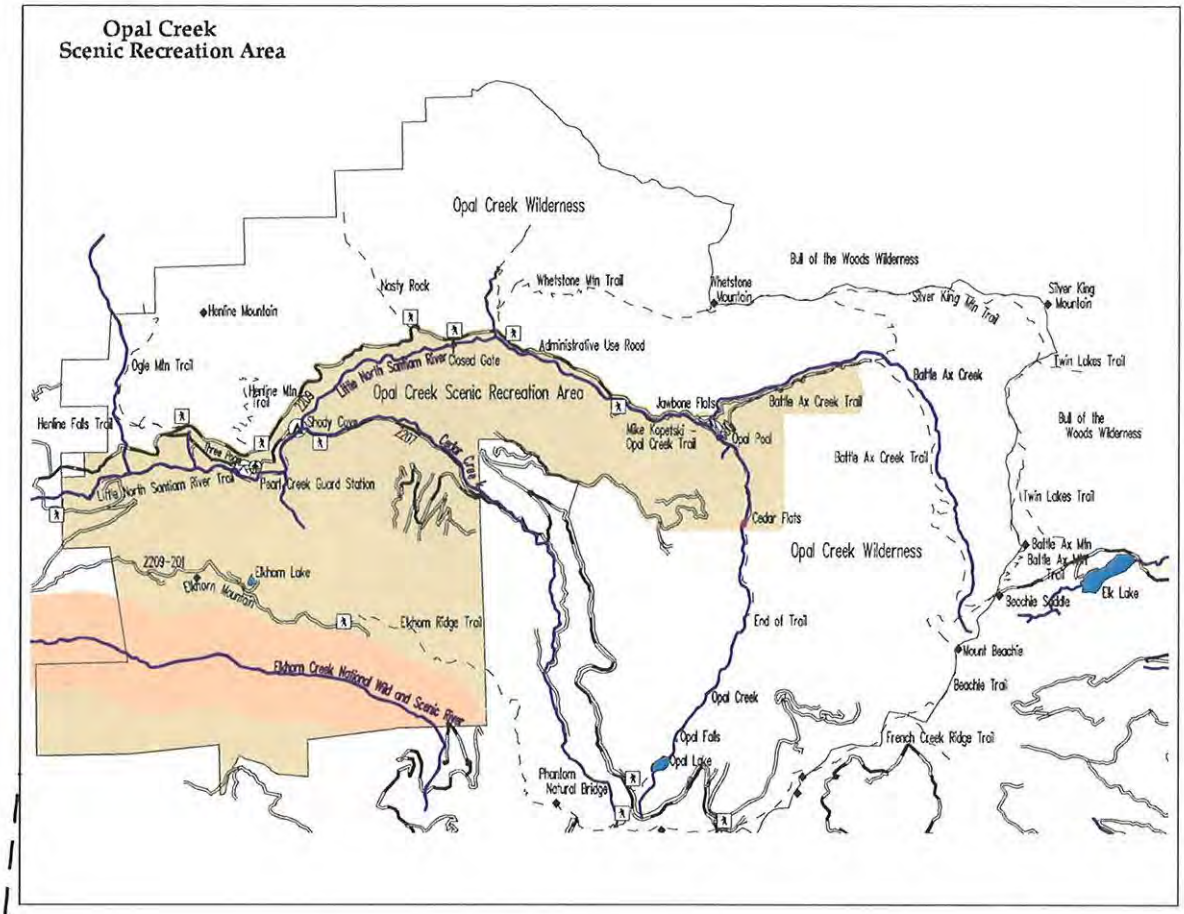
The Morning Star Mine site is located in an old growth hemlock-dominated forest, undergrowth characterized by salal, Oregon grape, and shade-tolerant hemlock and red cedar saplings. Open spaces are characterized by red alder, bigleaf maple, and vine maple. The site is contained within the Opal Creek Scenic Recreation Area.

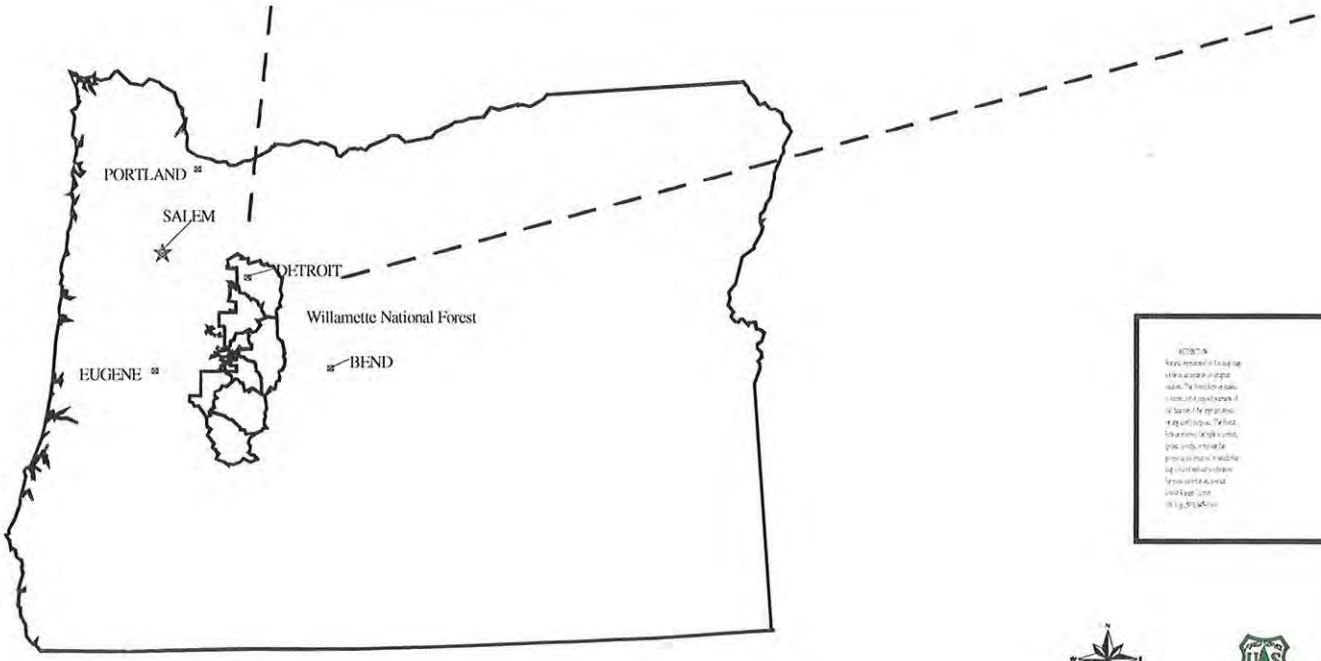
The mine site is located along the Battle Ax Creek trail and a US Forest Service access road approximately 2.5 miles from the Opal Creek Ancient Forest Center at Jawbone Flats, which contains several public accommodations and on-site residences. There are no residences at the mine site. There are no current residents and no allowable future residents at the site due to the the designation as a Scenic and Recreastion Area. Since the mine is abandoned, there are no on-site workers at the site. Only US Forest Service vehicles and Opal Creek Ancient Forest Center vehicles are allowed to use the access road. There are no residential land uses in the area outside of the caretakers of the Opal Creek Ancient Forest Center, and occupational uses consist of US Forest Service workers and trail guides.

Figure 2-1. Location of Morning Star Mine Site

Opal Creek Scenic Recreation Area
Vicinity Map

Figure 2-1.





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The Morning Star Mine adit is approximately 300 feet up the slope above the Battle Ax Creek trail, alongside Blue Jay Creek, a small tributary that flows north to Battle Ax Creek. The tributary flows underground part of the way to Battle Ax Creek, including in the area near the adit and the waste rock piles. The access road and trail follow Battle Ax Creek and pass below the historical mining operations at the mine, at the crossing of Blue Jay Creek. Recreational uses of the land consist of hiking, fishing, hunting, and horseback riding.

2.3 Sources of Contamination

The primary sources of contamination at the site are historical mining activities related to operations of the Morning Star Mine. Ore was brought up from mines, with the adit located near an access road and serving as the primary source of ore wastes, processed to some extent at the site, and waste rock was deposited in and adjacent to Blue Jay Creek in the ravine below the adit.

Waste rock from mine activities at the adit is present in Blue Jay Creek, which runs from the adit to Battle Ax Creek. Deposits in Blue Jay Creek may have contributed sedimentary material that washed into Battle Ax Creek. Blue Jay Creek water may have leached metals from the waste rock into surface water and transported dissolved metals to Battle Ax Creek. Over time, rain and snow melt may have transported dissolved metals or waste rock particles, particularly from the area around the adit, down the Blue Jay Creek ravine to Battle Ax Creek. Once in the creeks, contaminated sedimentary particles may deposit or transport downstream. Dissolved metals in the surface water may bind to particulates and deposit in the creek or transport downstream.

2.4 Identification of Contaminants of Potential Concern

The available site data are used to identify COPCs for soil, surface water, and sediment. The specific data that are used in the screening are identified in the following section that describes the exposure scenarios that are evaluated. In the first step of the HHRA, COPCs are identified by screening data on chemicals of interest (COIs) that were analyzed at the site, following the procedure in Section 2.3.2 of ODEQ (2000) guidelines:

- *Frequency of Detection* –COIs detected in less than 5% of the samples of a given medium are excluded from the list of COPCs.
- *Background* – COIs that are at background concentrations are typically not selected as COPCs. Comparison of the maximum concentration of each COI in soil samples against the 90th percentile of background soil data was performed for the background screening.
- *Screening of COIs against PRGs* – The final screening step to select COPCs consists of comparison of maximum concentrations of COIs in soils, surface waters, and sediments with USEPA Preliminary Remediation Goals (PRGs) for residential and industrial exposures. Both soil and sediment concentrations of COIs are compared with soil PRGs, and surface water concentrations of COIs are compared with industrial tap water PRGs. The industrial soil criteria are designed for evaluating continuous exposures to industrial workers over a

standard working time period. Industrial criteria for soils and water are also used to select COPCs for the recreational scenario since recreational screening criteria are not available, and the industrial criteria are considered to be protective of recreational exposures since they are based on exposures that would be higher than those for intermittent exposures under a recreational scenario. For example, the industrial criteria assume full time occupational exposures to environmental media, whereas recreational exposures would entail much less exposure times and less exposure frequencies on an annual basis. Industrial tap water criteria are designed for screening drinking water uses and are conservative for application to surface waters that may be contacted by infrequent recreational activities.

The screening procedures and their results are described in the following sections.

2.4.1 FREQUENCY OF DETECTION

COIs in each environmental medium were first screened on the basis of frequency of detection. If COIs were not detected above a frequency of five percent, they can be eliminated as a COPC (ODEQ 2000). COIs were identified for waste rock soils, surface water, and sediment at the Morning Star Mine site. Data showing detected concentrations of COIs in each sample in waste rock soils, surface water, and sediment at the Morning Star Mine site are presented in tables attached to the Screening Ecological Risk Assessment for the Morning Star Mine site. Sediment porewater data are not used in the HHRA and are not discussed in this document. Surface water and sediment samples consisted of the surface water from the single adit, and surface water and sediment samples from stations in Blue Jay Creek and Battle Ax Creek immediately downstream of the confluence with Blue Jay Creek.

Surface water and sediment data from Battle Ax Creek stations located upstream of the confluence with Blue Jay Creek and located further downstream near the Ruth Mine drainage were not used to identify COIs. COIs are identified as chemical contaminants related to the releases from the site, and those locations are not considered to be adequately representative of site releases. The upstream samples located in Battle Ax Creek upstream of the confluence with Blue Jay Creek would not be related to discharges from the mine site or from Blue Jay Creek, which would be transported downstream of that confluence, and the samples collected in the downstream reaches of Battle Ax Creek would be contaminated by discharges from Ruth Creek, or would be located so far downstream as to be outside the major influence of discharges from Blue Jay Creek. Thus, the COIs were identified from stations located either in Blue Jay Creek or in Battle Ax Creek at areas with the highest potential to be influenced by discharges from the mine site.

Results of the frequency screen are shown in Table 2-1. COIs that were screened out from further evaluation for waste rock soils on the basis of detection frequency consist of beryllium, thallium, and hexavalent chromium. In surface water, all but aluminum, arsenic, barium, calcium, lead, magnesium, manganese, potassium, sodium, and zinc were eliminated from further consideration based on lack of detection in any surface water sample, which included the adit water, Blue Jay Creek surface water, and surface water of Battle Ax Creek.

In sediment, antimony, beryllium, selenium, and thallium were never detected in any of the samples, including Blue Jay Creek and Battle Ax Creek sediments.

Table 2-1. Screening of COIs for Detection Frequency

Chemical of Interest (COI)	Frequency of Detection		
	Waste Rock Soil	Surface Water	Sediment
Aluminum	11/11	1/6	4/4
Antimony	8/11	0/6	0/4
Arsenic	11/11	5/8	3/4
Barium	11/11	1/8	4/4
Beryllium	0/11	0/6	0/4
Cadmium	11/11	0/8	3/4
Calcium	11/11	6/6	4/4
Chromium	11/11	0/8	4/4
Cobalt	11/11	0/6	4/4
Copper	11/11	0/8	4/4
Iron	11/11	0/8	4/4
Lead	11/11	6/8	4/4
Magnesium	11/11	6/6	4/4
Manganese	11/11	1/8	4/4
Mercury	11/11	0/8	1/4
Nickel	11/11	0/8	4/4
Potassium	11/11	6/6	4/4
Selenium	6/11	0/8	0/4
Silver	9/11	0/8	1/4
Sodium	3/11	6/6	3/4
Thallium	0/11	0/6	0/4
Vanadium	11/11	0/6	4/4
Zinc	11/11	7/8	4/4
Hex Chromium	0/11	---	---

Surface water stations = All surface water data from adit, Blue Jay Creek, and Battle Ax Creek immediately downstream of confluence
Sediment stations = All sediment data from Blue Jay Creek and Battle Ax Creek immediately downstream of confluence

2.4.2 BACKGROUND CONCENTRATION SCREENING

Following the screen for frequency of detection, COIs were screened against background concentrations. Background concentrations are set at the 95UCL of the mean concentration of background samples, and the maximum concentration in site soil is compared to this background value, as per ODEQ (2000) guidance. Chemicals with maximum concentrations exceeding the 95 UCL of background samples were retained for further evaluation.

Background concentrations were identified for COIs in soils, surface water, and sediment. The screening for background is presented in tables in Attachment A of the Screening

Ecological Risk Assessment for the site. Chemical concentration data for soils, surface water, and sediment data, and the 95 UCL concentrations, are presented in Attachment B of the Screening Ecological Risk Assessment. For soils, background concentrations were determined using data from 20 samples, which were collected from locations around the Morning Star Mine site and the Ruth Mine site that were not impacted by mining-related activities. Locations of the background soil samples can be found in the Site Inspection report for the Morning Star Mine site.

A set of background samples was collected for surface water and sediment for the Morning Star site. Background surface water and sediment samples were collected in Battle Ax Creek upstream of its confluence with Blue Jay Creek. These sample stations were identified as locations that are not impacted by discharges from the Morning Star Mine site or other mining activities. Locations of the surface water and sediment samples are presented on a map of the site in the Screening Ecological Risk Assessment. Background surface water stations are identified as SW-8, SW-MS-14, SW-MS-15, and SW-MS-16. Background sediment stations are identified as SED-MS-14, SED-MS-15, and SED-MS-16. Surface water and sediment data and 95 UCL concentrations are presented in Attachment B of the Screening Ecological Risk Assessment.

Table 2-2 summarizes the chemicals that pass the detection frequency and background comparison screens for soils, surface water, and sediment at the Morning Star Mine site.

Table 2-2. Summary of COIs Passing Detection Frequency and Background Screens, Morning Star Mine Site

Waste Rock Soils	Surface Water – Site-Related Samples	Surface Water - Battle Ax Creek	Sediment
Antimony	Aluminum	Aluminum	Arsenic
Arsenic	Arsenic	Arsenic	Cadmium
Cadmium	Barium	Calcium	Cobalt
Calcium	Calcium	Lead	Copper
Cobalt	Lead	Manganese	Iron
Copper	Manganese	Potassium	Lead
Iron	Potassium	Sodium	Magnesium
Lead	Sodium	Zinc	Manganese
Magnesium	Zinc		Mercury
Manganese			Nickel
Mercury			Potassium
Potassium			Silver
Silver			Zinc
Zinc			

Surface water site-related samples and sediment samples consist of adit, Blue Jay Creek, and Battle Ax Creek downstream of confluence with Blue Jay Creek

2.4.3 SCREENING AGAINST PRGS AND SELECTION OF COPCS

Tables A-1 through A-3 in Attachment A presents the results of the screening against PRGs. Screening against PRGs was performed on those COIs that passed the detection frequency screen and the screen against background. As per ODEQ guidance, the screen against PRGs identified multiple COPCs in multiple media. A summary of the screening results and selection of COPCs in each of the exposure media for the Morning Star Mine site is presented in Table 2-3.

Table 2-3. Contaminants of Potential Concern

Exposure Media	Results of Screen
Waste rock soil	Arsenic exceeded the PRG by a factor of 19 Lead exceeded the PRG by a factor of 15
Surface water	Arsenic exceeded the PRG by a factor of 106
Sediment	Arsenic exceeded the PRG by a factor of 26. Lead exceeded the PRG by a factor of 1.7

COPCs were selected by screening chemical concentrations against USEPA Consolidated Preliminary Remediation Goals for industrial soil and for tapwater.

2.5 IDENTIFICATION OF POTENTIALLY EXPOSED POPULATIONS AND SCENARIOS

Potentially exposed populations are identified for the site for which risks are estimated. There are no residences at the mine site; the nearest residence is located approximately 2.5 miles down a US Forest Service access road at the Opal Creek Ancient Forest Center in Jawbone Flats, which contains several public accommodations and on-site residences. Because of the remoteness of the mine and the steep grades, there is little likelihood of full-time residents at the site in the future. Since the mine is abandoned, there are no on-site workers at the site. Only US Forest Service vehicles and Opal Creek Ancient Forest Center vehicles are allowed to use the access road. The access road from Jawbone Flats to Morning Star Mine encompasses the Battle Ax Creek trail; with the entire mine site and portions of the access road and trail located in the Opal Creek Scenic Recreation Area. The access road and trail pass immediately below the historical mining operations. Hence recreational users of the area, primarily for hiking but also fishing, hunting, and horseback riding, are assumed to have the highest potential exposures to COPCs at the mine site.

The estimation of exposure and risk depends on the identification of exposure pathways, scenarios, and exposure routes. Complete exposure pathways consist of four elements: a source of chemical release into the environment, an environmental medium for transport of the chemical (e.g., soil, surface water, and air), a point of potential human exposure, and an exposure route by which the chemical can get into the body.

Potential exposures to recreational users of the site are evaluated through construction of a recreational exposure scenario. The recreational exposure scenario incorporates considerations of the above-mentioned factors, i.e., identification of exposure pathways and exposure routes. The highest exposures to site-related chemicals for recreational users are assumed to be for persons who have hiked into the site and that spend time directly on the waste rock piles and who come in contact with surface water and sediment of the adit, Blue Jay Creek, and Battle Ax Creek. The persons with highest potential exposures would likely be hikers into the area, particularly young children, but would also include hunters and fishers who visit the area. The exposure pathways and routes of exposure to site-related chemicals are evaluated for reasonable maximum, or worst case, exposures. Any persons visiting the site and exposed to waste rock or the surface waters for less time than evaluated under this recreational scenario would have less exposures and less potential health risks. For example, hikers, hunters, and fishers who may visit the site for shorter periods of time than evaluated under this recreational scenario would have lower potential health risks than estimated in this risk assessment.

For people who catch and consume fish from Battle Ax Creek, potential exposures to site-related chemicals and associated health risks related to fish consumption are not quantified. Reasonable maximum exposure of fish consumers to site-related chemicals would be related to the catch and consumption of fish from Battle Ax Creek in the reach below the drainage of the Morning Star Mine site. Because of the lack of easy access to the creek and the lack of data indicating how much consumable fish might be present in the creek and what the annual consumption rate might be, the exposures from consumption of fish from the creek cannot be quantified. Because of the lack of easy access and the lack of observations of consumable fish in Battle Ax Creek during the site visit and Scoping Level Ecological Risk Assessment, the amount of fish that might reside in the reach downstream of the Morning Star drainage and that would be caught and consumed by fishers is not considered to be sufficient to present a significant risk. To quantify exposures, any consumed fish would need to reside in the downstream reach of the creek in order to take up metals related to the mine site drainage. Thus, for the purpose of quantifying exposures to chemicals in fish, this risk assessment assumes that there is an insufficient number of fish that reside in the reach downstream of the drainage to present significant exposures from annual consumption over a 30-year period. For the identification of significant exposure pathways to site-related chemicals, consumption of fish from Battle Ax Creek is possible but is not considered to be significant and presents an unknown risk.

Based on the above analysis of potential activities and exposure pathways, the following exposure scenarios were developed for complete and significant exposure pathways for recreational exposures to COPCs at the Morning Star Mine site.

Adult Recreational Scenario

- Adults who may come in contact with waste rock soil during recreational activities at the mine site, through the following exposure routes:
  - Inadvertent ingestion of dirt particles that consist only of waste rock soil
  - Direct skin contact with waste rock soil

- Inhalation of dust particles comprised solely of waste rock soil.

- Adults who may contact surface water (which includes the adit water and waters of the creeks) and creek sediment at the site, through the following exposure routes:
  - Ingestion of surface water
  - Dermal contact with surface water
  - Ingestion of sediment
  - Dermal contact with sediment.

Child Recreational Scenario

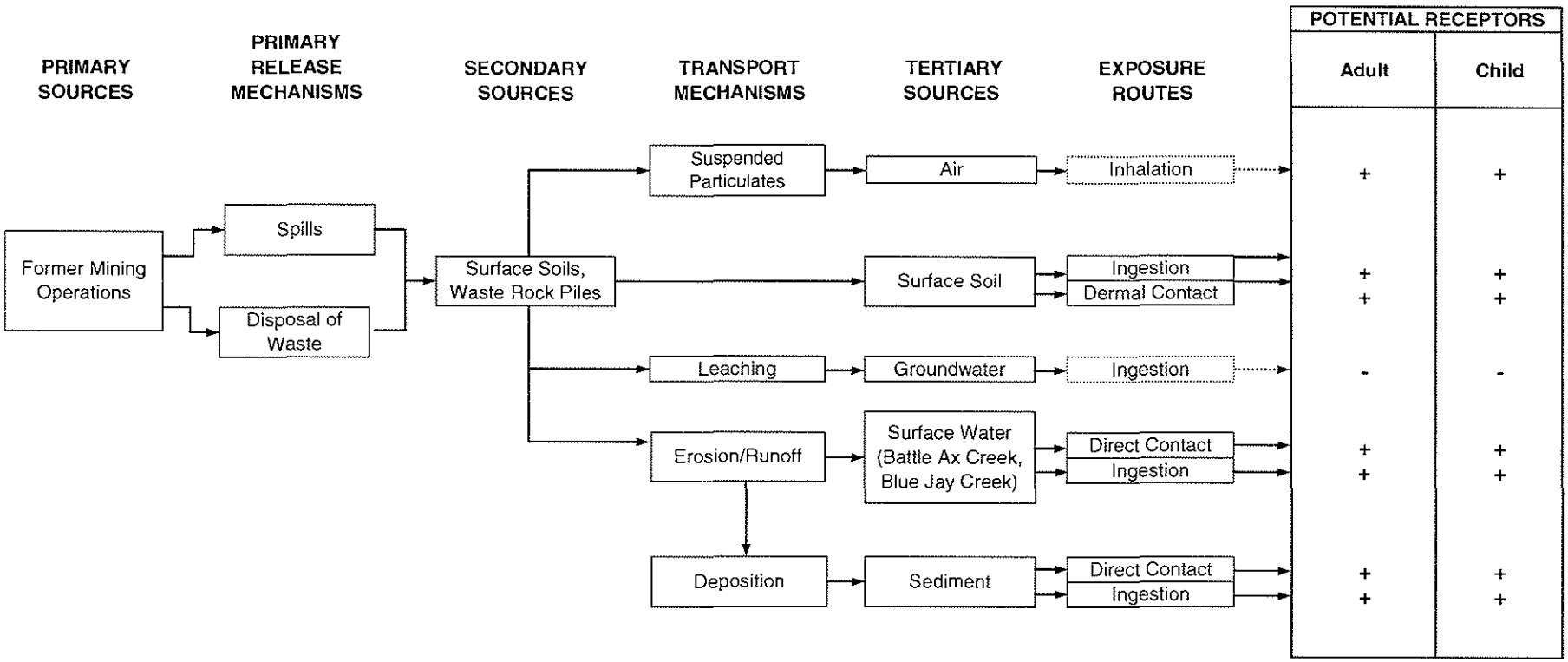
- Children who may come in contact with waste rock soil during recreational activities at the mine site, through the following exposure routes:
  - Inadvertent ingestion of dirt particles that consist only of waste rock soil
  - Direct skin contact with waste rock soil
  - Inhalation of dust particles comprised solely of waste rock soil.
- Children who may play in the surface waters (which includes the adit water and waters of the creeks) and sediment at the site, exposed through the following routes:
  - Ingestion of surface water
  - Dermal contact with surface water
  - Ingestion of sediment
  - Dermal contact with sediment.

For both the adult and child exposure scenarios, risks under reasonable maximum exposure (RME) conditions and central tendency exposure (CTE) conditions are estimated. The RME exposure conditions are designed to estimate a reasonable worst case type of exposure at the site, whereas the CTE conditions represent a more typical exposure. As per ODEQ (2000) guidance, children are defined as age < 6 years and adults as age > 7 years.

2.6 Conceptual Exposure Model for Human Health

The conceptual exposure model (CEM) for human exposures to COPCs at the Morning Star Mine site is presented in Figure 2-2. The CEM depicts the sources of the COPCs, the media to which humans may be exposed, likely exposure pathways, human receptors, and routes of exposure for the scenarios identified in the exposure analysis above. The CEM is an integration of the information presented in the subsections above.

Figure 2-2. Conceptual Exposure Model for the Morning Star Mine Site



Notes:

+ Complete and potentially significant exposure
- Insignificant or incomplete exposure pathway or medium

3 EXPOSURE ANALYSIS

The Exposure Analysis develops the exposure scenarios and exposure pathways, and quantifies the concentrations of COPCs in the exposure media that humans may contact.

3.1 EXPOSURE ASSUMPTIONS

The parameters that are used to quantify potential exposures for the scenarios described above include many assumptions. Some parameters are quantified following ODEQ (2000) or USEPA (1989) guidance, and some parameters that are specific to the site, such as the amount of time that recreational users may spend at the site, are based on best professional judgment or information from the managers of the Opal Creek Ancient Forest Center at Jawbone Flats. The US Forest Service (2005) has identified the Battle Ax Creek portion of the Opal Creek Scenic Recreation Area as a "Low Use" zone in its recreation management plan for the area (Figure 3-1). The durations and frequencies of exposures that are assumed for this risk assessment are considered reasonably conservative given the current and future anticipated use of the site for recreational purposes.

The following assumptions were made for recreational exposures at the site. Exposure parameters are developed for both the CTE and RME conditions. The parameters and their values are also listed in Table A-4 of Attachment A.

- Body Weight – A body weight of 15 kg for child represents the mean weight of children between the ages of 0 and 6. A body weight of 70 kg for adults is the mean weight of men and women between the ages of 18 and 70. Both values are taken from ODEQ (2000) guidance.
- Exposure Duration – The exposure duration is the number of years over which exposures may occur. For children, values of 2 and 6 years are used for the CTE and RME conditions, respectively. For adults, the values of 9 and 30 years are assumed for CTE and RME conditions, respectively, based on ODEQ (2000) guidance on lengths of residence in a given area.

Figure 3-1. Recreational Zones for the Opal Creek Area

Source: USFS (2005)

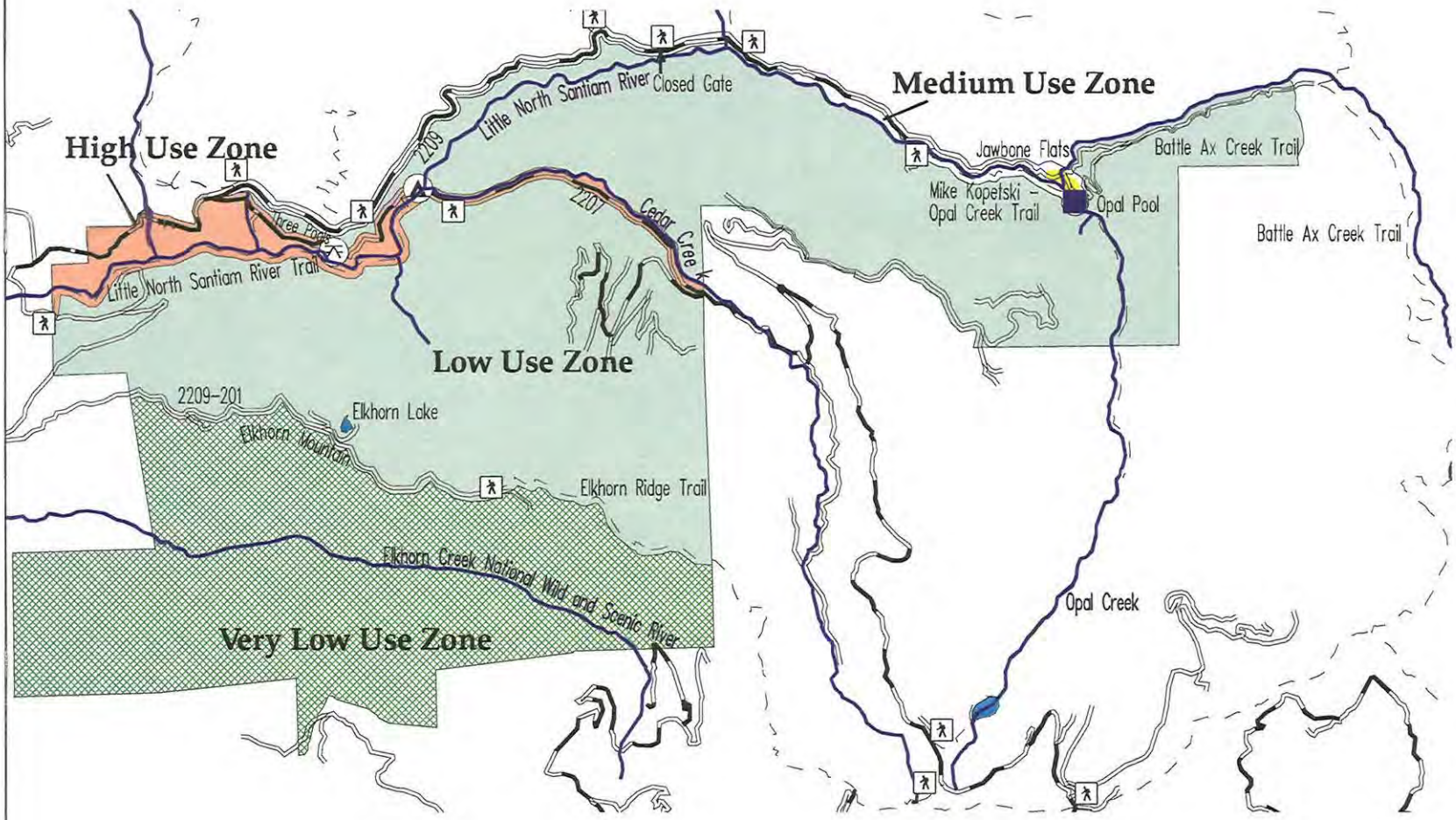
Opal Creek Scenic Recreation Area
Proposed Recreation Management Intensity Zones

Figure 3-1.

ATTENTION
Features represented on this map may not be in an accurate geographic location. The Forest Service makes no expressed or implied warranty of this data nor of the appropriateness for any user's purposes. The Forest Service reserves the right to correct, update, modify, or replace the geospatial information on which this map is based without notification. For more information, contact
Detroit Ranger District GIS shop (503) 845-3366

Legend
- High Use
- Medium Use
- Low Use

Legend
- Very Low Use
- Improved Gravel Road
- Low Maintenance Road
- Trails
- Streams
- Day Use
- Campground
- Trailheads
- Peaks



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1" = 1.14 miles
0 miles 1 2

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- Exposure Frequency – Exposure frequency is number of days per year that a person may spend at the site, engaged in recreational activities. Frequencies for child exposures are assumed to be 2 weekends in summer, for 2 days each weekend, for a total of 4 days per year for CTE; and 20 days for the RME (i.e., assuming a two-week vacation during summer months when the soils are accessible plus six additional days during the year) for every year over 6 years. For adults, 4 and 20 days per year are also used for the CTE and RME conditions, respectively.
- Exposure Time – It is assumed that young children are accompanied by adults to the mine site, and both children and adults spend 4 hours exposed to waste rock soils during each of the visits to the site. In other words, the exposure time assumes that the child and adult visitors spend all 4 hours actively engaged in activities that result in continuous direct exposure to COPCs in waste rock soils. The time of exposure to contaminated surface water and sediment is assumed to be 0.5 and 1 hour for each daily visit for the CTE and RME exposures, respectively.
- Surface Area – Values for body surface areas for dermal contact for exposures to soil, surface water, and sediment are taken from ODEQ (2000) guidance on soil contact. Swimmable water bodies are not available at the site.
- Pathway Specific Parameters:

  Soil Ingestion – Children are assumed to ingest waste rock pile soils at rates of 25 and 100 mg/day during each 4-hour visit, for CTE and RME conditions, respectively. Adults are assumed to ingest waste rock pile soils at rates of 12 and 25 mg/day during each visit, for CTE and RME conditions, respectively. Ingestion rates are one-quarter the values recommended in ODEQ (2000) and USEPA (1997) for combined ingestion of house dust and soil under continuous exposures in a residential setting. The selected ingestion rates are assumed to be representative of activities that would occur throughout the exposure time of 4 hours per day at the waste rock soils.

  Soil Adherence Factor – Adherence factors for determining the amount of soil and sediment that may stick to skin are taken from USEPA (2004) guidance on dermal risk assessment.

  Inhalation of Fugitive Particulate Dust – Inhalation rates of 1.2 m^3/hr and 1.5 m^3/hr, for children and adults, respectively, for the 4 hours during each visit to the site, are taken from USEPA (1997) guidance.

  Surface Water Ingestion – The rate of surface water ingestion during recreational activities by children and adults is taken from USEPA (1997) guidance, at 0.01 L/hr.

  Sediment Ingestion – Rates of sediment ingestion are assumed to be one-quarter the rates of soil ingestion for the RME.

Slightly different values for some of these parameters, such as exposure duration for children, are assumed by USEPA for evaluating risks from child exposure to lead, as described in the lead risk section (Section 5.3.3).

3.2 Exposure Point Concentrations

Exposure point concentrations (EPCs) are those concentrations of COPCs in environmental media that humans may be exposed to. For the Morning Star Mine site, data on concentrations of COIs are available for waste rock soils, and surface waters and sediments of the mine adit, Blue Jay Creek, and Battle Ax Creek. From those data, EPCs are developed for soils, surface waters, sediments, and air. Air EPCs are developed for particulate dust that is modeled as releases from waste rock soils.

Analytical chemical data to develop EPCs for the site were collected during the November 2005 and the October 2008 site sampling events. The November 2005 data that are used in this HHRA for the Morning Star Mine site consist of one sample in Battle Ax Creek upstream of the confluence with Blue Jay Creek and two samples immediately downstream of the confluence. All remaining sediment data and all surface water and waste rock soils data for the Morning Star Mine site were collected during the October 2008 site visit.

For each environmental medium, EPCs are developed as the upper 90 percent confidence limit (90UCL) on the mean concentration, following ODEQ (2000) guidance. The 90UCL concentrations are used to quantify exposures with the assumption that they best represent the concentrations of COPCs that a person would contact over chronic time periods, assuming that a person moves randomly throughout the exposure area.

The USEPA ProUCL program was used for statistical analyses and to develop the 90UCL concentrations (USEPA 2007). ProUCL 4.0 contains rigorous parametric and nonparametric (including bootstrap methods) statistical methods (instead of simple ad hoc or substitution methods) that can be used on both full data sets without nondetects and for data sets with non detected concentration (i.e., qualified by the analytical laboratory or data validators as "ND", non-detect). The program uses state-of-the-art parametric (e.g., ROS methods) and nonparametric (Kaplan-Meier method) computation methods for UCLs for data sets with non detected concentrations.

The ProUCL program uses both detected and undetected values, and creates interpolated values for non-detects based on the estimated distribution of the detected concentrations. For chemicals with non-detected values, ProUCL fills in a set of concentrations for nondetects that would result in a better estimate of central tendency than other substitution methods (e.g., use of ½ the detection limit for the non-detected value). ProUCL assumes the distribution of the non-detected values based on the distribution of the detected concentrations, and substitutes values for the non-detects based on that assumed distribution. The full dataset, including the substituted concentrations, is then used by ProUCL to identify the underlying distribution of the data set, to estimate upper confidence limits on the mean concentration for various distribution types, and to recommend the most appropriate 95 UCL based on the data distribution. ProUCL does not provide a recommendation for the 90 UCL, so the same statistical test basis that was recommended for the 95 UCL was used to identify the most

appropriate 90 UCL. Based on the distribution, each COI in each environmental medium was assigned a normal distribution, a log-normal distribution, a gamma distribution, or an undeterminable distribution by ProUCL, for which ProUCL uses non-parametric statistics in the UCL determination.

The technical guidance document for the software states that the UCL calculated from datasets with very few (i.e., 6 or less) detected concentrations are not reliable enough for deriving EPCs. In this screening ecological risk assessment, EPCs for any COPCs with 6 or less detections are not based on the 90 UCL but on the maximum concentration instead. In many instances, particularly for 6 or fewer detected values, the 90UCL was calculated to be higher than the maximum concentration, and the maximum concentration was subsequently used in the risk ratio calculations. Thus, in determining the EPCs, none of the UCLs are based on the use of ½ detection limits, and EPCs are either the ProUCL-derived value for the 90 UCL or the maximum concentration.

EPCs are developed for each COPC in each of the environmental media that receptors may contact.

- *Soils* – Recreational users are assumed to be exposed only to waste rock soils for the duration of their soil exposures at the site. The EPC is based on the 11 waste rock soil samples collected in 2008. Exposures to background soils are not included.
- *Surface Water* – Recreational users are assumed to be exposed to surface waters that were sampled at the site. Surface waters consist of a total of 8 samples: one sample of adit water, one sample in Blue Jay Creek upstream of the adit, two samples from Blue Jay Creek downstream of the adit, one sample in Battle Ax Creek at the confluence with Blue Jay Creek, and one sample from Battle Ax Creek downstream of the confluence, all collected in 2008; and including a sample in Battle Ax Creek at the confluence with Blue Jay Creek, and a second sample from Battle Ax Creek downstream of the confluence, collected in 2005. The EPC does not include samples from Battle Ax Creek upstream of Blue Jay Creek, which consists of four samples that are considered to be upstream background locations, three of them collected in 2008 and one in 2005. It was assumed that visitors to the site could have equal access to all environmental media at the site; e.g., exposures could occur to waters in the adit, Battle Ax Creek, and Blue Jay Creek of equal accessibility under future conditions.
- *Sediments* – Recreational users are assumed to be exposed to sediment in the same surface waters as under the surface water exposures. Sediment samples consist of two in Blue Jay Creek, one in Battle Ax Creek at the confluence with Blue Jay Creek, and one in Battle Ax Creek downstream of the confluence, all collected in 2008. The three sediment samples collected in 2008 from Battle Ax Creek upstream of the confluence with Blue Jay Creek are not used to develop the EPC, but are considered as upstream background locations.
- *Air* – Recreational users are assumed to breathe particulates that have been released only from the waste rock soils. It is assumed that the particulates derive from the waste rock soils and do not include particulates that may derive from nearby background soils.

Metals concentrations in air are modeled from the waste rock soil samples by the following equation:

$$C_{air} = \left(\frac{C_{soil}}{PEF} \times F_c \right)$$

where:

C_{air} = concentration in air (mg/m^3)
C_{soil} = 90UCL in waste rock soil
PEF = Particulate emission factor, set at 1.32E+09 m^3/kg as per ODEQ (2000) guidance
F_c = Fraction of soil that is contaminated; assumed to be 100%.

Air particulate modeling results are displayed in Table A-33 of Attachment A.

Table 3-1 presents the EPCs for the COPCs at the Morning Star Mine site.

Table 3-1. Exposure Point Concentrations

Chemical of Potential Concern	Soil CTE/RME (90UCL) (mg/kg)	Surface Water CTE/RME (90UCL) (mg/L)	Sediment CTE/RME (90UCL) (mg/kg)	Air CTE/RME (modeled) (mg/m3)
Arsenic	21.5	0.0017	29.5	1.63E-08
Lead	6,208	0.005	1,045	4.70E-06

Chemicals of Potential Concern are based on screens for detection frequency, and exceedances of background and USEPA preliminary remediation goals

CTE/RME = central tendency exposures/reasonable maximum exposures

90UCL = 90% upper confidence limit on the mean concentration

NA = Not applicable, not a COPC for that medium based on lack of detections.

3.3 Intake Estimation

The final step in the exposure assessment is the estimation of chemical intake and resulting dose for each chemical and each of the pathways considered in the assessment. The extent of potential intake received through the various pathways is dependent on an individual's location and behavior. A series of simplifying assumptions are made to calculate chemical intakes that yield conservatively high estimates of potential exposures. Calculations of intake follow the procedures in ODEQ (2000) guidance.

For long-term (i.e., chronic) exposures to noncarcinogenic chemicals, intakes are averaged over the period of exposure (i.e., the averaging time, AT), and are referred to as the average daily dose (ADD) (USEPA 1989). For carcinogens, intakes are averaged over an entire lifetime and are referred to as the lifetime average daily dose (LADD) (USEPA 1989).

The equations used to estimate intakes for each of the exposure pathways follow those presented in ODEQ (2000) guidance.

3.3.1 INCIDENTAL INGESTION OF SOIL OR SEDIMENT

$$(L)ADD = \frac{C_s \ x \ IR_s \ x \ EF \ x \ ED}{BW \ x \ AT} \ x \ CF$$

where:

(L)ADD	=	(Lifetime) Average Daily Dose (mg/kg-day)
C_s	=	Concentration of chemical in soil or sediment (mg/kg)
IR_s	=	Ingestion Rate of soil or sediment (mg/day)
EF	=	Exposure Frequency (days/year)
ED	=	Exposure Duration (years)
BW	=	Body Weight (kg)
AT	=	Averaging Time (days)
CF	=	Conversion Factor (10^{-6} kg/mg).

For noncarcinogens, intakes are calculated by averaging the daily doses over the averaging time (AT), which is set equal to the exposure duration (ED). For carcinogens, AT is an average upper bound duration of human lifetime, which is assumed by ODEQ (2000) to be 70 years (25,550 days).

3.3.2 DERMAL CONTACT WITH SOIL OR SEDIMENT

$$(L)ADD = \frac{C_s \ x \ SA \ x \ AF \ x \ DAF \ x EF \ x \ ED}{BW \ x \ AT} \ x \ CF$$

where:

(L)ADD	=	(Lifetime) Average Daily Dose (mg/kg-day)
C_s	=	Concentration in soil or sediment (mg/kg)
SA	=	Surface Area of skin contact (cm^2/event)
AF	=	Adherence Factor for soil or sediment to skin (mg/cm^2)
DAF	=	Dermal Absorption Factor (unitless)
EF	=	Exposure Frequency (events/year)
ED	=	Exposure Duration (years)
BW	=	Body Weight (kg)
AT	=	Averaging Time (days)
CF	=	Conversion Factor (10^{-6} kg/mg).

3.3.3 INHALATION OF SOIL PARTICLES

$$(L)ADD = \frac{C_s \ x \ IR_p \ x \ ET \ x \ EF \ x \ ED}{BW \ x \ AT}$$

where:

(L)ADD	=	(Lifetime) Average Daily Dose (mg/kg-day)
C_s	=	Concentration in soil particulates (mg/kg)
IR_p	=	Inhalation Rate of particulates (m^3/hour)
ET	=	Exposure Time (hours/day)
EF	=	Exposure Frequency (days/year)

ED	=	Exposure Duration (years)
BW	=	Body Weight (kg)
AT	=	Averaging Time (days).

3.3.4 INGESTION OF SURFACE WATER

$$(L)ADD = \frac{C_{sw}\ x\ IR_{sw}\ x\ ET\ x\ EF\ x\ ED}{BW\ x\ AT}$$

where:

(L)ADD	=	(Lifetime) Average Daily Dose from ingestion of surface water (mg/kg-day)
C_{sw}	=	Concentration of chemical in surface water (mg/L)
IR_{sw}	=	Ingestion Rate of surface water (L/day)
ET	=	Exposure Time (hours/day)
EF	=	Exposure Frequency (days/year)
ED	=	Exposure Duration (years)
BW	=	Body Weight (kg)
AT	=	Averaging Time (days).

3.3.5 DERMAL CONTACT WITH SURFACE WATER

$$(L)ADD = \frac{C_{sw}\ x\ SA\ x\ PC\ x\ ET\ xEF\ x\ ED}{BW\ x\ AT}\ x\ CF$$

where:

(L)ADD	=	(Lifetime) Average Daily Dose (mg/kg-day)
C_{sw}	=	Concentration in surface water (mg/kg)
SA	=	Surface Area of skin contact (cm^2/event)
PC	=	Permeability Coefficient of chemical (cm/hour)
ET	=	Exposure Time (hours/day)
EF	=	Exposure Frequency (days/year)
ED	=	Exposure Duration (years)
BW	=	Body Weight (kg)
AT	=	Averaging Time (days)
CF	=	Conversion Factor (10^{-3} L/cm^3).

Calculated doses, or intakes, of all COPCs in soil, sediment, and surface water are displayed in the risk calculation tables presented in Tables A-5 through A-32 of Attachment A.

4 TOXICITY ASSESSMENT

The Toxicity Assessment presents the toxicity information and criteria for the COPCs that are used with the exposure intake doses to quantify risks. Toxicity criteria are based on the types of potential adverse health affects associated with exposures to the COPC; the relationship between magnitude of exposure and potential adverse effects; and related uncertainties, such as the weight of evidence of a particular chemical's carcinogenicity in humans. The toxicity criteria rely on existing toxicity information developed for specific chemical constituents. USEPA has evaluated existing toxicity information and characterized the relationship between the dose of the chemical administered or received and the incidence of potentially adverse health effects in the exposed population. From this quantitative dose-response relationship, specific toxicity values have been derived that can be used to estimate the incidence of potentially adverse effects at different exposure levels (USEPA 1989). These toxicity values are called reference doses (RfDs) for non-carcinogens and slope factors (SFs) for potential carcinogens.

All carcinogenicity and non-carcinogenicity toxicity values come from USEPA sources, as per ODEQ guidance. The sources of toxicity values follow the hierarchy of sources as listed in USEPA (2003), with the primary source consisting of the USEPA Integrated Risk Information Systems (IRIS) database, from which toxicity values for all COPCs were available.

4.1 NON-CARCINOGENIC TOXICITY VALUES

Reference doses are expressed in units of milligrams of chemical per kilogram of body weight per day (mg/kg-bw/day). They are derived from either animal laboratory experiments or human epidemiology investigations (usually workplace studies), and include uncertainty factors to account for specific types of uncertainty inherent in extrapolation from the available data, and modifying factors to account for the confidence in the scientific studies. The use of these factors is a conservative approach to the protection of human health and is likely to overestimate the risks associated with chemical exposure.

The primary source for toxicity values for non-carcinogens was the USEPA Integrated Risk Information Systems (IRIS) database. Toxicity values were available for all COPCs in the IRIS database and no alternative sources were necessary.

Toxicity values used for exposures that involve dermal contact with chemicals may require adjustment of the oral toxicity values (oral RfDs) to allow for the difference between the daily intake dose through absorption via dermal contact and the amount that is ingested in the toxicity study used to derive the oral RfD (i.e., the administered dose). Most toxicity values are based on the administered dose, and must be corrected for the percent of chemical-specific absorption that occurs across the gastrointestinal tract prior to their use in dermal contact risk assessment (USEPA 1989, 2004). Ingestion route toxicity values were adjusted by absorption factors in USEPA (2004) guidance to account for the differences between the administered dose and the absorbed dose across the skin. This adjustment lowers the reference doses for use in dermal exposures.

US EPA quantifies non-carcinogenic effects for arsenic via ingestion and dermal absorption, for which reference doses are derived (Table 4-1). For lead, USEPA does not recommend the use of a reference dose, but instead provides models to estimate the contribution of the site to blood lead levels in children and fetus through maternal exposures (see Section 5.3)

The toxicity values used for non-carcinogenic chemicals are presented in Table 4-1.

4.2 Carcinogenic Toxicity Values

Unlike non-carcinogens, carcinogens are generally assumed to have no threshold, that is, there is presumed to be no level of exposure below which carcinogenic effects will not manifest themselves. This "non-threshold" concept is based on the idea that there are small, finite probabilities of inducing a carcinogenic response associated with every level of exposure to a potential carcinogen. US EPA has quantified cancer toxic potency concentrations, *i.e.,* the slope factor, which reflects the dose-response data for the carcinogenic endpoint (USEPA 1989).

The slope factor is determined by US EPA as the upper 95th percentile confidence limit of the probability of response per unit daily intake of a chemical over a lifetime. Typically, the slope factor is used to estimate the upper-bound lifetime probability of a person developing cancer from exposure to a given concentration of a carcinogen. Slope factors are generally based on experimental animal data, unless suitable epidemiologic studies are available. Due to the difficulty in detecting and measuring carcinogenic endpoints at low exposure concentrations, slope factors are typically developed by using a model to fit the available high-dose, experimental animal data, and then extrapolating downward to the low-dose range to which humans are typically exposed. The models used by US EPA are conservative and provide an upper bound estimate of excess lifetime cancer risk. Thus, the actual risk may be lower and could be zero (USEPA 1989). The toxicity values used for carcinogenic metals are presented in Table 4-1.

Of the COPCs at the site, US EPA has identified arsenic as carcinogenic via ingestion, dermal absorption, and inhalation, for which slope factors have been derived (Table 4-1).

Table 4-1. Toxicity Values

Carcinogenicity					
Chemical of Potential Concern	Cancer Slope Factor			Weight-of-Evidence Classification	Basis of Slope Factor
	Oral (mg/kg-day)-1	Dermal (mg/kg-day)-1	Inhalation (mg/kg-day)-1		
Arsenic	1.5	1.58	15.1	A Known Human Carcinogen	Skin cancer, human epidemiology studies (drinking water)
Non-Carcinogenicity					
Chemical of Potential	Reference Dose			Basis of RfD	Target Endpoint
	Oral	Dermal	Inhalation		

Concern	(mg/kg-day)	(mg/kg-day)	(mg/kg-day)		Effects
Arsenic	0.0003	0.00029	NA	Human epidemiology studies, drinking water	Skin, vascular effects
Lead	NA	NA	NA	See text	Blood lead

Sources: USEPA IRIS database; USEPA HEAST; USEPA NCEA; USEPA 2004
Dermal RfDs are derived from oral RfDs (USEPA 2004).
NA = not available; lead is evaluated through the USEPA blood lead model.

4.3 Chemical Factors

Other chemical factors for calculating exposures include the gastrointestinal absorption factor and the dermal absorption factor. Chemical parameters are listed in Table 4-2. Gastrointestinal and dermal absorption factors were taken from US EPA (1989, 1994b, 2004) guidance.

Table 4-2. Chemical-Specific Parameters

Chemical of Potential Concern	GI Absorption Factor GI ABS	Dermal Absorption Factor DAF	Dermal Permeability Coefficient PC (cm/hr)
Arsenic	0.95	0.03	1.00E-03
Lead	0.3	0.01	1.00E-03

Sources: USEPA 1989, 1994b, 2004

5 RISK CHARACTERIZATION

Risk Characterization is the final step of the HHRA process. In this step, the toxicity values are combined with the estimated chemical intakes for the receptor populations to quantitatively estimate health risks associated with carcinogen and non-carcinogen exposures. Human health risks are deliberately characterized in a conservative manner in order to determine an upper range of potential risks for exposures to chemicals at the site. The characterization is considered screening level because it is based on limited sampling data and conservative simplifying assumptions about how much a recreational user is exposed to metals in the waste rock and surface waters of the site.

The methodologies used to estimate potential cancer risks and chronic risks for non-carcinogens for conventional chemicals are described below.

5.1 Method for Noncarcinogenic Risks

The potential human health risks associated with exposures to non-carcinogenic COPCs were estimated by comparing ADDs with established RfDs, as per ODEQ (2000) and US EPA (1989) guidance. A hazard quotient (HQ) was derived for each chemical, as shown in the following equation:

$$HQ = \frac{ADD}{RfD}$$

where:

HQ	=	Hazard Quotient (unitless); ratio of average daily dose or intake level (ADD) to acceptable daily intake level or reference dose (RfD)
ADD	=	Average Daily Dose (mg/kg-day)
RfD	=	Reference Dose (mg/kg-day).

If the ADD exceeds the RfD, the HQ will exceed 1.0 and there may be concern that potential adverse systemic health effects could be observed in the exposed populations. If the ADD does not exceed the RfD, the HQ will not exceed 1.0 and there is no concern that potential adverse systemic health effects will be observed in the exposed populations. However, if the sum of several HQs exceeds 1.0, and the chemicals affect the same target organ, there may be concern that potential adverse systemic health effects will be observed in the exposed populations. In general, the greater the value of the HQ above 1.0, the greater the level of concern. However, the HQ does not represent a statistical probability that an adverse health effect will occur.

For consideration of exposures to more than one chemical causing systemic toxicity via several different pathways, the individual chemical HQs are summed to provide an exposure pathway Hazard Index (HI). If the HI is less than 1.0, then no adverse health effects are likely to be associated with exposures via that pathway at the site. However, if the total HI is greater than 1.0, separate endpoint-specific HIs may be calculated based on a toxic endpoint of concern or target organ (*e.g.*, HQs for neurotoxins are summed separately from HQs for renal toxins). Only if an endpoint-specific HI is greater than one is there reason for concern about potential health effects for that endpoint.

5.2 Method for Cancer Risks

Carcinogenic risk was estimated as the incremental probability of an individual developing cancer over a lifetime as a result of exposure to a potential carcinogen at the site. The numerical estimate of excess lifetime cancer risk was calculated by multiplying the lifetime average daily dose (ADD) by the risk per unit dose (the slope factor), as shown in the following equation:

$$Risk = ADD \times SF$$

where:

Risk	=	The unitless probability of an exposed individual developing cancer
ADD	=	Average Daily Dose over a lifetime (mg/kg-day)
SF	=	Cancer Slope Factor $(mg/kg\text{-}day)^{-1}$.

Because the slope factor is the statistical 95th percent upper confidence limit on the slope of the dose-response curve, this method provides a conservative, upper-bound estimate of risk.

5.3 Non-Cancer and Cancer Risk Estimates for Recreational Users

Estimates of potential cancer and noncancer health risks under CTE and RME conditions at the mine site are presented in the following subsections. Estimates are presented for adult and children for each of the exposure pathways.

Noncancer hazard quotients and excess cancer risks under CTE and RME conditions are summarized for adults and children under various exposure scenarios in Tables 5-1 and 5-2. Summary tables of risk estimates are presented for each COPC in Tables A-5 through A-32 in Attachment A. Within each summary table, risks are presented for exposure to waste rock soils, surface waters, sediments, and waste rock soils resuspended as particulates in breathable air.

Table 5-1. Summary of NonCancer Hazard Quotients

Route of Exposure	Children		Adults	
	CTE	RME	CTE	RME
Incidental Ingestion of Surface Soil	0.001	0.03	0.0001	0.001
Dermal Contact with Surface Soil	0.0001	0.01	0.00005	0.0003
Inhalation of Particles from Surface Soil	0.00001	0.00003	0.000002	0.00001
Incidental Ingestion of Surface Water	0.00002	0.0002	0.000005	0.00005
Dermal Contact with Surface Water	0.00001	0.0001	0.000002	0.00003
Incidental Ingestion of Sediment	0.002	0.036	0.0002	0.002
Dermal Contact with Sediment	0.0001	0.008	0.00007	0.00007

Table 5-2. Summary of Cancer Risks

Route of Exposure	Children		Adults	
	CTE	RME	CTE	RME
Incidental Ingestion of Surface Soil	2E-08	1E-06	8E-09	3E-07
Dermal Contact with Surface Soil	1E-09	2E-07	3E-09	6E-08
Inhalation of Particles from Surface Soil	3E-11	4E-10	3E-11	5E-10

Incidental Ingestion of Surface Water	3E-10	8E-09	3E-10	9E-09
Dermal Contact with Surface Water	1E-10	4E-09	1E-10	6E-09
Incidental Ingestion of Sediment	2E-08	1E-06	1E-08	4E-07
Dermal Contact with Sediment	2E-09	3E-07	4E-09	9E-08

5.3.1 NONCARCINOGENIC RISKS

Calculations of exposures as daily doses, and noncarcinogenic risks for adult and child recreational users, are presented in Attachment A to this HHRA.

Waste rock soils – Arsenic and lead were identified as noncarcinogenic COPCs for waste rock soils. All of the arsenic HQs for ingestion of soil and dermal contact with soil were below 1.0. Risks associated with lead exposures are discussed in a following subsection.

Surface water – Surface water samples consisted of adit water, Blue Jay Creek running past the adit, and Battle Ax Creek at and down stream of the confluence with Blue Jay Creek. Arsenic was identified as the noncarcinogenic COPC for surface waters. All of the arsenic HQs for incidental ingestion and dermal contact with surface waters were below 1.0.

Sediment – Sediment consisted of sediments from the same sources as the surface waters. Arsenic and lead was identified as a noncarcinogenic COPC for sediment. All of the arsenic HQs for ingestion and dermal contact with sediment were below 1.0.

Inhalation of soil particulates – Arsenic and lead were identified as noncarcinogenic COPCs for soil particles. All of the HQs for children and adults were below 1.0.

The risk characterization of noncarcinogenic hazards for recreational exposures at the Morning Star Mine site suggests that the potential for noncarcinogenic health effects are negligible.

5.3.2 CARCINOGENIC RISKS

Calculations of exposures as daily doses, and carcinogenic risks for adult and child recreational users, are presented in Attachment A.

Waste rock soils – Arsenic was identified as the only carcinogenic COPC for waste rock soils. The highest excess cancer risk was estimated for the child ingestion of waste rock soil under RME conditions, at 1E-06. The RME conditions for child ingestion of waste rock soil assumes that the child plays on the waste rock for 20 days every year from the ages of 1 through 6, and that they can ingest waste rock soil at the rate of 100 mg during each 4 hour visit on each of those 20 days. The EPC for arsenic in waste rock soil associated with the 1E-06 cancer risk estimate is 21.5

mg/kg. Excess cancer risk estimates for all of the other exposure pathways for child and adult were also below 1E-06.

Surface water – Arsenic was identified as the only carcinogenic COPC for surface water. Excess cancer risk estimates for all exposure pathways for children and adults were below 1E-06.

Sediment – Arsenic was identified as the only carcinogenic COPC for sediment. Excess cancer risk estimates for all exposure pathways for children and adults were at or below 1E-06.

Inhalation of soil particulates – Arsenic was the only carcinogenic COPC identified for soil particles. All excess cancer risk estimates for children and adults were less than 1E-06.

The risk characterization for cancer risks for recreational exposures at the Morning Star Mine site suggests that estimated excess cancer risks for children and adults are negligible.

5.3.3 RISKS FROM LEAD EXPOSURES

Risks from potential exposures to lead in the environment are not evaluated by the methods used for the other COPCs. Regulatory agencies do not provide toxicity criteria for lead, and instead recommend evaluating lead by use of a model to predict blood levels of lead. Lead effects on neurological development of children are best related to blood lead levels rather than to doses or intake levels. USEPA has developed models that predict blood lead levels in children and in the developing fetus from maternal exposures based on multiple sources of lead in the environment. The contribution of lead in site-related media to the total blood lead levels in a child or developing fetus exposed to the site is modeled, and the resultant total blood levels are compared with a health-based criterion for lead in blood.

For the Morning Star Mine site, it was assumed that both children and adults are exposed to lead in waste rock soils and air at the site. The mean concentration in waste rock soil (4,731 mg/kg) was used as the exposure point concentration for site-related exposures, as per USEPA (1994a) guidance for the lead model. For the child modeling, the lead level in air was assumed to be the default value in the model, at 0.1 $\mu g/m^3$; the lower concentration of 0.0047 $\mu g/m^3$ that was modeled from the waste rock soils (see Table A-33, Attachment A) was not used. Model parameterization for the child and adult lead models are described separately below.

5.3.3.1 Child Exposures

The model developed for estimating child blood levels is the Integrated Exposure Uptake BioKinetic (IEUBK) model, available as a downloadable model from USEPA (http://www.epa.gov/superfund/programs/lead/products.htm#ieubk). The child model was developed for exposures of young children to lead in a residential environment. The default parameters of the model assume that the child is exposed to lead through multiple environmental media typical of a residential location, including yard soil, house dust, air, food sources, drinking water, and perinatal exposures (i.e., fetal and nursing) from the mother. The ingestion of soil pathway in the model assumes that house dust is comprised partly of outside yard soil that is contaminated with lead. The model assumes that the child is exposed

continuously to the above sources from a developing fetus through 7 years of age, with varying rates of exposure to different media for each year of age.

The IEUBK model is designed to predict blood lead levels for residential exposures, rather than recreational exposures that would occur on an intermittent basis. To account for intermittent exposures during recreational activities that would typically occur for a limited frequency each year, the IEUBK model was run by replacing the default soil lead concentration with a time-weighted concentration based on the time spent at the site with exposures to waste rock soils. A time-weighted soil concentration was calculated from the model default concentration of 200 mg/kg for lead in household dust and yard soils by weighting the concentration for 20 days per year at the mean lead concentration in waste rock. The mean concentration of lead in waste rock at the Morning Star Mine site is 4,731 mg/kg. Table 5-3 shows the calculation of the time-weighted concentration of 448 mg/kg. The gastrointestinal absorption of lead from the ingested waste rock soil was left at the same absorption that the model uses for soils (i.e., 30 percent).

In addition to this time-weighted average soil lead concentration, alternative values for the lead concentration were developed under differing frequencies of exposure of children to the waste rock soils at the site. The differing frequencies of exposure and resultant alternative time-weighted average soil concentrations of lead that were evaluated are discussed in the Uncertainty Analysis of Section 6. In the Uncertainty Analysis of alternative time-weighted average lead concentrations, the frequency that a child would need to visit the site each year for the first 7 years of life that would result in a possible exceedance of the blood lead threshold was explored. The blood lead levels using alternative exposure frequencies were evaluated using the same IEUBK modeling described in this section.

Table 5-3. Development of Child Lead Model Data Input for the Morning Star Mine

Exposure Medium: Soil			
	Mean lead concentration in waste rock	4,731	mg/kg dw
	Time-weighted average lead concentration based on waste rock and default soil concentrations	448	mg/kg dw

Calculation of time-weighted lead concentration in waste rock + default soil:

Parameter	**Description**		
EF waste rock	child exposure days	20	
EF waste rock + EF soil	days per year	365	
PB soil	Lead default concentration (mg/kg)	200	
EF soil	Days per year - EF waste rock	351	
(Pbwaste x EF waste rock) + (Pbsoil x EF soil)/(Efwaste rock + EF		**448 mg/kg**	time-weighted lead concentration in

		soil)	soil

Source: Integrated Exposure Uptake Biokinetic Model for Lead in Children (IEUBK) (USEPA 1994a)
dw = dry weight

The calculation shown in Table 5-3 above incorporates the time exposed to the waste rock soil as 20 out of the 365 days per year. The exposure time of 4 hours per day is not incorporated, but instead the assumption is made that the exposure occurs throughout the day, similar to the exposures to yard and indoor dust lead that is incorporated into the default exposure assumptions of the IEUBK model. Thus, the time-weighted average concentration includes the lead intake associated with recreational activities by the child at the Morning Star Mine site based on more conservative assumptions than were used for recreational exposures to other COPCs that were limited to 4 hours a day. With this added exposure incorporated into the time-weighted average, lead intake due to activities while visiting the Morning Star Mine site are added under a conservative approach to the exposures included in the IEUBK model as default residential exposures.

In running the model with the time-weighted average concentration for lead in soils, all other exposure pathways and parameters in the IEUBK model were retained at the default values. These include default values for lead levels in food and drinking water, lead in outdoor and indoor air, the relative amounts of yard soil and house dust that a child is assumed to ingest, maternal contribution of lead to the fetus, and absorption of lead from soils and other sources. Within the model, only the daily lead exposure through soil ingestion was altered by the time-weighting procedure to account for added waste rock soil ingestion during each of the seven years of child exposure.

The print-out from the IEUBK model run is presented in Attachment B, using the default residential exposure setting with the RME conditions as described above, and including the time-weighted average daily lead ingestion from soil and waste rock soil. Under this scenario, the highest geometric mean blood lead levels for children between 0.5 and 7 years of age are predicted to be 6.8 μg/dL. This concentration is below the threshold of concern level for child blood lead that USEPA has set at 10 μg/dL. The IEUBK model result is also displayed as a probability density function, which shows the probability of child blood lead levels due to the exposures parameterized in the model. The probability density print out from the model is shown in Attachment B. The probability that a child blood lead level would be below the target level of 10 μg/dL was calculated at 90 percent.

The bioavailability of lead from soil decreases as the amount of lead ingested increases, due to saturation limitations of the uptake from the gastrointestinal tract (USEPA 1994b). The IEUBK model was developed for soil lead concentrations generally around 200 mg/kg; the waste rock soil concentration of 4,731 mg/kg is substantially above that level. Lead in ingested soils that are at concentrations above the model range are absorbed at lower rates than the model assumes (USEPA 1994b). In addition, the absorption efficiency for lead from minerals such as galena, which is found in the Cascades mining districts in which the Morning Star Mine site is located, are lower than the absorption assumed in the model (USEPA 1999). For these reasons, the 30 percent absorption efficiency for lead from ingested soil that is assumed in the model is likely an overestimate for the waste rock soils. In addition, the size of particles at hard rock mining sites are generally larger than the sizes of

yard and dust particles that formed the basis for skin adherence that is assumed in the model, as recently reviewed for Superfund mining sites (NRC 2005). Thus, the model assumption for the ingestion of soil that adheres to skin is likely overestimated for waste rock soil. Because both of these factors, the percent absorption and soil adherence factor, are conservatively assumed for this modeling, the model result is a very conservative estimate of potential risks from lead exposure.

5.3.3.2 Adult Exposures

A separate model is available from the USEPA web page on estimating lead risks (http://www.epa.gov/superfund/programs/lead/products.htm#ieubk) that can be used to evaluate blood lead levels of a fetus in an exposed adult. The adult exposure model assumes that adults have a baseline level of lead in their blood, and then adds to that a contribution of lead from outside soil and house dust. The model then predicts the blood levels of lead in a fetus of a pregnant adult at those exposures. The predicted blood levels of lead in the fetus are compared to the same criterion as with the IEUBK model.

The adult model was run using 20 days as the RME exposure duration and the average lead concentration of 4,731 mg/kg. The remaining parameters were kept at the default levels, such as blood lead levels from background sources, and used an adult waste rock soil ingestion rate of 25 mg/day under RME conditions. Results of the modeling of fetal blood lead levels from adult exposures predicted 95th percentile fetal blood lead levels to range from 6.0 to 8.2 μg/dL (Attachment B). These concentrations are below the threshold of concern level for fetal and child blood lead that USEPA has set at 10 μg/dL.

5.4 Summary of Human Health Risks

Of the 24 metals and other inorganic COIs analyzed in environmental media at the site, arsenic and lead were identified as COPCs by the screening procedure. These two COPCs were evaluated quantitatively for human health risks following ODEQ guidance. Health risks were evaluated for people who would visit the site for recreational purposes. It was assumed that visitors would be exposed to COPCs in the waste rock soils and in the surface waters of the mine adit, Blue Jay Creek that flows past the mine adit, and in Battle Ax Creek downstream of the confluence with Blue Jay Creek. The likelihood of exposure to COPCs in the surface waters was assumed to be similar across the site, assuming that both adults and children engaged in recreational activities, both presently and in the future, would have access to all contaminated areas. The exposure parameters used in the assessment were assumed to be health protective for reasonable maximum future recreational exposures at the site. The US Forest Service has identified the Battle Ax Creek portion of the Opal Creek Scenic Recreation Area as a "Low Use" zone in its recreation management plan for the area.

Exposures and risks were evaluated for incidental ingestion of waste rock soil, dermal contact with waste rock soil, inhalation of waste rock soil particulates released to air; and ingestion and dermal contact with both surface water and sediments of the adits, tributary, and Battle Ax Creek at the site. Risks were not evaluated for potential exposures to background soils or to other creeks in the area.

Results of the risk assessment indicate that noncarcinogenic risks for all exposure pathways for adults and children are below regulatory levels of concern. Risks to young children for exposure to lead in waste rock soils are at acceptable levels under the assumptions of the RME exposure conditions.

Results of the assessment of excess cancer risks above background risk levels indicate that the highest cancer risk is associated with child ingestion of waste rock soils, at 1E-06 cancer risk, associated with arsenic levels of 21.5 mg/kg in the waste rock. Excess cancer risks for all other pathways of exposure for both children and adults were estimated to be below the DEQ acceptable cancer risk level of 1E-06, as defined in OAR 340-122-115(2)(a), (3)(a), and (4)(a).

6 UNCERTAINTY ANALYSIS

This section discusses some of the uncertainties in the human health risk assessment described above. Some uncertainties are specific to the site conditions and some are inherent to the risk assessment process. An analysis of uncertainties provides the risk managers with information on the limitations and interpretation of the risk estimates and potential exposures for use in future decision making.

6.1.1 SAMPLING AND ANALYSIS

The sampling approach for the Morning Star Mine site was a focused design, with sampling of waste rock soils and surface waters located in areas of suspected contamination and in areas identified as background to the site. The area was not sampled randomly and the results are not considered representative of average exposures to recreational users of the site. Only samples from the waste rock soils were used for the soil exposure pathways; data on lower contaminated background soils in the area were not used. Average exposures would typically result from varied movement throughout the site, with a mix of exposures to both contaminated and uncontaminated soils and waters, rather than only to contaminated soils as was assumed for this risk assessment.

Focusing on samples with high levels of contamination, such as soils that appear to consist primarily of waste rock, results in exposure point concentrations and subsequent risks to be overestimated compared to actual exposures encountered by random movement across the area. In other words, since the soil samples collected were mostly biased toward contaminated areas, the measured concentrations and calculated health risks are overestimated.

6.1.2 EXPOSURE POINT CONCENTRATIONS

Estimates of potential exposure to metals at the Morning Star Mine site were based on a limited number of samples to represent the various exposure media. For the waste rock soils, 11 samples were used to develop exposure concentrations; for surface water and sediment only eight and four samples were available, respectively. Typically the use of a low number of samples in the development of exposure concentrations typically results in skewed data sets and high upper confidence limits on the mean values, frequently close to or exceeding the maximum concentration. However, with the use of gamma distribution statistics, a 90UCL was calculable for the EPC for all waste rock soil, surface water, and sediment samples regardless of the the skewness of the data. However, due a large number of non-detects in upstream background surface water and sediment samples, 90 UCL and 95 UCL values exceeded maximum concentrations. Therefore, in the evaluation of upstream data for background surface water and sediment, only maximum concentrations were used.

Combining data from different types of environmental sources into a single EPC for an environmental medium may also over-estimate overall risks. For example, the extent of exposure to surface water from the adit and Blue Jay Creek may differ from exposures to the more accessible Battle Ax Creek. Combining data from those three sources into the exposure

point concentration increases the uncertainty of the exposure estimates. In addition, inclusing of adit water data is a conservative estimation of exposures.

6.1.3 EXPOSURE FACTORS

Exposure frequency – The exposure frequency for recreational activities at the mine site was assumed to be 20 days per year for each of 30 years for an adult and for each of the first six years of a child's life. This frequency was based on the best professional judgment following discussions with the Opal Creek Education Center located in Jawbone Flats at the base of the trail leading to the mine site; it was not based on documented visits to the site. The frequency was designed to represent a reasonable maximum exposure for people involved in recreational activities under future conditions who may visit the site.

Because of the lack of documentation of this frequency, there is uncertainty as to its accuracy for potential future conditions. To address this uncertainty, additional risk estimates were calculated under the assumptions of increased exposure frequencies. The exposure frequency of 20 days per year that was used in the risk assessment resulted in the highest excess cancer risk estimate of 1×10^{-6} for children ingesting waste rock soil while playing on the waste rock piles, which is at the low end of EPA's range of regulatory cancer risk thresholds for hazardous waste sites. The US EPA range of thresholds is from 1×10^{-6} to 1×10^{-4} excess cancer risks. The exposure frequency was increased to determine the days per year of exposure that would result in 1×10^{-5} and 1×10^{-4} excess cancer risks for a young child playing in the waste rock soils. These estimates were performed with all other exposure parameters remaining the same, except for the frequency of days per year.

Results of these risk estimates resulted in the identification of 200 days per year to result in estimated excess cancer risks of 1×10^{-5} for a young child playing in the waste rock soils. At 365 days per year of playing in the waste rock soils, cancer risks for the young child would increase to 2×10^{-5}. Increasing the number of days of exposure of a young child to the waste rock soils from 20 days per year to 30 days per year would increase excess cancer risk estimates to 1.5×10^{-6}, and for 40 days of exposure would increase them to 2×10^{-6}.

Soil ingestion rate - A major source of uncertainty in exposure factors is the selection of the soil ingestion rate for recreational exposures, particularly for children. Soil ingestion for children under the RME scenario was assumed to be 100 mg/day, with all of the ingestion consisting of waste rock soil and all occurring during the 4 hours each day that the child is assumed to be present on the waste rock soil. For lead in waste rock soil, the exposures are assumed to occur throughout the day, rather than limited to 4 hours. This rate of soil ingestion is considered to be conservative and is assumed to not underestimate potential exposures to waste rock soil by ingestion, and thus uncertainty with the soil ingestion rate is high.

Sediment ingestion rate - The sediment ingestion rate was derived from the soil ingestion rate. The sediment ingestion rate is considered sufficiently conservative by this approach.

Gastrointestinal Absorption - A major source of uncertainty for the soil and sediment ingestion pathways is the amount of lead and arsenic that is absorbed from the ingested

material. Metals in waste rock are unlikely to be as bioavailable at the fractions recommended for soils by USEPA (1994a, 2004). As noted in the lead modeling section of this risk assessment, NRC (2005) estimates that lead bioavailability from hard rock mining substrate is less than that associated with more typical sources of lead at hazardous waste sites. Uncertainty with gastrointestinal absorption of metals from hard rock substrate is considered moderate.

Dermal contact - A major source of uncertainty in the direct contact pathway is the absorption of metals across the skin and the resulting toxicity. The dermal absorption factors for the metals used in the modeling were taken from US EPA guidance. The dermal absorption factors are typically based on laboratory studies, and are not specific to the environment in which the metals are found. Specifically, the absorption of arsenic from weathered waste rock is unknown. Uncertainty in the dermal absorption factors is considered high.

Another factor in the dermal contact risk estimates is the adherence factor for soil and sediment adhering to skin. The adherence factor determines how much of the soil or sediment adheres to an area of the skin. The values used are taken from ODEQ and US EPA guidance and are derived from studies with children exposed to dry and wet soil, but not to sediment. The values are not specific to the site. The type of soils used to derive the adherence factors are more typical soil materials that contain organic material, to which metals may desorb from. However, the waste rock soil and sediment at the mine site are very grainy with likely low organic material present.

Also a factor in the dermal contact risk estimates is the frequency of exposures to the sediments. The frequency of exposure was assumed to be 20 days per year, every year, for the RME child recreational user. This value is assumed to be conservatively representative of exposures for an individual who may visit the mine area.

6.1.4 TOXICOLOGY

The toxicity values for metals in any risk assessment are considered uncertain because most of the values are extrapolated from laboratory studies or adult occupational studies performed elsewhere. The toxicity values used in this risk assessment are not specific to the site or conditions, but they have been generated, reviewed, and accepted by various regulatory agencies. Because resolution of the uncertainty in toxicity of metals to humans is considered difficult, the uncertainty is not considered major.

6.1.5 LEAD EVALUATION

Uncertainties with the use of the IEUBK model to evaluate the potential for child blood lead levels to exceed a health-based threshold due to exposures to soil at the Morning Star Mine site are discussed above in Section 5.3.3. As an additional means to address uncertainty in the lead modeling, alternative evaluations of lead exposures and lead modeling were performed. In addition to the IEUBK model run using 20 days per year exposure to the waste rock soils described in Section 5.3.3, the model was also run under alternative exposure frequency conditions. Alternative exposure frequencies included 30 and 40 days, the annual frequency of exposure to the waste rock soils that would result in the geometric mean blood lead

concentration to exceed the US EPA blood lead threshold of 10 μg/dL. For this modeling, the IEUBK model was run exactly the same as in Section 5.3.3, except that the time-weighted average soil concentration of lead was increased until the threshold was reached. All other lead exposures that are mentioned in Section 5.3.3, such as maternal lead concentration, and lead in air, food, house dust, and yard soils, were retained at the default levels.

The IEUBK model outputs for 30 and 40 day exposures of children to the waste rock soils are shown in Attachment B. The highest geometric mean blood lead level for a child between 0.5 and 7 years of age is predicted to be 8.1 μg/dL and 9.2 μg/dL for the 30 day and40 day exposures, respectively. The graphical depictions of the probability distributions for these exposure frequencies are also shown in Attachment B. The percent of children with blood lead levels lower than the threshold decreases with increasing exposure. The 30 day per year exposure would result in 83 percent probability of blood lead lower than 10 μg/dL, compared with over 90 percent for the 20 day per year exposure, and the 40 day per year exposure would result in 74 percent probability of blood lead levels below the threshold.

The time-weighted soil concentration of lead in waste rock soil that resulted in the geometric mean for a child between 0.5 and 7 years of age at the blood lead threshold was found to be 800 mg/kg. At that time-weighted concentration, the blood lead level of the 1-2 year old would be 10.1 μg/dL, and the probability of blood lead levels below the threshold decreases to 67 percent. The time-weighted average lead concentration of 800 mg/kg corresponds with 48 days per year exposure to waste rock soils at the Morning Star Mine site, meaning that a child would need to be present on the waste rock soils and to consume the waste rock soil all day for 48 days each year. Note that this concentration of 800 mg/kg is the same as the US EPA preliminary remediation goal for industrial soil that was used as the screening level in the initial step of this risk assessment. The 800 mg/kg screening level was developed by US EPA using the IEUBK model following the same procedure used in the present modeling, which accounts for the similar results.

7 CONCLUSIONS

The human health risk assessment was performed for recreational exposures at the Morning Star Mine site. The exposures were based on estimates of reasonable maximum future exposures due to recreational activities directly in the contaminated waste soils and surface waters of the site. The exposures are not documented to presently occur, and would be much less than those estimated for this risk assessment. Exposures were assumed to occur to waste rock soils and to surface waters and sediments of the mine adit, Blue Jay Creek, and Battle Ax Creek for children and adults who may visit the site for 4 hours a day during 20 days out of each of the first 6 years of a child's life and each of 30 years for an adult. Risks were estimated for chemicals of potential concern that had passed screening tests for detection frequency, elevation above background, and for potential toxicity. The chemicals selected as COPCs consisted of arsenic and lead. Arsenic exposures were evaluated for carcinogenic and noncarcinogenic effects, whereas lead was evaluated for noncarcinogenic effects by using EPA models for predicting blood lead levels in exposed children (IEUBK model) and in the fetus of an exposed pregnant woman (ALM model). Young children and the developing fetus have been identified as the most sensitive receptors to the effects of lead.

Exposures were estimated for ingestion of arsenic in waste rock soils, surface water, and sediment; inhalation of dusts containing arsenic from waste rock soil; and skin contact with arsenic in waste rock soils, sediment, and surface waters. Exposures to lead were modeled for ingestion of waste rock soils and inhalation of waste rock soil dust. All arsenic exposures were shown to result in estimated cancer risks that did not exceed the threshold of 1×10^{-6}. Noncancer risks were estimated as hazard quotients well below a threshold of 1. For children playing on the waste rock soils and pregnant women visiting the site, blood lead levels in young children or the developing fetus were modeled to be below the USEPA threshold.

These risk estimates suggest that the metals, particularly arsenic and lead, detected in waste rock soils, sediments, and surface waters of the Morning Star Mine site do not pose unacceptable risks under the exposure assumptions for recreational visitors to the site, including young children.

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ATTACHMENT A – RISK CALCULATION TABLES

Table A-1. Waste Rock Soil PRG Screen

Chemical of Interest (COI)	Cancer/ Noncancer	Maximum Detected Concentration (mg/kg)	USEPA Region 6 Industrial Soil PRG (mg/kg)	Individual COI Risk Ratio (Ri)	Individual COPC?	Multiple COIs Ri/Rtotal	Multiple COPC in Soil?
Antimony	NC	3.90	410	0.010	No	0.00	No
Arsenic	C	30.0	1.6	19	**Yes**	0.54	**Yes**
Cadmium	NC	405	810	0.500	No	0.01442	No
Calcium	-	34,300	NA	NA	No	NA	NA
Cobalt	NC	21.5	300	0.072	No	0.002	No
Copper	NC	4,040	41,000	0.099	No	0.00	No
Iron	NC	71,900	720,000	0.100	No	0.003	No
Lead	NC	11,700	800	15	**Yes**	0.422	**Yes**
Magnesium	-	14,100	NA	NA	No	NA	NA
Manganese	NC	7,810	23,000	0.340	No	0.01	No
Mercury	NC	0.63	310	0.002	No	0.0001	No
Potassium	-	3,450	NA	NA	No	NA	NA
Silver	NC	21.9	5,100	0.004	No	0.00012	No
Zinc	NC	51,900	310,000	0.167	No	0.0048	No
			Sum of Risk Ratios (Rtotal)	35			
			Number of COIs (N)	11			
			1/N	0.09			

Samples consist of all soil and waste rock samples on-site (N=11).

COIs selected by screening for frequency of detection and comparison with background concentrations.

Table A-2. Surface Water PRG Screen

Chemical of Interest (COI)	Cancer/ Noncancer	Maximum Detected Concentration (µg/L)	USEPA Region 6 Tapwater PRG (µg/L)	Individual COI Risk Ratio (Rwater)	Individual COPC?	Multiple COIs Rwater/ Rwtotal	Multiple COPC in Surface Water?
Aluminum	NC	101	37,000	0.003	No	0.00003	No
Arsenic	C	4.76	0.045	106	**Yes**	0.99	**Yes**
Barium	NC	1.73	7,300	0.0002	No	0.000002	No
Calcium	--	12,100	NA	NA	Yes	NA	NA
Lead	NC	12.7	15	0.8	No	0.01	No
Manganese	NC	4.93	880	0.006	No	0.0001	No
Potassium	--	240	NA	NA	Yes	NA	NA
Sodium	--	6870	NA	NA	Yes	NA	NA
Zinc	NC	81.7	11,000	0.01	No	0.0001	No
			Sum of Risk Ratios (Rwtotal)	107			
			Number of COIs (N)	6			
			1/N	0.17			

Surface water samples include all downstream Battle Ax Creek, Blue Jay Creek, and adit water on-site (N=6-8).

PRG is drinking water value.

COIs were selected by screening for frequency of detection and by comparison with Battle Ax Creek upstream concentrations.

Table A-3. Sediment PRG Screen

Chemical of Interest (COI)	Cancer/ Noncancer	Maximum Detected Concentration (mg/kg)	USEPA Region 6 Industrial Soil PRG (mg/kg)	Individual COI Risk Ratio (Rsed)	Individual COPC in Sediment?	Multiple COIs (Rsed/Rsedtotal)	Multiple COPC in Sediment?
Arsenic	C	41	1.6	26	**Yes**	0.93	**Yes**
Cadmium	NC	10	810	0.012	No	0.000	No
Cobalt	NC	16	300	0.05	No	0.002	No
Copper	NC	231	41,000	0.01	No	0.000	No
Iron	NC	37,600	720,000	0.05	No	0.002	No
Lead	NC	1,370	800	1.7	**Yes**	0.06	No
Magnesium	-	15,200	NA	NA	Yes	NA	NA
Manganese	NC	2,820	23,000	0.12	No	0.00	No
Mercury							
Nickel	NC	89	20,000	0.0045	No	0.0002	No
Potassium	-	1,410	NA	NA	Yes	NA	NA
Silver							
Zinc	NC	2,920	310,000	0.0094	No	0.0003	No
			Sum of Risk Ratios (Rsedtotal)	27.8			
			Number of COIs (N)	9			
			1/N	0.11			

Samples consist of sediment samples in downstream Battle Ax Creek and Blue Jay Creek (N=4).

Table A-4. Exposure Parameters

Variable	Definition	Units	Child Recreational User			Adult Recreational User		
			CTE	RME	REFERENCE	CTE	RME	REFERENCE
	Ingestion of Surface Soil							
IR	Ingestion Rate	mg/day	25	100	ODEQ 1998, BPJ	12	25	ODEQ 1998, BPJ
EF	Exposure Frequency	day/yr	4	20	BPJ	4	20	BPJ
ED	Exposure Duration	yr	2	6	ODEQ 1998	9	30	ODEQ 1998
BW	Body Weight	kg	15	15	ODEQ 1998	70	70	ODEQ 1998
AT-NC	Averaging time - Noncancer	days	730	2,190	ODEQ 1998	3,285	10,950	ODEQ 1998
AT-C	Averaging Time - Cancer	days	25,550	25,550	ODEQ 1998	25,550	25,550	ODEQ 1998
CF	Conversion Factor	kg/mg	1.00E-06	1.00E-06		1.00E-06	1.00E-06	0
	Dermal Contact With Soil							0
SA	Surface Area for Contact	cm2/event	4,500	5,000	ODEQ 1998	5,200	6,900	ODEQ 1998
AF	Adherence Factor	mg/cm2	0.04	0.4	USEPA 2004	0.08	0.08	ODEQ 1998
EF	Exposure Frequency	event/yr	4	20	BPJ	4	20	BPJ
ED	Exposure Duration	yr	2	6	ODEQ 1998	9	30	ODEQ 1998
BW	Body Weight	kg	15	15	ODEQ 1998	70	70	ODEQ 1998
AT-NC	Averaging time - Noncancer	days	730	2,190	ODEQ 1998	3,285	10,950	ODEQ 1998
AT-C	Averaging Time - Cancer	days	25,550	25,550	ODEQ 1998	25,550	25,550	ODEQ 1998
CF	Conversion Factor	kg/mg	1.00E-06	1.00E-06		1.00E-06	1.00E-06	
	Inhalation from Soil							
IR	Inhalation Rate	m3/hr	1.2	1.2	USEPA 1997	1.5	1.5	USEPA 1997
ET	Exposure Time	hr/day	4	4	BPJ	4	4	BPJ
EF	Exposure Frequency	day/yr	4	20	BPJ	4	20	BPJ
ED	Exposure Duration	yr	2	6	ODEQ 1998	9	30	ODEQ 1998
BW	Body Weight	kg	15	15	ODEQ 1998	70	70	ODEQ 1998
AT-NC	Averaging time - Noncancer	days	730	2,190	ODEQ 1998	3,285	10,950	ODEQ 1998
AT-C	Averaging Time - Cancer	days	25,550	25,550	ODEQ 1998	25,550	25,550	ODEQ 1998
	Ingestion of Surface Water							
IR	Ingestion Rate	L/hr	0.01	0.01	USEPA 1997	0.01	0.01	USEPA 1997
ET	Exposure Time	hr/day	0.5	1	ODEQ 1998, BPJ	0.5	1	ODEQ 1998, BPJ
EF	Exposure Frequency	day/yr	4	20	BPJ	4	20	BPJ
ED	Exposure Duration	yr	2	6	ODEQ 1998	9	30	ODEQ 1998
BW	Body Weight	kg	15	15	ODEQ 1998	70	70	ODEQ 1998
AT-NC	Averaging time-Noncancer	days	730	2,190	ODEQ 1998	3,285	10,950	ODEQ 1998

Variable	Definition	Units	Child Recreational User			Adult Recreational User		
AT-C	Averaging Time - Cancer	days	25,550	25,550	ODEQ 1998	25,550	25,550	ODEQ 1998
	Dermal Contact with Surface Water							
SA	Surface Area for Contact	cm2	4,500	5,000	ODEQ 1998	5,200	6,900	ODEQ 1998
ET	Exposure Time	hr/day	0.5	1.0	ODEQ 1998, BPJ	0.5	1.0	ODEQ 1998, BPJ
EF	Exposure Frequency	day/yr	4	20	BPJ	4	20	BPJ
ED	Exposure Duration	yr	2	6	ODEQ 1998	9	30	ODEQ 1998
BW	Body Weight	kg	15	15	ODEQ 1998	70	70	ODEQ 1998
AT-NC	Averaging time - Noncancer	days	730	2,190	ODEQ 1998	3,285	10,950	ODEQ 1998
AT-C	Averaging Time - Cancer	days	25,550	25,550	ODEQ 1998	25,550	25,550	ODEQ 1998
CF	Conversion Factor	L/cm3	1.00E-03	1.00E-03		1.00E-03	1.00E-03	
	Ingestion of Sediment							
IR	Ingestion Rate	mg/day	10	25	BPJ, USEPA 1997	10	25	BPJ, USEPA 1997
EF	Exposure Frequency	day/yr	4	20	BPJ	4	20	BPJ
ED	Exposure Duration	yr	2	6	ODEQ 1998	9	30	ODEQ 1998
BW	Body Weight	kg	15	15	ODEQ 1998	70	70	ODEQ 1998
AT-NC	Averaging time - Noncancer	days	730	2,190	ODEQ 1998	3,285	10,950	ODEQ 1998
AT-C	Averaging Time - Cancer	days	25,550	25,550	ODEQ 1998	25,550	25,550	ODEQ 1998
CF	Conversion Factor	kg/g	1.00E-06	1.00E-06		1.00E-06	1.00E-06	
	Dermal Contact with Sediment							
SA	Surface Area for Contact	cm2	4,500	5,000	ODEQ 1998	5,200	6,900	ODEQ 1998
AF	Adherence Factor	mg/cm2	0.2	1	USEPA 2004; ODEQ 1998	0.08	0.08	ODEQ 1998
EF	Exposure Frequency	day/yr	4	20	BPJ	4	20	BPJ
ED	Exposure Duration	yr	2	6	ODEQ 1998	9	30	ODEQ 1998
BW	Body Weight	kg	15	15	ODEQ 1998	70	70	ODEQ 1998
AT-NC	Averaging time - Noncancer	days	730	2,190	ODEQ 1998	3,285	10,950	ODEQ 1998
AT-C	Averaging Time - Cancer	days	25,550	25,550	ODEQ 1998	25,550	25,550	ODEQ 1998
CF	Conversion Factor	kg/mg	1.00E-06	1.00E-06		1.00E-06	1.00E-06	

Notes:

BPJ = Best Professional Judgment

CTE, RME = Central Tendency Exposure, Reasonable Maximum Exposure

Surface area for contact assumes arms, hands, leg, and feet (ODEQ 1998); for both soil and surface water.

Table A-5. Estimates of Cancer and Noncancer Risks for Child Recreational Users

CTE - Incidental Ingestion of Soil

CTE - Incidental Ingestion of Soil

Ingestion Rate = IR	25	mg/day
Exposure Frequency = EF	4	day/yr
Exposure Duration = ED	2	yr
Body Weight = BW	15	kg
Averaging Time (Noncancer) = AT	730	days
Averaging Time (Cancer) = AT	25,550	days
Conversion Factor = CF	1.00E-06	kg/mg

Intake (mg/kg-day) = Conc * IR * EF * ED *CF / (BW * AT)

NCADD = Average Daily Dose - Noncarcinogens
CADD = Average Daily Dose - Carcinogens
HQ = Hazard Quotient, Noncarcinogens = NCADD/ RfD
Risk = Cancer Risk = CADD * SF

Chemical of Potential Concern	EPC (mg/kg)	NCADD (mg/kg-day)	CADD (mg/kg-day)	Chronic Oral RfD (mg/kg-day)	Oral SF per (mg/kg-day)	HQ	Risk
Arsenic	21.5	3.93E-07	1.12E-08	3.00E-04	1.50E+00	1.31E-03	1.69E-08
Lead	6,208	1.13E-04	3.24E-06	NA	NA	--	--
Cumulative Risk						**1.31E-03**	**1.69E-08**

NA = Not applicable if chemical is not a COPC for the exposure route, or toxicity value is not available

Table A-6. Estimates of Cancer and Noncancer Risks for Child Recreational Users

RME- Incidental Ingestion of Soil

RME- Incidental Ingestion of Soil

Ingestion Rate = IR	100	mg/day
Exposure Frequency = EF	20	day/yr
Exposure Duration = ED	6	yr
Body Weight = BW	15	kg
Averaging Time (Noncancer) = AT	2,190	days
Averaging Time (Cancer) = AT	25,550	days
Conversion Factor = CF	1.00E-06	kg/mg

Intake (mg/kg-day) = Conc * IR * EF * ED *CF / (BW * AT)

NCADD = Average Daily Dose - Noncarcinogens
CADD = Average Daily Dose - Carcinogens
HQ = Hazard Quotient, Noncarcinogens = NCADD/ RfD
Risk = Cancer Risk = CADD * SF

Chemical of Potential Concern	EPC (mg/kg)	NCADD (mg/kg-day)	CADD (mg/kg-day)	Chronic Oral RfD (mg/kg-day)	Oral SF per (mg/kg-day)	HQ	Risk
Arsenic	21.5	7.86E-06	6.74E-07	3.00E-04	1.50E+00	2.62E-02	1.01E-06
Lead	6,208	2.27E-03	1.94E-04	NA	NA	--	--
Cumulative Risk						**2.62E-02**	**1.01E-06**

NA = Not applicable if chemical is not a COPC for the exposure route, or toxicity value is not available

Table A-7. Estimates of Cancer and Noncancer Risks for Child Recreational Users
CTE- Dermal Contact with Soil

CTE- Dermal Contact with Soil

Surface Area for Contact=SA	4.500	cm2/event
Adherence Factor=AF	0.04	mg/cm2
Dermal Absorption Factor=DAF	chemical-specific	
Exposure Frequency = EF	4	event/yr
Exposure Duration = ED	2	yr
Body Weight = BW	15	kg
Averaging Time (Noncancer) = AT	730	days
Averaging Time (Cancer) = AT	25,550	days
Conversion Factor = CF	1.00E-06	kg/mg

Intake (mg/kg-day) = Conc * SA * AF * DAF * EF * ED * CF / (BW * AT)

NCADD = Average Daily Dose - Noncarcinogens
CADD = Average Daily Dose - Carcinogens
HQ = Hazard Quotient, Noncarcinogens = NCADD/ RfD
Risk = Cancer Risk = CADD * SF

Chemical of Potential Concern	EPC (mg/kg)	NCADD (mg/kg-day)	CADD (mg/kg-day)	Dermal RfD (mg/kg-day)	Dermal SF per (mg/kg-day)	HQ	Risk
Arsenic	21.5	2.83E-08	8.09E-10	2.85E-04	1.58E+00	9.93E-05	1.28E-09
Lead	6,208	8.16E-06	2.33E-07	NA	NA	--	--
Cumulative Risk						**9.93E-05**	**1.28E-09**

NA = Not applicable if chemical is not a COPC for the exposure route, or toxicity value is not available

Table A-8. Estimates of Cancer and Noncancer Risks for Child Recreational Users RME- Dermal Contact with Soil

RME- Dermal Contact with Soil

Surface Area for Contact=SA	5,000	cm2/event
Adherence Factor=AF	0.4	mg/cm2
Dermal Absorption Factor=DAF	chemical-specific	
Exposure Frequency = EF	20	event/yr
Exposure Duration = ED	6	yr
Body Weight = BW	15	kg
Averaging Time (Noncancer) = AT	2,190	days
Averaging Time (Cancer) = AT	25,550	days
Conversion Factor = CF	1.00E-06	kg/mg

Intake (mg/kg-day) = Conc * SA * AF * DAF * EF * ED * CF / (BW * AT)

NCADD = Average Daily Dose - Noncarcinogens
CADD = Average Daily Dose - Carcinogens
HQ = Hazard Quotient, Noncarcinogens = NCADD/ RfD
Risk = Cancer Risk = CADD * SF

Chemical of Potential Concern	EPC (mg/kg)	NCADD (mg/kg-day)	CADD (mg/kg-day)	Dermal RfD (mg/kg-day)	Dermal SF per (mg/kg-day)	HQ	Risk
Arsenic	21.5	1.57E-06	1.35E-07	2.85E-04	1.58E+00	5.52E-03	2.13E-07
Lead	6,208	4.54E-04	3.89E-05	NA	NA	--	--
Cumulative Risk						**5.52E-03**	**2.13E-07**

NA = Not applicable if chemical is not a COPC for the exposure route, or toxicity value is not available

Table A-9. Estimates of Cancer and Noncancer Risks for Child Recreational Users
CTE- Inhalation of Particles from Soil

CTE- Inhalation of Particles from Soil

Inhalation Rate = IR	1.2	m3/hr
Exposure Time = ET	4	hr/day
Exposure Frequency = EF	4	day/yr
Exposure Duration = ED	2	yr
Body Weight = BW	15	kg
Averaging Time (Noncancer) = AT	730	days
Averaging Time (Cancer) = AT	25550	days

Intake (mg/kg-day) = Conc * IR * ET * EF * ED / (BW * AT)

NCADD = Average Daily Dose - Noncarcinogens
CADD = Average Daily Dose - Carcinogens
HQ = Hazard Quotient, Noncarcinogens = NCADD/ RfD
Risk = Cancer Risk = CADD * SF

Chemical of Potential Concern	EPC (mg/m3)	NCADD (mg/kg-day)	CADD (mg/kg-day)	Inhalation RfD (mg/kg-day)	Inhalation SF per (mg/kg-day)	HQ	Risk
Arsenic	1.63E-08	5.72E-11	1.63E-12	8.60E-06	1.51E+01	6.65E-06	2.47E-11
Lead	4.70E-06	1.65E-08	4.71E-10	NA	NA	--	--
Cumulative Risk						**6.65E-06**	**2.47E-11**

NA = Not applicable if chemical is not a COPC for the exposure route, or toxicity value is not available

Table A-10. Estimates of Cancer and Noncancer Risks for Child Recreational Users RME- Inhalation of Particles from Soil

RME- Inhalation of Particles from Soil

Inhalation Rate = IR	1.2	m3/hr
Exposure Time = ET	4	hr/day
Exposure Frequency = EF	20	day/yr
Exposure Duration = ED	6	yr
Body Weight = BW	15	kg
Averaging Time (Noncancer) = AT	2190	days
Averaging Time (Cancer) = AT	25550	days

Intake (mg/kg-day) = Conc * IR * ET * EF * ED / (BW * AT)

NCADD = Average Daily Dose - Noncarcinogens
CADD = Average Daily Dose - Carcinogens
HQ = Hazard Quotient, Noncarcinogens = NCADD/ RfD
Risk = Cancer Risk = CADD * SF

Chemical of Potential Concern	EPC (mg/m3)	NCADD (mg/kg-day)	CADD (mg/kg-day)	Inhalation RfD (mg/kg-day)	Inhalation SF per (mg/kg-day)	HQ	Risk
Arsenic	1.63E-08	2.86E-10	2.45E-11	8.60E-06	1.51E+01	3.33E-05	3.70E-10
Lead	4.70E-06	8.25E-08	7.07E-09	NA	NA	--	--
Cumulative Risk						**3.33E-05**	**3.70E-10**

NA = Not applicable if chemical is not a COPC for the exposure route, or toxicity value is not available

Table A-11. Estimates of Cancer and Noncancer Risks for Adult Recreational Users
CTE- Incidental Ingestion of Soil

CTE- Incidental Ingestion of Soil

Ingestion Rate = IR	12 mg/day
Exposure Frequency = EF	4 day/yr
Exposure Duration = ED	9 yr
Body Weight = BW	70 kg
Averaging Time (Noncancer) = AT	3,285 days
Averaging Time (Cancer) = AT	25,550 days
Conversion Factor = CF	1.00E-06 kg/mg

Intake (mg/kg-day) = Conc * IR * EF * ED *CF / (BW * AT)

NCADD = Average Daily Dose - Noncarcinogens
CADD = Average Daily Dose - Carcinogens
HQ = Hazard Quotient, Noncarcinogens = NCADD/ RfD
Risk = Cancer Risk = CADD * SF

Chemical of Potential Concern	EPC (mg/kg)	NCADD (mg/kg-day)	CADD (mg/kg-day)	Chronic Oral RfD (mg/kg-day)	Oral SF per (mg/kg-day)	HQ	Risk
Arsenic	21.5	4.04E-08	5.20E-09	3.00E-04	1.50E+00	1.35E-04	7.80E-09
Lead	6,208	1.17E-05	1.50E-06	NA	NA	--	--
Cumulative Risk						**1.35E-04**	**7.80E-09**

NA = Not applicable if chemical is not a COPC for the exposure route, or toxicity value is not available

Table A-12. Estimates of Cancer and Noncancer Risks for Adult Recreational Users
RME- Incidental Ingestion of Soil

RME- Incidental Ingestion of Soil

Ingestion Rate = IR	25 mg/day
Exposure Frequency = EF	20 day/yr
Exposure Duration = ED	30 yr
Body Weight = BW	70 kg
Averaging Time (Noncancer) = AT	10,950 days
Averaging Time (Cancer) = AT	25,550 days
Conversion Factor = CF	1.00E-06 kg/mg

Intake (mg/kg-day) = Conc * IR * EF * ED *CF / (BW * AT)

NCADD = Average Daily Dose - Noncarcinogens
CADD = Average Daily Dose - Carcinogens
HQ = Hazard Quotient, Noncarcinogens = NCADD/ RfD
Risk = Cancer Risk = CADD * SF

Chemical of Potential Concern	EPC (mg/kg)	NCADD (mg/kg-day)	CADD (mg/kg-day)	Chronic Oral RfD (mg/kg-day)	Oral SF per (mg/kg-day)	HQ	Risk
Arsenic	21.5	4.21E-07	1.81E-07	3.00E-04	1.50E+00	1.40E-03	2.71E-07
Lead	6,208	1.21E-04	5.21E-05	NA	NA	--	--
Cumulative Risk						**1.40E-03**	**2.71E-07**

NA = Not applicable if chemical is not a COPC for the exposure route, or toxicity value is not available

Table A-13. Estimates of Cancer and Noncancer Risks for Adult Recreational Users

CTE- Dermal Contact with Soil

CTE- Dermal Contact with Soil

Surface Area for Contact=SA	5,200 cm2/event
Adherence Factor=AF	0.08 mg/cm2
Dermal Absorption Factor=DAF	chemical specific
Exposure Frequency = EF	4 event/yr
Exposure Duration = ED	9 yr
Body Weight = BW	70 kg
Averaging Time (Noncancer) = AT	3,285 days
Averaging Time (Cancer) = AT	25,550 days
Conversion Factor = CF	1.00E-06 kg/mg

Intake (mg/kg-day) = Conc * SA * AF * DAF * EF * ED * CF / (BW * AT)

NCADD = Average Daily Dose - Noncarcinogens

CADD = Average Daily Dose - Carcinogens

HQ = Hazard Quotient, Noncarcinogens = NCADD/ RfD

Risk = Cancer Risk = CADD * SF

Chemical of Potential Concern	EPC (mg/kg)	NCADD (mg/kg-day)	CADD (mg/kg-day)	Dermal RfD (mg/kg-day)	Dermal SF per (mg/kg-day)	HQ	Risk
Arsenic	21.5	1.40E-08	1.80E-09	2.85E-04	1.58E+00	4.92E-05	2.85E-09
Lead	6,208	4.04E-06	5.20E-07	NA	NA	--	--
Cumulative Risk						**4.92E-05**	**2.85E-09**

NA = Not applicable if chemical is not a COPC for the exposure route, or toxicity value is not available

Table A-14. Estimates of Cancer and Noncancer Risks for Adult Recreational Users

RME- Dermal Contact with Soil

RME- Dermal Contact with Soil

Surface Area for Contact=SA	6,900 cm2/event
Adherence Factor=AF	0.08 mg/cm2
Dermal Absorption Factor=DAF	chemical specific
Exposure Frequency = EF	20 event/yr
Exposure Duration = ED	30 yr
Body Weight = BW	70 kg
Averaging Time (Noncancer) = AT	10,950 days
Averaging Time (Cancer) = AT	25,550 days
Conversion Factor = CF	1.00E-06 kg/mg

Intake (mg/kg-day) = Conc * SA * AF * DAF * EF * ED * CF / (BW * AT)

NCADD = Average Daily Dose - Noncarcinogens
CADD = Average Daily Dose - Carcinogens
HQ = Hazard Quotient, Noncarcinogens = NCADD/ RfD
Risk = Cancer Risk = CADD * SF

Chemical of Potential Concern	EPC (mg/kg)	NCADD (mg/kg-day)	CADD (mg/kg-day)	Dermal RfD (mg/kg-day)	Dermal SF per (mg/kg-day)	HQ	Risk
Arsenic	21.5	9.30E-08	3.99E-08	2.85E-04	1.58E+00	3.26E-04	6.30E-08
Lead	6.208	2.68E-05	1.15E-05	NA	NA	--	--
Cumulative Risk						**3.26E-04**	**6.30E-08**

NA = Not applicable if chemical is not a COPC for the exposure route, or toxicity value is not available

Table A-15. Estimates of Cancer and Noncancer Risks for Adult Recreational Users

CTE- Inhalation of Particles from Soil

CTE- Inhalation of Particles from Soil

Inhalation Rate = IR	1.5 m3/hr
Exposure Time = ET	4 hr/day
Exposure Frequency = EF	4 day/yr
Exposure Duration = ED	9 yr
Body Weight = BW	70 kg
Averaging Time (Noncancer) = AT	3285 days
Averaging Time (Cancer) = AT	25550 days

Intake (mg/kg-day) = Conc * IR * ET * EF * ED / (BW * AT)

NCADD = Average Daily Dose - Noncarcinogens
CADD = Average Daily Dose - Carcinogens
HQ = Hazard Quotient, Noncarcinogens = NCADD/ RfD
Risk = Cancer Risk = CADD * SF

Chemical of Potential Concern	EPC (mg/m3)	NCADD (mg/kg-day)	CADD (mg/kg-day)	Inhalation RfD (mg/kg-day)	Inhalation SF per (mg/kg-day)	HQ	Risk
Arsenic	1.63E-08	1.53E-11	1.97E-12	8.60E-06	1.51E+01	1.78E-06	2.97E-11
Lead	4.70E-06	4.42E-09	5.68E-10	NA	NA	--	--
Cumulative Risk						**1.78E-06**	**2.97E-11**

NA = Not applicable if chemical is not a COPC for the exposure route, or toxicity value is not available

Table A-16. Estimates of Cancer and Noncancer Risks for Adult Recreational Users

RME- Inhalation of Particles from Soil

RME- Inhalation of Particles from Soil

Inhalation Rate = IR	1.5 m3/hr
Exposure Time = ET	4 hr/day
Exposure Frequency = EF	20 day/yr
Exposure Duration = ED	30 yr
Body Weight = BW	70 kg
Averaging Time (Noncancer) = AT	10950 days
Averaging Time (Cancer) = AT	25550 days

Intake (mg/kg-day) = Conc * IR * ET * EF * ED / (BW * AT)

NCADD = Average Daily Dose - Noncarcinogens
CADD = Average Daily Dose - Carcinogens
HQ = Hazard Quotient, Noncarcinogens = NCADD/ RfD
Risk = Cancer Risk = CADD * SF

Chemical of Potential Concern	EPC (mg/L)	NCADD (mg/kg-day)	CADD (mg/kg-day)	Inhalation RfD (mg/kg-day)	Inhalation SF per (mg/kg-day)	HQ	Risk
Arsenic	1.63E-08	7.66E-11	3.28E-11	8.60E-06	1.51E+01	8.91E-06	4.96E-10
Lead	4.70E-06	2.21E-08	9.47E-09	NA	NA	--	--
Cumulative Risk						**8.91E-06**	**4.96E-10**

NA = Not applicable if chemical is not a COPC for the exposure route, or toxicity value is not available

Table A-17. Estimates of Cancer and Noncancer Risks for Child Recreational Users
CTE - Ingestion of Surface Water

CTE - Ingestion of Surface Water

Ingestion Rate = IR	0.01 L/hr
Exposure Time = ET	0.5 hr/day
Exposure Frequency = EF	4 day/yr
Exposure Duration = ED	2 yr
Body Weight = BW	15 kg
Averaging Time (Noncancer) = AT	730 days
Averaging Time (Cancer) = AT	25,550 days

Intake (mg/kg-day) = Conc * IR * ET * EF * ED / (BW * AT)

NCADD = Average Daily Dose - Noncarcinogens
CADD = Average Daily Dose - Carcinogens
HQ = Hazard Quotient, Noncarcinogens = NCADD/ RfD
Risk = Cancer Risk = CADD * SF

Chemical of Potential Concern	EPC (mg/L)	NCADD (mg/kg-day)	CADD (mg/kg-day)	Chronic Oral RfD (mg/kg-day)	Oral SF per (mg/kg-day)	HQ	Risk
Arsenic	1.73E-03	6.32E-09	1.81E-10	3.00E-04	1.50E+00	2.11E-05	2.71E-10
Lead	5.19E-03	1.90E-08	5.42E-10	NA	NA	--	--
Cumulative Risk						**2.11E-05**	**2.71E-10**

NA = Not applicable if chemical is not a COPC for the exposure route, or toxicity value is not available

Table A-18. Estimates of Cancer and Noncancer Risks for Child Recreational Users
RME- Ingestion of Surface Water

RME- Ingestion of Surface Water

Ingestion Rate = IR	0.01 L/hr
Exposure Time = ET	1 hr/day
Exposure Frequency = EF	20 day/yr
Exposure Duration = ED	6 yr
Body Weight = BW	15 kg
Averaging Time (Noncancer) = AT	2,190 days
Averaging Time (Cancer) = AT	25,550 days

0

Intake (mg/kg-day) = Conc * IR * ET * EF * ED / (BW * AT)

NCADD = Average Daily Dose - Noncarcinogens
CADD = Average Daily Dose - Carcinogens
HQ = Hazard Quotient, Noncarcinogens = NCADD/ RfD
Risk = Cancer Risk = CADD * SF

Chemical of Potential Concern	EPC (mg/L)	NCADD (mg/kg-day)	CADD (mg/kg-day)	Chronic Oral RfD (mg/kg-day)	Oral SF per (mg/kg-day)	HQ	Risk
Arsenic	1.73E-03	6.32E-08	5.42E-09	3.00E-04	1.50E+00	2.11E-04	8.13E-09
Lead	5.19E-03	1.90E-07	1.63E-08	NA	NA	--	--
Cumulative Risk						**2.11E-04**	**8.13E-09**

NA = Not applicable if chemical is not a COPC for the exposure route, or toxicity value is not available

Table A-19. Estimates of Cancer and Noncancer Risks for Child Recreational Users

CTE- Dermal Contact with Surface Water

CTE- Dermal Contact with Surface Water

Surface Area Available for Contact = SA	4,500 cm2
Event Time = ET	1 hr/day
Permeability Coefficient = PC	chemical-specific cm/hr
Exposure Frequency = EF	4 day/yr
Exposure Duration = ED	2 yr
Body Weight = BW	15 kg
Averaging Time (Noncancer) = AT	730 days
Averaging Time (Cancer) = AT	25,550 days
Conversion Factor = CF	1.0E-03 L/cm3

Intake (mg/kg-day) = Conc * SA * PC * ET * EF * ED * CF / (BW * AT)

NCADD = Average Daily Dose - Noncarcinogens
CADD = Average Daily Dose - Carcinogens
HQ = Hazard Quotient, Noncarcinogens = NCADD/ RfD
Risk = Cancer Risk = CADD * SF

Chemical of Potential Concern	EPC (mg/L)	NCADD (mg/kg-day)	CADD (mg/kg-day)	Dermal RfD (mg/kg-day)	Dermal SF per (mg/kg-day)	HQ	Risk
Arsenic	1.73E-03	2.84E-09	8.13E-11	2.85E-04	1.58E+00	9.98E-06	1.28E-10
Lead	5.19E-03	8.53E-09	2.44E-10	NA	NA	--	--
Cumulative Risk						**9.98E-06**	**1.28E-10**

NA = Not applicable if chemical is not a COPC for the exposure route, or toxicity value is not available

Table A-20. Estimates of Cancer and Noncancer Risks for Child Recreational Users
RME- Dermal Contact with Surface Water

RME- Dermal Contact with Surface Water

Surface Area Available for Contact = SA	5,000 cm2
Event Time = ET	1 hr/day
Permeability Coefficient = PC	chemical-specific cm/hr
Exposure Frequency = EF	20 day/yr
Exposure Duration = ED	6 yr
Body Weight = BW	15 kg
Averaging Time (Noncancer) = AT	2,190 days
Averaging Time (Cancer) = AT	25,550 days
Conversion Factor = CF	1.0E-03 L/cm3

Intake (mg/kg-day) = Conc * SA * PC * ET * EF * ED * CF / (BW * AT)

NCADD = Average Daily Dose - Noncarcinogens
CADD = Average Daily Dose - Carcinogens
HQ = Hazard Quotient, Noncarcinogens = NCADD/ RfD
Risk = Cancer Risk = CADD * SF

Chemical of Potential Concern	EPC (mg/L)	NCADD (mg/kg-day)	CADD (mg/kg-day)	Dermal RfD (mg/kg-day)	Dermal SF per (mg/kg-day)	HQ	Risk
Arsenic	1.73E-03	3.16E-08	2.71E-09	2.85E-04	1.58E+00	1.11E-04	4.28E-09
Lead	5.19E-03	9.48E-08	8.13E-09	NA	NA	--	--
Cumulative Risk						**1.11E-04**	**4.28E-09**

NA = Not applicable if chemical is not a COPC for the exposure route, or toxicity value is not available

Table A-21. Estimates of Cancer and Noncancer Risks for Adult Recreational Users
CTE - Ingestion of Surface Water

CTE - Ingestion of Surface Water

Ingestion Rate = IR	0.01 L/hr
Exposure Time = ET	0.5 hr/day
Exposure Frequency = EF	4 day/yr
Exposure Duration = ED	9 yr
Body Weight = BW	70 kg
Averaging Time (Noncancer) = AT	3,285 days
Averaging Time (Cancer) = AT	25,550 days

Intake (mg/kg-day) = Conc * IR * ET * EF * ED / (BW * AT)

NCADD = Average Daily Dose - Noncarcinogens
CADD = Average Daily Dose - Carcinogens
HQ = Hazard Quotient, Noncarcinogens = NCADD/ RfD
Risk = Cancer Risk = CADD * SF

Chemical of Potential Concern	EPC (mg/L)	NCADD (mg/kg-day)	CADD (mg/kg-day)	Chronic Oral RfD (mg/kg-day)	Oral SF per (mg/kg-day)	HQ	Risk
Arsenic	1.73E-03	1.35E-09	1.74E-10	3.00E-04	1.50E+00	4.51E-06	2.61E-10
Lead	5.19E-03	4.06E-09	5.22E-10	NA	NA	--	--
Cumulative Risk						**4.51E-06**	**2.61E-10**

NA = Not applicable if chemical is not a COPC for the exposure route, or toxicity value is not available

Table A-22. Estimates of Cancer and Noncancer Risks for Adult Recreational Users
RME - Ingestion of Surface Water

RME - Ingestion of Surface Water

Ingestion Rate = IR	0.01 L/hr
Exposure Time = ET	1 hr/day
Exposure Frequency = EF	20 day/yr
Exposure Duration = ED	30 yr
Body Weight = BW	70 kg
Averaging Time (Noncancer) = AT	10,950 days
Averaging Time (Cancer) = AT	25,550 days

Intake (mg/kg-day) = Conc * IR * ET * EF * ED / (BW * AT)

NCADD = Average Daily Dose - Noncarcinogens
CADD = Average Daily Dose - Carcinogens
HQ = Hazard Quotient, Noncarcinogens = NCADD/ RfD
Risk = Cancer Risk = CADD * SF

Chemical of Potential Concern	EPC (mg/L)	NCADD (mg/kg-day)	CADD (mg/kg-day)	Chronic Oral RfD (mg/kg-day)	Oral SF per (mg/kg-day)	HQ	Risk
Arsenic	1.73E-03	1.35E-08	5.80E-09	3.00E-04	1.50E+00	4.51E-05	8.71E-09
Lead	5.19E-03	4.06E-08	1.74E-08	NA	NA	--	--
Cumulative Risk						**4.51E-05**	**8.71E-09**

NA = Not applicable if chemical is not a COPC for the exposure route, or toxicity value is not available

Table A-23. Estimates of Cancer and Noncancer Risks for Adult Recreational Users
CTE- Dermal Contact with Surface Water

CTE- Dermal Contact with Surface Water

Surface Area Available for Contact = SA	5,200 cm2
Event Time = ET	1 hr/day
Permeability Coefficient = PC	chemical-specific
Exposure Frequency = EF	4 day/yr
Exposure Duration = ED	9 yr
Body Weight = BW	70 kg
Averaging Time (Noncancer) = AT	3,285 days
Averaging Time (Cancer) = AT	25,550 days
Conversion Factor = CF	1.0E-03 L/cm3

Intake (mg/kg-day) = Conc * SA * PC * ET * EF * ED * CF / (BW * AT)

NCADD = Average Daily Dose - Noncarcinogens
CADD = Average Daily Dose - Carcinogens
HQ = Hazard Quotient, Noncarcinogens = NCADD/ RfD
Risk = Cancer Risk = CADD * SF

Chemical of Potential Concern	EPC (mg/L)	NCADD (mg/kg-day)	CADD (mg/kg-day)	Dermal RfD (mg/kg-day)	Dermal SF per (mg/kg-day)	HQ	Risk
Arsenic	1.73E-03	7.04E-10	9.05E-11	2.85E-04	1.58E+00	2.47E-06	1.43E-10
Lead	5.19E-03	2.11E-09	2.72E-10	NA	NA	--	--
Cumulative Risk						**2.47E-06**	**1.43E-10**

NA = Not applicable if chemical is not a COPC for the exposure route, or toxicity value is not available

Table A-24. Estimates of Cancer and Noncancer Risks for Adult Recreational Users
RME- Dermal Contact with Surface Water

RME- Dermal Contact with Surface Water

Surface Area Available for Contact = SA	6,900 cm2
Event Time = ET	1 hr/day
Permeability Coefficient = PC	chemical-specific
Exposure Frequency = EF	20 day/yr
Exposure Duration = ED	30 yr
Body Weight = BW	70 kg
Averaging Time (Noncancer) = AT	10,950 days
Averaging Time (Cancer) = AT	25,550 days
Conversion Factor = CF	1.0E-03 L/cm3

Intake (mg/kg-day) = Conc * SA * PC * ET * EF * ED * CF / (BW * AT)

NCADD = Average Daily Dose - Noncarcinogens
CADD = Average Daily Dose - Carcinogens
HQ = Hazard Quotient, Noncarcinogens = NCADD/ RfD
Risk = Cancer Risk = CADD * SF

Chemical of Potential Concern	EPC (mg/L)	NCADD (mg/kg-day)	CADD (mg/kg-day)	Dermal RfD (mg/kg-day)	Dermal SF per (mg/kg-day)	HQ	Risk
Arsenic	1.73E-03	9.34E-09	4.00E-09	2.85E-04	1.58E+00	3.28E-05	6.32E-09
Lead	5.19E-03	2.80E-08	1.20E-08	NA	NA	--	--
Cumulative Risk						**3.28E-05**	**6.32E-09**

NA = Not applicable if chemical is not a COPC for the exposure route, or toxicity value is not available

Table A-25. Estimates of Cancer and Noncancer Risks for Child Recreational Users
CTE - Incidental Ingestion of Sediment

CTE - Incidental Ingestion of Sediment

Ingestion Rate = IR	25 mg/day
Exposure Frequency = EF	4 day/yr
Exposure Duration = ED	2 yr
Body Weight = BW	15 kg
Averaging Time (Noncancer) = AT	730 days
Averaging Time (Cancer) = AT	25,550 days
Conversion Factor = CF	1.00E-06 kg/g

Intake (mg/kg-day) = Conc * IR * EF * ED *CF / (BW * AT)

NCADD = Average Daily Dose - Noncarcinogens
CADD = Average Daily Dose - Carcinogens
HQ = Hazard Quotient, Noncarcinogens = NCADD/ RfD
Risk = Cancer Risk = CADD * SF

Chemical of Potential Concern	EPC (mg/kg)	NCADD (mg/kg-day)	CADD (mg/kg-day)	Chronic Oral RfD (mg/kg-day)	Oral SF per (mg/kg-day)	HQ	Risk
Arsenic	29.5	5.39E-07	1.54E-08	3.00E-04	1.50E+00	1.80E-03	2.31E-08
Lead	1045.0	1.91E-05	5.45E-07	NA	NA	--	--
Cumulative Risk						**1.80E-03**	**2.31E-08**

NA = Not applicable if chemical is not a COPC for the exposure route, or toxicity value is not available

Table A-26. Estimates of Cancer and Noncancer Risks for Child Recreational Users
RME- Incidental Ingestion of Sediment

RME- Incidental Ingestion of Sediment

Ingestion Rate = IR	100 mg/day
Exposure Frequency = EF	20 day/yr
Exposure Duration = ED	6 yr
Body Weight = BW	15 kg
Averaging Time (Noncancer) = AT	2,190 days
Averaging Time (Cancer) = AT	25,550 days
Conversion Factor = CF	1.00E-06 kg/g

Intake (mg/kg-day) = Conc * IR * EF * ED *CF / (BW * AT)

NCADD = Average Daily Dose - Noncarcinogens
CADD = Average Daily Dose - Carcinogens
HQ = Hazard Quotient, Noncarcinogens = NCADD/ RfD
Risk = Cancer Risk = CADD * SF

Chemical of Potential Concern	EPC (mg/kg)	NCADD (mg/kg-day)	CADD (mg/kg-day)	Chronic Oral RfD (mg/kg-day)	Oral SF per (mg/kg-day)	HQ	Risk
Arsenic	29.5	1.08E-05	9.24E-07	3.00E-04	1.50E+00	3.59E-02	1.39E-06
Lead	1045.0	3.82E-04	3.27E-05	NA	NA	--	--
Cumulative Risk						**3.59E-02**	**1.39E-06**

NA = Not applicable if chemical is not a COPC for the exposure route, or toxicity value is not available

Table A-27. Estimates of Cancer and Noncancer Risks for Child Recreational Users

CTE- Dermal Contact with Sediment

CTE- Dermal Contact with Sediment

Surface Area for Contact=SA	4,500 cm2
Adherence Factor=AF	0.04 mg/cm2
Dermal Absorption Factor=DAF	chemical-specific
Exposure Frequency = EF	4 day/yr
Exposure Duration = ED	2 yr
Body Weight = BW	15 kg
Averaging Time (Noncancer) = AT	730 days
Averaging Time (Cancer) = AT	25,550 days
Conversion Factor = CF	1.00E-06 kg/mg

Intake (mg/kg-day) = Conc * SA * AF * DAF * EF * ED * CF / (BW * AT)

NCADD = Average Daily Dose - Noncarcinogens
CADD = Average Daily Dose - Carcinogens
HQ = Hazard Quotient, Noncarcinogens = NCADD/ RfD
Risk = Cancer Risk = CADD * SF

Chemical of Potential Concern	EPC (mg/kg)	NCADD (mg/kg-day)	CADD (mg/kg-day)	Dermal RfD (mg/kg-day)	Dermal SF per (mg/kg-day)	HQ	Risk
Arsenic	29.5	3.88E-08	1.11E-09	2.85E-04	1.58E+00	1.36E-04	1.75E-09
Lead	1045.0	1.37E-06	3.93E-08	NA	NA	--	--
Cumulative Risk						**1.36E-04**	**1.75E-09**

NA = Not applicable if chemical is not a COPC for the exposure route, or toxicity value is not available

Table A-28. Estimates of Cancer and Noncancer Risks for Child Recreational Users
RME- Dermal Contact with Sediment

RME- Dermal Contact with Sediment

Surface Area for Contact=SA	5,000 cm2
Adherence Factor=AF	0.4 mg/cm2
Dermal Absorption Factor=DAF	chemical-specific
Exposure Frequency = EF	20 day/yr
Exposure Duration = ED	6 yr
Body Weight = BW	15 kg
Averaging Time (Noncancer) = AT	2,190 days
Averaging Time (Cancer) = AT	25,550 days
Conversion Factor = CF	1.00E-06 kg/mg

Intake (mg/kg-day) = Conc * SA * AF * DAF * EF * ED * CF / (BW * AT)

NCADD = Average Daily Dose - Noncarcinogens
CADD = Average Daily Dose - Carcinogens
HQ = Hazard Quotient, Noncarcinogens = NCADD/ RfD
Risk = Cancer Risk = CADD * SF

Chemical of Potential Concern	EPC (mg/kg)	NCADD (mg/kg-day)	CADD (mg/kg-day)	Dermal RfD (mg/kg-day)	Dermal SF per (mg/kg-day)	HQ	Risk
Arsenic	29.5	2.16E-06	1.85E-07	2.85E-04	1.58E+00	7.56E-03	2.92E-07
Lead	1045.0	7.63E-05	6.54E-06	NA	NA	--	--
Cumulative Risk						**7.56E-03**	**2.92E-07**

NA = Not applicable if chemical is not a COPC for the exposure route, or toxicity value is not available

Table A-29. Estimates of Cancer and Noncancer Risks for Adult Recreational Users
CTE - Incidental Ingestion of Sediment

CTE - Incidental Ingestion of Sediment

Ingestion Rate = IR	12 mg/day
Exposure Frequency = EF	4 day/yr
Exposure Duration = ED	9 yr
Body Weight = BW	70 kg
Averaging Time (Noncancer) = AT	3,285 days
Averaging Time (Cancer) = AT	25,550 days
Conversion Factor = CF	1.00E-06 kg/g

Intake (mg/kg-day) = Conc * IR * EF * ED *CF / (BW * AT)

NCADD = Average Daily Dose - Noncarcinogens
CADD = Average Daily Dose - Carcinogens
HQ = Hazard Quotient, Noncarcinogens = NCADD/ RfD
Risk = Cancer Risk = CADD * SF

Chemical of Potential Concern	EPC (mg/kg)	NCADD (mg/kg-day)	CADD (mg/kg-day)	Chronic Oral RfD (mg/kg-day)	Oral SF per (mg/kg-day)	HQ	Risk
Arsenic	29.5	5.54E-08	7.13E-09	3.00E-04	1.50E+00	1.85E-04	1.07E-08
Lead	1045.0	1.96E-06	2.52E-07	NA	NA	--	--
Cumulative Risk						**1.85E-04**	**1.07E-08**

NA = Not applicable if chemical is not a COPC for the exposure route, or toxicity value is not available

Table A-30. Estimates of Cancer and Noncancer Risks for Adult Recreational Users
RME- Incidental Ingestion of Sediment

RME- Incidental Ingestion of Sediment

Ingestion Rate = IR	25 mg/day
Exposure Frequency = EF	20 day/yr
Exposure Duration = ED	30 yr
Body Weight = BW	70 kg
Averaging Time (Noncancer) = AT	10,950 days
Averaging Time (Cancer) = AT	25,550 days
Conversion Factor = CF	1.00E-06 kg/g

Intake (mg/kg-day) = Conc * IR * EF * ED *CF / (BW * AT)

NCADD = Average Daily Dose - Noncarcinogens
CADD = Average Daily Dose - Carcinogens
HQ = Hazard Quotient, Noncarcinogens = NCADD/ RfD
Risk = Cancer Risk = CADD * SF

Chemical of Potential Concern	EPC (mg/kg)	NCADD (mg/kg-day)	CADD (mg/kg-day)	Chronic Oral RfD (mg/kg-day)	Oral SF per (mg/kg-day)	HQ	Risk
Arsenic	29.5	5.77E-07	2.47E-07	3.00E-04	1.50E+00	1.92E-03	3.71E-07
Lead	1045.0	2.05E-05	8.76E-06	NA	NA	--	--
Cumulative Risk						**1.92E-03**	**3.71E-07**

NA = Not applicable if chemical is not a COPC for the exposure route, or toxicity value is not available

Table A-31. Estimates of Cancer and Noncancer Risks for Adult Recreational Users
CTE- Dermal Contact with Sediment

CTE- Dermal Contact with Sediment

Surface Area for Contact=SA	5,200 cm2
Adherence Factor=AF	0.08 mg/cm2
Dermal Absorption Factor=DAF	chemical specific
Exposure Frequency = EF	4 day/yr
Exposure Duration = ED	9 yr
Body Weight = BW	70 kg
Averaging Time (Noncancer) = AT	3,285 days
Averaging Time (Cancer) = AT	25,550 days
Conversion Factor = CF	1.00E-06 kg/mg

Intake (mg/kg-day) = Conc * SA * AF * DAF * EF * ED * CF / (BW * AT)

NCADD = Average Daily Dose - Noncarcinogens
CADD = Average Daily Dose - Carcinogens
HQ = Hazard Quotient, Noncarcinogens = NCADD/ RfD
Risk = Cancer Risk = CADD * SF

Chemical of Potential Concern	EPC (mg/kg)	NCADD (mg/kg-day)	CADD (mg/kg-day)	Dermal RfD (mg/kg-day)	Dermal SF per (mg/kg-day)	HQ	Risk
Arsenic	29.5	1.92E-08	2.47E-09	2.85E-04	1.58E+00	6.74E-05	3.90E-09
Lead	1045.0	6.81E-07	8.75E-08	NA	NA	--	--
Cumulative Risk						**6.74E-05**	**3.90E-09**

NA = Not applicable if chemical is not a COPC for the exposure route, or toxicity value is not available

Table A-32. Estimates of Cancer and Noncancer Risks for Adult Recreational Users

RME- Dermal Contact with Sediment

RME- Dermal Contact with Sediment

Surface Area for Contact=SA	6,900 cm2
Adherence Factor=AF	0.08 mg/cm2
Dermal Absorption Factor=DAF	chemical specific
Exposure Frequency = EF	20 day/yr
Exposure Duration = ED	30 yr
Body Weight = BW	70 kg
Averaging Time (Noncancer) = AT	10,950 days
Averaging Time (Cancer) = AT	25,550 days
Conversion Factor = CF	1.00E-06 kg/mg

Intake (mg/kg-day) = Conc * SA * AF * DAF * EF * ED * CF / (BW * AT)

NCADD = Average Daily Dose - Noncarcinogens
CADD = Average Daily Dose - Carcinogens
HQ = Hazard Quotient, Noncarcinogens = NCADD/ RfD
Risk = Cancer Risk = CADD * SF

Chemical of Potential Concern	EPC (mg/kg)	NCADD (mg/kg-day)	CADD (mg/kg-day)	Dermal RfD (mg/kg-day)	Dermal SF per (mg/kg-day)	HQ	Risk
Arsenic	29.5	1.27E-07	5.46E-08	2.85E-04	1.58E+00	4.47E-04	8.63E-08
Lead	1045.0	4.52E-06	1.94E-06	NA	NA	--	--
Cumulative Risk						**4.47E-04**	**8.63E-08**

NA = Not applicable if chemical is not a COPC for the exposure route, or toxicity value is not available

Table A-33. Air Particulate Modeling

Chemical	C_{soil}	PEF	Fraction Contaminated	C_{air}, Particulate	
	mg/kg	m3/kg	100%	g/cm3	mg/m3
			(ODEQ 1998)		
Arsenic	21.5	1.32E+09	100%	1.63E-17	1.63E-08
Lead	6,208	1.32E+09	100%	4.70E-15	4.70E-06

C_{soil} = Exposure Point Concentration (90UCL) in waste rock soil

PEF = Particulate Emission Factor; default value from ODEQ (1998)

Cair = Csoil/PEF * Fraction contaminated

ATTACHMENT B – PRINTOUTS OF CHILD AND ADULT LEAD MODEL RUNS

Model Results for 20 days per year exposure frequency

LEAD MODEL FOR WINDOWS Version 1.0

==========

Model Version: 1.0 Build 264
User Name:
Date:
Site Name:
Operable Unit:
Run Mode: Research

==========

The time step used in this model run: 1 - Every 4 Hours (6 times a day).

****** Air ******

Indoor Air Pb Concentration: 30.000 percent of outdoor.
Other Air Parameters:

Age	Time Outdoors (hours)	Ventilation Rate (m^3/day)	Lung Absorption (%)	Outdoor Air Pb Conc (ug Pb/m^3)
.5-1	1.000	2.000	32.000	0.100
1-2	2.000	3.000	32.000	0.100
2-3	3.000	5.000	32.000	0.100
3-4	4.000	5.000	32.000	0.100
4-5	4.000	5.000	32.000	0.100
5-6	4.000	7.000	32.000	0.100
6-7	4.000	7.000	32.000	0.100

****** Diet ******

Age	Diet Intake(ug/day)
.5-1	5.530
1-2	5.780
2-3	6.490
3-4	6.240
4-5	6.010
5-6	6.340
6-7	7.000

****** Drinking Water ******

Water Consumption:

Age	Water (L/day)
.5-1	0.200
1-2	0.500

2-3	0.520
3-4	0.530
4-5	0.550
5-6	0.580
6-7	0.590

Drinking Water Concentration: 4.000 ug Pb/L

****** Soil & Dust ******

Multiple Source Analysis Used
Average multiple source concentration: 323.600 ug/g

Mass fraction of outdoor soil to indoor dust conversion factor: 0.700
Outdoor airborne lead to indoor household dust lead concentration: 100.000
Use alternate indoor dust Pb sources? No

Age	Soil (ug Pb/g)	House Dust (ug Pb/g)
.5-1	448.000	323.600
1-2	448.000	323.600
2-3	448.000	323.600
3-4	448.000	323.600
4-5	448.000	323.600
5-6	448.000	323.600
6-7	448.000	323.600

****** Alternate Intake ******

Age	Alternate (ug Pb/day)
.5-1	0.000
1-2	0.000
2-3	0.000
3-4	0.000
4-5	0.000
5-6	0.000
6-7	0.000

****** Maternal Contribution: Infant Model ******

Maternal Blood Concentration: 2.500 ug Pb/dL

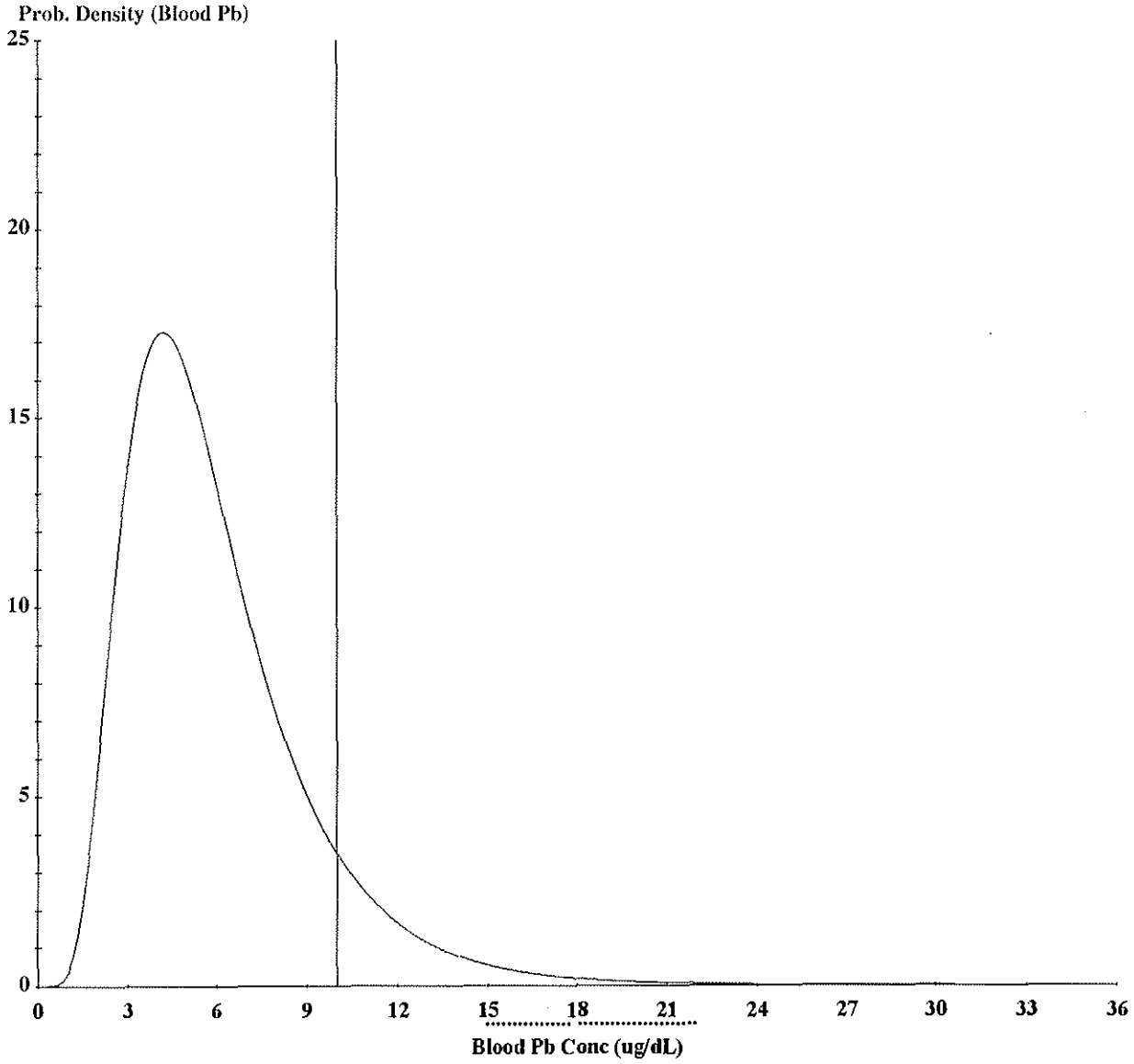
****

CALCULATED BLOOD LEAD AND LEAD UPTAKES:

****

Year	Air (ug/day)	Diet (ug/day)	Alternate (ug/day)	Water (ug/day)
.5-1	0.021	2.428	0.000	0.351
1-2	0.034	2.492	0.000	0.862
2-3	0.062	2.848	0.000	0.913
3-4	0.067	2.788	0.000	0.947
4-5	0.067	2.777	0.000	1.016
5-6	0.093	2.966	0.000	1.085
6-7	0.093	3.295	0.000	1.111

Year	Soil+Dust (ug/day)	Total (ug/day)	Blood (ug/dL)
.5-1	8.498	11.298	6.1
1-2	13.257	16.646	6.8
2-3	13.494	17.317	6.4
3-4	13.738	17.540	6.1
4-5	10.522	14.382	5.1
5-6	9.588	13.732	4.4
6-7	9.111	13.610	3.9



Cutoff = 10.000 ug/dl
Geo Mean = 5.480
GSD = 1.600 %
Above = 10.031 %
Below = 89.969

Age Range = 0 to 84 months
Time Step = Every 4 Hours
Run Mode = Research

Probability Density Curve for 20 Days per Year Exposure Frequency

Adult Lead Model for 20 days per year Exposure Frequency

Calculations of Blood Lead Concentrations (PbBs)

U.S. EPA Technical Review Workgroup for Lead, Adult Lead Committee

Version date 05/19/05

Exposure Variable	Description of Exposure Variable	Units	Region OR Ethnic GSDi and PbBo Data from NHANES III Analysis							
			All/All	All/ White	All/ Black	All/ Mexican	Northeast/All	Midwest/All	South/ All	West/ All
PbS	Soil lead concentration	µg/g or ppm	4731	4731	4731	4731	4731	4731	4731	4731
$R_{fetal/maternal}$	Fetal/maternal PbB ratio	--	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
BKSF	Biokinetic Slope Factor	µg/dL per µg/day	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
GSD_i	Geometric standard deviation PbB	--	2.1	2.1	2.2	2.3	2.0	2.2	2.1	2.1
PbB_0	Baseline PbB	µg/dL	1.5	1.5	1.8	1.7	2.0	1.5	1.4	1.4
IR_S	Soil ingestion rate (including soil-derived indoor dust)	g/day	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
IR_{S+D}	Total ingestion rate of outdoor soil and indoor dust	g/day	--	--	--	--	--	--	--	--
W_S	Weighting factor; fraction of IR_{S+D} ingested as outdoor soil	--	--	--	--	--	--	--	--	--
K_{SD}	Mass fraction of soil in dust	--	--	--	--	--	--	--	--	--
$AF_{S,D}$	Absorption fraction (same for soil and dust)	--	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
$EF_{S,D}$	Exposure frequency (same for soil and dust)	days/yr	20	20	20	20	20	20	20	20
$AT_{S,D}$	Averaging time (same for soil and dust)	days/yr	365	365	365	365	365	365	365	365
PbB_{adult}	**PbB of adult worker, geometric mean**	**ug/dL**	**2.2**	**2.1**	**2.4**	**2.3**	**2.6**	**2.2**	**2.0**	**2.0**
$PbB_{fetal,0.95}$	95th percentile PbB among fetuses of adult workers	µg/dL	6.6	6.3	7.7	8.2	7.3	7.0	6.0	6.2
PbB_t	Target PbB level of concern (e.g., 10 µg/dL)	µg/dL	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
$P(PbB_{fetal} > PbB_t)$	**Probability that fetal PbB > PbB_t, assuming lognormal distribution**	**%**	**1.4%**	**1.1%**	**2.3%**	**2.9%**	**1.8%**	**1.8%**	**0.9%**	**1.1%**

[1] Equation 1 does not apportion exposure between soil and dust ingestion (excludes W_S, K_{SD}).

When $IR_S = IR_{S+D}$ and $W_S = 1.0$, the equations yield the same $PbB_{fetal,0.95}$.

Model Results for 30 days per year exposure frequency

LEAD MODEL FOR WINDOWS Version 1.0

==========

Model Version: 1.0 Build 264
User Name:
Date:
Site Name:
Operable Unit:
Run Mode: Research

==========

The time step used in this model run: 1 - Every 4 Hours (6 times a day).

****** Air ******

Indoor Air Pb Concentration: 30.000 percent of outdoor.
Other Air Parameters:

Age	Time Outdoors (hours)	Ventilation Rate (m^3/day)	Lung Absorption (%)	Outdoor Air Pb Conc (ug Pb/m^3)
.5-1	1.000	2.000	32.000	0.100
1-2	2.000	3.000	32.000	0.100
2-3	3.000	5.000	32.000	0.100
3-4	4.000	5.000	32.000	0.100
4-5	4.000	5.000	32.000	0.100
5-6	4.000	7.000	32.000	0.100
6-7	4.000	7.000	32.000	0.100

****** Diet ******

Age	Diet Intake(ug/day)
.5-1	5.530
1-2	5.780
2-3	6.490
3-4	6.240
4-5	6.010
5-6	6.340
6-7	7.000

****** Drinking Water ******

Water Consumption:

Age	Water (L/day)
.5-1	0.200
1-2	0.500

2-3	0.520
3-4	0.530
4-5	0.550
5-6	0.580
6-7	0.590

Drinking Water Concentration: 4.000 ug Pb/L

****** Soil & Dust ******

Multiple Source Analysis Used
Average multiple source concentration: 410.400 ug/g

Mass fraction of outdoor soil to indoor dust conversion factor: 0.700
Outdoor airborne lead to indoor household dust lead concentration: 100.000
Use alternate indoor dust Pb sources? No

Age	Soil (ug Pb/g)	House Dust (ug Pb/g)
.5-1	572.000	410.400
1-2	572.000	410.400
2-3	572.000	410.400
3-4	572.000	410.400
4-5	572.000	410.400
5-6	572.000	410.400
6-7	572.000	410.400

****** Alternate Intake ******

Age	Alternate (ug Pb/day)
.5-1	0.000
1-2	0.000
2-3	0.000
3-4	0.000
4-5	0.000
5-6	0.000
6-7	0.000

****** Maternal Contribution: Infant Model ******

Maternal Blood Concentration: 2.500 ug Pb/dL

****

CALCULATED BLOOD LEAD AND LEAD UPTAKES:

****

Year	Air (ug/day)	Diet (ug/day)	Alternate (ug/day)	Water (ug/day)
.5-1	0.021	2.371	0.000	0.343
1-2	0.034	2.423	0.000	0.838
2-3	0.062	2.779	0.000	0.891
3-4	0.067	2.728	0.000	0.927
4-5	0.067	2.736	0.000	1.002
5-6	0.093	2.930	0.000	1.072
6-7	0.093	3.260	0.000	1.099

Year	Soil+Dust (ug/day)	Total (ug/day)	Blood (ug/dL)
.5-1	10.562	13.297	7.1
1-2	16.405	19.701	8.1
2-3	16.756	20.488	7.6
3-4	17.109	20.831	7.2
4-5	13.197	17.001	6.0
5-6	12.058	16.153	5.1
6-7	11.475	15.927	4.6

Model Results for 40 days per year exposure frequency

LEAD MODEL FOR WINDOWS Version 1.0

==========

Model Version: 1.0 Build 264
User Name:
Date:
Site Name:
Operable Unit:
Run Mode: Research

==========

The time step used in this model run: 1 - Every 4 Hours (6 times a day).

****** Air ******

Indoor Air Pb Concentration: 30.000 percent of outdoor.
Other Air Parameters:

Age	Time Outdoors (hours)	Ventilation Rate (m^3/day)	Lung Absorption (%)	Outdoor Air Pb Conc (ug Pb/m^3)
.5-1	1.000	2.000	32.000	0.100
1-2	2.000	3.000	32.000	0.100
2-3	3.000	5.000	32.000	0.100
3-4	4.000	5.000	32.000	0.100
4-5	4.000	5.000	32.000	0.100
5-6	4.000	7.000	32.000	0.100
6-7	4.000	7.000	32.000	0.100

****** Diet ******

Age	Diet Intake(ug/day)
.5-1	5.530
1-2	5.780
2-3	6.490
3-4	6.240
4-5	6.010
5-6	6.340
6-7	7.000

****** Drinking Water ******

Water Consumption:

Age	Water (L/day)
.5-1	0.200
1-2	0.500

2-3	0.520
3-4	0.530
4-5	0.550
5-6	0.580
6-7	0.590

Drinking Water Concentration: 4.000 ug Pb/L

****** Soil & Dust ******

Multiple Source Analysis Used
Average multiple source concentration: 497.900 ug/g

Mass fraction of outdoor soil to indoor dust conversion factor: 0.700
Outdoor airborne lead to indoor household dust lead concentration: 100.000
Use alternate indoor dust Pb sources? No

Age	Soil (ug Pb/g)	House Dust (ug Pb/g)
.5-1	697.000	497.900
1-2	697.000	497.900
2-3	697.000	497.900
3-4	697.000	497.900
4-5	697.000	497.900
5-6	697.000	497.900
6-7	697.000	497.900

****** Alternate Intake ******

Age	Alternate (ug Pb/day)
.5-1	0.000
1-2	0.000
2-3	0.000
3-4	0.000
4-5	0.000
5-6	0.000
6-7	0.000

****** Maternal Contribution: Infant Model ******

Maternal Blood Concentration: 2.500 ug Pb/dL

****

CALCULATED BLOOD LEAD AND LEAD UPTAKES:

****

Year	Air (ug/day)	Diet (ug/day)	Alternate (ug/day)	Water (ug/day)
.5-1	0.021	2.317	0.000	0.335
1-2	0.034	2.358	0.000	0.816
2-3	0.062	2.713	0.000	0.870
3-4	0.067	2.671	0.000	0.907
4-5	0.067	2.697	0.000	0.987
5-6	0.093	2.896	0.000	1.060
6-7	0.093	3.226	0.000	1.088

Year	Soil+Dust (ug/day)	Total (ug/day)	Blood (ug/dL)
.5-1	12.552	15.225	8.1
1-2	19.416	22.625	9.2
2-3	19.895	23.540	8.7
3-4	20.370	24.015	8.3
4-5	15.816	19.567	6.9
5-6	14.489	18.538	5.9
6-7	13.809	18.216	5.2

APPENDIX D

PASCOE environmental consulting

Screening Ecological Risk Assessment

Morning Star Mine Site
Willamette National Forest, Oregon

May 2009

Prepared for

GeoDesign, Inc.
Portland, Oregon

210 Taylor Street, Room 15 ▲ Port Townsend ▲ WA 98368

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1 INTRODUCTION

A screening-level ecological risk assessment was performed for the Morning Star Mine Site, Willamette National Forest, Marion County, Oregon. The ecological risk assessment analyzes the potential for adverse effects to local ecological receptors and communities that may be exposed to chemicals at the mine site. The risk assessment follows Oregon Department of Environmental Quality (ODEQ) guidance on performing a Level II screening ecological risk assessment (ODEQ 2001). In addition, impacts to macroinvertebrate communities in the sediment habitat of Battle Ax Creek are evaluated using the macroinvertebrate bioassessment protocol of the Oregon Plan for Salmon and Watersheds (OPSW 1999). Macroinvertebrate data and their evaluation are presented in Attachment C, and results are integrated into the screening ecological risk assessment following discussions of potential ecological risks related to sediment chemical concentrations. The ecological risk assessment is also consistent with USEPA guidance (1998) on performing screening level ecological risk assessments and with the general report format in USEPA guidance while presenting the information requested in ODEQ guidance for Level II ecological risk assessment.

The components of this assessment consist of the following:

- Description of the ecological elements and habitats of the site.
- Identification of site-specific ecological receptors, potential exposure pathways, and chemicals of interest (COIs).
- Identification of assessment and measurement endpoints for the ecological receptors, and risk-based screening criteria consistent with those endpoints.
- Selection of contaminants of potential ecological concern (CPECs) based on screening against risk-based ecological criteria.
- Description of potential links between the CPECs and ecological receptors at the site.
- Evaluation of macroinvertebrate communities in Battle Ax Creek.
- Evaluation of the potential for site-related ecological risk.

The assessment is considered screening-level because it relies on readily available information for exposure assessment, toxicology of metals, and screening against risk-based criteria. All potential exposures are based on metals data from samples collected of waste rock soils, background soils, surface water in mine adits, and surface water and sediments in Battle Ax Creek and Blue Jay Creek, which is a tributary that runs through the Morning Star Mine site to Battle Ax Creek. The site was visited in November 2005 and again in October 2008 for the collection of sample data. Description of the site ecology is based on publically available information and on the site visit.

2 PROBLEM FORMULATION

The Problem Formulation step presents a description of the site and the ecological habitats, ecological receptors, and contamination. This information is used to construct a conceptual ecological exposure model, which describes the potential exposures of ecological receptors to contaminants of interest (COIs) at the site.

2.1 ECOLOGICAL SETTING

Information on regional and site-specific ecology is summarized to provide an understanding of the environment and the wildlife, fish, plants, invertebrates, and birds that may be exposed at the site. In general, an ecological risk assessment assumes that local species are resident on the site or use the site in sufficient abundance such that exposure to site contaminants could potentially affect the species population. Species populations and communities of populations are the critical ecological components that are evaluated for risks, with the understanding that impacts to individual organisms do not necessarily indicate that populations are at risk.

2.1.1 LOCATION AND GEOLOGY

The Morning Star Mine site is located in the Western Cascades in central Oregon (Figure 2-1). The mine site is located in the Battle Ax Creek drainage, which flows west to join with Opal Creek to form the Little North Santiam River, which continues west to the Willamette River valley. The site is located in the Opal Creek Creek Scenic and Recreation Area, adjacent to the Opal Creek Wilderness. Most of the valleys in the higher elevations, including the Battle Ax Creek/Opal Creek valleys, were formed during the last glacial period 15,000 years ago.

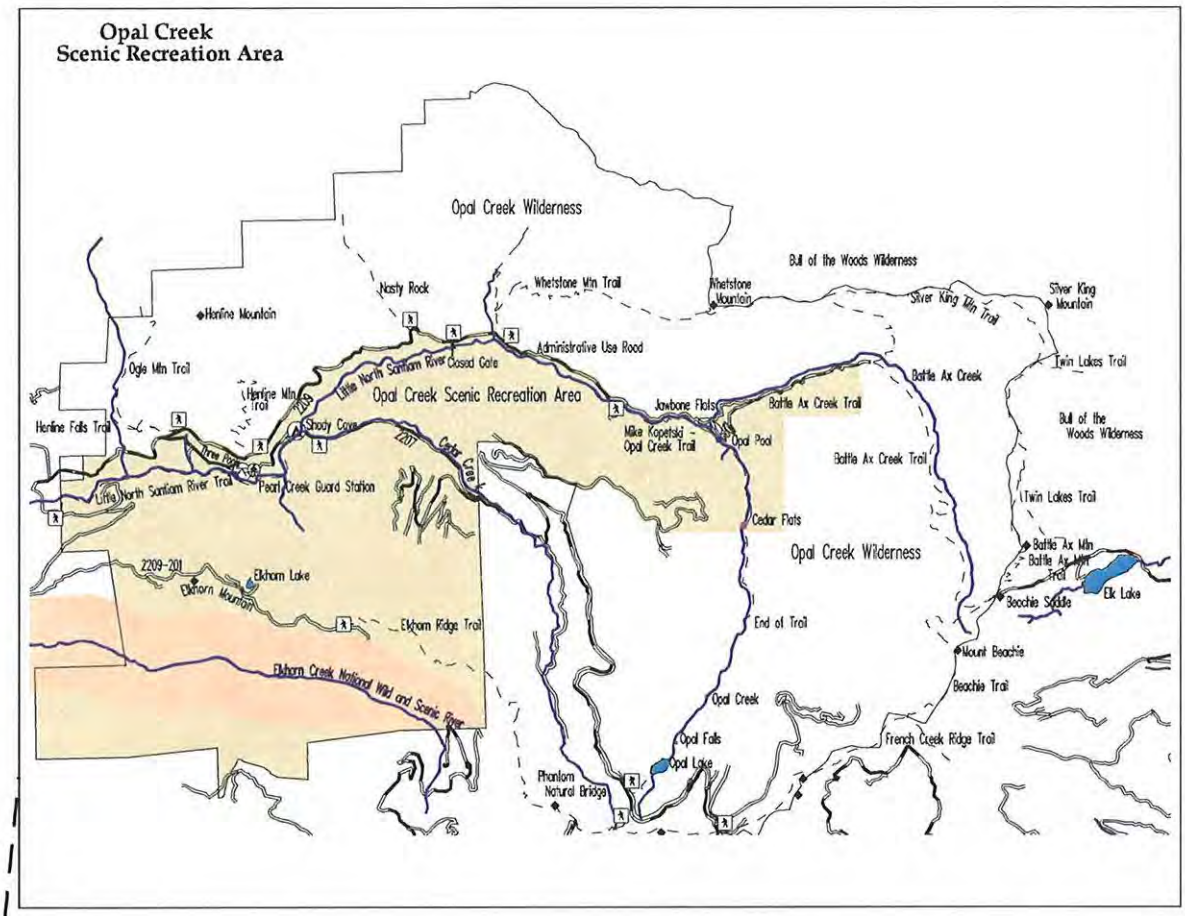
The Western Cascades range is composed almost entirely of volcanic rocks, the remnant of a volcanic range that shifted east to form the High Cascades, which forms the present active Cascade volcanic range. The Western Cascades range is a low elevation eroded volcanic range that runs north-south, parallel to the Pacific coast. The Western Cascades receive 60 to 100 inches of precipitation annually which causes deep weathering of geologic features.

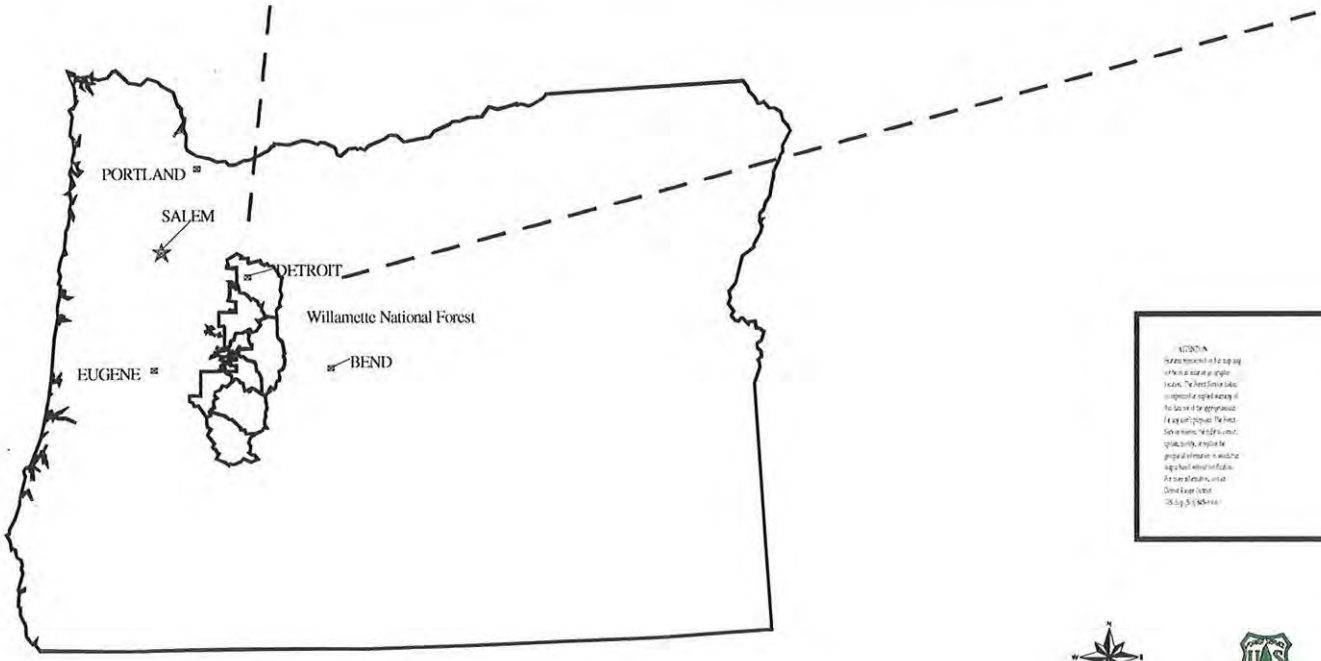
Gold and silver deposits have been found to exist in a 25-30 mile wide, north-south belt in the Western Cascades (Orr et al. 1992). Deposits of lead, zinc, and copper in the forms of pyrite, galena, sphalerite, and chalcopyrite, in addition to gold and silver, are found in this region. These ores are found in either veins or porphyry deposits formed when fractured areas of volcanic rock were invaded by mineral rich hydrothermal solutions at temperatures of 250 to 350 degrees F.

Figure 2-1. Location of the Morning Star Mine Site

Opal Creek Scenic Recreation Area
Vicinity Map

Figure 2-1.





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Weathering processes have deeply eroded the Western Cascades exposing the ore-bearing rocks near the valley floors. The North Santiam mining district, which includes the Morning Star Mine site, contains the most rugged terrain of all the five mining districts of the Cascades. Most of the Morning Star Mine ore produced lead and zinc, although small amounts of gold and silver were also recovered.

2.1.2 HABITAT

A thorough study of the site ecology is not available. Information on the ecological setting is taken from available sources and observations during the 2005 sampling event for the nearby Ruth Mine site.

The mine site is located in an old growth hemlock-dominated montane habitat transitioning into a higher elevation Pacific Silver Fir-dominated habitat (Figure 2-2). Typical vegetation in the western hemlock habitat (NPS 1998) consists of western hemlock (*Tsuga heterophylla*), with a mix of Douglas-fir (*Pseudotsuga menziesii*), western red cedar (*Thuja plicata*), and Pacific yew (*Taxus brevifolius*). Undergrowth is characterized by salal, Oregon grape, and shade-tolerant hemlock and red cedar saplings. Open spaces are characterized by red alder (*Alnus rubra*), bigleaf maple (*Acer macrophylum*), and vine maple (*Acer circinatum*). Small mammals in the hemlock-dominant forest typically include Douglas squirrel (*Tamiasciurus douglasii*) and red tree voles (*Phenacomys longicaudus*).

The Opal Creek Ancient Forest Center, located in Jaw Bone Flats in the Opal Creek Scenic Recreation Area, maintains a list of plant, fish, amphibian, mammal, and invertebrate species that may be present in the area (http://www.opalcreek.org/eco/all-list.html). Threatened and endangered species in the State of Oregon are identified by the Oregon Natural Heritage Center (2004). Of the species identified by the Oregon Natural Heritage Center, the threatened and endangered species that may be present in the habitat of the Opal Creek area are presented in Table 2-1.

Battle Ax Creek provides habitat for aquatic receptors and for organisms that may use the surface water and sediments for foraging. Blue Jay Creek is smaller in size and flows down a steep gradient, and flows underground or under the rock piles in areas of the mine shaft and the waste rock piles. The lack of flow in areas of the creek result in a lack of suitable sediment for biological habitat, and the steep gradient may result in high flows that inhibit deposition or scour deposits.

Figure 2-2. Plant Association Groups in the Opal Creek Area

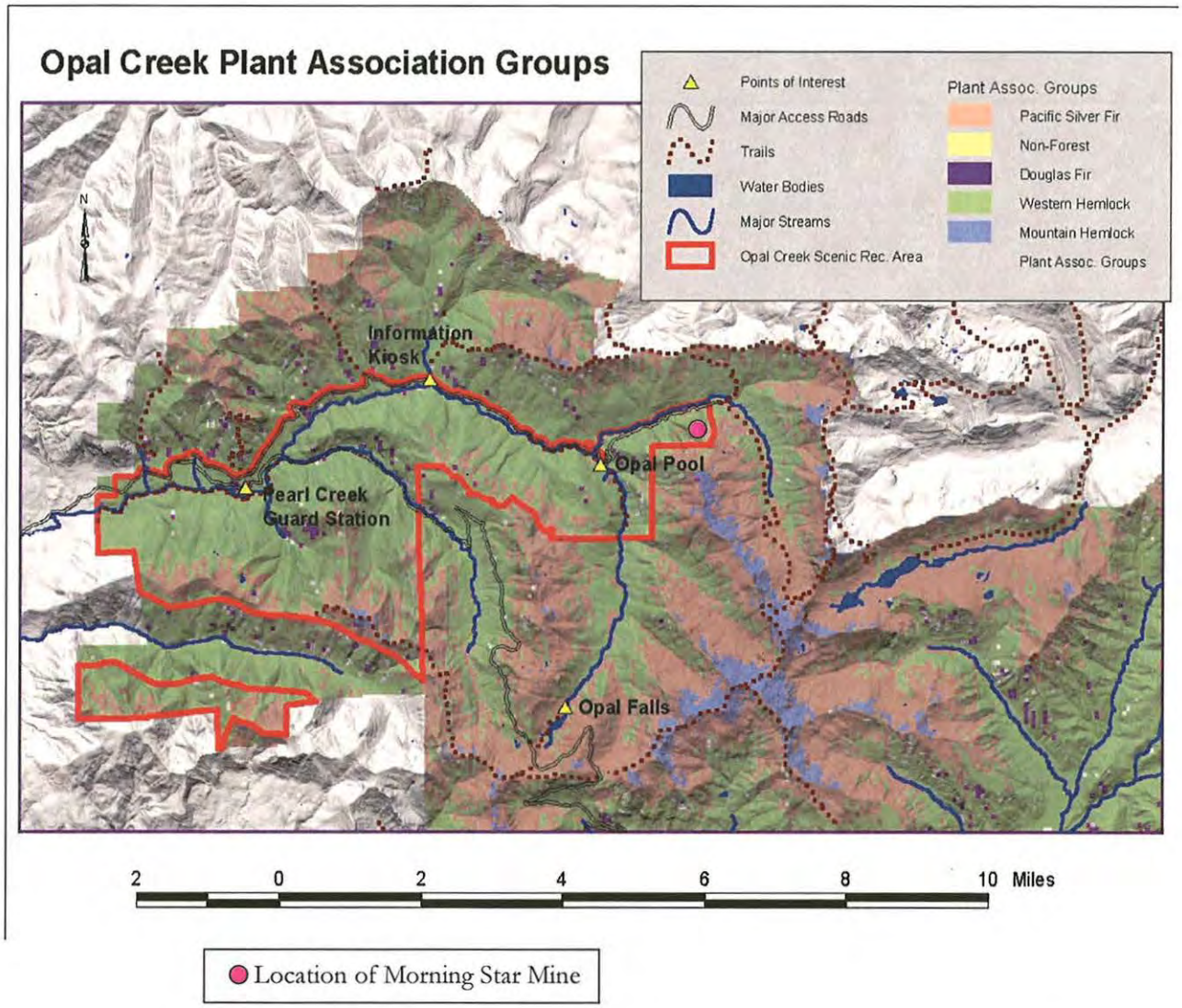


Table 2-1. Threatened and Endangered Species at Opal Creek

AMPHIBIANS			
Common Name	**Scientific Name**	**Federal Status**	**OR State Status**
Salamander, Cascade torrent	Rhyacotriton cascadae		Sensitive
Salamander, Clouded	Aneides ferreus		Sensitive
Salamander, Oregon slender	Batrachoseps wrighti		Sensitive
Frog, Tailed	Ascaphus truei	Species of Concern	Sensitive
Frog, Cascades	Rana cascadae	Species of Concern	Sensitive
Toad, Western	Bufo boreas		Sensitive
BIRDS			
Common Name	**Scientific Name**	**Federal Status**	**OR State Status**
Goshawk, Northern	Accipiter gentilis	Species of Concern	Sensitive
Woodpecker, Black-backed	Picoides arcticus		Sensitive
Nighthawk, Common	Chordeiles minor		Sensitive
Duck, Harlequin	Histrionicus histrionicus	Species of Concern	Sensitive
Quail, Mountain	Oreortyx pictus		Sensitive
Owl, Northern pygmy	Glaucidium gnoma		Sensitive
Owl, Northern spotted	Strix occidentalis caurina	Threatened	Threatened
Woodpecker, Pileated	Dryocopus pileatus		Sensitive
Bluebird, Western	Sialia mexicana		Sensitive
MAMMALS			
Common Name	**Scientific Name**	**Federal Status**	**OR State Status**
Marten, American	Martes americana		Sensitive
Long-eared Bat	Myotis evotis	Species of Concern	Sensitive
Lynx, North American	Lynx canadensis	Threatened	
Wolf, Gray	Canis lupus	Endangered	Endangered
Wolverine	Gulo gulo	Species of Concern	Threatened
FISH			
Common Name	**Scientific Name**	**Federal Status**	**OR State Status**
Salmon, Chinook	Oncorhynchus tshawytscha	Endangered & Threatened	Threatened
Salmon, Steelhead	Oncorhynchus mykiss	Endangered & Threatened	
Trout, Westslope cutthroat	Oncorhynchus clarki lewisi	Species of Concern	
PLANTS			
No plants on the Opal Creek list were found on the Federal or Oregon T&E list			

Lists of species observed at Opal Creek Ancient Forest Center were matched with the federal and Oregon T&E lists.

Sources:

Threatened and Endangered Species List: http://www.pacificbio.org/ESIN/Infopages/Oregonlist.html

Species List for Opal Creek: http://www.opalcreek.org/eco/all-list.html

2.2 Contaminants of Interest (COI)

Chemicals that may adversely affect ecological receptors, including populations of individual organisms and communities, are defined as chemical stressors on the environment. Stressors may also be biological, such as pathogens, or physical. Physical stressors at the mine site include alterations in the habitat such as mine and road construction, waste rock accumulation, removal of canopy cover, stream diversions and bed alterations, and physical blockages to fish movement. Physical barriers to fish movement are present in the Upper North Santiam River, and may impact fish populations in Battle Ax Creek. This risk assessment does not evaluate risk of impacts to ecological receptors due to biological or physical stressors.

The COIs are identified as those metals that were analyzed and detected in environmental media at the site:

- Aluminum
- Antimony
- Arsenic
- Barium
- Beryllium
- Cadmium
- Calcium
- Chromium
- Cobalt
- Copper
- Iron
- Lead
- Magnesium
- Manganese
- Mercury
- Nickel
- Potassium
- Selenium
- Silver
- Sodium
- Thallium
- Vanadium
- Zinc.

2.3 Conceptual Ecological Exposure Model

The conceptual ecological exposure model (CEEM) depicts the sources of contamination, contaminant release and possible transport mechanisms, impacted exposure media, and exposure routes for ecological receptors at the site. A graphical presentation of the CEEM is presented in Figure 2-3.

2.3.1 SOURCES OF CONTAMINATION

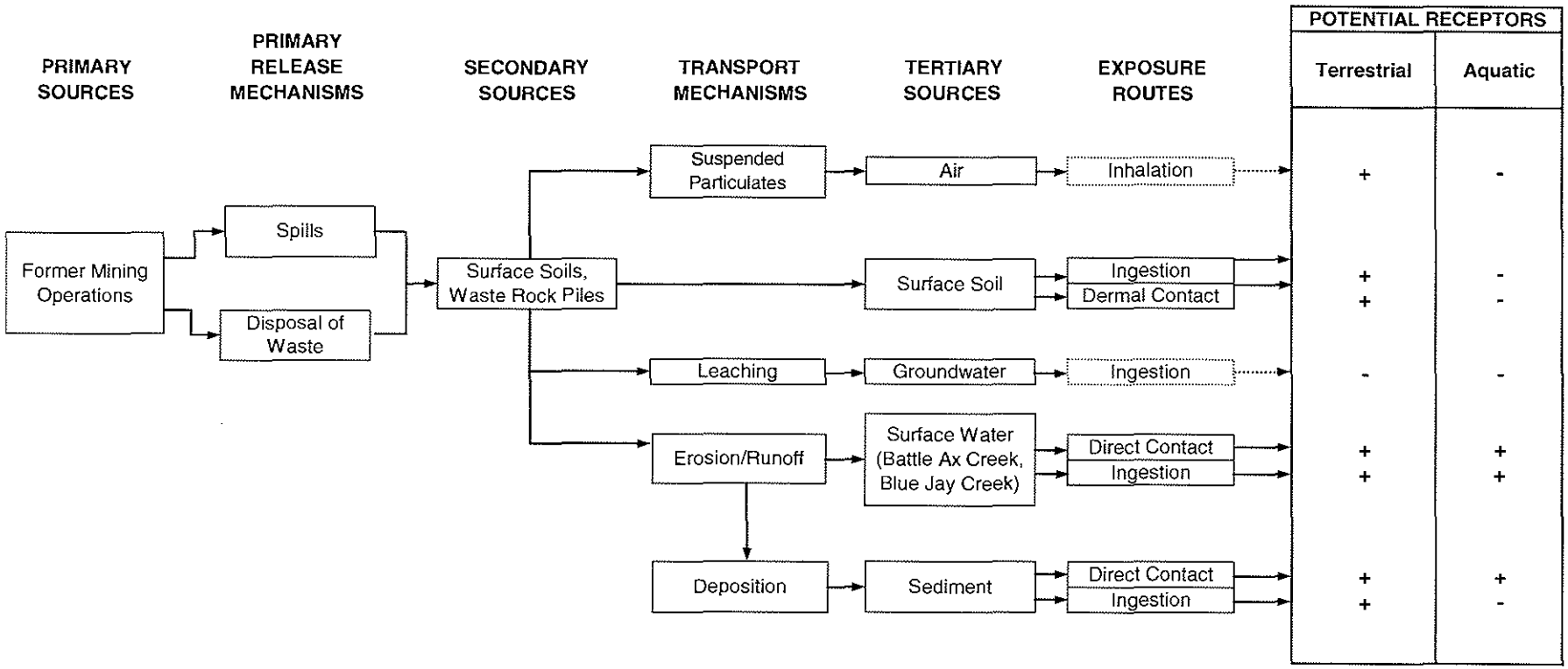
The primary sources of contamination at the site are historical mining activities related to operations of the Morning Star Mine. Ore was brought up from mines, with the adit located near an access road and serving as the primary source of ore wastes, processed to some extent at the site, and waste rock was deposited in the ravine and adjacent to Blue Jay Creek below the adit.

Waste rock from mine activities at the adit is present in Blue Jay Creek, which runs from the adit to Battle Ax Creek. Deposits in Blue Jay Creek are likely to have contributed sedimentary material that washed into Battle Ax Creek. Blue Jay Creek water may have leached metals from the waste rock into surface water and transported dissolved metals to Battle Ax Creek. Over time, rain and snow melt may have transported dissolved metals or waste rock particles, particularly from the area around the adit, down the Blue Jay Creek ravine to Battle Ax Creek. Once in the creeks, contaminated sedimentary particles may deposit or transport downstream. Dissolved metals in the surface water may bind to particulates and deposit in the creek or transport downstream.

2.3.2 ECOLOGICAL RECEPTORS AND EXPOSURE PATHWAYS

Based on the habitat types at the Morning Star Mine site, expected wildlife in that habitat, and the species of wildlife that have been observed at the Opal Creek Ancient Forest Center, ecological receptors of potential concern and their possible site-related exposures are identified in Table 2-2.

Figure 2-3. Conceptual Ecological Exposure Model for the Morning Star Mine Site



Notes:

+ Complete and potentially significant exposure
- Insignificant or incomplete exposure pathway or medium

Table 2-2. Ecological Receptors of Concern and Exposures

Ecological Receptor of Concern	Exposure Media and Pathway
Small mammals	Direct exposure to COIs in waste rock soils, surface water, sediments
	Ingestion of COIs in surface water
	Ingestion of COIs in waste rock soil is considered unlikely since the locations are primarily on existing access road bed or in piles of hard rock and not suitable habitat for small mammals nesting or burrowing.
Terrestrial forbs and grasses	Direct contact and root uptake of waste rock COIs is considered a marginal possibility since most of the waste rock is located on existing access road bed or in piles of hard rock and not suitable habitat for most plants.
Terrestrial trees and shrubs	Root uptake of COIs in waste rock soil may be considered an exposure pathway for trees located near the road bed.
Terrestrial invertebrates	Direct exposure to waste rock soil is considered not of ecological significance since the road bed and hard rock piles are not ideal habitat for soil invertebrates.
Wildlife (birds, mammals)	Birds and mammals may be exposed to COIs in waste rock soil through direct contact, and to COIs in surface water through ingestion. However, because of the extensive habitat in the surrounding landscape for birds and large mammals, the relatively limited amount of site soil habitat that is impacted by waste rock is considered to contribute negligible exposures to wildlife.
	Birds and large mammals may be exposed to bioaccumulative COIs through the ingestion of contaminated food sources, such as plants, invertebrates, or small mammals at the site.
Amphibians	Direct contact with COIs in surface water is considered a likely exposure pathway for Battle Ax Creek. Most of Blue Jay Creek is not considered suitable aquatic habitat due to the steep gradient, high flow rate, intermittent flows, and apparent lack of organic material in much of the sediment that would provide substrate for adequate food sources.
Fish	Fish may be exposed to COIs in surface water and sediment of Battle Ax Creek. Fish barriers are present that prevent fish migration; rainbow trout may be present. Blue Jay Creek is not considered suitable habitat for fish due to the steep gradient, high flow rate, and intermittent flows.
Aquatic invertebrates (benthic and water column)	Aquatic invertebrates may be exposed to COIs in surface water and sediment of Battle Ax Creek. Most of Blue Jay Creek is not considered suitable aquatic habitat due to the steep gradient, high flow rate, intermittent flows, and apparent lack of organic material in much of the sediment.

3 ASSESSMENT ENDPOINTS AND MEASURES OF EFFECT

Assessment endpoints are defined as the explicit expression of an ecological value deemed important to protect, operationally defined by a receptor and one or more of that receptor's measurable attributes (ODEQ 2001). Assessment endpoints link the ecological risk assessment and risk management by highlighting ecological processes that are important to risk managers. Unless an ecological receptor is listed as a Threatened and Endangered (T&E) species, assessment endpoints are selected that are relevant to population-level rather than individual effects. For T&E species, risks to individuals are important to the evaluation.

Assessment endpoints are listed for each receptor of concern in Table 3-1, along with measures of effects and exposures used in the risk assessment. Survival, growth, and reproduction are the key endpoints for ecological receptors in this assessment. Measures of effect and exposure for the screening level II ecological risk assessment under ODEQ (2001) guidelines consist of comparison of the exposure concentrations in various environmental media with the appropriate screening level value (SLV). The SLVs are intended to be protective of the key assessment endpoints. For chemicals for which SLVs are unavailable, surrogate risk-based screening criteria were identified. Ecological receptors, the assessment endpoints, and the environmental media and appropriate SLV types are identified in Table 3-1.

Table 3-1. Assessment Endpoints and Measures of Effect and Exposure

Ecological Receptor of Concern	Assessment Endpoint	Measures of Effect and Exposure
Small mammals	Survival, growth, reproduction	Comparison of waste rock soil exposure concentrations to soil screening criteria for mammals[a]
Terrestrial forbs and grasses	Survival, growth, development	Comparison of waste rock soil exposure concentrations to soil screening criteria for plants
Terrestrial trees and shrubs	Survival, growth, development	Comparison of waste rock soil exposure concentrations to soil screening criteria for plants
Terrestrial invertebrates	Survival, growth, reproduction	Comparison of waste rock soil exposure concentrations to soil screening criteria for invertebrates
Wildlife (birds, large mammals)	Survival, growth, reproduction	Comparison of waste rock soil exposure concentrations to soil screening criteria for birds and mammals Comparison of surface water exposure concentrations to surface water screening criteria for birds and mammals Comparison of sediment exposure concentrations to sediment screening criteria for bioaccumulation in

Ecological Receptor of Concern	Assessment Endpoint	Measures of Effect and Exposure
		wildlife
Amphibians	Survival, growth, reproduction	Comparison of surface water exposure concentrations to surface water screening criteria for aquatic organisms
Fish	Survival, growth, reproduction	Comparison of surface water exposure concentrations to surface water screening criteria for aquatic organisms
Aquatic invertebrates (benthic and water column)	Survival, growth, reproduction	Comparison of surface water exposure concentrations to surface water screening criteria for aquatic organisms Comparison of sediment exposure concentrations to sediment screening criteria for benthic organisms

a. Screening criteria are the SLVs provided by ODEQ (2001).

4 IDENTIFICATION OF CONTAMINANTS OF POTENTIAL ECOLOGICAL CONCERN

Contaminants of potential ecological concern (CPECs) are identified by screening of COIs on the basis of physiochemical properties and their toxicity and bioaccumulation potential (ODEQ 2001). The screening based on physiochemical properties of a COI is performed by consideration of frequency of detection and background concentrations. Screening does not include whether the COI is an essential nutrient.

4.1 INITIAL SCREENING

4.1.1 FREQUENCY OF DETECTION

COIs in each environmental medium were first screened on the basis of frequency of detection. If COIs were not detected above a frequency of five percent, they can be eliminated as a CPEC (ODEQ 2001). Data showing detected concentrations of COIs in each sample in waste rock soils, surface water, sediment, and sediment porewater at the Morning Star Mine site are presented in Attachment B. Surface water and sediment samples consisted of the surface water from the single adit, and surface water and sediment samples from stations in Blue Jay Creek and Battle Ax Creek immediately downstream of the confluence with Blue Jay Creek. Sediment porewater samples were collected from Battle Ax Creek. Surface water and sediment data from Battle Ax Creek stations located upstream of the confluence with Blue Jay Creek and located further downstream near the Ruth Mine drainage were not used in this screen, since they would not be representative of locations of highest exposures from Morning Star mine adit discharges or from surface runoff to Battle Ax Creek.

Results of the frequency screen are shown in Table 4-1. COIs that were screened out from evaluation as CPECs for waste rock soils on the basis of detection frequency consist of beryllium, thallium, and hexavalent chromium. In surface water, all but aluminum, arsenic, barium, calcium, lead, magnesium, manganese, potassium, sodium, and zinc were eliminated as CPECs based on lack of detection in any surface water sample, which included the adit water, Blue Jay Creek surface water, and surface water of Battle Ax Creek. In sediment, antimony, beryllium, selenium, and thallium were never detected in any of the samples, including Blue Jay Creek and Battle Ax Creek sediments. In the single sample of sediment porewater, no heavy metals were detected; detections were limited to calcium, magnesium, manganese, potassium, and sodium.

Table 4-1. Screening of COIs for Detection Frequency

Chemical of Interest (COI)	Frequency of Detection		
	Waste Rock Soil	Surface Water	Sediment
Aluminum	11/11	1/6	4/4
Antimony	8/11	0/6	0/4
Arsenic	11/11	5/8	3/4

Barium	11/11	1/8	4/4
Beryllium	0/11	0/6	0/4
Cadmium	11/11	0/8	3/4
Calcium	11/11	6/6	4/4
Chromium	11/11	0/8	4/4
Cobalt	11/11	0/6	4/4
Copper	11/11	0/8	4/4
Iron	11/11	0/8	4/4
Lead	11/11	6/8	4/4
Magnesium	11/11	6/6	4/4
Manganese	11/11	1/8	4/4
Mercury	11/11	0/8	1/4
Nickel	11/11	0/8	4/4
Potassium	11/11	6/6	4/4
Selenium	6/11	0/8	0/4
Silver	9/11	0/8	1/4
Sodium	3/11	6/6	3/4
Thallium	0/11	0/6	0/4
Vanadium	11/11	0/6	4/4
Zinc	11/11	7/8	4/4
Hex Chromium	0/11	---	---

Surface water stations = All surface water data from adit, Blue Jay Creek, and Battle Ax Creek immediately downstream of confluence
Sediment stations = All sediment data from Blue Jay Creek and Battle Ax Creek immediately downstream of confluence

4.1.2 BACKGROUND CONCENTRATION SCREENING

Following the screen for frequency of detection, COIs were screened against background concentrations. Background concentrations are set at the 95UCL of the mean concentration of background samples, and the maximum concentration in site soil is compared to this background value, as per ODEQ (2001) guidance. Chemicals with maximum concentrations exceeding the 95 UCL of background samples were retained as CPECs for further evaluation.

Background concentrations were identified for COIs in soils, surface water, bulk sediment, and sediment porewater. For soils, background concentrations were determined using data from 20 samples, labeled BG-1 through BG-20 in Table B-1 of Attachment B, which were collected from locations around the Morning Star Mine site and the Ruth Mine site that were not impacted by mining-related activities. Locations of the background soil samples can be found in the Site Inspection report for the Morning Star Mine site. Data and 95 UCL concentrations for the background soil screen are presented in Table B-1, Attachment B, with results of the screen presented below in Table 4-2. Note that although the maximum waste rock soil concentrations of chromium, nickel, and selenium exceed their 95 UCL background concentrations, the 95 UCLs and ranges of values for all three COIs in waste rock soils do not exceed those of background samples, suggesting that chromium, nickel, and selenium concentrations in waste rock soil are not elevated. Nickel was not elevated in Blue Jay Creek sediments, and chromium and selenium were not detected in sediments, and none of them

were detected in any surface water sample (see data tables of Attachment B). For these reasons, chromium, nickel, and selenium are not selected as CPECs for soils.

Table 4-2. Waste Rock Comparison to Soils Background

Chemical of Interest (COI)	Background (95UCL mg/kg)	Maximum Waste Rock (mg/kg)	95 UCL Waste Rock (mg/kg)	Detected > 5% and Exceeds Background?
Aluminum	39,635	34,800	27,039	No
Antimony	1.50	3.90	2.50	**Yes**
Arsenic	9.35	30.0	22.7	**Yes**
Barium	82.1	73.6	49.0	No
Beryllium	---	ND	---	No
Cadmium	16.8	405	234.3	**Yes**
Calcium	2,246	34,300	20,577	**Yes**
Chromium	22.8	24.2	20.2	No
Cobalt	11.5	21.5	18.3	**Yes**
Copper	256	4,040	1,868	**Yes**
Iron	31,706	71,900	49,846	**Yes**
Lead	914	11,700	6,682	**Yes**
Magnesium	5,437	14,100	11,483	**Yes**
Manganese	3,282	7,810	4,818	**Yes**
Mercury	0.12	0.627	0.493	**Yes**
Nickel	22.4	27.0	22.4	No
Potassium	1,128	3,450	2,941	**Yes**
Selenium	1.55	2.11	1.53	No
Silver	3.47	21.9	14.5	**Yes**
Sodium	200.5	190	176.6	No
Thallium	---	ND<1.35	---	No
Vanadium	77.7	50.3	42.0	No
Zinc	13,960	51,900	30,766	**Yes**
Hex Chromium	<1.27	<1.17	---	No

Soil background samples = BG1 through BG20
--- = not calculable due to lack of detections

A set of background samples was collected for surface water and sediment for the Morning Star site. Background surface water and sediment samples were collected in Battle Ax Creek upstream of its confluence with Blue Jay Creek. These sample stations were identified as locations that are not impacted by discharges from the Morning Star Mine site or other mining activities. Locations of the surface water and sediment samples are shown in Figure 4-1. Background surface water stations are identified as SW-8, SW-MS-14, SW-MS-15, and SW-MS-16. Background sediment stations for bulk sediment and sediment porewater are identified as SED-MS-14, SED-MS-15, and SED-MS-16. Surface water total metals, bulk sediment total metals, and sediment porewater dissolved metals data and 95 UCL concentrations are presented in Tables B-2, B-3, and B-4, respectively, of Attachment B.

Comparison of surface water maximum concentrations of COIs passing the detection frequency screen with the background 95UCL concentrations identified aluminum, arsenic, barium, calcium, lead, manganese, potassium, sodium, and zinc as exceeding background for surface water (Table 4-3). In addition, separate comparisons were made for metals detected

in Battle Ax Creek alone, where maximum concentrations of aluminum, arsenic, calcium, lead, manganese, potassium, sodium, and zinc were found to exceed upstream background (Table 4-4).

For bulk sediment in Battle Ax Creek and Blue Jay Creek, the screen against background identified arsenic, cadmium, cobalt, copper, iron, lead, magnesium, manganese, mercury, nickel, potassium, silver, and zinc as exceeding background (Table 4-5). For Battle Ax Creek sediment porewater, no metals or inorganics were found to be elevated above background concentrations. Table 4-6 summarizes the chemicals that pass the detection frequency and background comparison screens for soils, surface water, and bulk sediment at the Morning Star Mine site.

Figure 4-1. Location of Surface Water and Sediment Samples

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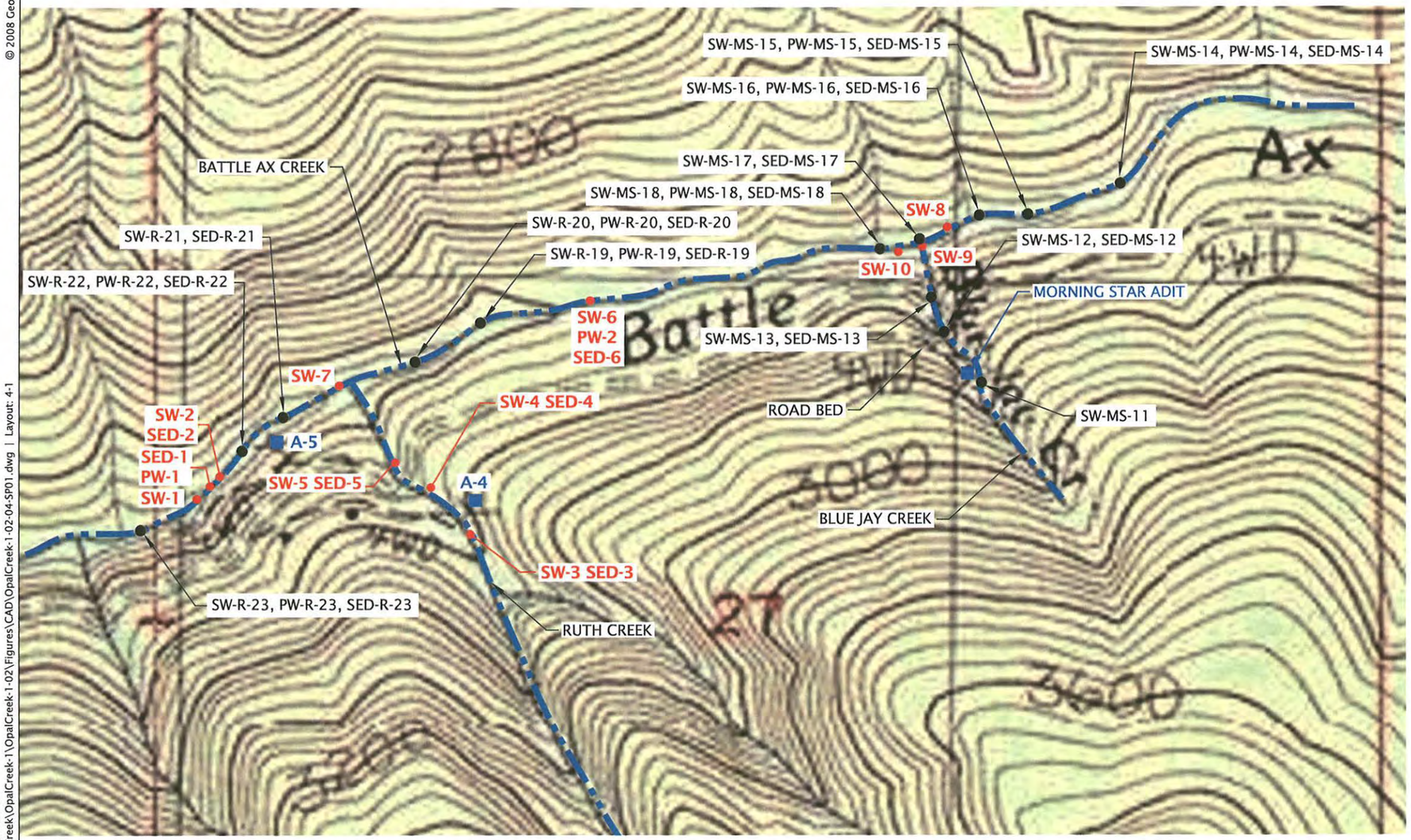

EXPLANATION:

A-4	■	ADIT
SW-1	●	PREVIOUS SAMPLE LOCATION
SW-11	●	SURFACE WATER SAMPLE
PW-14	●	PORE WATER SAMPLE
SED-12	●	SEDIMENT SAMPLE

NOTE:
PREVIOUS WASTE ROCK SAMPLE LOCATIONS NOT SHOWN ON FIGURE.

N

0 500 1000

(SCALE IN APPROXIMATE FEET)

USGS QUADRANGLE MAP
MAP CREATED WITH TOPO!®
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IN-STREAM SAMPLE LOCATIONS

RUTH AND MORNING STAR MINE SITES AT OPAL CREEK
MARION COUNTY, OR

4-1

OPALCREEK-1-02

FEBRUARY 2009

GEODESIGN INC
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File Name: \\chromite\Files\Jobs\M-R\OpalCreek\OpalCreek-1\OpalCreek-1-02\Figures\CAD\OpalCreek-1-02-04-SP01.dwg | Layout: 4-1

Table 4-3. Site-Related Surface Water Comparison to Upstream Background

Chemical of Interest (COI)	Maximum Upstream (mg/L)	Maximum Site-Related (mg/L)	Detected > 5% and Exceeds Background?
Aluminum	ND<0.1	0.101	**Yes**
Antimony	ND<0.001	ND<0.001	No
Arsenic	ND<0.001	0.005	**Yes**
Barium	ND<0.001	0.002	**Yes**
Beryllium	ND<0.001	ND<0.001	No
Cadmium	ND<0.001	ND<0.001	No
Calcium	4.050	12.100	**Yes**
Chromium	ND<0.001	ND<0.001	No
Cobalt	ND<0.002	ND<0.002	No
Copper	ND<0.004	ND<0.004	No
Iron	ND<0.1	ND<0.1	No
Lead	ND<0.001	0.013	**Yes**
Magnesium	0.483	0.481	No
Manganese	ND<0.001	0.005	**Yes**
Mercury	ND<0.0001	ND<0.0001	No
Nickel	ND<0.001	ND<0.001	No
Potassium	0.117	0.240	**Yes**
Selenium	ND<0.001	ND<0.001	No
Silver	ND<0.002	ND<0.002	No
Sodium	1.320	6.870	**Yes**
Thallium	ND<0.001	ND<0.001	No
Vanadium	ND<0.002	ND<0.002	No
Zinc	0.011	0.082	**Yes**

Upstream background = Battle Ax Creek upstream of confluence with Blue Jay Creek (n=3-4)

Site-Related = All data from Adit, Blue Jay Creek, and Battle Ax Creek immediately downstream of confluence (n=6-8)

Table 4-4. Battle Ax Creek Surface Water Comparison to Upstream Background

Chemical of Interest (COI)	Maximum Upstream (mg/L)	Maximum Downstream Battle Ax Creek (mg/L)	Detected > 5% and Exceeds Upstream?
Aluminum	ND<0.1	0.101	**Yes**
Antimony	ND<0.001	ND<0.001	No
Arsenic	ND<0.001	0.001	**Yes**
Barium	ND<0.001	ND<0.001	No
Beryllium	ND<0.001	ND<0.001	No
Cadmium	ND<0.001	ND<0.001	No
Calcium	4.050	5.300	**Yes**
Chromium	ND<0.001	ND<0.001	No
Cobalt	ND<0.002	ND<0.002	No
Copper	ND<0.004	ND<0.004	No

Iron	ND<0.1	ND<0.1	No
Lead	ND<0.001	0.013	**Yes**
Magnesium	0.483	0.481	No
Manganese	ND<0.001	0.005	**Yes**
Mercury	ND<0.0001	ND<0.0001	No
Nickel	ND<0.001	ND<0.001	No
Potassium	0.117	0.137	**Yes**
Selenium	ND<0.001	ND<0.001	No
Silver	ND<0.002	ND<0.002	No
Sodium	1.320	2.340	**Yes**
Thallium	ND<0.001	ND<0.001	No
Vanadium	ND<0.002	ND<0.002	No
Zinc	0.011	0.082	**Yes**

Upstream background = Battle Ax Creek upstream of confluence with Blue Jay Creek (n=3-4)

Downstream = Battle Ax Creek samples immediately downstream of confluence with Blue Jay Creek (n=2-4)

Table 4-5. Screen of Site-Related and Battle Ax Creek Sediment

Chemical of Interest (COI)	Background Upstream of Blue Jay Cr. (95 UCL or max, mg/kg)	Site-Related Maximum (mg/kg)	Downstream Battle Ax Cr. (max, mg/kg)	Detected > 5% and Exceeds Upstream?
Aluminum	24,100	21,600	21,600	No
Antimony	ND<1.32	ND<1.40	ND<1.40	No
Arsenic	1.42	41.40	2.31	**Yes**
Barium	51.6	56.0	56.0	No
Beryllium	ND<2.63	ND<2.8	ND<2.8	No
Cadmium	22	9.86	2.11	**Yes**
Calcium	7,490	7,280	7,280	No
Chromium	22.3	19.3	18.5	No
Cobalt	12.5	16.0	15.7	**Yes**
Copper	24.3	231.0	40.7	**Yes**
Iron	25,000	37,600	35,700	**Yes**
Lead	3.44	1,370	50.8	**Yes**
Magnesium	10,600	15,200	15,200	**Yes**
Manganese	466	2,820	525	**Yes**
Mercury	ND<0.105	0.16	ND<0.112	**Yes**
Nickel	28.7	89.1	89.1	**Yes**
Potassium	844	1,410	860	**Yes**
Selenium	ND<1.32	ND<1.40	ND<1.40	No
Silver	ND<2.63	2.60	ND<2.8	**Yes**
Sodium	445	374	374	No
Thallium	ND<1.32	ND<1.40	ND<1.40	No
Vanadium	43.4	47.2	47.2	No
Zinc	50.5	2,920	608	**Yes**

Upstream = Battle Ax Creek upstream of confluence with Blue Jay Creek (n=3); 95UCL values exceeded max values.

Site-Related = All data from Blue Jay Creek and Battle Ax Creek immediately downstream of confluence (n=4)

Downstream = Battle Ax Creek samples immediately downstream of confluence with Blue Jay Creek (n=2)

Table 4-6. Summary of COIs Passing Detection Frequency and Background Screens, Morning Star Mine Site

Waste Rock Soils	Surface Water – Site-Related Samples	Surface Water - Battle Ax Creek	Sediment	Sediment Porewater
Antimony	Aluminum	Aluminum	Arsenic	(none)
Arsenic	Arsenic	Arsenic	Cadmium	
Cadmium	Barium	Calcium	Cobalt	
Calcium	Calcium	Lead	Copper	
Cobalt	Lead	Manganese	Iron	
Copper	Manganese	Potassium	Lead	
Iron	Potassium	Sodium	Magnesium	
Lead	Sodium	Zinc	Manganese	
Magnesium	Zinc		Mercury	
Manganese			Nickel	
Mercury			Potassium	
Potassium			Silver	
Silver			Zinc	
Zinc				

Surface water site-related samples and sediment samples consist of adit, Blue Jay Creek, and Battle Ax Creek downstream of confluence with Blue Jay Creek

4.2 ENVIRONMENTAL CONCENTRATIONS

Environmental concentrations (ECs) are those concentrations of chemicals in environmental media to which ecological receptors may be exposed. For the Morning Star Mine site, data on concentrations of COIs are available for waste rock soils, and surface waters and sediments of the mine adit, Blue Jay Creek, and Battle Ax Creek. Analytical chemical data to develop ECs for the site were collected during the November 2005 and the October 2008 site sampling events. The November 2005 data consisted of one sample in Battle Ax Creek upstream of the confluence with Blue Jay Creek and two samples immediately downstream of the confluence. All remaining sediment and sediment porewater data and all surface water and waste rock soils data for the Morning Star Mine site were collected during the October 2008 site visit.

For each environmental medium, ECs are developed as the upper 90 percent confidence limit (90UCL) on the mean concentration for each chemical in the site-related samples, following ODEQ (2001) guidance. The 90UCL concentrations are used to quantify exposures with the assumption that they best represent an upper bound of concentrations of COIs that an ecological receptor would contact. 90UCL concentrations are developed for the COIs that passed the detection frequency and background screens, as summarized above in Table 4-6. Concentration data for each sample in all media and 90UCL concentrations for waste rock soils, surface water, and bulk sediment are presented in Attachment B.

The USEPA ProUCL program was used for statistical analyses and to develop the 90UCL concentrations (USEPA 2007). ProUCL 4.0 contains rigorous parametric and nonparametric (including bootstrap methods) statistical methods (instead of simple ad hoc or substitution methods) that can be used on both full data sets without nondetects and for data sets with non

detected concentration (i.e., qualified by the analytical laboratory or data validators as "ND", non-detect). The program uses state-of-the-art parametric (e.g., ROS methods) and nonparametric (Kaplan-Meier method) computation methods for upper confidence limits (UCL) for data sets with non detected concentrations.

The ProUCL program uses both detected and undetected values, and creates interpolated values for non-detects based on the estimated distribution of the detected concentrations. For chemicals with non-detected values, ProUCL fills in a set of concentrations for nondetects that would result in a better estimate of central tendency than other substitution methods (e.g., use of ½ the detection limit for the non-detected value). ProUCL assumes the distribution of the non-detected values based on the distribution of the detected concentrations, and substitutes values for the non-detects based on that assumed distribution. The full dataset, including the substituted concentrations, is then used by ProUCL to identify the underlying distribution of the data set, to estimate upper confidence limits on the mean concentration for various distribution types, and to recommend the most appropriate 95 UCL based on the data distribution. ProUCL does not provide a recommendation for the 90 UCL, so the same statistical test basis that was recommended for the 95 UCL was used to identify the most appropriate 90 UCL. Based on the distribution, each COI in each environmental medium was assigned a normal distribution, a log-normal distribution, a gamma distribution, or an undeterminable distribution by ProUCL, for which non-parametric statistics were used in the UCL determination.

The technical guidance document for the software states that the UCL calculated from datasets with very few (i.e., 6 or less) detected concentrations are not reliable enough for deriving ECs. In this screening ecological risk assessment, ECs for any COPCs with 6 or less detections are not based on the 90 UCL but on the maximum concentration instead. In many instances, particularly for 6 or fewer detected values, the 90UCL was calculated to be higher than the maximum concentration, and the maximum concentration was subsequently used in the risk ratio calculations. Thus, in determining the ECs, none of the UCLs are based on the use of ½ detection limits, and ECs are either the ProUCL-derived value for the 90 UCL or the maximum concentration.

ECs are developed for each COI in each of the environmental media that receptors may contact.

- *Waste Rock Soils* – The EC is based on the 11 waste rock soil samples collected in 2008. Terrestrial plants, invertebrates, birds, and mammals are assumed to be exposed only to waste rock soils for the duration of their soil exposures at the site. Exposures to background soils are not included.
- *Surface Water* – Aquatic organisms, birds, and mammals are assumed to be exposed to all surface waters that were sampled at the site. Surface waters consist of a total of 8 samples: one sample of adit water, one sample in Blue Jay Creek upstream of the adit, two samples from Blue Jay Creek downstream of the adit, one sample in Battle Ax Creek at the confluence with Blue Jay Creek, and one sample from Battle Ax Creek downstream of the confluence, all collected in 2008; and including a sample in Battle Ax Creek at the confluence with Blue Jay Creek, and a second sample from Battle Ax Creek downstream of the confluence, collected in 2005. The EC does not include samples from Battle Ax Creek

upstream of Blue Jay Creek, which consists of four samples that are used as upstream background locations, three of them collected in 2008 and one in 2005. It was assumed that receptors could have equal access to all environmental media at the site; e.g., exposures could occur to waters in Battle Ax Creek downstream of the confluence and with Blue Jay Creek and the adit with equal accessibility. All EC are total metals; data were not collected on dissolved metals.

- *Sediments* – Benthic invertebrates and wildlife are assumed to be exposed to sediment in the same surface waters as for the surface water exposures. Sediment samples consist of two in Blue Jay Creek, one in Battle Ax Creek at the confluence with Blue Jay Creek, and one in Battle Ax Creek downstream of the confluence, all collected in 2008. Porewater data are not further evaluated since no metals were detected above background. The three sediment samples collected in 2008 from Battle Ax Creek upstream of the confluence with Blue Jay Creek are not used to develop the EC, but are used as upstream background locations.

ECs are developed for all chemicals that passed the screening for frequency of detection and for comparison with background. Table 4-7 summarizes the ECs for the COIs at the Morning Star Mine site.

Table 4-7. Environmental Concentrations, Morning Star Mine Site

Chemical of Interest (COI)	Waste Rock Soil 90 UCL Concentration (mg/kg)	Surface Water[a] 90 UCL Concentration (mg/L)	Sediment[b] 90 UCL Concentration (mg/kg)
Aluminum	NA	0.101	NA
Antimony	2.4	NA	NA
Arsenic	21.5	0.002	29.5
Barium	NA	0.002	NA
Cadmium	197.9	NA	7.6
Calcium	18,546	8.26	NA
Cobalt	18.0	NA	15.8
Copper	1,631	NA	187.8
Iron	48,385	NA	36,452
Lead	6,208	0.0052	1,045
Magnesium	11,255	NA	13,732
Manganese	4,543	0.0049	2,187
Mercury	0.47	NA	0.162
Nickel	NA	NA	70.9
Potassium	2,844	0.1790	1,344
Silver	13.7	NA	2.6
Sodium	NA	4.43	NA
Zinc	28,538	0.0532	2,288

NA = not applicable, chemical was either not detected or did not exceed background.
90 UCL = 90% upper confidence limit on the mean concentration
a. Total metals concentrations
b. Bulk sediment

4.3 RISK-BASED SCREENING

Ecological risk-based screening consists of a comparison of ECs with risk-based screening criteria. ECs are identified for each COI in the previous section. Screening criteria are defined by ODEQ (2001) as the SLVs for each environmental medium at the site. The comparison of the ECs with the SLVs comprises a screening based on chemistry and toxicity. The result of the screening is a list of CPECs for each medium at the site that have the potential to pose risks to ecological receptors. The screening accounts for exposure to individual COIs, exposures to multiple COIs within a given media, and exposure to individual or multiple COIs within different media. The SLVs that are used in the comparison are considered applicable to the types of ecological receptors that may be present at the site.

4.3.1 RISK-BASED SCREENING CRITERIA

Screening criteria are provided by ODEQ (2001) as SLVs for soils, surface water, and sediment. SLVs are available for exposures of terrestrial plants, invertebrates, birds, and mammals to soils; aquatic organisms, birds, and mammals to surface waters; benthic invertebrates to bulk sediments, and wildlife that may bioaccumulate COIs from sediments. SLVs are not available from ODEQ for a few COIs, such as antimony, iron, and silver for birds and mammals exposed to soil, and exposure of invertebrates to cobalt in sediment, but also for calcium, magnesium, potassium, and sodium for all environmental media. For those COIs, various sources of criteria were searched in order to identify surrogate values for the missing SLVs. Sources included soil (EcoSSLs) and water screening benchmarks for wildlife developed by USEPA (2005, 2008) and Oak Ridge National Laboratory (Efroymson et al., 1997; Suter and Tsao, 1996; Jones et al., 1997; Sample et al., 1996), and NOAA and Washington Department of Ecology benchmarks for freshwater sediment (MacDonald et al., 2000; Ecology 2003). Surrogate screening values for soil were found as USEPA (2008) EcoSSLs for cobalt and silver for birds, and antimony for soil invertebrates; a surrogate value for cobalt for freshwater sediments was taken from USEPA (2005) Region 5 screening criteria. No other surrogate screening criteria were found for other COIs for which ODEQ SLVs are unavailable.

4.3.2 SCREENING PROCEDURE

The screening procedure consists of the comparison of the ECs for each COI in each environmental medium with their respective SLVs or surrogate criteria for that medium. Results of each step of the screening calculations are displayed in the tables in Attachment A, which follow the format provided in the ODEQ (2001) guidance on Level II screening ecological risk assessment.

For each COI *i* in each medium *j*, a chemical-specific risk ratio is calculated (T_{ij}) as the ratio of the EC to the SLV or surrogate criterion, as per the following equation:

$$T_{ij} = \frac{C_{ij}}{SLV_{ij}}$$

where:

T_{ij}	=	Risk ratio
C_{ij}	=	90UCL in given medium
SLV	=	Screening level value or risk-based criterion.

The individual risk ratio T_{ij} is compared with the receptor designator *Q*, which for soils is defined as Q=1 for listed threatened and endangered species, and Q=5 for non-T&E species, whereas for surface water and sediment, Q=1. The following relationships identify the COI as a CPEC:

- If the individual risk ratio T_{ij} is greater than 5 for soils or greater than 1 for surface water or sediment, the COI is selected as a CPEC
- If T&E species are present and T_{ij} is greater than 1, the COI is selected as a CPEC
- For benthic invertebrates, if T_{ij} is greater than 1, the COI is selected as a CPEC.

Thus, for soil, a risk ratio greater than 5 indicates a potential for ecological risk to that non-T&E receptor type; whereas a risk ratio greater than 1 indicates a potential for ecological risk to the T&E receptor type. For surface water and sediment, a risk ratio greater than 1 indicates a potential for ecological risk to the either T&E receptors or non-T&E receptors. Those COIs for which ecological risks are indicated become the CPECs for that medium at the site. The predicted risks for those CPECs are discussed further in the risk characterization section.

Overall risk (T_j) for each medium *j* was calculated as the sum of the individual chemical risk ratio T_{ij} values. To account for the cumulative risk from multiple COIs in a medium, ODEQ (2001) provides the following equation, whereby if this relationship holds true, the COI is identified as a CPEC, for those receptors and media where $T_{ij} > Q$:

$$T_{ij} / T_j \geq \frac{1}{N_{ij}} xQ$$

where:

T_{ij}	=	Risk ratio for the individual chemical *i* in medium *j*
T_j	=	Sum of risk ratios for medium *j*
N_{ij}	=	Total number of COIs for medium *j*
Q	=	Value of 1 for T&E species for soil and for surface water and sediment, value of 5 for non-T&E species in soil.

To account for COIs detected in multiple media, those detected COIs are selected as CPECs if the sum of the T_{ij} values is greater than Q. To account for potential bioaccumulation through aquatic food chains, ODEQ (2001) provides bioaccumulative SLVs for sediment, in addition to SLVs for freshwater benthos in sediment, for comparison with sediment concentrations.

4.3.3 SCREENING RESULTS

Surface Soil – The waste rock soil screen is shown in Tables A-1A through A-1E of Attachment A. The results of the screen and identification of CPECs for waste rock soil are summarized in Table 4-8 below. Most of the COIs detected in waste rock soils were elevated above background and exceeded one or more of the soil SLVs: cadmium, copper, iron, lead, manganese, selenium, silver, and zinc. Of the COIs detected above background soil levels, antimony, arsenic, calcium, cobalt, magnesium, mercury, and potassium were not selected as CPECs based on the screen. Risks were predicted to terrestrial plants for cadmium, copper, iron, lead, manganese, silver, and zinc; to soil invertebrates for cadmium, copper, iron, lead, manganese, and zinc; to birds for cadmium, copper, lead, and zinc; to protected mammals for cadmium, copper, lead, and zinc; and no chemicals were selected as CPECs for non-protected mammals.

Table 4-8. Waste Rock Soils CPECs, Morning Star Mine Site

Chemical of Interest (COI)	Selected as CPEC?					Highest Risk Ratio
	Plants	Invertebrates	Birds	Non-Protected Mammals	Protected Mammals	
Antimony	No	No	No	No	No	<5
Arsenic	No	No	No	No	No	<5
Cadmium	**Yes**	**Yes**	**Yes**	No	**Yes**	49 (plants)
Calcium	No	No	No	No	No	NA
Cobalt	No	No	No	No	No	<5
Copper	**Yes**	**Yes**	**Yes**	No	**Yes**	33 (inverts)
Iron	**Yes**	**Yes**	No	No	No	4,839 (plants)
Lead	**Yes**	**Yes**	**Yes**	No	**Yes**	388 (birds)
Magnesium	No	No	No	No	No	NA
Manganese	**Yes**	**Yes**	No	No	No	45 (inverts)
Mercury	No	No	No	No	No	<5
Potassium	No	No	No	No	No	NA
Silver	**Yes**	No	No	No	No	7 (plants)
Zinc	**Yes**	**Yes**	**Yes**	No	**Yes**	571 (plants)

Note: Habitat conditions not accounted for in the screening.
NA = SLV not available

Surface Water - The surface water screen for CPECs is shown in Tables A-2A through A-2E in Attachment A; results of the CPEC selection for surface water are summarized in Table 4-9 below. Although the SLVs for surface water are presented for dissolved forms of the metals, the data used for comparison are total metals concentrations in surface waters. Aluminum and lead were identified as CPECs in surface water, based on the exceedance of SLVs for aquatic organisms and for multiple chemical exceedances. Potential risks are not predicted to birds or mammals for surface water exposures to any COIs at the Morning Star Mine site.

Table 4-9. Surface Water CPECs, Morning Star Mine Site

Chemical of Interest (COI)	Selected as CPEC?				
	Aquatic	Risk Ratio	Birds	Non-Protected Mammals	Protected Mammals
Aluminum	**Yes**	1.2	No	No	No
Arsenic	No	<1	No	No	No
Barium	No	<1	No	No	No
Calcium	No	<1	No	No	No
Lead	**Yes**	2.1	No	No	No
Manganese	No	<1	No	No	No
Potassium	No	<1	No	No	No
Sodium	No	<1	No	No	No
Zinc	No	<1	No	No	No

Note: Habitat conditions not accounted for in the screening.

Sediment - The sediment screen for CPECs in bulk sediment is shown in Tables A-3A and A-3B in Attachment A; results of the CPEC selection for sediment are summarized in Table 4-10 below. Many COIs were detected in sediment and selected as CPECs for sediment benthos: arsenic, cadmium, copper, lead, manganese, nickel, and zinc; and arsenic, cadmium, copper, lead, and zinc based on potential bioaccumulation in wildlife.

Table 4-10. Sediment CPECs, Morning Star Mine Site

Chemical of Interest (COI)	Selected as CPEC for sediment?			
	Freshwater Sediment Benthos	Risk Ratio	Wildlife Bioaccumulation	Risk Ratio
Arsenic	**Yes**	4.9	**Yes**	7.4
Cadmium	**Yes**	12.7	**Yes**	2,539
Cobalt	No	<1	No	NA
Copper	**Yes**	5.2	**Yes**	19
Iron	No	<1	No	NA
Lead	**Yes**	29.9	**Yes**	8.2
Magnesium	No	NA	No	NA
Manganese	**Yes**	2.0	No	NA
Mercury	No	<1	No	NA
Nickel	**Yes**	3.9	No	<1
Potassium	No	NA	No	NA
Silver	No	<1	No	NA
Zinc	**Yes**	18.6	**Yes**	763

NA = SLV not available

Many of the CPECs showed only slight exceedances of their SLVs whereas others showed much higher elevations, as can be seen with the individual risk ratios in the above Tables 4-8, 4-9, and 4-10. Those CPECs showing the highest exceedances for each of the environmental

media are identified as the chemicals with the highest potential for ecological risks at the site. In summary, the following CPECs showed the highest potential risks to ecological receptors at the Morning Star Mine Site, based on individual risk ratios:

Waste rock soils

- *Plants* - iron, lead, and zinc
- *Invertebrates* - iron and zinc
- *Birds* - lead and zinc
- *Mammals* - cadmium, copper, lead, and zinc.

Surface waters – aluminum and lead for aquatic species; no CPECs and no risks are predicted for birds or mammals.

Sediment – cadmium, lead, and zinc for freshwater benthos and potential risks to wildlife through bioaccumulation.

5 RISK CHARACTERIZATION

Risk characterization is the step that describes the screening risk results that were calculated in the previous section, and includes an uncertainty analysis. The predicted risks are described in context of the exposure media, the receptor types present at the site, and the conservativeness of the risk screening procedure, and gives a general idea of the likelihood of actual risk. Uncertainties in parameter values and assumptions associated with the screening process are discussed, including their impact on whether risks may be under-estimated or over-estimated.

5.1 RISK DESCRIPTION

5.1.1 WASTE ROCK SOIL

Numerous metals are identified as CPECs for potential risks to plants, invertebrates, and birds that may be exposed to waste rock soil at the site. Most of the metals in waste rock soil exceeded the background levels, as determined by comparison of the waste rock soil maximum concentrations with the 95 UCL for the 20 background soil samples that were located in areas removed from impacts of activities at the mine site or other known local anthropogenic influences. Note that almost all of the background concentrations of metals in soils also exceed the lowest of the four soil SLVs, as listed in Table 5-1. The exceedance of soil screening criteria by background concentrations suggests that a simple exceedance of a Level II SLV by a waste rock soil chemical may not necessarily indicate a high level of risk to ecological receptors, since they are exposed to levels of metals in the background soils of the site that may also indicate a risk. This comparison indicates that many of the Level II SLVs are lower than the natural levels of these metals in the soils of the environs where the Morning Star Mine is located.

Table 5-1. Background Soil Exceedances of Lowest Level II SLV

CPEC for Waste Rock Soil	Maximum Background Concentration Exceed Level II?	95 UCL Background Concentration Exceed Level II?
Arsenic	**Yes**	No
Cadmium	**Yes**	**Yes**
Copper	**Yes**	**Yes**
Iron	**Yes**	**Yes**
Lead	**Yes**	**Yes**
Manganese	**Yes**	**Yes**
Mercury	**Yes**	**Yes**
Silver	**Yes**	**Yes**
Zinc	**Yes**	**Yes**

The ranges of background soil concentrations for most metals were very wide, and particularly for lead and zinc, they spanned two to three orders of magnitude (see Table B.1, Attachment B). The high concentrations of metals in background soils relative to soil SLVs and the wide range of concentrations reflect discrete locations of highly mineralized soils in

the general area where the site is located. This characteristic may be considered typical of the enriched veins of metals found in the Western Cascade mining districts. The highest elevated concentrations in waste rock soils, and consequent highest risk ratios, are consistently associated with lead and zinc, which were the primary metals mined at the site. How much of a risk the elevated metals in the waste rock soils pose to receptors that may also be exposed to naturally high levels of metals in the surrounding environment is unknown. Nonetheless, the concentrations of many waste rock soil metals are substantially higher than the background soils, up to 10-times higher for cadmium, copper, and lead based on maximum concentrations. These high concentrations are identified as posing potential ecological risks to soil receptors based on their individual risk ratios.

The locations of the waste rock soil samples were selected to characterize the areas of the site where waste rock was deposited, which consisted of areas in the vicinity and downgradient of the mine shaft area of operation. The area of the waste rock soils is not large, and not larger than foraging ranges of small mammals and birds that may frequent the site (assumed to be about one acre for shrews and two acres for robin fledglings [USEPA 1993], for which the Level II SLVs for mammals and birds are applicable). Small mammals and birds would not be expected to spend a substantial amount of foraging time on the waste rocks due to lack of food resources or suitable burrowing material. Similarly, the presence of substantial rock would likely minimize the quality of habitat for plants or invertebrates, including their use as food sources.

Waste rock piles do not present high quality habitat for plants or invertebrates due to the presence of hard surface and minimal organic material. Small mammals could use rock piles as habitat and could be at risk from exposure at the piles; however the bioavailability of the waste rock metals to small mammals is uncertain, and the extent of the exposure would be limited to the area of the pile. As mentioned above, the lack of vegetation and food resources in the waste rock piles would limit exposures of small mammals to waste rock metals.

5.1.2 SURFACE WATER

Aluminum and lead in surface water were found to pose potential ecological risks to aquatic receptors only; no potential risks were predicted for plants or animals due to exposure to surface water. Although the SLVs are presented for dissolved forms of the metals, the comparisons were made using data on total metals in surface water rather than dissolved forms. The concentrations of the dissolved forms of aluminum and lead in surface waters of the site would not be greater than the concentrations of totals, and would likely be lower. Total aluminum was detected in only a single surface water sample located at the confluence of Blue Jay Creek and Battle Ax Creek, at a concentration barely above detection limits. Aluminum was not detected in samples from Blue Jay Creek or the adit of Morning Star Mine. Because of this single detection at a low concentration, and that the detection was of total aluminum, the potential risks from aluminum to aquatic organisms at the site are uncertain and probably a low level of concern.

Lead was detected in site-related surface waters but not detected in background surface water locations. Lead in surface water at the site was calculated to possibly pose a risk to aquatic

receptors, but not to plants or animals that may use the surface water. However, only a single lead sample in Battle Ax Creek at the confluence with Blue Jay Creek was found to drive the risk ratio; lead concentrations within the adit water and surface water samples of Blue Jay Creek and Battle Ax Creek were either below or very close to the Level II SLV. In addition, the concentration of lead was for total lead rather than dissolved form of the metal; the concentration of dissolved lead may be lower than the value used in the comparison with the aquatic receptor SLV. These results suggest that the remaining sample locations would not pose risks to aquatic receptors due to lead levels, and that the potential risk associated with the single elevated lead concentration entails high uncertainty and is likely of low concern.

5.1.3 SEDIMENT

Cadmium, lead, and zinc showed the highest exceedances of sediment SLVs in site-related sediment. Because sediment benthos would generally be exposed to localized concentrations of CPECs, they are also evaluated on a single station basis. Exceedances of sediment SLVs were greatest at Stations SED-MS-12 and SED-MS-13 both located downstream of the adit in Blue Jay Creek (see Table B-3). Station SED-MS-12 is located closest to the adit, and Station SED-MS-13 is located approximately half way down Blue Jay Creek toward the confluence with Battle Ax Creek. Station SED-MS-17 is located in Battle Ax Creek at the confluence with Blue Jay Creek and showed lower concentrations of metals than the two stations in Blue Jay Creek. Station SED-MS-18, located in Battle Ax Creek further downstream of the confluence showed concentrations lower than those in SED-MS-17 at the confluence, and approached the concentrations of the background stations located in Battle Ax Creek upstream of the confluence (Stations SED-MS-14, SED-MS-15, and SED-MS-16).

The highest exceedances of freshwater benthos SLVs in Station SED-MS-12 for lead and zinc were 40 to 20 times the SLV, respectively. The greatest sediment SLV exceedances in Blue Jay Creek were for wildlife bioaccumulation, for cadmium and zinc. The exceedances of SLVs for cadmium, lead, and zinc suggest that the sediment could pose risks to organisms if they used it for food sources. However, the habitat of Blue Jay Creek is of poor quality as a food source because of the lack of sufficient sedimentary material and organic material over the hard rock substrate, and the lack of surface flow in the area of the waste rock pile.

The sediment stations in Battle Ax Creek showed exceedances of the SLV for several metals, but in contrast to Blue Jay Creek sediment, they were all less than 5-fold above the SLV, with zinc showing the highest exceedance in Station SED-MS-17, located at the confluence with Blue Jay Creek. The likelihood that this exceedance of sediment SLVs would adversely affect benthic receptors is unknown given the naturally enriched metals concentrations in local soils, which would serve as a major contributing source to the general sediment load in Battle Ax Creek. At Station SED-MS-18, located in Battle Ax Creek downstream of the confluence, lead and zinc concentrations in sediment are just slightly above background concentrations, and do not exceed sediment SLVs. These results suggest a potential risk to sediment benthos only at the station located in Battle Ax Creek at the confluence with Blue Jay Creek, which receives drainage from the Morning Star Mine. The evaluation of macroinvertebrates in sediment of Battle Ax Creek, summarized below, suggest that the potential risk to macroinvertebrates is highly uncertain.

5.1.4 MACROINVERTEBRATE EVALUATION

An evaluation of macroinvertebrates in Battle Ax Creek was performed with data collected during the October 2008 site visit. The evaluation of stream bed macroinvertebrates in Battle Ax Creek provides a more direct assessment of the biological community in the creek sediments than does a comparison of sediment chemical concentrations with screening criteria such as the SLVs. The use of SLVs in the screening procedure is designed partly to determine a potential for risk based on potential toxicity to macroinvertebrates and consequent effects on the community or population of the macroinvertebrates. The evaluation of the macroinvertebrate community provides a more direct evaluation of the impacts of sediment chemicals on that community. Macroinvertebrates are fairly stationary, easy to collect, and are responsive to human disturbance. In addition, the relative sensitivity or tolerance of many macroinvertebrates to stream conditions is well known. For these reasons, USEPA (1990) recommends their evaluation in an assessment of ecological integrity of streams.

The evaluation of stream macroinvertebrates in Battle Ax Creek followed the macroinvertebrate bioassessment protocol of the Oregon Plan for Salmon and Watersheds (OPSW 1999). The protocol was adapted from the USEPA Rapid Bioassessment Protocols (Barbour 1999) for use in the state of Oregon. The OPSW protocol provides three levels of evaluation; for Battle Ax Creek, Level 3 was followed. The evaluation is described in detail in Attachment C. The results of the evaluation are summarized herein.

Macroinvertebrate stations were selected in Battle Ax Creek to characterize the sediment biological integrity upstream and downstream of the Morning Star Mine drainage, which is carried by Blue Jay Creek as it flows past the Morning Star Mine adit. Stations BI-MS-14 Pool, BI-MS-15 Riffle, BI-MS-16 Pool are located in Battle Ax Creek upstream of the confluence with Blue Jay Creek, and station BI-MS-18 Riffle is located approximately 100 feet downstream of the confluence. Macroinvertebrate collection stations are shown on a map in Figure C-1.

The OPSW scores provide an indication of the level of impairment of the macroinvertebrate community. Impairment levels are identified as *No Impairment, Slight Impairment, Moderate Impairment, and Severe Impairment.* Total abundances and species diversities of macroinvertebrate communities in two of the three upstream stations BI-MS-14 Pool and BI-MS-16 Pool were very similar, and results of the OPSW scoring for both stations were *No Impairment* as would be expected for upstream background stations with no contamination. For station BI-MS-15 Riffle, the abundance was slightly lower than the other two stations and the metrics scores were slightly lower, resulting in an evaluation of *Slight Impairment.* However, the remaining biological indices for station BI-MS-15 Riffle were not largely different from those for the other two upstream stations. In addition, concentrations of metals in sediments of the three upstream stations were all very similar (see stations MS-14, MS-15, and MS-16 in Table B-3 of Attachment B). The reasons for the lower metric scores at BI-MS-15 Riffle may be due to the lower abundance of macroinvertebrates. The reason for the lower abundance is unknown, but may be an artifact of the cobble substrate that characterized sample locations in Battle Ax Creek.

The single downstream station in Battle Ax Creek (BI-MS-18 Riffle) did not show any differences from the upstream stations with regards to any of the OPSW metrics. The metric evaluation resulted in *No Impairment*. Results of the scoring suggest that the macroinvertebrate community of the downstream station BI-MS-18 Riffle BI-1 is not impaired and is similar in benthic macroinvertebrate community structure to the upstream stations.

Each of the macroinvertebrate stations was also evaluated relative to metals concentrations in the sediment of the station. The relationships between the OPSW scores and the metals concentrations of sediments of the three upstream stations and the single downstream benthic macroinvertebrate station were examined by graphically comparing the scores with sediment metals data for each station. The evaluation demonstrated the lack of influence of the sediment metals on the OPSW scores. Many of the metals concentrations in the downstream station, as well as some upstream stations, exceeded their Level II SLV, whereas the OPSW scores for the stations indicated *No Impairment* to the benthic community. This lack of relationship between sediment metals concentrations and level of macroinvertebrate community impairment further supports a lack of impacts to the benthic community in the sediments of Battle Ax Creek due to Morning Star Mine drainage.

The lack of impacts to the benthic community in the downstream station despite elevated concentrations of sediment metals suggests that the metals are very limited in bioavailability to the benthic organisms. The Level II SLVs do not account for the bioavailability of lead or zinc in the hard rock particles that make up the sediments of Battle Ax Creek, and their application to predicting potential risks to sediment macroinvertebrates in Battle Ax Creek entails high uncertainty.

5.2 UNCERTAINTY ANALYSIS

This section discusses some of the uncertainties in the Level II screening ecological risk assessment described above. Some uncertainties are specific to the site conditions and some are inherent to the risk assessment process. An analysis of uncertainties provides the risk managers with information on the limitations and interpretation of the risk estimates and potential exposures for use in future decision making.

5.2.1 SAMPLING AND ANALYSIS

The sampling approach for the Morning Star Mine site was a focused design, with sampling of waste rock soils and surface waters located in areas of suspected contamination and in areas identified as background to the site. The data used to quantify exposures consist of the focused sample locations and are not considered representative of average exposures to ecological receptors or wildlife that may reside or forage at the site. For example, only samples from the waste rock soils were used to quantify the soil exposure pathways; data on lower contaminated soils in the area were not used. For wildlife such as birds and large mammals, foraging areas would be larger than the focused sampling of waste rock soils, and average exposures would typically result from movement throughout the site, with a mix of exposures to both contaminated and uncontaminated soils and waters.

Focusing on samples with high contamination, such as soils that consist of waste rock, results in exposure concentrations and subsequent risk ratios to be overestimated compared to actual exposures encountered by random movement of mobile ecological receptors through the area.

5.2.2 EXPOSURE CONCENTRATIONS

Estimates of exposure to metals at the mine site were based on a limited number of samples to represent the various exposure media. For the waste rock soils, 11 samples were used to develop exposure concentrations; for surface water and sediment only eight and four samples were available, respectively. Use of a low number of samples in the development of exposure concentrations typically results in highly skewed data sets and high upper confidence limits on the mean values, frequently close to or exceeding the maximum concentration. With the use of gamma distribution statistics, a 90UCL was calculable for the EC for all waste rock soil, surface water, and sediment samples regardless of the low number or the skewness of the data. However, due a large number of non-detects in upstream background surface water and sediment samples, 90UCL values exceeded maximum concentrations for all of the COIs that have ODEQ screening levels. Maximum concentrations were used for evaluation of surface waters, which would over-estimate actual long term average exposures to ecological receptors that may be exposed to the surface water.

Combining data from different types of environmental sources into a single EC for an environmental medium may also over-estimate overall risks. For example, combining surface water data from Blue Jay Creek that may not present suitable habitat for aquatic organisms with data from Battle Ax Creek that does present suitable habitat may lead to imprecision in the risk ratios for aquatic organisms. Evaluation of the specific locations where exceedances of SLVs were observed, particularly for Blue Jay Creek, helps to place these exceedances in perspective with actual habitats and receptor types that may be exposed.

Lead in surface water at the site was calculated to possibly pose a risk to aquatic receptors, but not to plants or animals that may use the surface water. However, only a single lead sample in Battle Ax Creek at the confluence with Blue Jay Creek was found to drive the risk ratio for lead; lead concentrations within the adit water and surface water samples of Blue Jay Creek and Battle Ax Creek were either below or very close to the Level II SLV. These results suggest that the remaining sample locations would not pose risks to aquatic receptors due to lead levels, and that the potential risks to aquatic receptors associated with the single elevated lead concentration entail high uncertainty.

5.2.3 TOXICOLOGY

The Level II SLVs are derived from a mix of sources identified in ODEQ (2001). The various sources present a variety of criteria that have been developed following differing methodologies. Many of the criteria are based on observed no-effect-levels in laboratory studies on organisms and do not present levels where low frequency of effects might occur. Low frequency of effects on reproduction and survival of organisms in a laboratory-based test system may be adequately protective of populations and communities of the organisms in the field. For this reason, the Level II SLVs as based on no-effects levels are considered to be substantially conservative for the protection of populations and communities.

The Level II SLVs are also not based on toxicity data or effects that are specific to the site or to the conditions at the site, although they have been generated, reviewed, and accepted by various regulatory agencies. As befitting their use to screen for potential ecological risks, the SLVs are considered to be conservative and to not under-protect ecological receptors in contaminated environments. The resultant risk ratios are best used to identify potential ecological risks, as per ODEQ guidance, rather than to represent site-specific estimates of risk or impacted ecological communities or populations. The use of site-specific toxicity tests with media collected from the site and organisms that are ecologically relevant for the site habitat would reduce uncertainties in the risk estimates. The performance of macroinvertebrate community analyses also provides a more site-specific evaluation of whether sediment benthic organisms display impacts of exposure to toxic chemicals in the sediment.

The SLVs for bioaccumulative compounds and for wildlife are based on the assumption that a certain amount of chemical in the soil, water, or sediment will be transferred to relevant food sources at the site. The SLVs do not take into account the differences between the conditions under which the bioaccumulation tests and screening values were developed and the conditions of the site that may govern site-specific bioaccumulation. These differences entail uncertainty, and the bioaccumulation assumed in the SLVs likely over-estimates actual bioaccumulation of site-related metals.

5.2.4 MACROINVERTEBRATE ANALYSIS

The macroinvertebrate analysis was performed for one sediment station located in Battle Ax Creek downstream of the confluence with Blue Jay Creek (station BI-MS-18 Riffle). Use of the results of a single station to evaluate potential ecological risks to a local population has high uncertainty. Insufficient sediment material at other sample locations prevented a more thorough macroinvertebrate evaluation. Sediments located at the confluence with Blue Jay Creek showed the highest metals concentrations in Battle Ax Creek, yet insufficient material was available for the macroinvertebrate evaluation.

The lack of impacts to the benthic community in the downstream station despite elevated concentrations of sediment metals suggests that the metals are very limited in bioavailability to the benthic organisms. The Level II SLVs do not account for the bioavailability of lead or zinc in the hard rock particles that make up the sediments of Battle Ax Creek, and their application to predicting potential risks to sediment macroinvertebrates in Battle Ax Creek entails high uncertainty.

The apparent lack of bioavailability of metals from the hard rock sedimentary material is further evidenced by the porewater data. Porewater data are available for the downstream sediment station BI-MS-18 Riffle and the three upstream background stations, presented in Table B-4 of Attachment B. The data show a lack of detection of lead and zinc in the porewater sample of the downstream station. The sediment at station BI-MS-18 Riffle had higher concentrations of lead and zinc than sediments in the upstream background stations. The lack of detection of the metals in porewater is consistent with low releases from the sedimentary material, resulting in low availability of dissolved metals in porewater for uptake by biological organisms present in the sediment.

6 CONCLUSIONS

Based on the Level II screening ecological risk assessment for the Morning Star Mine site, waste rock soils are identified to pose a potential risk to plants and invertebrates that grow or reside in the soils due to the elevated levels of metals, particularly cadmium, copper, lead, and zinc. However, the waste rock soils do not present high quality habitat for plants or invertebrates due to their substrate condition as hard rock piles. Potential risks are also identified for birds and protected mammals, however, due to the lack of suitable habitat, mammals are unlikely to use the waste rock soils in the road bed for burrowing or for much food resource. The hard rock piles could present habitat for small mammals but the surrounding terrain presents much higher quality habitat and reliable food sources than the hard rock piles. It would be expected that small mammals would not use the waste rock soils to much extent. The hard rock piles also present poor quality habitat or food sources to birds or larger mammals, and they would be expected to have minimal exposures to the CPECs in the waste rock soils.

Aluminum and lead were identified as CPECs for surface waters at the site. Aluminum exceedance of the Level II SLV was found at a single station and did not appear to be related to surface water in the drainage of the mine. Lead exceedance was only found in the adit water; none of the surface water concentrations in either Blue Jay Creek or Battle Ax Creek exceeded Level II SLVs, and potential ecological risks are not predicted for those surface waters.

Seven CPECs were identified for sediment in Blue Jay Creek and Battle Ax Creek, with the highest exceedances of SLVs found for cadmium, lead, and zinc in Blue Jay Creek sediment. Blue Jay Creek sediment is unlikely to present a suitable habitat for freshwater sediment invertebrates due to the very small amount of sediment observed in the creek and the intermittent flow. Cadmium, copper, lead, and zinc are also identified as CPECs for the sediment stations of Battle Ax Creek downstream of the confluence with Blue Jay Creek. These metals may pose a potential risk to sediment invertebrates of Battle Ax Creek, because of the level of exceedance of SLVs. Cadmium and zinc exceeded the wildlife bioaccumulation SLV by about 600 and 200-fold, respectively.

In contrast to predictions of the sediment screening evaluation, the macroinvertebrate evaluation demonstrated that sediments in Battle Ax Creek downstream of the confluence with Blue Jay Creek did not show community impairment, despite the exceedances of the SLVs. These results suggest that the sediment metals are not sufficiently bioavailable to result in impacts or risks to ecological receptors at the Morning Star Mine site. The lack of bioavailability of metals in sediments at the site may be related to the hard rock matrix and natural source of the sedimentary material in which the metals are contained.

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ATTACHMENT A – RISK RATIO CALCULATION TABLES

Table A-1A. Waste Rock Soil Screen, Morning Star Mine Site

Chemical of Interest (COI)	90 UCL Concentration (mg/kg)	Maximum Detected Concentration (mg/kg)	Screening Level Value			
			Plants (mg/kg)	Invertebrates (mg/kg)	Birds (mg/kg)	Mammals (mg/kg)
Antimony	2.4	3.9	5	78	NA	15
Arsenic	21.5	30.0	10	60	10	29
Cadmium	197.9	405	4	20	6	125
Calcium	18,546	34,300	NA	NA	NA	NA
Cobalt	18.0	21.5	20	1000	120	150
Copper	1,631	4,040	100	50	190	390
Iron	48,385	71,900	10	200	NA	NA
Lead	6,208	11,700	50	500	16	4000
Magnesium	11,255	14,100	NA	NA	NA	NA
Manganese	4,543	7,810	500	100	4125	11000
Mercury	0.47	0.63	0.3	0.1	1.5	73
Potassium	2,844	3,450	NA	NA	NA	NA
Silver	13.7	21.9	2	50	4.2	NA
Zinc	28,538	51,900	50	200	60	20000

Samples consist of all waste rock samples on-site (N=11).

90 UCL concentrations determined with ProUCL program (USEPA 2007)

COIs selected by screening for frequency of detection and comparison with site-related background.

Antimony screening criterion for invertebrates = EcoSSL (USEPA 2008)

Cobalt screening criterion for birds = EcoSSL (USEPA 2008)

Silver screening criterion for birds = EcoSSL (USEPA 2008)

Table A-1B. Waste Rock Soil Screen, Morning Star Mine Site

Chemical of Interest (COI)	COI Risk Ratio			
	Plants (Tij)	Invertebrates (Tij)	Birds (Tij)	Mammals (Tij)
Antimony	0.5	0.03	NA	0.2
Arsenic	2.2	0.4	2.2	0.7
Cadmium	49	10	33	1.6
Calcium	NA	NA	NA	NA
Cobalt	0.9	0.018	0.150	0.1
Copper	16	33	8.6	4.2
Iron	4,839	242	NA	NA
Lead	124	12	388	1.6
Magnesium	NA	NA	NA	NA
Manganese	9.1	45.4	1.1	0.4
Mercury	1.6	4.7	0.3	0.01
Potassium	NA	NA	NA	NA
Silver	6.8	0.3	3	NA
Zinc	571	143	476	1.4
Sum of Risk Ratios (Tj)	5,620	490	912	10.0
Number of COIs (Nij)	10	10	9	8
1/Nij	0.10	0.10	0.11	0.13

Risk Ratio (Tij) = (COI concentration)/SLV

Table A-1C. Waste Rock Soil Screen, Morning Star Mine Site

Chemical of Interest (COI)	Potential Risk to Non-Protected Species?				Potential Risk to Protected Mammals? (Tij>1)
	Plants (Tij>5)	Invertebrates (Tij>5)	Birds (Tij>5)	Mammals (Tij>5)	
Antimony	No	No	NA	No	No
Arsenic	No	No	No	No	No
Cadmium	**Yes**	**Yes**	**Yes**	No	**Yes**
Calcium	NA	NA	NA	NA	NA
Cobalt	No	No	No	No	No
Copper	**Yes**	**Yes**	**Yes**	No	**Yes**
Iron	**Yes**	**Yes**	NA	NA	NA
Lead	**Yes**	**Yes**	**Yes**	No	**Yes**
Magnesium	NA	NA	NA	NA	NA
Manganese	**Yes**	**Yes**	No	No	No
Mercury	No	No	No	No	No
Potassium	NA	NA	NA	NA	NA
Silver	**Yes**	No	No	NA	NA
Zinc	**Yes**	**Yes**	**Yes**	No	**Yes**

Potential Risk = Tij > Q

Q = 5 for non-T&E species

Q = 1 for T&E species

Table A-1D. Waste Rock Soil Screen, Morning Star Mine Site

Chemical of Interest (COI)	Risks to Non-Protected Species Due to Multiple Contaminants? (Tij/Tj>(1/Nij)*Q)				Risks to Protected Mammals Due to Multiple Contaminants? (Tij/Tj>(1/Nij)*Q)
	Plants	Invertebrates	Birds	Mammals	
Antimony	No	No	NA	No	No
Arsenic	No	No	No	No	No
Cadmium	No	No	No	No	**Yes**
Calcium	NA	NA	NA	NA	NA
Cobalt	No	No	No	No	No
Copper	No	No	No	No	**Yes**
Iron	**Yes**	No	NA	NA	NA
Lead	No	No	No	No	**Yes**
Magnesium	NA	NA	NA	NA	NA
Manganese	No	No	No	No	No
Mercury	No	No	No	No	No
Potassium	NA	NA	NA	NA	NA
Silver	No	No	No	NA	NA
Zinc	No	No	No	No	**Yes**
		Q=5			Q=1

Table A-1E. Waste Rock Soil Screen, Morning Star Mine Site

Chemical of Interest (COI)	Selected as CPEC?				
	Plants	Invertebrates	Birds	Non-Protected Mammals	Protected Mammals
Antimony	No	No	No	No	No
Arsenic	No	No	No	No	No
Cadmium	**Yes**	**Yes**	**Yes**	No	**Yes**
Calcium	No	No	No	No	No
Cobalt	No	No	No	No	No
Copper	**Yes**	**Yes**	**Yes**	No	**Yes**
Iron	**Yes**	**Yes**	No	No	No
Lead	**Yes**	**Yes**	**Yes**	No	**Yes**
Magnesium	No	No	No	No	No
Manganese	**Yes**	**Yes**	No	No	No
Mercury	No	No	No	No	No
Potassium	No	No	No	No	No
Silver	**Yes**	No	No	No	No
Zinc	**Yes**	**Yes**	**Yes**	No	**Yes**

Note: Habitat suitability is not accounted for in the screening.

Table A-2A. Surface Water SLV Screen, Morning Star Mine Site

Chemical of Interest (COI)	90 UCL or Maximum Concentration (mg/L)	Screening Level Value		
		Aquatic (mg/L)	Birds (mg/L)	Mammals (mg/L)
Aluminum	0.101	0.087	797	8
Arsenic	0.002	0.15	18	6
Barium	0.002	0.004	150	39
Calcium	8.26	116	NA	NA
Lead	0.0052	0.0025	28	323
Manganese	0.0049	0.12	7242	676
Potassium	0.1790	53	NA	NA
Sodium	4.43	680	NA	NA
Zinc	0.0532	0.12	105	1230

Surface water samples include Blue Jay Creek, Battle Ax Creek, and adit waters on-site (N=6-8).
90 UCL concentrations determined with ProUCL program (USEPA 2007); max values used where UCL not calculable.
COIs selected by screening for frequency of detection and comparison with upstream concentrations.

Table A-2B. Surface Water SLV Screen, Morning Star Mine Site

Chemical of Interest (COI)	COI Risk Ratio		
	Aquatic (Tij)	Birds (Tij)	Mammals (Tij)
Aluminum	1.2	0.00013	0.01263
Arsenic	0.016	0.0001	0.0004
Barium	0.433	0.00001	0.00004
Calcium	0.071	NA	NA
Lead	2.1	0.00019	0.00002
Manganese	0.04	0.000001	0.00001
Potassium	0.003	NA	NA
Sodium	0.007	NA	NA
Zinc	0.4	0.001	0.00004
Sum of Risk Ratios (Tj)	4.3	0.001	0.0131
Number of COIs (Nij)	9	6	6
1/Nij	0.11	0.17	0.17

Risk Ratio (Tij) = (COI concentration)/SLV

Table A-2C. Surface Water SLV Screen, Morning Star Mine Site

Chemical of Interest (COI)	Potential Risk to Non-Protected Species?			Potential Risk to Protected Mammals? (Tij>1)
	Aquatic (Tij>1)	Birds (Tij>1)	Mammals (Tij>1)	
Aluminum	**Yes**	No	No	No
Arsenic	No	No	No	No
Barium	No	No	No	No
Calcium	No	NA	NA	NA
Lead	**Yes**	No	No	No
Manganese	No	No	No	No
Potassium	No	NA	NA	NA
Sodium	No	NA	NA	NA
Zinc	No	No	No	No

Potential Risk = Tij > Q

Q = 1 for non-T&E and for T&E species

Table A-2D. Surface Water SLV Screen, Morning Star Mine Site

Chemical of Interest (COI)	Risks to Non-Protected Species Due to Multiple Contaminants? (Tij/Tj>(1/Nij)*Q)			Risks to Protected Mammals Due to Multiple Contaminants? (Tij/Tj>(1/Nij)*Q)
	Aquatic	Birds	Mammals	
Aluminum	**Yes**	No	No	No
Arsenic	No	No	No	No
Barium	No	No	No	No
Calcium	No	NA	NA	NA
Lead	**Yes**	No	No	No
Manganese	No	No	No	No
Potassium	No	NA	NA	NA
Sodium	No	NA	NA	NA
Zinc	No	No	No	No

Q = 1 for non-T&E and for T&E species

Table A-2E. Surface Water SLV Screen, Morning Star Mine Site

Chemical of Interest (COI)	Selected as CPEC?			
	Aquatic	Birds	Non-Protected Mammals	Protected Mammals
Aluminum	**Yes**	No	No	No
Arsenic	No	No	No	No
Barium	No	No	No	No
Calcium	No	No	No	No
Lead	**Yes**	No	No	No
Manganese	No	No	No	No
Potassium	No	No	No	No
Sodium	No	No	No	No
Zinc	No	No	No	No

Habitat suitability is not accounted for in the screening.

Table A-3A. Sediment Screen, Morning Star Mine Site

Chemical of Interest (COI)	90 UCL or Maximum Concentration (mg/kg)	Screening Level Value: Freshwater Sediment Benthos (mg/kg)	Screening Level Value: Wildlife Bioaccumulation (mg/kg)	COI Risk Ratio: Freshwater Sediment Benthos (Tij)	COI Risk Ratio: Wildlife Bioaccumulation (Tij)
Arsenic	29.5	6	4	4.9	7.4
Cadmium	7.62	0.6	0.003	12.7	2,539
Cobalt	15.8	50	NA	0.3	NA
Copper	187.8	36	10	5.2	19
Iron	36,452	188,400	NA	0.19	NA
Lead	1,045	35	128	29.9	8.2
Magnesium	13,732	NA	NA	NA	NA
Manganese	2,187	1100	NA	2.0	NA
Mercury	0.162	0.2	NA	0.8	NA
Nickel	70.9	18	316	3.9	0.2
Potassium	1,344	NA	NA	NA	NA
Silver	2.60	4.5	NA	0.6	NA
Zinc	2,288	123	3	18.6	763
			Sum of Risk Ratios (Tj):	79.1	3,336
			Number of COIs (Nij):	11	6
			1/Nij:	0.09	0.17

Risk Ratio (Tij) = (90UCL COI concentration)/SLV

Samples consist of sediment samples in downstream Battle Ax Creek and Blue Jay Creek (N=4).

90 UCL concentrations determined with ProUCL program (USEPA 2007)

Source of SLV for iron = NOAA (2004) SQuiRT

Source of SLV for cobalt = USEPA (2005) Region 5 Eco screening criteria

Table A-3B. Sediment Screen, Morning Star Mine Site

Chemical of Interest (COI)	Potential Risk to Sediment-Exposed Species?		Risks Due to Multiple Contaminants? (Tij/Tj>(1/Nij)*Q)		Selected as CPEC?	
	Freshwater Sediment Benthos (Tij>1)	Wildlife Bioaccumulation (Tij>1)	Freshwater Sediment Benthos	Wildlife Bioaccumulation	Freshwater Sediment Benthos	Wildlife Bioaccumulation
Arsenic	**Yes**	**Yes**	No	No	**Yes**	**Yes**
Cadmium	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
Cobalt	No	NA	No	NA	No	No
Copper	**Yes**	**Yes**	No	No	**Yes**	**Yes**
Iron	No	NA	No	NA	No	No
Lead	**Yes**	**Yes**	**Yes**	No	**Yes**	**Yes**
Magnesium	NA	NA	NA	NA	No	No
Manganese	**Yes**	NA	No	NA	**Yes**	No
Mercury	No	NA	No	NA	No	No
Nickel	**Yes**	No	No	No	**Yes**	No
Potassium	NA	NA	NA	NA	No	No
Silver	No	NA	No	NA	No	No
Zinc	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**

Potential Risk = Tij > Q

Q = 1 for all sediment species (ODEQ 1998)

Table A-4A. Battle Ax Creek Surface Water SLV Screen, Morning Star Mine Site

Chemical of Interest (COI)	Maximum Concentration (mg/L)	Screening Level Value		
		Aquatic (mg/L)	Birds (mg/L)	Mammals (mg/L)
Aluminum	0.101	0.087	797	8
Arsenic	0.0013	0.15	18	6
Calcium	5.30	116	NA	NA
Lead	0.0127	0.0025	28	323
Manganese	0.0049	0.12	7242	676
Potassium	0.137	53	NA	NA
Sodium	2.34	680	NA	NA
Zinc	0.082	0.12	105	1230

Surface water samples consist of Battle Ax Creek (N=2-4).
90 UCL concentrations determined with ProUCL program (USEPA 2007); max values used where UCL not calculable.
COIs selected by screening for frequency of detection and comparison with upstream concentrations.

Table A-4B. Battle Ax Creek Surface Water SLV Screen, Morning Star Mine Site

Chemical of Interest (COI)	COI Risk Ratio		
	Aquatic (Tij)	Birds (Tij)	Mammals (Tij)
Aluminum	1.2	0.0001	0.01263
Arsenic	0.009	0.0001	0.00022
Calcium	0.046	NA	NA
Lead	5.1	0.0005	0.00004
Manganese	0.041	0.000001	0.00001
Potassium	0.003	NA	NA
Sodium	0.003	NA	NA
Zinc	0.7	0.0008	0.00007
Sum of Risk Ratios (Tj)	7	0.001	0.013
Number of COIs (Nij)	8	5	5
1/Nij	0.13	0.20	0.20

Risk Ratio (Tij) = (COI concentration)/SLV

Table A-4C. Battle Ax Creek Surface Water SLV Screen, Morning Star Mine Site

Chemical of Interest (COI)	Potential Risk to Non-Protected Species?			Potential Risk to Protected Mammals? (Tij>1)
	Aquatic (Tij>1)	Birds (Tij>1)	Mammals (Tij>1)	
Aluminum	**Yes**	No	No	No
Arsenic	No	No	No	No
Calcium	No	NA	NA	NA
Lead	**Yes**	No	No	No
Manganese	No	No	No	No
Potassium	No	NA	NA	NA
Sodium	No	NA	NA	NA
Zinc	No	No	No	No

Potential Risk = Tij > Q

Q = 1 for non-T&E and for T&E species

Table A-4D. Battle Ax Creek Surface Water SLV Screen, Morning Star Mine Site

Chemical of Interest (COI)	Risks to Non-Protected Species Due to Multiple Contaminants? (Tij/Tj>(1/Nij)*Q)			Risks to Protected Mammals Due to Multiple Contaminants? (Tij/Tj>(1/Nij)*Q)
	Aquatic	Birds	Mammals	
Aluminum	**Yes**	No	No	No
Arsenic	No	No	No	No
Calcium	No	NA	NA	NA
Lead	**Yes**	No	No	No
Manganese	No	No	No	No
Potassium	No	NA	NA	NA
Sodium	No	NA	NA	NA
Zinc	No	No	No	No

Q = 1 for non-T&E and for T&E species

Table A-4E. Battle Ax Creek Surface Water SLV Screen, Morning Star Mine Site

Chemical of Interest (COI)	Selected as CPEC?			
	Aquatic	Birds	Non-Protected Mammals	Protected Mammals
Aluminum	**Yes**	No	No	No
Arsenic	No	No	No	No
Calcium	No	No	No	No
Lead	**Yes**	No	No	No
Manganese	No	No	No	No
Potassium	No	No	No	No
Sodium	No	No	No	No
Zinc	No	No	No	No

Habitat suitability is not accounted for in the screening.

ATTACHMENT B - STATISTICAL TABLES

TABLE B-1. Soil Samples Statistics, Morning Star Mine Site

Background Soils

Sample I.D.	Total Metals (mg/kg)																							Hexavalent Chromium
	Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chrom.	Cobalt	Copper	Iron	Lead	Magnes-ium	Mangan-ese	Mercury	Nickel	Potas-sium	Selenium	Silver	Sodium	Thallium	Vanadium	Zinc	
BG-1	---	---	2.55	92.3	---	ND<0.657	---	17.0	---	42.9	17,700	26.0	---	516	ND<0.0876	22.2	---	ND<0.657	ND<0.657	---	---	---	126	ND<1.27
BG-2	---	---	2.41	40.7	---	ND<0.570	---	18.4	---	48.7	16,200	25.1	---	807	ND<0.0891	24.2	---	ND<0.570	ND<0.570	---	---	---	469	ND<1.16
BG-3	---	---	3.23	75.7	---	ND<0.595	---	18.8	---	57.4	19,100	2.9	---	450	ND<0.0972	25.6	---	ND<0.595	ND<0.595	---	---	---	86.7	442
BG-4	---	---	30.5	21.4	---	98.4	---	20.5	---	868	47,700	5450	---	7700	ND<0.0593	23.8	---	3.56	9.09	---	---	---	24600	ND<1.15
BG-5	---	---	17.3	66.7	---	3.28	---	38.5	---	365	29,200	2020	---	5340	0.121	30.9	---	1.3	3.33	---	---	---	1700	ND<1.21
BG-6	---	---	2.48	42.1	---	ND<0.608	---	18.0	---	40.0	16,700	16.7	---	722	ND<0.0627	25.4	---	ND<0.608	ND<0.608	---	---	---	83.0	ND<1.24
BG-7	---	---	12.0	22.2	---	23.5	---	28.3	---	506	24,000	936	---	3620	0.123	31.0	---	1.18	2.39	---	---	---	4160	ND<1.12
BG-8	---	---	2.54	63.3	---	ND<0.581	---	14.9	---	51.9	17,600	27.3	---	648	ND<0.103	23.8	---	ND<0.581	ND<0.581	---	---	---	107	ND<1.19
BG-9	---	---	3.43	69.6	---	1.16	---	21.4	---	196	15,400	146	---	893	ND<0.0879	27.7	---	ND<0.586	ND<0.586	---	---	---	2470	ND<1.19
BG-10	---	---	8.45	110	---	ND<0.599	---	16.7	---	73.5	16,900	68.2	---	959	ND<0.0659	21.9	---	ND<0.599	ND<0.599	---	---	---	268	ND<1.16
BG-11	33,200	ND<1.55	7.37	55.2	ND<3.11	ND<1.55	2,690	22.8	7.03	25.3	33,800	13.5	4,270	234	0.14	14.1	944	ND<1.55	ND<3.11	ND<155	ND<1.55	81.8	52.4	---
BG-12	28,800	1.53	4.97	121	ND<2.55	ND<1.27	2,170	11.1	11.3	15	32,800	8.53	4,680	1,050	ND<0.102	7.49	1,300	ND<1.27	ND<2.55	295	ND<1.27	73.6	69.5	---
BG-13	35,500	ND<1.43	5.86	92.9	ND<2.86	ND<1.43	2,090	12.2	13.7	21.7	32,400	8.38	6,440	1,270	ND<0.144	11.7	834	ND<1.43	ND<2.86	196	ND<1.43	69.8	77.5	---
BG-14	19,700	ND<1.50	5.1	48.2	ND<3.01	ND<1.50	727	19.2	4.54	14.5	34,100	15.8	2,270	169	ND<0.120	7.96	533	ND<1.50	ND<3.01	ND<150	ND<1.50	88	42.9	---
BG_15	31,700	ND<1.72	3.88	78.7	ND<3.44	ND<1.72	1,280	19.9	7.4	23.5	29,700	22.1	3,340	367	ND<0.137	12.1	780	ND<1.72	ND<3.44	ND<172	ND<1.72	63.4	69.2	---
BG-16	40,400	ND<1.21	4.86	123	ND<2.42	ND<1.21	2,130	24.7	12.9	50.6	39,300	160	6,470	773	0.121	20	1,480	ND<1.21	ND<2.42	138	ND<1.21	76.4	352	---
BG-17	45,300	ND<1.17	5.8	75.3	ND<2.34	ND<1.17	983	19.7	8.45	30.8	33,600	105	2,630	641	0.117	12.7	708	ND<1.17	ND<2.34	201	ND<1.17	68.2	520	---
BG-18	49,900	1.48	5.68	103	ND<2.49	ND<1.25	1,180	29	13.3	48	42,700	66.4	6,320	742	ND<0.0996	21.1	1,260	ND<1.25	ND<2.49	139	ND<1.25	78.1	392	---
BG-19	34,800	ND<1.53	5.47	67.6	ND<3.07	ND<1.53	2,080	23.5	11.1	38.4	31,700	80.9	5,670	750	0.138	18.9	1,030	ND<1.53	ND<3.07	ND<153	ND<1.53	64.8	264	---
BG-20	12,700	ND<1.36	1.97	42	ND<2.72	ND<1.36	2,880	12	3.69	5.78	15,300	8.31	1,890	437	0.109	5.78	459	ND<1.36	ND<2.72	171	ND<1.36	47	33.8	---
Maximum detected	49,900	1.53	30.5	123	ND	98.4	2,880	38.5	13.7	868	47,700	5,450	6,470	7,700	0.140	31.0	1,480	3.56	9.09	295	ND	88.0	24,600	442
95 UCL	39,635	1.50	9.35	82.1	---	16.8	2,246	22.8	11.5	256	31,706	914	5,437	3,282	0.12	22.4	1,128	1.55	3.47	201	---	77.7	13,960	<1.27
Distribution	N	NonPara	Log	N	---	N	N	N	N	Log	Gamma A	Log	N	NonPara	N	N	N	N	N	N	---	N	NonPara	---

Waste Rock Soils

WRS-MS-1	20,400	2.25	25.3	29.1	ND<2.35	171	11,600	15.4	17.8	2,210	49,800	5,310	9,620	4,150	0.471	16.3	3,450	1.45	21.9	ND<118	ND<1.18	30.1	42,800	---
WRS-MS-2	16,000	1.42	18.6	19.8	ND<2.35	144	7,620	14.1	21.5	4,040	44,200	2,050	7,460	2,360	0.458	19.2	2,490	1.2	15.6	ND<117	ND<1.17	21.8	35,100	---
WRS-MS-3	18,200	ND<1.12	7.54	25.5	ND<2.24	37.6	34,300	18.7	16.1	806	33,800	2,940	9,880	3,000	0.47	21.2	3,030	ND<1.12	5.91	ND<112	ND<1.12	26.8	11,800	---
WRS-MS-4	19,200	1.52	14.7	25.4	ND<2.38	49.9	8,640	18.7	16	1,030	38,500	3,100	10,300	3,550	0.429	19.7	2,780	ND<1.19	7.31	ND<119	ND<1.19	27.3	15,400	---
WRS-MS-5	22,600	3.9	30	20.5	ND<2.20	112	29,300	15.3	16.8	679	46,100	8,390	11,300	5,300	0.627	16.5	2,550	2.11	20.8	ND<110	ND<1.10	32	30,300	---
WRS-MS-6	19,600	3.28	24.7	27.6	ND<2.42	215	23,000	14.9	16.7	668	48,400	11,700	9,600	5,080	0.617	16.4	2,410	1.57	12.6	ND<121	ND<1.21	30.1	51,900	---
WRS-MS-7	28,400	1.53	13.4	68	ND<2.49	405	4,070	21.7	16	408	37,200	3,600	10,800	2,510	0.46	21.2	3,100	ND<1.24	10.2	174	ND<1.24	47.5	23,700	---
WRS-MS-8	33,100	ND<1.33	5.89	73.6	ND<2.67	4.3	4,950	24	15.2	173	33,200	279	11,100	771	0.213	27	1,650	ND<1.33	ND<2.67	171	ND<1.33	46.7	884	---
WRS-MS-9	27,200	ND<1.20	7.23	60.4	ND<2.4	3.33	4,370	24.2	17.3	96.9	34,300	409	12,300	997	0.132	26.7	921	ND<1.20	ND<2.40	190	ND<1.20	48.9	718	---
WRS-MS-10	20,000	2.07	24.3	21.2	ND<2.29	39	5,470	12.5	14.2	696	41,900	7,790	9,530	5,020	0.229	16.3	2,350	1.3	8.45	ND<115	ND<1.15	27.9	15,700	---
WRS-MS-11	34,800	2.11	25.8	45.2	ND<2.70	33.7	8,650	19	20.3	412	71,900	6,470	14,100	7,810	0.364	21	3,220	1.39	8.89	ND<135	ND<1.35	50.3	9,220	---
Frequency of Detection	11/11	8/11	11/11	11/11	0/11	11/11	11/11	11/11	11/11	11/11	11/11	11/11	11/11	11/11	11/11	11/11	11/11	6/11	9/11	3/11	0/11	11/11	11/11	0/11
Max concentration	34,800	3.90	30.0	73.6	ND	405	34,300	24.2	21.5	4,040	71,900	11,700	14,100	7,810	0.627	27.0	3,450	2.11	21.9	190	ND<1.35	50.3	51,900	<1.17
90 UCL	26,202	2.39	21.5	46.3	---	198	18,546	19.7	18.0	1,631	48,385	6,208	11,255	4,543	0.472	21.9	2,844	1.49	13.7	175.8	---	40.5	28,538	---
95 UCL	27,039	2.50	22.7	49.0	---	234	20,577	20.2	18.3	1,868	49,846	6,682	11,483	4,818	0.493	22.4	2,941	1.53	14.5	176.6	---	42.0	30,766	---
Distribution	N	N	N	Log	---	Gamma	Gamma	N	N	Gamma	Gamma	N	N	N	N	Gamma	N	N	N	N	---	Gamma A	N	---

UCL determined with ProUCL (USEPA 2007) UCLs for all COIs with ND are determined by Kaplan-Meier method of data substitution; distribution is for detected values only.

Background determined as 95 UCL of the mean of all BG samples

Gamma A = Approximate gamma

Gamma = gamma

Log = Lognormal

N = normal

NonPara = Nonparametric

Table B-2. Surface Water Samples Statistics, Morning Star Mine Site

Sample I.D.	Location	Total Metals (mg/L)																						
		Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead	Magnes-ium	Manga-nese	Mercury	Nickel	Potas-sium	Selenium	Silver	Sodium	Thallium	Vanadium	Zinc
AW-MS-1	Adit	ND<0.1	ND<0.001	0.00476	ND <0.001	ND<0.001	ND<0.001	12.1	ND<0.001	ND <0.002	ND<0.004	ND<0.1	0.00223	0.263	ND<0.001	ND <0.0001	ND <0.001	0.24	ND<0.001	ND <0.002	6.87	ND<0.001	ND<0.002	0.0565
SW-MS-11	Blue Jay Cr., upstream of adit	ND<0.1	ND<0.001	ND<0.001	0.00173	ND<0.001	ND<0.001	3.3	ND<0.001	ND <0.002	ND<0.004	ND<0.1	0.00171	0.337	ND<0.001	ND <0.0001	ND <0.001	0.127	ND<0.001	ND <0.002	1.11	ND<0.001	ND<0.002	0.0229
SW-MS-12	Blue Jay Cr., downstream of adit	ND<0.1	ND<0.001	0.001	ND <0.001	ND<0.001	ND<0.001	4.98	ND<0.001	ND <0.002	ND<0.004	ND<0.1	0.00248	0.28	ND<0.001	ND <0.0001	ND <0.001	0.141	ND<0.001	ND <0.002	2.16	ND<0.001	ND<0.002	0.0415
SW-MS-13	Blue Jay Cr., downstream of adit	ND<0.1	ND<0.001	0.00134	ND <0.001	ND<0.001	ND<0.001	5.25	ND<0.001	ND <0.002	ND<0.004	ND<0.1	0.00344	0.258	ND<0.001	ND <0.0001	ND <0.001	0.137	ND<0.001	ND <0.002	2.18	ND<0.001	ND<0.002	0.00646
SW-MS-17	Battle Ax Cr., confluence of Blue Jay Cr.	0.101	ND<0.001	0.0013	ND <0.001	ND<0.001	ND<0.001	5.3	ND<0.001	ND <0.002	ND<0.004	ND<0.1	0.0127	0.27	0.00493	ND <0.0001	ND <0.001	0.137	ND<0.001	ND <0.002	2.34	ND<0.001	ND<0.002	0.0817
SW-MS-18	Battle Ax Cr., downstream of Blue Jay Cr.	ND<0.1	ND<0.001	ND<0.001	ND <0.001	ND<0.001	ND<0.001	4.05	ND<0.001	ND <0.002	ND<0.004	ND<0.1	ND <0.001	0.481	ND<0.001	ND <0.0001	ND <0.001	0.11	ND<0.001	ND <0.002	1.37	ND<0.001	ND<0.002	0.0196
SW-9	Battle Ax Cr., confluence of Blue Jay Cr.	---	---	0.00133	ND <0.001	---	ND<0.001	---	ND<0.001	---	ND<0.002	ND<0.01	0.00252	---	ND<0.002	ND <0.0002	ND <0.002	---	ND<0.002	ND <0.001	---	---	---	0.0724
SW-10	Battle Ax Cr., downstream of Blue Jay Cr.	---	---	ND<0.001	ND <0.001	---	ND<0.001	---	ND<0.001	---	ND<0.002	ND<0.01	ND <0.001	---	ND<0.002	ND <0.0002	ND <0.002	---	ND<0.002	ND <0.001	---	---	---	ND <0.005
Frequency of Detection		1/6	0/6	5/8	1/8	0/6	0/8	6/6	0/8	0/6	0/8	0/8	6/8	6/6	1/8	0/8	0/8	6/6	0/8	0/8	6/6	0/6	0/6	7/8
Maximum detected		0.101	ND<0.001	0.00476	0.00173	ND<0.001	ND<0.001	12.1	ND<0.001	ND <0.002	ND<0.004	ND<0.1	0.0127	0.481	0.00493	ND <0.0001	ND <0.001	0.24	ND<0.001	ND <0.002	6.87	ND<0.001	ND<0.002	0.0817
90 UCL		---	---	0.00241	0.002	---	---	8.26	---	---	---	---	0.005	0.377	---	---	---	0.179	---	---	4.432	---	---	0.053
Distribution		---	---	NonPara	---	---	---	Gamma A	---	---	---	---	NonPara	Gamma A	---	---	---	Log	---	---	Gamma A	---	---	NonPara
Battle Ax downstream																								
Battle Ax Maximum		0.101	ND<0.001	0.00133	ND <0.001	ND<0.001	ND<0.001	5.3	ND<0.001	ND <0.002	ND<0.004	ND<0.1	0.0127	0.481	0.00493	ND <0.0001	ND <0.001	0.137	ND<0.001	ND <0.002	2.34	ND<0.001	ND<0.002	0.0817
Battle Ax 90 UCL		---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Upstream Background																								
SW-8	Battle Ax Cr., upstream of Blue Jay Cr.	---	---	ND<0.001	ND <0.001	---	ND<0.001	---	ND<0.001	---	ND<0.002	ND<0.01	ND <0.001	---	ND<0.002	ND <0.0002	ND <0.002	---	ND<0.002	ND <0.001	---	---	---	ND <0.005
SW-MS-14	Battle Ax Cr., upstream of Blue Jay Cr.	ND<0.1	ND<0.001	ND<0.001	ND <0.001	ND<0.001	ND<0.001	4.05	ND<0.001	ND <0.002	ND<0.004	ND<0.1	ND <0.001	0.483	ND<0.001	ND <0.0001	ND <0.001	0.11	ND<0.001	ND <0.002	1.32	ND<0.001	ND<0.002	0.00689
SW-MS-15	Battle Ax Cr., upstream of Blue Jay Cr.	ND<0.1	ND<0.001	ND<0.001	ND <0.001	ND<0.001	ND<0.001	4.03	ND<0.001	ND <0.002	ND<0.004	ND<0.1	ND <0.001	0.473	ND<0.001	ND <0.0001	ND <0.001	0.108	ND<0.001	ND <0.002	1.29	ND<0.001	ND<0.002	0.0107
SW-MS-16	Battle Ax Cr., upstream of Blue Jay Cr.	ND<0.1	ND<0.001	ND<0.001	ND <0.001	ND<0.001	ND<0.001	3.91	ND<0.001	ND <0.002	ND<0.004	ND<0.1	ND <0.001	0.466	ND<0.001	ND <0.0001	ND <0.001	0.117	ND<0.001	ND <0.002	1.3	ND<0.001	ND<0.002	0.00978
Maximum detected		ND<0.1	ND<0.001	ND<0.001	ND <0.001	ND<0.001	ND<0.001	4.05	ND<0.001	ND <0.002	ND<0.004	ND<0.1	ND <0.001	0.483	ND<0.001	ND <0.0001	ND <0.001	0.117	ND<0.001	ND <0.002	1.32	ND<0.001	ND<0.002	0.0107
95 UCL		---	---	---	---	---	---	4.05	---	---	---	---	---	0.483	---	---	---	0.117	---	---	1.32	---	---	

Table B-3. Sediment Samples Statistics, Morning Star Mine Site

Sample I.D.	Location	Total Metals(mg/kg)																						
		Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead	Magnes-ium	Manga-nese	Mercury	Nickel	Potas-sium	Selenium	Silver	Sodium	Thallium	Vanadium	Zinc
SED-MS-12	Blue Jay Cr.	17,400	ND<1.16	41.40	15.3	ND<2.32	9.86	3,750	18.4	16.0	231	37,600	1,370	11,500	2,820	0.162	20.5	1,410	ND<1.16	2.6	ND<116	ND<1.16	29.2	2,920
SED-MS-13	Blue Jay Cr.	10,300	ND<1.09	5.91	20.1	ND<2.19	3.54	4,740	19.3	13.1	140	26,500	660	10,300	1,340	ND<0.0874	18.7	1,300	ND<1.09	ND<2.19	135	ND<1.09	31.4	1,480
SED-MS-17	Battle Ax Cr., confluence of Blue Jay Cr.	18,600	ND<1.30	2.31	56	ND<2.61	2.11	5,960	18.5	15.7	32.8	35,700	50.8	15,200	525	ND<0.104	89.1	839	ND<1.30	ND<2.61	355	ND<1.30	47.2	608
SED-MS-18	Battle Ax Cr., downstream of Blue Jay Cr.	21,600	ND<1.40	ND<1.40	46.5	ND<2.8	ND<1.4	7,280	16.0	13.4	40.7	23,700	6.69	10,400	484	ND<0.112	47.6	860	ND<1.40	ND<2.8	374	ND<1.40	38.3	68.5
Frequency of Detection		4/4	0/4	3/4	4/4	0/4	3/4	4/4	4/4	4/4	4/4	4/4	4/4	4/4	4/4	1/4	4/4	4/4	0/4	1/4	3/4	0/4	4/4	4/4
Maximum detected		21,600	ND<1.40	41.4	56.0	ND<2.8	9.86	7,280	19.3	16.0	231	37,600	1,370	15,200	2,820	0.162	89.1	1410.0	ND<1.40	2.6	374.0	ND<1.40	47.2	2,920
90 UCL		20,896	--	29.50	50.7	--	7.62	6,684	19.2	15.8	188	36,452	1,045	13,732	2187	--	70.9	1,344	--	--	365.0	--	43.16	2,288
Distribution		N	--	N	N	--	N	N	N	N	N	N	N	N	N		N	N	--		N	--	N	N
Downstream BA Creek																								
Maximum detected		21,600	ND<1.40	2	56	ND<2.8	2	7,280	19	16	41	35,700	51	15,200	525	ND<0.112	89	860	ND<1.40	ND<2.8	374	ND<1.40	47	608
Upstream Background																								
SED-MS-14	Battle Ax Cr., upstream of Blue Jay Cr.	17,900	ND<1.32	1.42	32.8	ND<2.63	ND<1.32	7,490	11.4	9.6	15.5	16,000	2.97	7,330	424	ND<0.105	16.3	844	ND<1.32	ND<2.63	267	ND<1.32	28.8	36.1
SED-MS-15	Battle Ax Cr., upstream of Blue Jay Cr.	24,100	ND<1.20	1.25	51.6	ND<2.4	ND<1.2	6,460	22.3	12.5	24.3	25,000	3.44	10,600	466	ND<0.0962	28.7	843	ND<1.2	ND<2.4	396	ND<1.2	43.4	50.5
SED-MS-16	Battle Ax Cr., upstream of Blue Jay Cr.	19,600	ND<1.31	ND<1.31	39.9	ND<2.61	ND<1.31	6,090	10.7	10.3	20.8	19,100	2.27	9,640	359	ND<0.105	21.2	547	ND<1.31	ND<2.61	445	ND<1.31	36.3	39.6
Maximum detected		24,100	ND<1.32	1.42	51.6	ND<2.63	ND<1.32	7,490	22.3	12.5	24.3	25,000	3.44	10,600	466	ND<0.105	28.7	844	ND<1.32	ND<2.63	445	ND<1.32	43.4	50.5
95 UCL		25,934	--	--	57.4	--	--	7,903	25.8	13.4	27.7	27,741	3.89	12,024	507	--	32.6	1,033	--	--	524	--	48.5	54.7
Distribution		N	--		N	--	--	N	N	N	N	N	N	N	N	--	N	N	--	--	N	--	N	N

Table B-4. Sediment Porewater Samples Statistics, Morning Star Mine Site

Porewater

Sample I.D.	Location	Dissolved Metals (mg/L)																						
		Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead	Magnes-ium	Manga-nese	Mercury	Nickel	Potas-sium	Selenium	Silver	Sodium	Thallium	Vanadium	Zinc
PW-MS-18	Battle Ax Cr., downstream of Blue Jay Cr.	ND<0.1	ND<0.001	ND <0.001	ND <0.001	ND<0.001	ND<0.001	3.76	ND<0.001	ND <0.002	ND <0.005	ND<0.1	ND <0.001	0.47	0.00257	ND <0.0001	ND<0.001	0.103	ND<0.001	ND<0.002	1.37	ND<0.001	ND<0.002	ND<0.004
Maximum detected		ND<0.1	ND<0.001	ND <0.001	ND <0.001	ND<0.001	ND<0.001	3.76	ND<0.001	ND <0.002	ND <0.005	ND<0.1	ND <0.001	0.47	0.0026	ND <0.0001	ND<0.001	0.1030	ND<0.001	ND<0.002	1.37	ND<0.001	ND<0.002	ND<0.004
Upstream Background																								
PW-MS-14	Battle Ax Cr., upstream of Blue Jay Cr.	ND<0.1	ND<0.001	ND <0.001	0.0015	ND<0.001	ND<0.001	3.9	ND<0.001	ND <0.002	ND <0.005	ND<0.1	ND <0.001	0.502	0.00521	ND <0.0001	0.00227	0.175	ND<0.001	ND<0.002	1.52	ND<0.001	ND<0.002	0.00547
PW-MS-15	Battle Ax Cr., upstream of Blue Jay Cr.	ND<0.1	ND<0.001	ND <0.001	0.00106	ND<0.001	ND<0.001	3.83	ND<0.001	ND <0.002	ND <0.005	ND<0.1	ND <0.001	0.494	0.00447	ND <0.0001	0.00213	0.138	ND<0.001	ND<0.002	1.37	ND<0.001	ND<0.002	0.00513
PW-MS-16	Battle Ax Cr., upstream of Blue Jay Cr.	ND<0.1	ND<0.001	ND <0.001	ND <0.001	ND<0.001	ND<0.001	3.8	ND<0.001	ND <0.002	ND <0.005	ND<0.1	ND <0.001	0.478	0.00191	ND <0.0001	ND<0.001	0.101	ND<0.001	ND<0.002	1.35	ND<0.001	ND<0.002	ND<0.004
Maximum detected		ND<0.1	ND<0.001	ND <0.001	0.0015	ND<0.001	ND<0.001	3.9	ND<0.001	ND <0.002	ND <0.005	ND<0.1	ND <0.001	0.502	0.0052	ND <0.0001	ND<0.001	0.175	ND<0.001	ND<0.002	1.520	ND<0.001	ND<0.002	0.0055

ATTACHMENT C - MACROINVERTEBRATE EVALUATION

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Table C-1. Summary of Macroinvertebrate Scoring for Battle Ax Creek C-6

INTRODUCTION

An evaluation of macroinvertebrates in Battle Ax Creek was performed as part of the screening ecological risk assessment for the Morning Star Mine Site, Opal Creek Recreation Area, Oregon. Concentrations of metals in surface water and sediment of the creek are evaluated in the Level II screening ecological risk assessment for their potential risk to ecological receptors in the creek. The evaluation of stream bed macroinvertebrates, described in this Attachment, provides a more direct assessment of the biological community in the creek sediments. Macroinvertebrates are fairly stationary, easy to collect, and are responsive to human disturbance. In addition, the relative sensitivity or tolerance of many macroinvertebrates to stream conditions is well known. For these reasons, USEPA (1990) recommends their evaluation in an assessment of ecological integrity of streams.

The evaluation of stream macroinvertebrates in Battle Ax Creek followed the macroinvertebrate bioassessment protocol of the Oregon Plan for Salmon and Watersheds (OPSW 1999). The protocol was adapted from the USEPA Rapid Bioassessment Protocols (Barbour 1999) for use in the state of Oregon. The OPSW protocol provides three levels of evaluation; for Battle Ax Creek, Level 3 was followed.

METHODS FOR DATA COLLECTION AND ANALYSIS

The following summarizes the procedures for sample collection and laboratory analyses. Descriptions of stream habitat and reaches for three sediment stations, and results of the macroinvertebrate evaluations at those stations, are presented in the following section.

SAMPLE COLLECTION

The Level 3 macroinvertebrate collection procedure followed the method provided in OPSW (1999), with some minor modifications. Because of the limited amount of riffle and pool habitats in the stream, a random selection of sample locations within each identified reach of the stream was not possible. Instead, all accessible riffles and pools were sampled within each reach. Stations were selected based on distance from the confluence of Battle Ax Creek and Blue Jay Creek, where the Morning Star Mine shaft, adit, and waste rocks are located. As a tributary to Battle Ax Creek, Blue Jay Creek serves as a source of drainage from the adit to the creek. Stations were identified as short reaches, at approximately 30 m length.

Riffle and pool samples were collected by the kick method. For the riffle sample from each station, all accessible riffles were disturbed by the kick method and macroinvertebrates were collected by flat net. Large substrate was rubbed by hand to dislodge organisms, and the substrate was discarded to the stream. Depth of disturbance of sediment was from two to five centimeters. Three kick dislodgings were collected for each sample. Each kick collection covered approximately 1.5 ft^2, for a total of approximately 4.5 ft^2 of coverage per sample. After each riffle sample collection, contents of the net were placed in a sieve bucket. All samples from the riffle areas of each station were combined in the sieve bucket, washed with river water and sieved, and

removed from the net by hand and placed into labeled sample jars. Samples were covered with 90% ethanol, placed on ice for two days, and then shipped to the enumeration laboratory for sorting and analysis.

SAMPLE ANALYSIS

Samples were shipped from GeoDesign and received by the lab with no deviations from the Level 3 protocol. All samples were analyzed at the laboratory following the OPSW (1999) Level 3 protocol. Sorting, species identification, and enumeration of all samples were performed by EcoAnalysts, Moscow, ID.

Sample results are provided by the lab as raw data and as various metrics, including those used in the OSPW protocol to characterize stream sediment macroinvertebrates. All data and metrics received from the lab are included in tables in this Attachment.

RESULTS

The locations of sediment stations for the collection of macroinvertebrates are identified, and the station reaches are described. Results of the enumeration of macroinvertebrates at each station are presented, with original data and laboratory metrics presented in the attached tables. Results of the metric scores are presented in a summary table, and characteristic metrics for the stations are presented graphically.

DESCRIPTIONS OF STATIONS AND HABITAT

Macroinvertebrate stations were selected in Battle Ax Creek to characterize the sediment biological integrity upstream and downstream of the Morning Star Mine drainage, which is carried by Blue Jay Creek as it flows past the Morning Star Mine adit. Stations selected for macroinvertebrate collection were matched with locations from which sediment and surface water samples were collected in Battle Ax Creek. Stations for macroinvertebrate collection for the Morning Star Mine site are labeled BI-MS-14 Pool, BI-MS-15 Riffle, BI-MS-16 Pool, and BI-MS-18 Riffle. Stations BI-MS-14 Pool, BI-MS-15 Riffle, BI-MS-16 Pool are located in Battle Ax Creek upstream of the confluence with Blue Jay Creek, and station BI-MS-18 Riffle is located approximately 100 feet downstream of the confluence. Macroinvertebrate collection stations are shown on a map in Figure C-1.

All stations were located in Battle Ax Creek. The creek is about 6 m across in these reaches. The reaches are characterized by steep, heavily vegetated banks. Water flow was rapid; sampling occurred in mid-October after start of the rain season. Depth in the middle of the reach was two to three feet. Because of the rapid flow and depth, samples were collected from riffles and pools located in the nearshore area of the reach in water depths of less than three feet.

The riparian zone is undisturbed from the creek shoreline up the slope over 20 m to either the mine access road (for BI-MS-18 Riffle) or a trail that leads upstream along Battle Ax Creek (for stations located upstream of the confluence with Blue Jay Creek). Riparian

vegetation is characterized as an advanced growth, hemlock dominant forest. Understory along the banks was heavily vegetated with various young trees, thick brush, and moss. The presence of downed trees, snags, large boulders, and extensive canopy provides high quality habitat for aquatic organisms.

Substrates of all reaches were dominated by boulders and large cobble, with very little gravel or sediment. The few areas where gravel and small cobble were present were sampled for the riffle sample. Little gravel or sediment was available in pools, with bare hard rock substrate or 1-2 cm of sandy-gravel material overlay. All accessible pools were sampled for the pool sample; available pools were located in depositional areas near shore.

Figure C-1. Locations of Macroinvertebrate Sample Collections

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EXPLANATION:

A-4 ■ ADIT

BI-MS-14 ● MACRO INVERTIBRATE SAMPLE (OCTOBER 2008)

NOTE:
PREVIOUS WASTE ROCK SAMPLE LOCATIONS NOT SHOWN ON FIGURE.

N

0 500 1000

(SCALE IN APPROXIMATE FEET)

USGS QUADRANGLE MAP
MAP CREATED WITH TOPO!®
©2002 NATIONAL GEOGRAPHIC

MACRO INVERTIBRATE SAMPLE LOCATIONS

RUTH AND MORNING STAR MINE SITES AT OPAL CREEK
MARION COUNTY, OR

C-1

OPALCREEK-1-02

FEBRUARY 2009

GEODESIGN INC
15575 SW Sequoia Parkway - Suite 100
Portland OR 97224
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MACROINVERTEBRATE COMMUNITY METRICS

OPDW Level 3 assessments are based on genus/species level identifications. A variety of metrics are used for comparison with the genus/species makeup of the macroinvertebrate community. The full suite of community metrics and metrics used in the OPSW procedure that were developed for each station are provided in the attached data tables, and are followed by the OPSW metric scoring procedure for that station.

Community Metrics

Pools

Pools were available for sample collection at two stations, BI-MS-14 Pool and BI-MS-16 Pool. Data on invertebrate abundance were very similar for these two stations, with the abundance for pool invertebrates at 159 and 163 in samples from BI-MS-14 Pool and BI-MS-16 Pool, respectively.

Riffles

Macroinvertebrates were successfully collected from riffles at two sediment stations: BI-MS-15 Riffle and BI-MS-18 Riffle. However, as shown in Table C-1, the abundance of the riffle sample at BI-MS-15 Riffle was much lower than for BI-MS-18 Riffle (78 organisms at BI-MS-15 Riffle compared with 185 organisms at BI-MS-18 Riffle). Station BI-MS-15 Riffle is an upstream background station, and since there are two other upstream background stations with sufficient abundance (i.e., BI-MS-14 Pool and BI-MS-16 Pool), the lack of comparability in abundances may not be critical. Chemical concentrations in the sediment of the upstream stations are very similar (see Table B-3 in Attachment B), there is no evidence to suggest that metals have impacted the macroinvertebrate abundance at Station BI-MS-15 Riffle.

OPSW Metric Scores

Level 3 of the OPSW (1999) protocol provides a sensitive measure of stream condition using macroinvertebrate communities as the primary indicator. The protocol uses a set of metrics that are considered the most reliable indicators of macroinvertebrate community conditions for streams in the Oregon coastal range. These metrics are a subset of the community metrics presented for each station in the attached tables. The metrics are used to generate a score that relates to the overall condition of the macroinvertebrate community at that station. Four classes of stream disturbance can be determined from the scores: *no impairment, slight impairment, moderate impairment,* and *severe impairment.*

The following metrics are used in the scoring system by OPSW:

Taxa Richness – total number of invertebrate taxa

Mayfly (Ephemeroptera) Richness – total number of mayfly taxa

Stonefly (Plecoptera) Richness – total number of stonefly taxa

Caddisfly (Trichoptera) Richness – total number of caddisfly taxa

Sensitive Taxa – Number of taxa known to be sensitive to human disturbance

Sediment Sensitive Taxa – Number of taxa known to be sensitive to fine sediment

Modified HBI – Hilsenhof Biotic Index, index of sensitivity to organic enrichment

% Tolerant Taxa – Percent of total invertebrates that belong to taxa tolerant to disturbance

% Sediment Tolerant Taxa – Percent of total invertebrates that belong to taxa sensitive to fine sediment

% Dominant (single taxa) – Percent to total invertebrates that are comprised of the single most abundant taxon.

Data on genus/species identifications at each station in Battle Ax Creek are presented in the following tables. Assignment of scores for each OPSW metric at each station, and results of the total metric score for each station are also provided in the following data tables. Because of the similarity in results in community metrics between pool and riffle stations, they are discussed together. A summary of the metric scoring for all stations is provided in Table C-1, and discussed below.

Table C-1. Summary of Macroinvertebrate Scoring for Battle Ax Creek

	Station			
	Upstream of Confluence			Downstream
Metric	**BI-MS-14 Pool**	**BI-MS-15 Riffle**	**BI-MS-16 Pool**	**BI-MS-18 Riffle**
Corrected Abundance	159	78	163	185
Taxa Richness	5	3	3	5
Mayfly Richness	3	3	5	3
Stonefly Richness	5	3	5	5
Caddisfly Richness	3	3	3	5
Sensitive Taxa	5	3	5	5
Sediment sens. Taxa	3	3	3	5
Modified HBI	5	5	5	5
% Tolerant Taxa	5	5	5	5
% Sed Tol Taxa	5	3	5	5
% Dominant (single taxa)	5	3	5	3
Total Score	**44**	**34**	**44**	**46**

Score Range	**Stream Condition**
>39	No Impairment: passes level 3 assessment. Indicates good diversity of invertebrates and stream conditions with little or no disturbance.
30-39	Slight Impairment: evidence of some impairment exists.
20-29	Moderate Impairment: clear evidence of disturbance exists.
<20	Severe Impairment: conditions indicate a high level of disturbance.

Upstream Stations

Upstream stations BI-MS-14 Pool, BI-MS-15 Riffle, and BI-MS-16 Pool are located in Battle Ax Creek upstream of the confluence with Blue Jay Creek, which is assumed to be a source of metals from drainage of the Morning Star adit and waste rock soils to Battle Ax Creek. The upstream stations are assumed to represent background conditions for benthic communities since no known mining or other impacts are apparent in the reaches, and the conditions of the reaches with regards to habitat appear to be the same as for reaches downstream of the confluence.

Total abundances and species diversities of macroinvertebrate communities in two of the three upstream stations BI-MS-14 Pool and BI-MS-16 Pool were very similar (see Figures C-2 through C-5), and results of the OPSW scoring were also similar for these stations. For station BI-MS-15 Riffle, the abundance was slightly lower than the other two stations (Figure C-2), and the metrics scores were slightly lower, resulting in an evaluation of *Slight Impairment*. However, remaining biological indices for station BI-MS-15 Riffle are not largely different from those for the other two upstream stations (Figure C-6). In addition, concentrations of metals in sediments of the three upstream stations were very similar (see Table B-3 of Attachment B). The reasons for the lower metric scores at BI-MS-15 Riffle may be due to the lower abundance, the reason for which is unknown, but may be an artifact of the cobble substrate that characterized sample locations in Battle Ax Creek.

Downstream Station

A single downstream station BI-MS-18 Riffle is located in Battle Ax Creek downstream of the confluence with Blue Jay Creek, and therefore downstream of the potential source of metals from the Morning Star adit and waste rock piles to Battle Ax Creek. The downstream station BI-MS-18 Riffle did not show any differences from the upstream stations with regards to the OPSW scores. The metric evaluation resulted in a total score of 46, which indicates *No Impairment*. Results of the scoring suggest that the macroinvertebrate community of the downstream station BI-MS-18 Riffle BI-1 is not impaired and is similar in benthic macroinvertebrate community structure to the upstream stations.

Relationship of Metric Scores with Potential Sources and Metals Concentrations

The relationship between the OPSW scores and the locations of the sample locations with respect to the potential sources of metals to the downstream station location was examined by graphically plotting the scores on a schematic of the reaches. Figure C-7 depicts the upstream and downstream stations by OPSW scores and location in the creek with respect to the Morning Star Mine adit drainage. The benthic community of station BI-MS-18 Riffle showed no apparent influence from the location downstream of the adit and waste rock pile drainage.

The relationships between the OPSW scores and the metals concentrations of sediments of the three upstream stations and the single downstream benthic macroinvertebrate

station were examined by graphically comparing the scores from the reaches with sediment metals data. Note that sediment samples for metals concentration data were collected from available sedimentation areas at each station location, consisting mostly of sediments in pools, whereas the OPSW scores were developed separately for the two different types of sedimentation (i.e., riffles and pools) within each station location. Thus, the metals concentrations that come from a mix of primarily pool with some riffle sediments may not adequately represent community conditions in specifically riffle or pool environments.

For depicting the relationship graphically between OPSW scores and metals concentrations, the concentrations of the metals with the highest exceedances of Level II screening criteria are plotted against the OPSW scores. Plots of metals concentrations and OPSW metric scores for the riffle and pool stations are depicted in Figure C-8. The Level II SLVs are also shown on this graphic, for comparison with the metals concentrations. The graphic of Figure C-8 shows the lack of a relationship between OPSW scores and the concentrations of metals in sediments of the Battle Ax Creek stations. Concentrations of copper and nickel in sediment of BI-MS-18 Riffle exceeded their Level II screening criteria but the OPSW scores for that station indicated *No Impairment* to the benthic community.

The lack of impacts to benthic communities despite elevated concentrations of sediment metals suggests that the metals are very limited in bioavailability to the benthic organisms. The Level II SLVs assume that the chemicals are bioavailable at the levels inherent in the studies from which the screening values are derived. The DEQ Level II SLVs for lead and zinc are taken from the TEL values in NOAA (1999) SQuiRT, which in turn are taken from the TELs in USEPA and USFWS reports that developed sediment screening values for the Great Lakes program (Fox and Tuchman 1996, Ingersoll et al 1996, USEPA 1996). The TELs developed in these reports are based on field-collected samples of sediment from the Great Lakes and toxicity tests for *Hyallela azteca*, and are generally identified as the concentrations presenting the fifth percentiles of the response values. The sediment samples from the Great Lakes were contaminated with metals from sources other than hard rock mining, primarily from industrial liquid effluent discharges. Liquid discharges likely contained metals in dissolved form that subsequently bound to the surfaces of suspended particles and settled out as sediments in the Great Lakes. The bioavailability of these surface-bound metals would be much greater than the bioavailability of metals contained within the mineral matrix of hard rock particles, which would characterize the sediments of Battle Ax Creek. Because these TELs do not account for the bioavailability of lead or zinc in the hard rock particles that make up the sediments of Battle Ax Creek, their application to predicting potential risks to sediment macroinvertebrates in Battle Ax Creek entails high uncertainty. The lack of accounting for the differences in bioaccumulation between the studies that form the basis of the SLVs and hard rock substrate found at the site may explain the lack of measurable macroinvertebrate impacts in Battle Ax Creek sediments with elevated metals concentrations.

CONCLUSIONS OF MACROINVERTEBRATE EVALUATION

Comparable data on macroinvertebrate community metrics were collected at stations in Battle Ax Creek located upstream (three stations) and downstream (one station) of the confluence with Blue Jay Creek, which flows past the adit and waste rock piles of the abandoned Morning Star Mine. The abundance of macroinvertebrates at one of the upstream background stations was low and the macroinvertebrate metric scored for slight impairment. At the other two upstream stations and the one station located downstream of the confluence, the community metric scoring indicated no impairment. Comparison of the community metric scores with metals concentrations in sediment samples showed no relationships, despite the concentrations of some metals elevated above Level II SLVs. In summary, the results of the macroinvertebrate evaluation suggest that the Morning Star Mine drainage through Blue Jay Creek to Battle Ax Creek does not result in impact to the macroinvertebrate communities in downstream sediments of Battle Ax Creek.

REFERENCES FOR ATTACHMENT C

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MACROINVERTEBRATE EVALUATION FIGURES

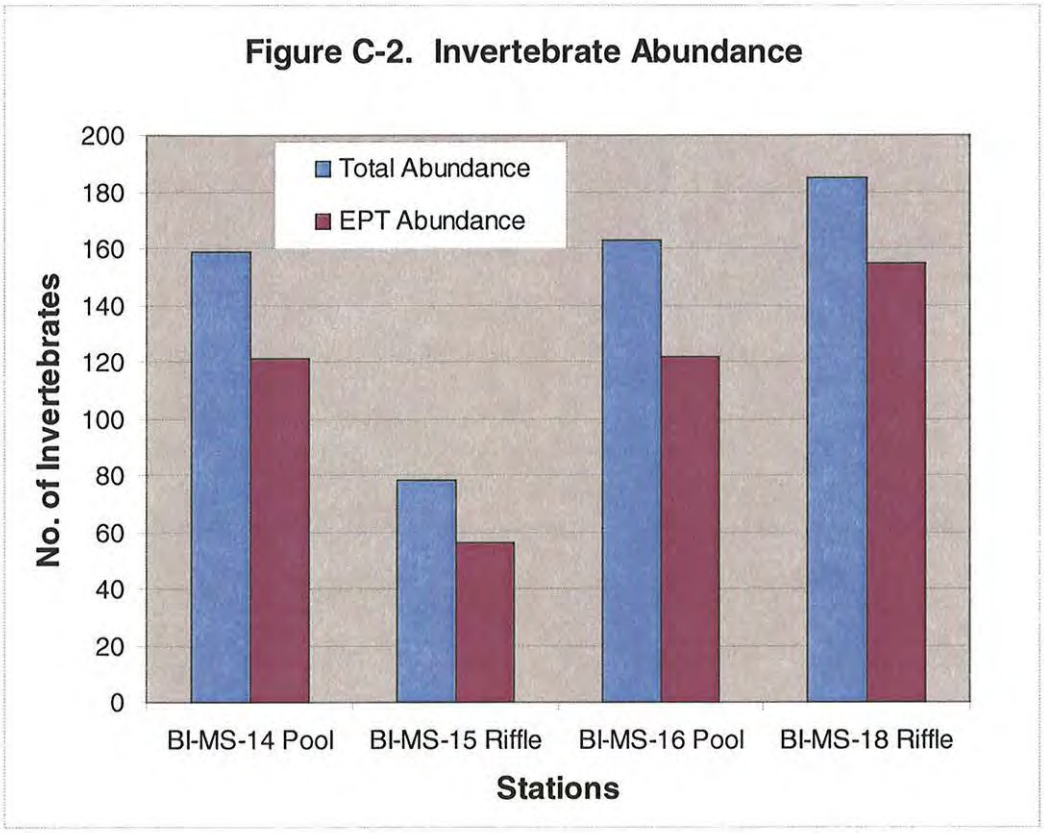


Figure C-2. Invertebrate Abundance
Total Abundance
EPT Abundance
No. of Invertebrates
200
180
160
140
120
100
80
60
40
20
0
BI-MS-14 Pool
BI-MS-15 Riffle
BI-MS-16 Pool
BI-MS-18 Riffle
Stations

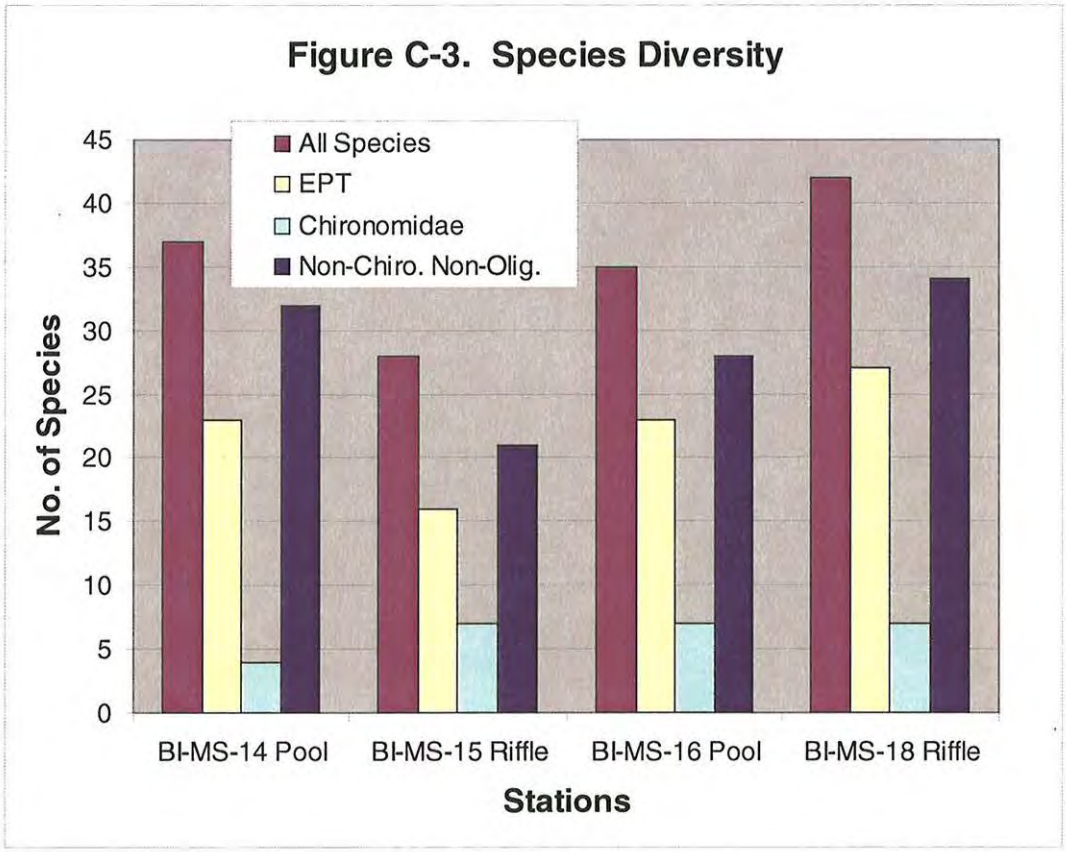
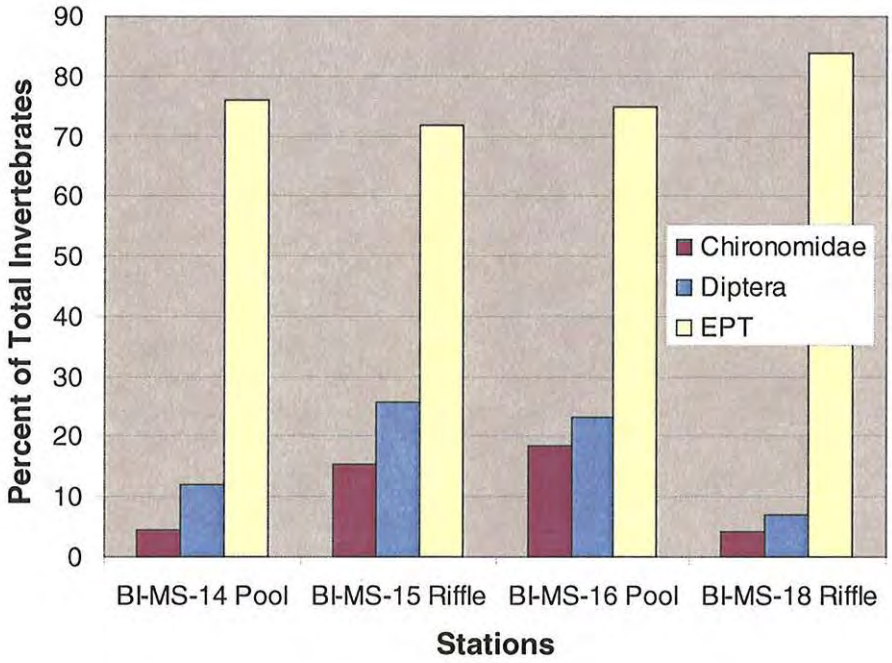


Figure C-3. Species Diversity
All Species
EPT
Chironomidae
Non-Chiro. Non-Olig.
No. of Species
45
40
35
30
25
20
15
10
5
0
BI-MS-14 Pool
BI-MS-15 Riffle
BI-MS-16 Pool
BI-MS-18 Riffle
Stations

Figure C-4. Community Composition



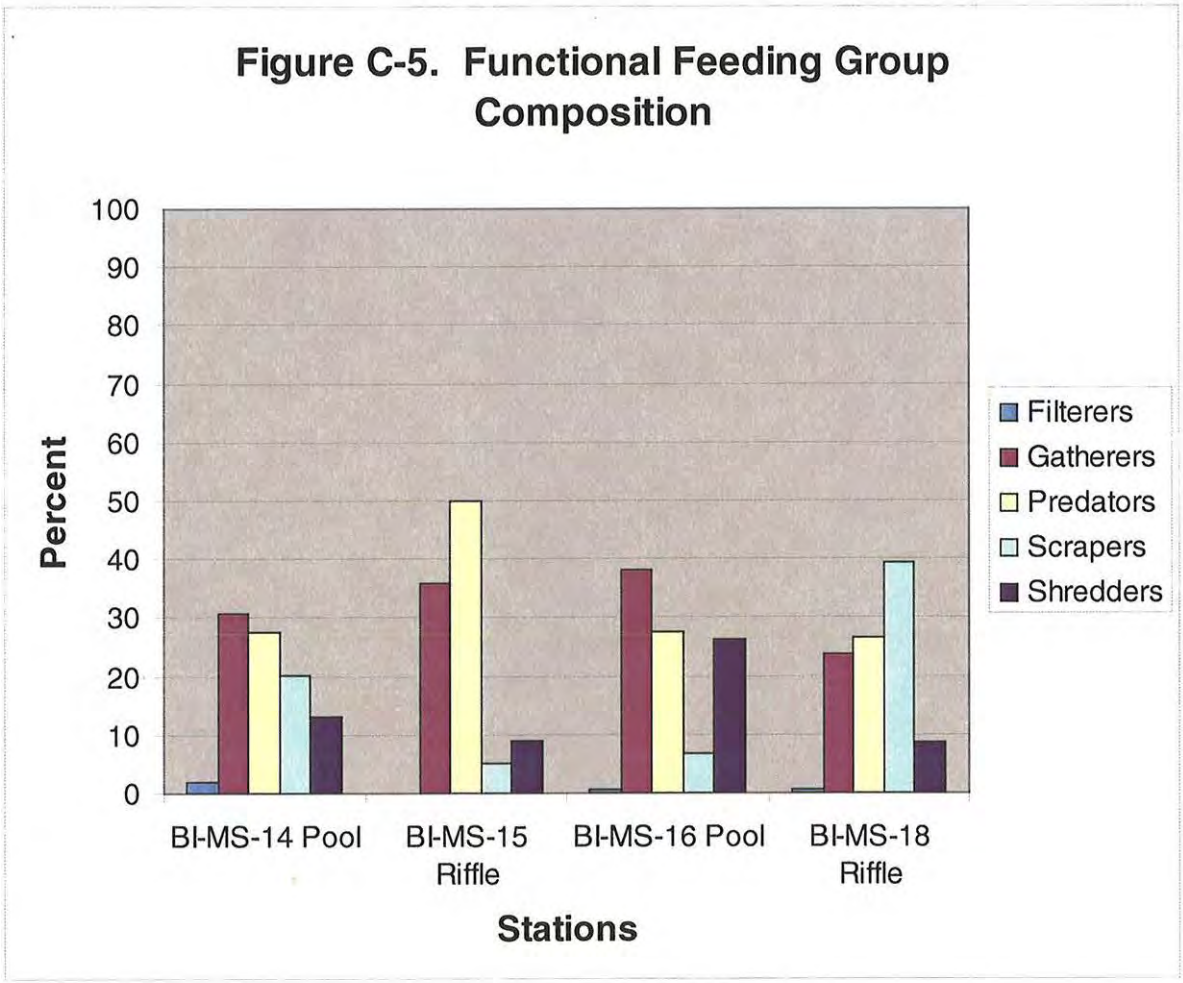


Figure C-5. Functional Feeding Group Composition
100
90
80
70
60
50
40
30
20
10
0
Percent
BI-MS-14 Pool
BI-MS-15 Riffle
BI-MS-16 Pool
BI-MS-18 Riffle
Stations
Filterers
Gatherers
Predators
Scrapers
Shredders

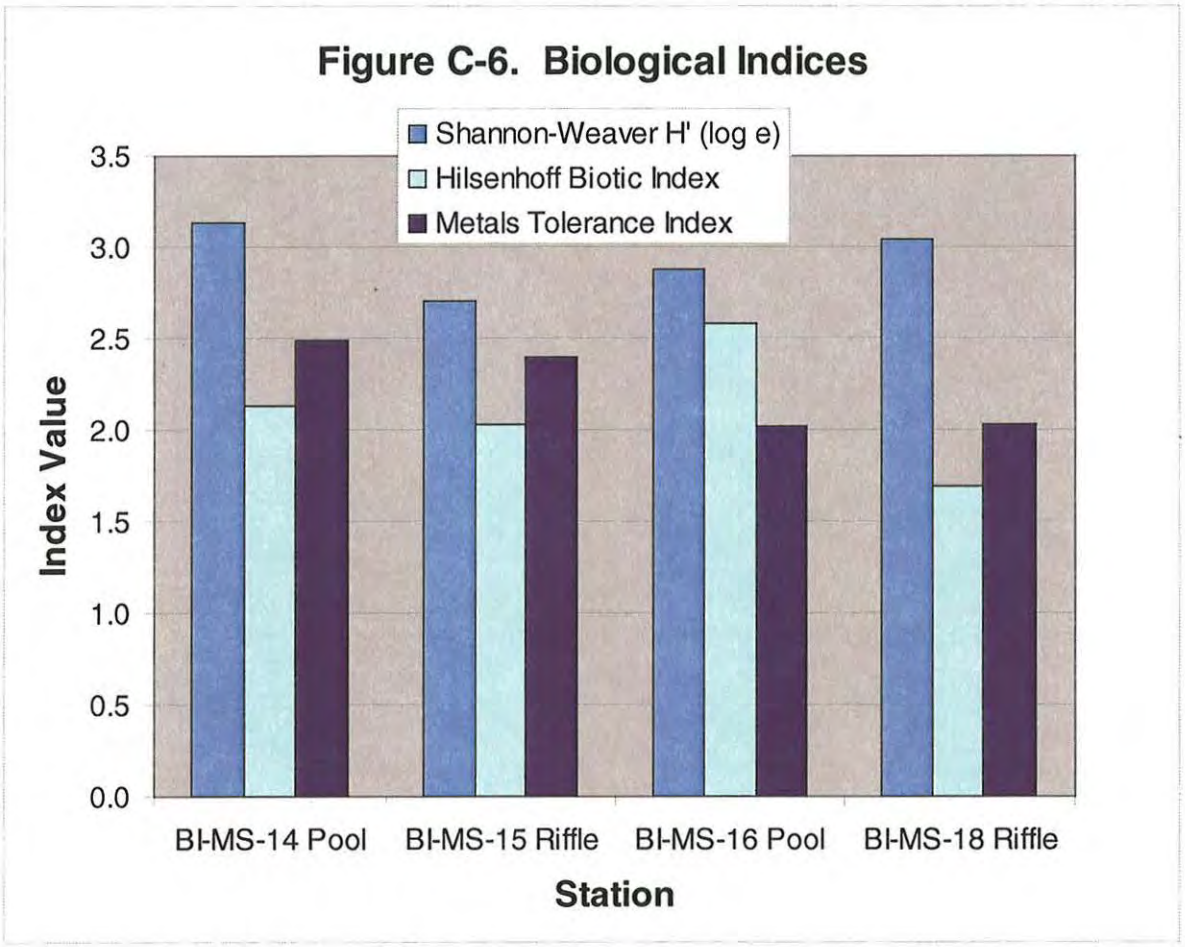


Figure C-6. Biological Indices
Shannon-Weaver H' (log e)
Hilsenhoff Biotic Index
Metals Tolerance Index
Index Value
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
BI-MS-14 Pool
BI-MS-15 Riffle
BI-MS-16 Pool
BI-MS-18 Riffle
Station

Figure C-7. OPSW Scores for Sediment Stations Relative to Location

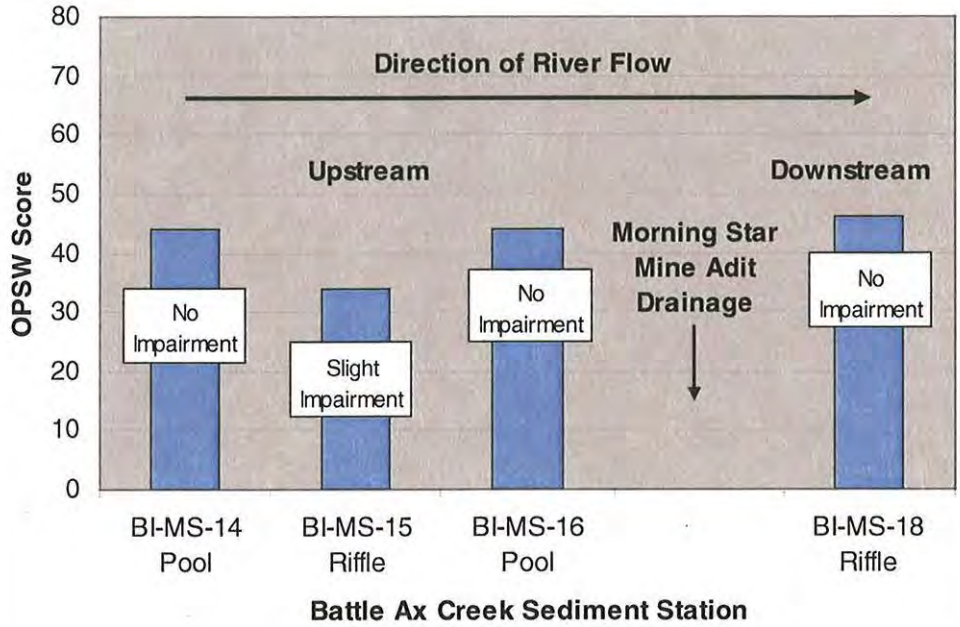
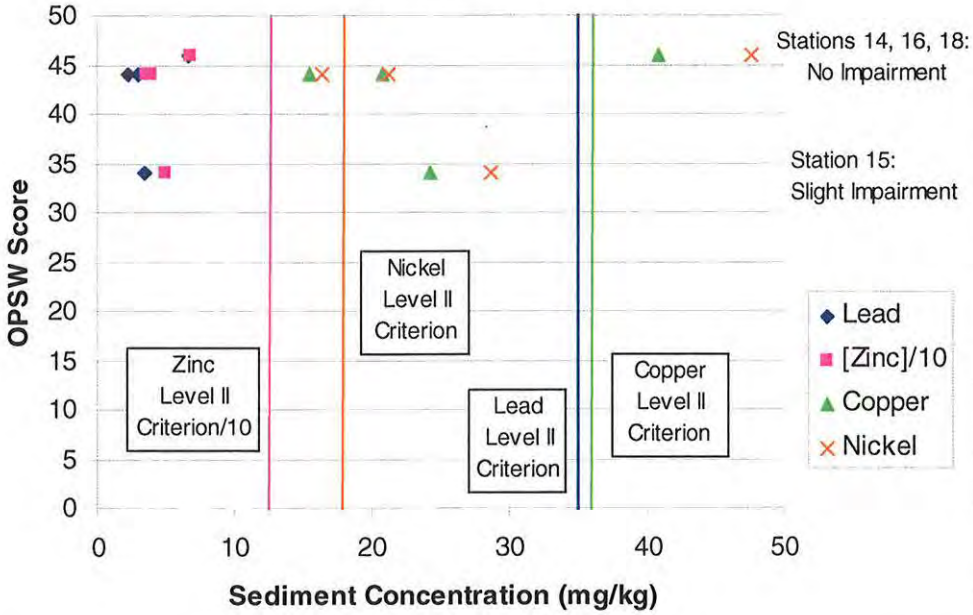


Figure C-8. Detected Metals Concentrations vs. OPSW Scores



MACROINVERTEBRATE EVALUATION
DATA TABLES AND METRIC SCORES

GeoDesign Opal Creek Benthos 2008
Data are NOT adjusted for subsampling

	Stream	Battle Ax				
	Site	BI-MS-14				
	Date		10-08-2008			
	Device	kick net				
	Habitat	pool				
	Percent Subsampled	100.00				
	EcoAnalysts Sample ID	5242.1-1				
			Sediment Tolerant to Fines Taxa (SDTOL)	Sediment Sensitive to Fines Taxa (SEDINTOL)	Tolerant to Disturbance (TOL)	Sensitive to Disturbance (SENS)
Ephemeroptera	Ameletus sp.	7				
	Baetis sp.	0				
	Baetis tricaudatus	27				
	Caudatella hystrix	0				Y
	Cinygmula sp.	7				
	Diphetor hageni	0				
	Drunella doddsi	5				5
	Drunella spinifera	3				3
	Epeorus grandis	0				Y
	Epeorus sp.	0				
	Ephemerella sp.	0				
	Ironodes sp.	0				
	Leptophlebiidae	2				
	Rhithrogena sp.	16				
Plecoptera	Calineuria californica	8				
	Chloroperlidae	1				
	Kathroperla sp.	0				Y
	Kogotus/Rickera sp.	2				
	Leuctridae	3				3
	Megarcys sp.	1				1
	Moselia infuscata	1				1
	Paraleuctra sp.	0				Y
	Pteronarcys sp.	0				
	Skwala sp.	2				
	Sweltsa sp.	7				
	Visoka cataractae	1				1
	Yoraperla sp.	9				9
	Zapada cinctipes	5				
	Zapada columbiana	0				Y
	Zapada frigida	0				Y
Coleoptera	Heterlimnius sp.	4				
	Narpus sp.	0				
	Optioservus sp.	0			Y	
Megaloptera	Orohermes crepusculus	0		Y		
Diptera-Chironomidae	Boreochlus sp.	0				
	Brillia sp.	0				
	Chaetocladius sp.	0				
	Corynoneura sp.	0				
	Cricotopus (Nostoc.) nostocicola	0				
	Diamesa sp.	1				
	Dicrotendipes sp.	0				
	Eukiefferiella sp.	0				
	Limnophyes sp.	0	Y			
	Micropsectra sp.	0				
	Orthocladius (Symp.) lignicola	0				
	Orthocladius Complex	0				

	Parametriocnemus sp.	0				
	Parorthocladius sp.	1				
	Polypedilum sp.	0				
	Reomyia sp.	0				
	Rheocricotopus sp.	0				
	Smittia sp.	0				
	Tanytarsus sp.	3				
	Thienemanniella sp.	0				
	Thienemannimyia gr. sp.	0				
	Tvetenia bavarica gr.	2				
Diptera	Bezzia/Palpomyia sp.	3				
	Dicranota sp.	4	4			
	Hesperoconopa sp.	1				1
	Hexatoma sp.	1	1			
	Oreogeton sp.	2				2
	Pericoma/Telmatoscopus sp.	0				
	Simulium sp.	0				
	Tipula sp.	1	1			
Trichoptera	Anagapetus sp.	0		Y		Y
	Arctopsyche grandis	0		Y		
	Ecclisomyia sp.	0				Y
	Glossosoma sp.	1		1		
	Hydatophylax sp.	0				
	Lepidostoma sp.	0				
	Limnephilidae	0				
	Micrasema sp.	1				
	Neophylax occidentis	0				
	Parapsyche elsis	0		Y		Y
	Polycentropodidae	0				
	Polycentropus sp.	2				
	Rhyacophila arnaudi	0				
	Rhyacophila betteni gr.	0				
	Rhyacophila brunnea gr.	0				
	Rhyacophila hyalinata gr.	1				
	Rhyacophila narvae	9				
Gastropoda	Menetus opercularis	0				
	Pristinicola hemphilli	10				
Annelida	Oligochaeta	4	4		4	
Acari	Oribatei	0				
	Protzia sp.	0				
Other Organisms	Polycelis sp.	1				
	TOTAL	**159**				
		No. of Taxa:	4	1	1	9
		Abundance:	10	1	4	26

GeoDesign Opal Creek Benthos 2008
Data are adjusted for subsampling

Stream	**Battle Ax**
Site	**BI-MS-14**
Date	**10-08-2008**
Device	**kick net**
Habitat	**pool**
Percent Subsampled	**100.00**
EcoAnalysts Sample ID	**5242.1-1**
Abundance Measures	
Corrected Abundance	159
EPT Abundance	121
Dominance Measures	
Dominant Taxon	Baetis tricaudatus
Dominant Abundance	27
2nd Dominant Taxon	Rhithrogena sp.
2nd Dominant Abundance	16
3rd Dominant Taxon	Pristinicola hemphilli
3rd Dominant Abundance	10
% Dominant Taxon	16.98
% 2 Dominant Taxa	27.04
% 3 Dominant Taxa	33.33
Richness Measures	
Species Richness	37
EPT Richness	23
Ephemeroptera Richness	7
Plecoptera Richness	11
Trichoptera Richness	5
Chironomidae Richness	4
Oligochaeta Richness	1
Non-Chiro. Non-Olig. Richness	32
Rhyacophila Richness	2
Community Composition	
% Ephemeroptera	42.14
% Plecoptera	25.16
% Trichoptera	8.81
% EPT	76.1
% Coleoptera	2.52
% Diptera	11.95
% Oligochaeta	2.52
% Baetidae	16.98
% Brachycentridae	0.63
% Chironomidae	4.4
% Ephemerellidae	5.03

% Hydropsychidae	0
% Odonata	0
% Perlidae	5.03
% Pteronarcyidae	0
% Simuliidae	0
Functional Group Composition	
% Filterers	1.89
% Gatherers	30.82
% Predators	27.67
% Scrapers	20.13
% Shredders	13.21
% Piercer-Herbivores	0
% Unclassified	6.29
Filterer Richness	1
Gatherer Richness	9
Predator Richness	14
Scraper Richness	5
Shredder Richness	7
Piercer-Herbivore Richness	0
Unclassified	1
Diversity/Evenness Measures	
Shannon-Weaver H' (log 10)	1.36
Shannon-Weaver H' (log 2)	4.52
Shannon-Weaver H' (log e)	3.13
Margalef's Richness	7.1
Pielou's J'	0.87
Simpson's Heterogeneity	0.94
Biotic Indices	
% Indiv. w/ HBI Value	91.82
Hilsenhoff Biotic Index	2.13
% Indiv. w/ MTI Value	74.21
Metals Tolerance Index	2.49
% Indiv. w/ FSBI Value	75.47
Fine Sediment Biotic Index	103
FSBI - average	2.78
FSBI - weighted average	4.88
% Indiv. w/ TPM Value	80.5
Temp. Pref. Metric - average	4.65
TPM - weighted average	6.35
Karr BIBI Metrics	
Long-Lived Taxa Richness	11
Clinger Richness	23
% Clingers	77.99
Intolerant Taxa Richness	22
% Tolerant Individuals	2.74
% Tolerant Taxa	2.7
Coleoptera Richness	1

Morning Star Mine Site
BI-MS-14 Pool
Genus/Species Level Metrics and Scoring Criteria.

Metric	Raw Value	Scoring Criteria 5	3	1	Score
Taxa Richness	37	>35	19-35	<19	5
Mayfly Richness	7	>8	4-8	<4	3
Stonefly Richness	11	>5	3-5	<3	5
Caddisfly Richness	5	>8	4-8	<4	3
Sensitive Taxa	9	>4	2-4	<2	5
Sediment sens. Taxa	1	>2	1	0	3
Modified HBI	2	<4.0	4-5	>5.0	5
% Tolerant Taxa	2.52	<15	15-45	>45	5
% Sed Tol Taxa	6.29	<10	10-25	>25	5
% Dominant (single taxa)	17	<20	20-40	>40	5
				Total score	**44**

Score Range	Stream Condition
>39	No Impairment: passes level 3 assessment. Indicates good diversity of invertebrates and stream conditions with little or no disturbance.
30-39	Slight Impairment: evidence of some impairment exists.
20-29	Moderate Impairment: clear evidence of disturbance exists.
<20	Severe Impairment: conditions indicate a high level of disturbance.

GeoDesign Opal Creek Benthos 2008
Data are NOT adjusted for subsampling

	Stream	**Battle Ax**				
	Site	**BI-MS-15**				
	Date	**10-08-2008**				
	Device	**kick net**				
	Habitat	**riffle**				
	Percent Subsampled	**100.00**				
	EcoAnalysts Sample ID	**5242.1-2**	Sediment Tolerant to Fines Taxa (SDTOL)	Sediment Sensitive to Fines Taxa (SEDINTOL)	Tolerant to Disturbance (TOL)	Sensitive to Disturbance (SENS)
Ephemeroptera	Ameletus sp.	11				
	Baetis sp.	6				
	Baetis tricaudatus	0				
	Caudatella hystrix	0				Y
	Cinygmula sp.	1				
	Diphetor hageni	0				
	Drunella doddsi	2				2
	Drunella spinifera	0				Y
	Epeorus grandis	0				Y
	Epeorus sp.	0				
	Ephemerella sp.	1				
	Ironodes sp.	0				
	Leptophlebiidae	1				
	Rhithrogena sp.	0				
Plecoptera	Calineuria californica	3				
	Chloroperlidae	0				
	Kathroperla sp.	0				Y
	Kogotus/Rickera sp.	0				
	Leuctridae	0				Y
	Megarcys sp.	1				1
	Moselia infuscata	0				Y
	Paraleuctra sp.	0				Y
	Pteronarcys sp.	0				
	Skwala sp.	0				
	Sweltsa sp.	22				
	Visoka cataractae	0				Y
	Yoraperla sp.	0				Y
	Zapada cinctipes	0				
	Zapada columbiana	0				Y
	Zapada frigida	0				Y
Coleoptera	Heterlimnius sp.	0				
	Narpus sp.	0				
	Optioservus sp.	0			Y	
Megaloptera	Orohermes crepusculus	0		Y		
Diptera-Chironomidae	Boreochius sp.	1				
	Brillia sp.	4				
	Chaetocladius sp.	0				
	Corynoneura sp.	0				
	Cricotopus (Nostoc.) nostocicola	0				
	Diamesa sp.	0				
	Dicrotendipes sp.	1				
	Eukiefferiella sp.	1				
	Limnophyes sp.	2	2			

	Micropsectra sp.	0				
	Orthocladius (Symp.) lignicola	1				
	Orthocladius Complex	0				
	Parametriocnemus sp.	2				
	Parorthocladius sp.	0				
	Polypedilum sp.	0				
	Reomyia sp.	0				
	Rheocricotopus sp.	0				
	Smittia sp.	0				
	Tanytarsus sp.	0				
	Thienemanniella sp.	0				
	Thienemannimyia gr. sp.	0				
	Tvetenia bavarica gr.	0				
Diptera	Bezzia/Palpomyia sp.	1				
	Dicranota sp.	5	5			
	Hesperoconopa sp.	0				Y
	Hexatoma sp.	1	1			
	Oreogeton sp.	0				Y
	Pericoma/Telmatoscopus sp.	0				
	Simulium sp.	0				
	Tipula sp.	1	1			
Trichoptera	Anagapetus sp.	1		1		1
	Arctopsyche grandis	0		Y		
	Ecclisomyia sp.	1				1
	Glossosoma sp.	0		Y		
	Hydatophylax sp.	1				
	Lepidostoma sp.	0				
	Limnephilidae	0				
	Micrasema sp.	1				
	Neophylax occidentis	0				
	Parapsyche elsis	0		Y		Y
	Polycentropodidae	0				
	Polycentropus sp.	1				
	Rhyacophila arnaudi	0				
	Rhyacophila betteni gr.	2				
	Rhyacophila brunnea gr.	0				
	Rhyacophila hyalinata gr.	0				
	Rhyacophila narvae	1				
Gastropoda	Menetus opercularis	0				
	Pristinicola hemphilli	0				
Annelida	Oligochaeta	0	Y		Y	
Acari	Oribatei	0				
	Protzia sp.	0				
Other Organisms	Polycelis sp.	2				
	TOTAL	**78**				
		No. of Taxa:	4	1	0	4
		Abundance:	9	1	0	5

GeoDesign Opal Creek Benthos 2008
Data are adjusted for subsampling

Stream	**Battle Ax**
Site	**BI-MS-15**
Date	**10-08-2008**
Device	**kick net**
Habitat	**riffle**
Percent Subsampled	**100.00**
EcoAnalysts Sample ID	**5242.1-2**
Abundance Measures	
Corrected Abundance	78
EPT Abundance	56
Dominance Measures	
Dominant Taxon	Sweltsa sp.
Dominant Abundance	22
2nd Dominant Taxon	Ameletus sp.
2nd Dominant Abundance	11
3rd Dominant Taxon	Baetis sp.
3rd Dominant Abundance	6
% Dominant Taxon	28.21
% 2 Dominant Taxa	42.31
% 3 Dominant Taxa	50
Richness Measures	
Species Richness	28
EPT Richness	16
Ephemeroptera Richness	6
Plecoptera Richness	3
Trichoptera Richness	7
Chironomidae Richness	7
Oligochaeta Richness	0
Non-Chiro. Non-Olig. Richness	21
Rhyacophila Richness	2
Community Composition	
% Ephemeroptera	28.21
% Plecoptera	33.33
% Trichoptera	10.26
% EPT	71.79
% Coleoptera	0
% Diptera	25.64
% Oligochaeta	0
% Baetidae	7.69
% Brachycentridae	1.28
% Chironomidae	15.38
% Ephemerellidae	3.85

% Hydropsychidae	0
% Odonata	0
% Perlidae	3.85
% Pteronarcyidae	0
% Simuliidae	0
Functional Group Composition	
% Filterers	0
% Gatherers	35.9
% Predators	50
% Scrapers	5.13
% Shredders	8.97
% Piercer-Herbivores	0
% Unclassified	0
Filterer Richness	0
Gatherer Richness	11
Predator Richness	10
Scraper Richness	3
Shredder Richness	4
Piercer-Herbivore Richness	0
Unclassified	0
Diversity/Evenness Measures	
Shannon-Weaver H' (log 10)	1.17
Shannon-Weaver H' (log 2)	3.9
Shannon-Weaver H' (log e)	2.7
Margalef's Richness	6.2
Pielou's J'	0.81
Simpson's Heterogeneity	0.89
Biotic Indices	
% Indiv. w/ HBI Value	98.72
Hilsenhoff Biotic Index	2.03
% Indiv. w/ MTI Value	57.69
Metals Tolerance Index	2.4
% Indiv. w/ FSBI Value	75.64
Fine Sediment Biotic Index	71
FSBI - average	2.54
FSBI - weighted average	4.17
% Indiv. w/ TPM Value	69.23
Temp. Pref. Metric - average	3.64
TPM - weighted average	6.74
Karr BIBI Metrics	
Long-Lived Taxa Richness	5
Clinger Richness	14
% Clingers	69.23
Intolerant Taxa Richness	14
% Tolerant Individuals	0
% Tolerant Taxa	7.14
Coleoptera Richness	0

Morning Star Mine Site
BI-MS-15 Riffle
Genus/Species Level Metrics and Scoring Criteria.

Metric	Raw Value	Scoring Criteria 5	3	1	Score
Taxa Richness	28	>35	19-35	<19	3
Mayfly Richness	6	>8	4-8	<4	3
Stonefly Richness	3	>5	3-5	<3	3
Caddisfly Richness	7	>8	4-8	<4	3
Sensitive Taxa	4	>4	2-4	<2	3
Sediment sens. Taxa	1	>2	1	0	3
Modified HBI	2	<4.0	4-5	>5.0	5
% Tolerant Taxa	0.00	<15	15-45	>45	5
% Sed Tol Taxa	11.54	<10	10-25	>25	3
% Dominant (single taxa)	28	<20	20-40	>40	3
				Total score	**34**

Score Range	Stream Condition
>39	No Impairment: passes level 3 assessment. Indicates good diversity of invertebrates and stream conditions with little or no disturbance.
30-39	Slight Impairment: evidence of some impairment exists.
20-29	Moderate Impairment: clear evidence of disturbance exists.
<20	Severe Impairment: conditions indicate a high level of disturbance.

GeoDesign Opal Creek Benthos 2008
Data are NOT adjusted for subsampling

	Stream	**Battle Ax**				
	Site	**BI-MS-16**				
	Date	**10-08-2008**				
	Device	**kick net**				
	Habitat	**pool**				
	Percent Subsampled	**100.00**				
	EcoAnalysts Sample ID	**5242.1-3**	Sediment Tolerant to Fines Taxa (SDTOL)	Sediment Sensitive to Fines Taxa (SEDINTOL)	Tolerant to Disturbance (TOL)	Sensitive to Disturbance (SENS)
Ephemeroptera	Ameletus sp.	8				
	Baetis sp.	0				
	Baetis tricaudatus	20				
	Caudatella hystrix	1				1
	Cinygmula sp.	2				
	Diphetor hageni	0				
	Drunella doddsi	5				5
	Drunella spinifera	2				2
	Epeorus grandis	0				Y
	Epeorus sp.	1				
	Ephemerella sp.	0				
	Ironodes sp.	0				
	Leptophlebiidae	1				
	Rhithrogena sp.	1				
Plecoptera	Calineuria californica	8				
	Chloroperlidae	0				
	Kathroperla sp.	0				Y
	Kogotus/Rickera sp.	2				
	Leuctridae	1				1
	Megarcys sp.	1				1
	Moselia infuscata	0				Y
	Paraleuctra sp.	0				Y
	Pteronarcys sp.	0				
	Skwala sp.	3				
	Sweltsa sp.	21				
	Visoka cataractae	0				Y
	Yoraperla sp.	2				2
	Zapada cinctipes	4				
	Zapada columbiana	0				Y
	Zapada frigida	0				Y
Coleoptera	Heterlimnius sp.	2				
	Narpus sp.	0				
	Optioservus sp.	0			Y	
Megaloptera	Orohermes crepusculus	1		1		
Diptera-Chironomidae	Boreochlus sp.	0				
	Brillia sp.	2				
	Chaetocladius sp.	0				
	Corynoneura sp.	0				
	Cricotopus (Nostoc.) nostocicola	0				
	Diamesa sp.	0				
	Dicrotendipes sp.	0				
	Eukiefferiella sp.	0				

	Limnophyes sp.	1	1			
	Micropsectra sp.	23				
	Orthocladius (Symp.) lignicola	0				
	Orthocladius Complex	0				
	Parametriocnemus sp.	0				
	Parorthocladius sp.	1				
	Polypedilum sp.	0				
	Reomyia sp.	0				
	Rheocricotopus sp.	0				
	Smittia sp.	0				
	Tanytarsus sp.	1				
	Thienemanniella sp.	0				
	Thienemannimyia gr. sp.	1				
	Tvetenia bavarica gr.	1				
Diptera	Bezzia/Palpomyia sp.	2				
	Dicranota sp.	4	4			
	Hesperoconopa sp.	0				Y
	Hexatoma sp.	0	Y			
	Oreogeton sp.	0				Y
	Pericoma/Telmatoscopus sp.	0				
	Simulium sp.	0				
	Tipula sp.	2	2			
Trichoptera	Anagapetus sp.	0		Y		Y
	Arctopsyche grandis	0		Y		
	Ecclisomyia sp.	4				4
	Glossosoma sp.	0		Y		
	Hydatophylax sp.	0				
	Lepidostoma sp.	26				
	Limnephilidae	4				
	Micrasema sp.	2				
	Neophylax occidentis	0				
	Parapsyche elsis	0		Y		Y
	Polycentropodidae	0				
	Polycentropus sp.	1				
	Rhyacophila arnaudi	0				
	Rhyacophila betteni gr.	0				
	Rhyacophila brunnea gr.	0				
	Rhyacophila hyalinata gr.	0				
	Rhyacophila narvae	2				
Gastropoda	Menetus opercularis	0				
	Pristinicola hemphilli	0				
Annelida	Oligochaeta	0	Y		Y	
Acari	Oribatei	0				
	Protzia sp.	0				
Other Organisms	Polycelis sp.	0				
	TOTAL	**163**				
		No. of Taxa:	3	1	0	7
		Abundance:	7	1	0	16

GeoDesign Opal Creek Benthos 2008
Data are adjusted for subsampling

Stream	**Battle Ax**
Site	**BI-MS-16**
Date	**10-08-2008**
Device	**kick net**
Habitat	**pool**
Percent Subsampled	**100.00**
EcoAnalysts Sample ID	**5242.1-3**
Abundance Measures	
Corrected Abundance	163
EPT Abundance	122
Dominance Measures	
Dominant Taxon	Lepidostoma sp.
Dominant Abundance	26
2nd Dominant Taxon	Micropsectra sp.
2nd Dominant Abundance	23
3rd Dominant Taxon	Sweltsa sp.
3rd Dominant Abundance	21
% Dominant Taxon	15.95
% 2 Dominant Taxa	30.06
% 3 Dominant Taxa	42.94
Richness Measures	
Species Richness	35
EPT Richness	23
Ephemeroptera Richness	9
Plecoptera Richness	8
Trichoptera Richness	6
Chironomidae Richness	7
Oligochaeta Richness	0
Non-Chiro. Non-Olig. Richness	28
Rhyacophila Richness	1
Community Composition	
% Ephemeroptera	25.15
% Plecoptera	25.77
% Trichoptera	23.93
% EPT	74.85
% Coleoptera	1.23
% Diptera	23.31
% Oligochaeta	0
% Baetidae	12.27
% Brachycentridae	1.23
% Chironomidae	18.4
% Ephemerellidae	4.91
% Hydropsychidae	0

% Odonata	0
% Perlidae	4.91
% Pteronarcyidae	0
% Simuliidae	0
Functional Group Composition	
% Filterers	0.61
% Gatherers	38.04
% Predators	27.61
% Scrapers	6.75
% Shredders	26.38
% Piercer-Herbivores	0
% Unclassified	0.61
Filterer Richness	1
Gatherer Richness	10
Predator Richness	10
Scraper Richness	5
Shredder Richness	8
Piercer-Herbivore Richness	0
Unclassified	1
Diversity/Evenness Measures	
Shannon-Weaver H' (log 10)	1.25
Shannon-Weaver H' (log 2)	4.15
Shannon-Weaver H' (log e)	2.88
Margalef's Richness	6.67
Pielou's J'	0.81
Simpson's Heterogeneity	0.92
Biotic Indices	
% Indiv. w/ HBI Value	98.16
Hilsenhoff Biotic Index	2.58
% Indiv. w/ MTI Value	78.53
Metals Tolerance Index	2.02
% Indiv. w/ FSBI Value	58.28
Fine Sediment Biotic Index	104
FSBI - average	2.97
FSBI - weighted average	4.76
% Indiv. w/ TPM Value	74.23
Temp. Pref. Metric - average	4.09
TPM - weighted average	5.73
Karr BIBI Metrics	
Long-Lived Taxa Richness	8
Clinger Richness	22
% Clingers	70.55
Intolerant Taxa Richness	19
% Tolerant Individuals	0
% Tolerant Taxa	2.86
Coleoptera Richness	1

Morning Star Mine Site
BI-MS-16 Pool
Genus/Species Level Metrics and Scoring Criteria.

Metric	Raw Value	Scoring Criteria 5	3	1	Score
Taxa Richness	35	>35	19-35	<19	3
Mayfly Richness	9	>8	4-8	<4	5
Stonefly Richness	8	>5	3-5	<3	5
Caddisfly Richness	6	>8	4-8	<4	3
Sensitive Taxa	7	>4	2-4	<2	5
Sediment sens. Taxa	1	>2	1	0	3
Modified HBI	3	<4.0	4-5	>5.0	5
% Tolerant Taxa	0.00	<15	15-45	>45	5
% Sed Tol Taxa	4.29	<10	10-25	>25	5
% Dominant (single taxa)	16	<20	20-40	>40	5
				Total score	**44**

Score Range	Stream Condition
>39	No Impairment: passes level 3 assessment. Indicates good diversity of invertebrates and stream conditions with little or no disturbance.
30-39	Slight Impairment: evidence of some impairment exists.
20-29	Moderate Impairment: clear evidence of disturbance exists.
<20	Severe Impairment: conditions indicate a high level of disturbance.

GeoDesign Opal Creek Benthos 2008
Data are NOT adjusted for subsampling

	Stream	Battle Ax				
	Site	BI-MS-18				
	Date	10-08-2008				
	Device	kick net				
	Habitat	riffle				
	Percent Subsampled	100.00				
	EcoAnalysts Sample ID	5242.1-4	Sediment Tolerant to Fines Taxa (SDTOL)	Sediment Sensitive to Fines Taxa (SEDINTOL)	Tolerant to Disturbance (TOL)	Sensitive to Disturbance (SENS)
Ephemeroptera	Ameletus sp.	13				
	Baetis sp.	0				
	Baetis tricaudatus	18				
	Caudatella hystrix	0				Y
	Cinygmula sp.	0				
	Diphetor hageni	0				
	Drunella doddsi	18				18
	Drunella spinifera	2				2
	Epeorus grandis	2				2
	Epeorus sp.	0				
	Ephemerella sp.	0				
	Ironodes sp.	1				
	Leptophlebiidae	0				
	Rhithrogena sp.	39				
Plecoptera	Calineuria californica	12				
	Chloroperlidae	0				
	Kathroperla sp.	2				2
	Kogotus/Rickera sp.	1				
	Leuctridae	0				Y
	Megarcys sp.	5				5
	Moselia infuscata	0				Y
	Paraleuctra sp.	0				Y
	Pteronarcys sp.	1				
	Skwala sp.	5				
	Sweltsa sp.	7				
	Visoka cataractae	1				1
	Yoraperla sp.	6				6
	Zapada cinctipes	1				
	Zapada columbiana	2				2
	Zapada frigida	0				Y
Coleoptera	Heterlimnius sp.	1				
	Narpus sp.	0				
	Optioservus sp.	2			2	
Megaloptera	Orohermes crepusculus	1		1		
Diptera-Chironomidae	Boreochlus sp.	0				
	Brillia sp.	2				
	Chaetocladius sp.	1				
	Corynoneura sp.	0				
	Cricotopus (Nostoc.) nostocicola	0				
	Diamesa sp.	0				
	Dicrotendipes sp.	0				
	Eukiefferiella sp.	0				

	Limnophyes sp.	0	Y			
	Micropsectra sp.	1				
	Orthocladius (Symp.) lignicola	0				
	Orthocladius Complex	0				
	Parametriocnemus sp.	0				
	Parorthocladius sp.	0				
	Polypedilum sp.	1				
	Reomyia sp.	1				
	Rheocricotopus sp.	0				
	Smittia sp.	1				
	Tanytarsus sp.	0				
	Thienemanniella sp.	1				
	Thienemannimyia gr. sp.	0				
	Tvetenia bavarica gr.	0				
Diptera	Bezzia/Palpomyia sp.	0				
	Dicranota sp.	4	4			
	Hesperoconopa sp.	0				Y
	Hexatoma sp.	0	Y			
	Oreogeton sp.	0				Y
	Pericoma/Telmatoscopus sp.	0				
	Simulium sp.	1				
	Tipula sp.	0	Y			
Trichoptera	Anagapetus sp.	5		5		5
	Arctopsyche grandis	0		Y		
	Ecclisomyia sp.	0				Y
	Glossosoma sp.	1		1		
	Hydatophylax sp.	0				
	Lepidostoma sp.	1				
	Limnephilidae	0				
	Micrasema sp.	1				
	Neophylax occidentis	3				
	Parapsyche elsis	2		2		2
	Polycentropodidae	0				
	Polycentropus sp.	0				
	Rhyacophila arnaudi	0				
	Rhyacophila betteni gr.	4				
	Rhyacophila brunnea gr.	1				
	Rhyacophila hyalinata gr.	1				
	Rhyacophila narvae	0				
Gastropoda	Menetus opercularis	0				
	Pristinicola hemphilli	1				
Annelida	Oligochaeta	6	6		6	
Acari	Oribatei	0				
	Protzia sp.	0				
Other Organisms	Polycelis sp.	6				
	TOTAL	**185**				
		No. of Taxa:	2	4	2	10
		Abundance:	10	9	8	45

GeoDesign Opal Creek Benthos 2008
Data are adjusted for subsampling

Stream	**Battle Ax**
Site	**Bi-MS-18**
Date	**10-08-2008**
Device	**kick net**
Habitat	**riffle**
Percent Subsampled	**100.00**
EcoAnalysts Sample ID	**5242.1-4**
Abundance Measures	
Corrected Abundance	185
EPT Abundance	155
Dominance Measures	
Dominant Taxon	Rhithrogena sp.
Dominant Abundance	39
2nd Dominant Taxon	Drunella doddsi
2nd Dominant Abundance	18
3rd Dominant Taxon	Baetis tricaudatus
3rd Dominant Abundance	18
% Dominant Taxon	21.08
% 2 Dominant Taxa	30.81
% 3 Dominant Taxa	40.54
Richness Measures	
Species Richness	42
EPT Richness	27
Ephemeroptera Richness	7
Plecoptera Richness	11
Trichoptera Richness	9
Chironomidae Richness	7
Oligochaeta Richness	1
Non-Chiro. Non-Olig. Richness	34
Rhyacophila Richness	3
Community Composition	
% Ephemeroptera	50.27
% Plecoptera	23.24
% Trichoptera	10.27
% EPT	83.78
% Coleoptera	1.62
% Diptera	7.03
% Oligochaeta	3.24
% Baetidae	9.73
% Brachycentridae	0.54
% Chironomidae	4.32
% Ephemerellidae	10.81
% Hydropsychidae	1.08

% Odonata	0
% Perlidae	6.49
% Pteronarcyidae	0.54
% Simuliidae	0.54
Functional Group Composition	
% Filterers	0.54
% Gatherers	23.78
% Predators	26.49
% Scrapers	39.46
% Shredders	8.65
% Piercer-Herbivores	0
% Unclassified	1.08
Filterer Richness	1
Gatherer Richness	9
Predator Richness	12
Scraper Richness	9
Shredder Richness	9
Piercer-Herbivore Richness	0
Unclassified	2
Diversity/Evenness Measures	
Shannon-Weaver H' (log 10)	1.32
Shannon-Weaver H' (log 2)	4.38
Shannon-Weaver H' (log e)	3.04
Margalef's Richness	7.85
Pielou's J'	0.81
Simpson's Heterogeneity	0.92
Biotic Indices	
% Indiv. w/ HBI Value	98.38
Hilsenhoff Biotic Index	1.69
% Indiv. w/ MTI Value	83.78
Metals Tolerance Index	2.03
% Indiv. w/ FSBI Value	82.7
Fine Sediment Biotic Index	132
FSBI - average	3.14
FSBI - weighted average	5.42
% Indiv. w/ TPM Value	85.95
Temp. Pref. Metric - average	4.64
TPM - weighted average	6.48
Karr BIBI Metrics	
Long-Lived Taxa Richness	11
Clinger Richness	28
% Clingers	83.78
Intolerant Taxa Richness	24
% Tolerant Individuals	3.3
% Tolerant Taxa	2.38
Coleoptera Richness	2

Morning Star Mine Site
BI-MS-18 Riffle
Genus/Species Level Metrics and Scoring Criteria.

Metric	Raw Value	Scoring Criteria 5	3	1	Score
Taxa Richness	42	>35	19-35	<19	5
Mayfly Richness	7	>8	4-8	<4	3
Stonefly Richness	11	>5	3-5	<3	5
Caddisfly Richness	9	>8	4-8	<4	5
Sensitive Taxa	10	>4	2-4	<2	5
Sediment sens. Taxa	4	>2	1	0	5
Modified HBI	2	<4.0	4-5	>5.0	5
% Tolerant Taxa	4.32	<15	15-45	>45	5
% Sed Tol Taxa	5.41	<10	10-25	>25	5
% Dominant (single taxa)	21	<20	20-40	>40	3
				Total score	**46**

Score Range	Stream Condition
>39	No Impairment: passes level 3 assessment. Indicates good diversity of invertebrates and stream conditions with little or no disturbance.
30-39	Slight Impairment: evidence of some impairment exists.
20-29	Moderate Impairment: clear evidence of disturbance exists.
<20	Severe Impairment: conditions indicate a high level of disturbance.

APPENDIX E

APPENDIX E

SAMPLING ACTIVITIES

Field sampling activities were completed at the Ruth Mine site on October 6 through 9, 2008. The sampling activities were completed by GeoDesign personnel. The approximate sample locations are presented on Figures 2 through 7.

WASTE ROCK/SOIL AND BACKGROUND ROCK/SOIL SAMPLING

Waste rock/soil samples and background rock/soil sampled were collected using a stainless steel trowel to dig approximately 6 inches below the soil surface, or 12 to 18 inches for deeper samples. Rock/soil material was then collected and placed in laboratory-prepared glass jars with Teflon®-lined lids. The soil samples were immediately placed in a cooler with ice for temporary storage.

The equipment used for soil sampling was cleaned between each sampling location with a tap water wash and a deionized water rinse. The GeoDesign representative wore new nitrile gloves during sample collection procedures.

SURFACE WATER SAMPLING

Surface water samples were collected from Battle Ax Creek, Blue Jay Creek, the Morning Star Mine adit, and Ruth Creek. Surface water samples were collected from approximately 6 inches below the stream surface and were collected in laboratory-supplied containers by submersing the inverted container approximately 6 inches below the surface and then slowly righting it. Surface water samples were collected in laboratory-supplied containers and then preserved in the field using nitric acid. Samples were immediately placed in a cooler with ice for temporary storage pending analytical laboratory submittal. Previously collected surface water samples (2005) included samples collected from Battle Ax Creek, Ruth Creek, Adit 4, and Adit 5.

PORE WATER SAMPLING

Pore water samples were collected from eight locations in Battle Ax Creek. Pore water samples were collected using a stainless steel probe with approximately 4 inches of screened area. The probe was inserted with the screened area approximately 4 to 8 inches below the sediment surface and a peristaltic pump with dedicated tubing, and a disposable 0.45-micron filter was used to collect the samples. Samples were collected in laboratory-supplied, preserved containers. A low flow pumping rate (approximately 40 milliliters per minute) was used to ensure that pore water was collected. Previously collected pore water samples (2005) were collected from Battle Ax Creek.

SEDIMENT SAMPLING

Sediment samples were collected from Battle Ax Creek and Blue Jay Creek. GeoDesign personnel completed the sediment sampling by hand using the laboratory-supplied glass jars to scoop available sediment from the stream locations. Following collection, samples were immediately placed in a cooler with ice for temporary storage pending analytical laboratory submittal. Previously collected sediment samples (2005) were also collected from Battle Ax Creek and Ruth Creek.

MACROINVERTEBRATE SAMPLING

Macroinvertebrate samples were collected from Battle Ax Creek at locations upstream and downstream of the confluence with Blue Jay Creek. The samples were collected from riffle or pool locations by using a kick net and completing three jabs to create a single composite sample for each station. Samples were then preserved using isopropyl alcohol as directed by the invertebrate laboratory. Sampling was completed per OPSW protocol.

ANALYTICAL LABORATORY TESTING

COC procedures were followed during the handling and transport of rock/soil, surface water, pore water, and sediment samples. All rock/soil, surface water, pore water, and sediment samples were submitted to Apex Laboratories, LLC of Tigard, Oregon, for chemical analysis. Macroinvertebrate samples were submitted for enumeration and speciation per Level 3 OPSW procedures to EcoAnalysts of Moscow, Idaho.

FIELD VOLUME MEASUREMENTS

Waste rock piles were measured in the field using a field tape to measure distances. Approximate depths were gauged visually and with the use of a steel probe where possible. The dimensions were used to approximate volumes of waste rock at both mine sites.

APPENDIX F

APPENDIX F

CHEMICAL ANALYTICAL PROGRAM

COC procedures were followed during handling and transport of the samples to the analytical laboratory. The laboratory holds the samples in cold storage pending extraction and/or analysis. The analytical results, analytical methods reference, and laboratory QC records are included in this appendix. The analytical results also are summarized in the tables of this report.

REVIEW OF ANALYTICAL DATA

The analytical laboratory maintains an internal quality assurance program, consisting of a combination of the following:

Blanks: Blanks are laboratory-prepared water samples that are free of contaminants. The blanks are carried through the analysis procedure along with the field samples to document that contaminants were not introduced to the samples during sample handling and analysis.

Surrogate Recoveries: Surrogates are organic compounds that are similar in nature to the analytes of concern but are not normally found in nature. The surrogates are added to QC and field samples prior to analysis. The percent recovery of the surrogate is calculated to demonstrate acceptable method performance.

Duplicates: Duplicates are obtained by splitting a sample into two parts. The two separate parts are carried through the analyses. The analytical results are then compared by calculating the relative percent difference between the samples.

Matrix Spike (MS)/Matrix Spike Duplicate (MSD) Recoveries: An MS sample is a sample that has been split into a second portion. The MSD is obtained by further splitting the MS sample. A known concentration of the analyte of interest is added to the MS and MSD samples. The analytical results for both samples are then compared for relative percent difference and percent recovery to demonstrate acceptable method performance.

Blank Spike (BS)/Blank Spike Duplicate (BSD) Recoveries: BS and BSD samples are obtained and analyzed in the same procedure as the MS/MSD samples. However, the laboratory blank sample is used to obtain the BS/BSD samples. The percent recovery and relative percent difference of the known concentration of analyte of interest added to the BS/BSD sample is calculated after chemical analyses to demonstrate acceptable method performance.

SUMMARY OF ANALYTICAL DATA REVIEW

GeoDesign reviewed the attached analytical data reports for data quality exceptions and deviations from acceptable method performance criteria. During the waste rock/soil and background rock/soil sample analyses, antimony was detected above the upper control limit in the laboratory control spike; therefore, the results may be biased high. In some cases, the QC laboratory duplicate samples and/or QC spike samples had percent recoveries outside control limits due to high concentrations of the analyte present and/or non-homogenous sample matrix. In our opinion, the analytical data are acceptable for their intended use.

Apex Labs

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503-718-2323 Phone
503-718-0333 Fax

Monday, November 3, 2008

Steve Nelson
GeoDesign, Inc.
15575 SW Sequoia Pkwy, Ste 100
Portland, OR 97224

RE: Opal Creek / [none]

Enclosed are the results of analyses for work order A810135, which was received by the laboratory on 10/13/2008 at 2:45:00PM.

Thank you for using Apex Labs. We appreciate your business and strive to provide the highest quality services to the environmental industry.

If you have any questions concerning this report or the services we offer, please feel free to contact me by email at: pnerenberg@apex-labs.com, or by phone at 503-718-2323.

Apex Laboratories

Philip Nerenberg, Lab Director

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Apex Labs

12232 S.W. Garden Place
Tigard, OR 97223
503-718-2323 Phone
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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

ANALYTICAL REPORT FOR SAMPLES

SAMPLE INFORMATION

Sample ID	Laboratory ID	Matrix	Date Sampled	Date Received
BG-11	A810135-01	Soil	10/06/08 11:40	10/13/08 14:45
BG-12	A810135-02	Soil	10/06/08 12:05	10/13/08 14:45
BG-13	A810135-03	Soil	10/06/08 12:30	10/13/08 14:45
BG-14	A810135-04	Soil	10/06/08 13:20	10/13/08 14:45
BG-15	A810135-05	Soil	10/06/08 14:25	10/13/08 14:45
BG-16	A810135-06	Soil	10/06/08 14:45	10/13/08 14:45
BG-17	A810135-07	Soil	10/06/08 15:30	10/13/08 14:45
BG-18	A810135-08	Soil	10/06/08 15:45	10/13/08 14:45
BG-19	A810135-09	Soil	10/06/08 16:05	10/13/08 14:45
BG-20	A810135-10	Soil	10/06/08 17:20	10/13/08 14:45
WRS-R-11	A810135-11	Soil	10/07/08 09:10	10/13/08 14:45
WRS-R-12	A810135-12	Soil	10/07/08 09:20	10/13/08 14:45
WRS-R-13	A810135-13	Soil	10/07/08 09:30	10/13/08 14:45
WRS-R-14	A810135-14	Soil	10/07/08 09:45	10/13/08 14:45
WRS-R-15	A810135-15	Soil	10/07/08 10:05	10/13/08 14:45
WRS-R-16	A810135-16	Soil	10/07/08 10:10	10/13/08 14:45
WRS-R-17	A810135-17	Soil	10/07/08 10:25	10/13/08 14:45
WRS-R-18	A810135-18	Soil	10/07/08 10:40	10/13/08 14:45
WRS-R-19	A810135-19	Soil	10/07/08 10:50	10/13/08 14:45
WRS-R-20	A810135-20	Soil	10/07/08 11:00	10/13/08 14:45
WRS-R-21	A810135-21	Soil	10/07/08 11:05	10/13/08 14:45
WRS-MS-1	A810135-22	Soil	10/07/08 14:00	10/13/08 14:45
WRS-MS-2	A810135-23	Soil	10/07/08 14:05	10/13/08 14:45
WRS-MS-3	A810135-24	Soil	10/07/08 14:10	10/13/08 14:45
WRS-MS-4	A810135-25	Soil	10/07/08 14:15	10/13/08 14:45
WRS-MS-5	A810135-26	Soil	10/07/08 14:20	10/13/08 14:45
WRS-MS-6	A810135-27	Soil	10/07/08 14:30	10/13/08 14:45
WRS-MS-7	A810135-28	Soil	10/07/08 14:35	10/13/08 14:45
WRS-MS-8	A810135-29	Soil	10/07/08 14:40	10/13/08 14:45
WRS-MS-9	A810135-30	Soil	10/07/08 14:45	10/13/08 14:45
WRS-MS-10	A810135-31	Soil	10/07/08 14:50	10/13/08 14:45
WRS-MS-11	A810135-32	Soil	10/07/08 14:55	10/13/08 14:45
WRS-R-22	A810135-33	Soil	10/07/08 16:00	10/13/08 14:45
WRS-R-23	A810135-34	Soil	10/07/08 16:05	10/13/08 14:45
WRS-R-24	A810135-35	Soil	10/07/08 16:10	10/13/08 14:45

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15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

ANALYTICAL REPORT FOR SAMPLES

SAMPLE INFORMATION

Sample ID	Laboratory ID	Matrix	Date Sampled	Date Received
WRS-R-25	A810135-36	Soil	10/07/08 16:15	10/13/08 14:45
WRS-R-26	A810135-37	Soil	10/07/08 16:20	10/13/08 14:45
WRS-R-27	A810135-38	Soil	10/07/08 16:25	10/13/08 14:45
WRS-R-28	A810135-39	Soil	10/07/08 16:30	10/13/08 14:45
WRS-R-29	A810135-40	Soil	10/07/08 16:35	10/13/08 14:45
WRS-R-DUP	A810135-41	Soil	10/07/08 16:35	10/13/08 14:45
WRS-R-30	A810135-42	Soil	10/07/08 16:40	10/13/08 14:45
AW-MA-1	A810135-43	Water	10/07/08 12:55	10/13/08 14:45
SW-MS-11	A810135-44	Water	10/07/08 12:45	10/13/08 14:45
SW-MS-12	A810135-45	Water	10/07/08 15:15	10/13/08 14:45
SW-MS-13	A810135-46	Water	10/07/08 15:20	10/13/08 14:45
SED-MS-12	A810135-47	Soil	10/08/08 14:05	10/13/08 14:45
SED-MS-13	A810135-48	Soil	10/08/08 14:10	10/13/08 14:45
SW-MS-14	A810135-49	Water	10/08/08 11:40	10/13/08 14:45
SED-MS-14	A810135-50	Soil	10/08/08 11:40	10/13/08 14:45
PW-MS-14	A810135-51	Water	10/08/08 11:40	10/13/08 14:45
SW-MS-15	A810135-52	Water	10/08/08 12:25	10/13/08 14:45
SED-MS-15	A810135-53	Soil	10/08/08 12:25	10/13/08 14:45
PW-MS-15	A810135-54	Water	10/08/08 12:25	10/13/08 14:45
SW-MS-16	A810135-55	Water	10/08/08 12:55	10/13/08 14:45
SED-MS-16	A810135-56	Soil	10/08/08 12:55	10/13/08 14:45
PW-MS-16	A810135-57	Water	10/08/08 12:55	10/13/08 14:45
SW-MS-17	A810135-58	Water	10/08/08 13:50	10/13/08 14:45
SED-MS-17	A810135-59	Soil	10/08/08 13:50	10/13/08 14:45
SW-MS-18	A810135-60	Water	10/08/08 13:35	10/13/08 14:45
SED-MS-18	A810135-61	Soil	10/08/08 13:35	10/13/08 14:45
PW-MS-18	A810135-62	Water	10/08/08 13:35	10/13/08 14:45
SW-R-19	A810135-63	Water	10/08/08 16:45	10/13/08 14:45
SED-R-19	A810135-64	Soil	10/08/08 16:45	10/13/08 14:45
PW-R-19	A810135-65	Water	10/08/08 16:45	10/13/08 14:45
SW-R-20	A810135-66	Water	10/08/08 17:15	10/13/08 14:45
SED-R-20	A810135-67	Soil	10/08/08 17:15	10/13/08 14:45
PW-R-20	A810135-68	Water	10/08/08 17:15	10/13/08 14:45
SW-R-21	A810135-69	Water	10/09/08 09:30	10/13/08 14:45
SED-R-21	A810135-70	Soil	10/09/08 09:30	10/13/08 14:45

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15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

ANALYTICAL REPORT FOR SAMPLES

SAMPLE INFORMATION

Sample ID	Laboratory ID	Matrix	Date Sampled	Date Received
SW-R-22	A810135-71	Water	10/09/08 10:15	10/13/08 14:45
SED-R-22	A810135-72	Soil	10/09/08 10:15	10/13/08 14:45
PW-R-22	A810135-73	Water	10/09/08 10:15	10/13/08 14:45
SW-R-23	A810135-74	Water	10/09/08 11:00	10/13/08 14:45
SED-R-23	A810135-75	Soil	10/09/08 11:00	10/13/08 14:45
PW-R-23	A810135-76	Water	10/09/08 11:00	10/13/08 14:45

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15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

ANALYTICAL SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
BG-11 (A810135-01)			**Matrix: Soil**					
Aluminum	**33200**	---	777	mg/kg dry	50	10/22/08 18:57	EPA 6020	
Antimony	ND	---	1.55	"	10	10/22/08 17:08	"	
Arsenic	**7.37**	---	1.55	"	"	"	"	
Barium	**55.2**	---	1.55	"	"	"	"	
Beryllium	ND	---	3.11	"	"	"	"	
Cadmium	ND	---	1.55	"	"	"	"	
Calcium	**2690**	---	155	"	"	"	"	
Chromium	**22.8**	---	3.11	"	"	"	"	
Cobalt	**7.03**	---	3.11	"	"	"	"	
Copper	**25.3**	---	6.22	"	"	"	"	
Iron	**33800**	---	777	"	50	10/22/08 18:57	"	
Lead	**13.5**	---	1.55	"	10	10/22/08 17:08	"	
Magnesium	**4270**	---	155	"	"	"	"	
Manganese	**234**	---	3.11	"	"	"	"	
Mercury	**0.140**	---	0.124	"	"	"	"	
Nickel	**14.1**	---	3.11	"	"	"	"	
Potassium	**944**	---	155	"	"	"	"	
Selenium	ND	---	1.55	"	"	"	"	
Silver	ND	---	3.11	"	"	"	"	
Sodium	ND	---	155	"	"	"	"	
Thallium	ND	---	1.55	"	"	"	"	
Vanadium	**81.8**	---	3.11	"	"	"	"	
Zinc	**52.4**	---	6.22	"	"	"	"	

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15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

ANALYTICAL SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
BG-12 (A810135-02)			**Matrix: Soil**					
Aluminum	**28800**	---	637	mg/kg dry	50	10/22/08 19:06	EPA 6020	
Antimony	**1.53**	---	1.27	"	10	10/22/08 17:30	"	Q-29
Arsenic	**4.97**	---	1.27	"	"	"	"	
Barium	**121**	---	1.27	"	"	"	"	
Beryllium	ND	---	2.55	"	"	"	"	
Cadmium	ND	---	1.27	"	"	"	"	
Calcium	**2170**	---	127	"	"	"	"	
Chromium	**11.1**	---	2.55	"	"	"	"	
Cobalt	**11.3**	---	2.55	"	"	"	"	
Copper	**15.0**	---	5.10	"	"	"	"	
Iron	**32800**	---	637	"	50	10/22/08 19:06	"	
Lead	**8.53**	---	1.27	"	10	10/22/08 17:30	"	
Magnesium	**4680**	---	127	"	"	"	"	
Manganese	**1050**	---	12.7	"	50	10/22/08 19:06	"	
Mercury	ND	---	0.102	"	10	10/22/08 17:30	"	
Nickel	**7.49**	---	2.55	"	"	"	"	
Potassium	**1300**	---	127	"	"	"	"	
Selenium	ND	---	1.27	"	"	"	"	
Silver	ND	---	2.55	"	"	"	"	
Sodium	**295**	---	127	"	"	"	"	
Thallium	ND	---	1.27	"	"	"	"	
Vanadium	**73.6**	---	2.55	"	"	"	"	
Zinc	**69.5**	---	5.10	"	"	"	"	

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15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

ANALYTICAL SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
BG-13 (A810135-03)			**Matrix: Soil**					
Aluminum	**35500**	---	715	mg/kg dry	50	10/22/08 19:09	EPA 6020	
Antimony	ND	---	1.43	"	10	10/22/08 17:42	"	
Arsenic	**5.86**	---	1.43	"	"	"	"	
Barium	**92.9**	---	1.43	"	"	"	"	
Beryllium	ND	---	2.86	"	"	"	"	
Cadmium	ND	---	1.43	"	"	"	"	
Calcium	**2090**	---	143	"	"	"	"	
Chromium	**12.2**	---	2.86	"	"	"	"	
Cobalt	**13.7**	---	2.86	"	"	"	"	
Copper	**21.7**	---	5.72	"	"	"	"	
Iron	**32400**	---	715	"	50	10/22/08 19:09	"	
Lead	**8.38**	---	1.43	"	10	10/22/08 17:42	"	
Magnesium	**6440**	---	143	"	"	"	"	
Manganese	**1270**	---	14.3	"	50	10/22/08 19:09	"	
Mercury	ND	---	0.114	"	10	10/22/08 17:42	"	
Nickel	**11.7**	---	2.86	"	"	"	"	
Potassium	**834**	---	143	"	"	"	"	
Selenium	ND	---	1.43	"	"	"	"	
Silver	ND	---	2.86	"	"	"	"	
Sodium	**196**	---	143	"	"	"	"	
Thallium	ND	---	1.43	"	"	"	"	
Vanadium	**69.8**	---	2.86	"	"	"	"	
Zinc	**77.5**	---	5.72	"	"	"	"	

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15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

ANALYTICAL SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
BG-14 (A810135-04)			**Matrix: Soil**					
Aluminum	**19700**	---	752	mg/kg dry	50	10/23/08 15:27	EPA 6020	
Antimony	ND	---	1.50	"	10	10/22/08 17:45	"	
Arsenic	**5.10**	---	1.50	"	"	"	"	
Barium	**48.2**	---	1.50	"	"	"	"	
Beryllium	ND	---	3.01	"	"	"	"	
Cadmium	ND	---	1.50	"	"	"	"	
Calcium	**727**	---	150	"	"	"	"	
Chromium	**19.2**	---	3.01	"	"	"	"	
Cobalt	**4.54**	---	3.01	"	"	"	"	
Copper	**14.5**	---	6.02	"	"	"	"	
Iron	**34100**	---	752	"	50	10/23/08 15:27	"	
Lead	**15.8**	---	1.50	"	10	10/22/08 17:45	"	
Magnesium	**2270**	---	150	"	"	"	"	
Manganese	**169**	---	3.01	"	"	"	"	
Mercury	ND	---	0.120	"	"	"	"	
Nickel	**7.96**	---	3.01	"	"	"	"	
Potassium	**533**	---	150	"	"	"	"	
Selenium	ND	---	1.50	"	"	"	"	
Silver	ND	---	3.01	"	"	"	"	
Sodium	ND	---	150	"	"	"	"	
Thallium	ND	---	1.50	"	"	"	"	
Vanadium	**88.0**	---	3.01	"	"	"	"	
Zinc	**42.9**	---	6.02	"	"	"	"	

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ANALYTICAL SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
BG-15 (A810135-05)			**Matrix: Soil**					
Aluminum	**31700**	---	859	mg/kg dry	50	10/22/08 19:28	EPA 6020	
Antimony	ND	---	1.72	"	10	10/22/08 17:48	"	
Arsenic	**3.88**	---	1.72	"	"	"	"	
Barium	**78.7**	---	1.72	"	"	"	"	
Beryllium	ND	---	3.44	"	"	"	"	
Cadmium	ND	---	1.72	"	"	"	"	
Calcium	**1280**	---	172	"	"	"	"	
Chromium	**19.9**	---	3.44	"	"	"	"	
Cobalt	**7.40**	---	3.44	"	"	"	"	
Copper	**23.5**	---	6.87	"	"	"	"	
Iron	**29700**	---	859	"	50	10/22/08 19:28	"	
Lead	**22.1**	---	1.72	"	10	10/22/08 17:48	"	
Magnesium	**3340**	---	172	"	"	"	"	
Manganese	**367**	---	3.44	"	"	"	"	
Mercury	ND	---	0.137	"	"	"	"	
Nickel	**12.1**	---	3.44	"	"	"	"	
Potassium	**780**	---	172	"	"	"	"	
Selenium	ND	---	1.72	"	"	"	"	
Silver	ND	---	3.44	"	"	"	"	
Sodium	ND	---	172	"	"	"	"	
Thallium	ND	---	1.72	"	"	"	"	
Vanadium	**63.4**	---	3.44	"	"	"	"	
Zinc	**69.2**	---	6.87	"	"	"	"	

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15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
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ANALYTICAL SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
BG-16 (A810135-06)			**Matrix: Soil**					
Aluminum	**40400**	---	605	mg/kg dry	50	10/22/08 19:31	EPA 6020	
Antimony	ND	---	1.21	"	10	10/22/08 17:51	"	
Arsenic	**4.86**	---	1.21	"	"	"	"	
Barium	**123**	---	1.21	"	"	"	"	
Beryllium	ND	---	2.42	"	"	"	"	
Cadmium	ND	---	1.21	"	"	"	"	
Calcium	**2130**	---	121	"	"	"	"	
Chromium	**24.7**	---	2.42	"	"	"	"	
Cobalt	**12.9**	---	2.42	"	"	"	"	
Copper	**50.6**	---	4.84	"	"	"	"	
Iron	**39300**	---	605	"	50	10/22/08 19:31	"	
Lead	**160**	---	1.21	"	10	10/22/08 17:51	"	
Magnesium	**6470**	---	121	"	"	"	"	
Manganese	**773**	---	12.1	"	50	10/22/08 19:31	"	
Mercury	**0.121**	---	0.0969	"	10	10/22/08 17:51	"	
Nickel	**20.0**	---	2.42	"	"	"	"	
Potassium	**1480**	---	121	"	"	"	"	
Selenium	ND	---	1.21	"	"	"	"	
Silver	ND	---	2.42	"	"	"	"	
Sodium	**138**	---	121	"	"	"	"	
Thallium	ND	---	1.21	"	"	"	"	
Vanadium	**76.4**	---	2.42	"	"	"	"	
Zinc	**352**	---	4.84	"	"	"	"	

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

ANALYTICAL SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
BG-17 (A810135-07)			**Matrix: Soil**					
Aluminum	**45300**	---	585	mg/kg dry	50	10/22/08 19:34	EPA 6020	
Antimony	ND	---	1.17	"	10	10/22/08 17:54	"	
Arsenic	**5.80**	---	1.17	"	"	"	"	
Barium	**75.3**	---	1.17	"	"	"	"	
Beryllium	ND	---	2.34	"	"	"	"	
Cadmium	ND	---	1.17	"	"	"	"	
Calcium	**983**	---	117	"	"	"	"	
Chromium	**19.7**	---	2.34	"	"	"	"	
Cobalt	**8.45**	---	2.34	"	"	"	"	
Copper	**30.8**	---	4.68	"	"	"	"	
Iron	**33600**	---	585	"	50	10/22/08 19:34	"	
Lead	**105**	---	1.17	"	10	10/22/08 17:54	"	
Magnesium	**2630**	---	117	"	"	"	"	
Manganese	**641**	---	11.7	"	50	10/22/08 19:34	"	
Mercury	**0.117**	---	0.0937	"	10	10/22/08 17:54	"	
Nickel	**12.7**	---	2.34	"	"	"	"	
Potassium	**708**	---	117	"	"	"	"	
Selenium	ND	---	1.17	"	"	"	"	
Silver	ND	---	2.34	"	"	"	"	
Sodium	**201**	---	117	"	"	"	"	
Thallium	ND	---	1.17	"	"	"	"	
Vanadium	**68.2**	---	2.34	"	"	"	"	
Zinc	**520**	---	4.68	"	"	"	"	

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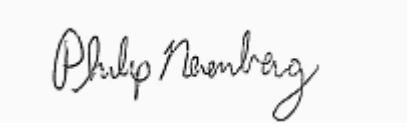

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

ANALYTICAL SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
BG-18 (A810135-08)			**Matrix: Soil**					
Aluminum	**49900**	---	623	mg/kg dry	50	10/22/08 19:37	EPA 6020	
Antimony	**1.48**	---	1.25	"	10	10/22/08 18:07	"	Q-29
Arsenic	**5.68**	---	1.25	"	"	"	"	
Barium	**103**	---	1.25	"	"	"	"	
Beryllium	ND	---	2.49	"	"	"	"	
Cadmium	ND	---	1.25	"	"	"	"	
Calcium	**1180**	---	125	"	"	"	"	
Chromium	**29.0**	---	2.49	"	"	"	"	
Cobalt	**13.3**	---	2.49	"	"	"	"	
Copper	**48.0**	---	4.98	"	"	"	"	
Iron	**42700**	---	623	"	50	10/22/08 19:37	"	
Lead	**66.4**	---	1.25	"	10	10/22/08 18:07	"	
Magnesium	**6320**	---	125	"	"	"	"	
Manganese	**742**	---	12.5	"	50	10/22/08 19:37	"	
Mercury	ND	---	0.0996	"	10	10/22/08 18:07	"	
Nickel	**21.2**	---	2.49	"	"	"	"	
Potassium	**1260**	---	125	"	"	"	"	
Selenium	ND	---	1.25	"	"	"	"	
Silver	ND	---	2.49	"	"	"	"	
Sodium	**139**	---	125	"	"	"	"	
Thallium	ND	---	1.25	"	"	"	"	
Vanadium	**78.1**	---	2.49	"	"	"	"	
Zinc	**392**	---	4.98	"	"	"	"	

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

ANALYTICAL SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
BG-19 (A810135-09)			**Matrix: Soil**					
Aluminum	**34800**	---	766	mg/kg dry	50	10/22/08 19:40	EPA 6020	
Antimony	ND	---	1.53	"	10	10/22/08 18:10	"	
Arsenic	**5.47**	---	1.53	"	"	"	"	
Barium	**67.6**	---	1.53	"	"	"	"	
Beryllium	ND	---	3.07	"	"	"	"	
Cadmium	ND	---	1.53	"	"	"	"	
Calcium	**2080**	---	153	"	"	"	"	
Chromium	**23.5**	---	3.07	"	"	"	"	
Cobalt	**11.1**	---	3.07	"	"	"	"	
Copper	**38.4**	---	6.13	"	"	"	"	
Iron	**31700**	---	766	"	50	10/22/08 19:40	"	
Lead	**80.9**	---	1.53	"	10	10/22/08 18:10	"	
Magnesium	**5670**	---	153	"	"	"	"	
Manganese	**750**	---	3.07	"	"	"	"	
Mercury	**0.138**	---	0.123	"	"	"	"	
Nickel	**18.9**	---	3.07	"	"	"	"	
Potassium	**1030**	---	153	"	"	"	"	
Selenium	ND	---	1.53	"	"	"	"	
Silver	ND	---	3.07	"	"	"	"	
Sodium	ND	---	153	"	"	"	"	
Thallium	ND	---	1.53	"	"	"	"	
Vanadium	**64.8**	---	3.07	"	"	"	"	
Zinc	**264**	---	6.13	"	"	"	"	

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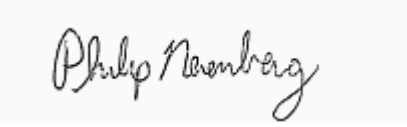

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15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

ANALYTICAL SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
BG-20 (A810135-10)			**Matrix: Soil**					
Aluminum	**12700**	---	136	mg/kg dry	10	10/22/08 18:13	EPA 6020	
Antimony	ND	---	1.36	"	"	"	"	
Arsenic	**1.97**	---	1.36	"	"	"	"	
Barium	**42.0**	---	1.36	"	"	"	"	
Beryllium	ND	---	2.72	"	"	"	"	
Cadmium	ND	---	1.36	"	"	"	"	
Calcium	**2880**	---	136	"	"	"	"	
Chromium	**12.0**	---	2.72	"	"	"	"	
Cobalt	**3.69**	---	2.72	"	"	"	"	
Copper	**5.78**	---	5.43	"	"	"	"	
Iron	**15300**	---	679	"	50	10/22/08 19:43	"	
Lead	**8.31**	---	1.36	"	10	10/22/08 18:13	"	
Magnesium	**1890**	---	136	"	"	"	"	
Manganese	**437**	---	2.72	"	"	"	"	
Mercury	**0.109**	---	0.109	"	"	"	"	
Nickel	**5.78**	---	2.72	"	"	"	"	
Potassium	**459**	---	136	"	"	"	"	
Selenium	ND	---	1.36	"	"	"	"	
Silver	ND	---	2.72	"	"	"	"	
Sodium	**171**	---	136	"	"	"	"	
Thallium	ND	---	1.36	"	"	"	"	
Vanadium	**47.0**	---	2.72	"	"	"	"	
Zinc	**33.8**	---	5.43	"	"	"	"	

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

ANALYTICAL SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
WRS-R-11 (A810135-11)			**Matrix: Soil**					
Aluminum	**29200**	---	659	mg/kg dry	50	10/22/08 19:46	EPA 6020	
Antimony	**1.52**	---	1.32	"	10	10/22/08 18:18	"	
Arsenic	**13.8**	---	1.32	"	"	"	"	
Barium	**40.7**	---	1.32	"	"	"	"	
Beryllium	ND	---	2.63	"	"	"	"	
Cadmium	**33.9**	---	1.32	"	"	"	"	
Calcium	**4350**	---	132	"	"	"	"	
Chromium	**24.6**	---	2.63	"	"	"	"	
Cobalt	**20.1**	---	2.63	"	"	"	"	
Copper	**409**	---	5.27	"	"	"	"	
Iron	**51500**	---	659	"	50	10/22/08 19:46	"	
Lead	**937**	---	6.59	"	"	"	"	
Magnesium	**9790**	---	132	"	10	10/22/08 18:18	"	
Manganese	**1890**	---	13.2	"	50	10/22/08 19:46	"	
Mercury	**0.250**	---	0.105	"	10	10/22/08 18:18	"	
Nickel	**26.6**	---	2.63	"	"	"	"	
Potassium	**1340**	---	132	"	"	"	"	
Selenium	ND	---	1.32	"	"	"	"	
Silver	ND	---	2.63	"	"	"	"	
Sodium	**168**	---	132	"	"	"	"	
Thallium	ND	---	1.32	"	"	"	"	
Vanadium	**56.5**	---	2.63	"	"	"	"	
Zinc	**8590**	---	105	"	200	10/23/08 15:30	"	

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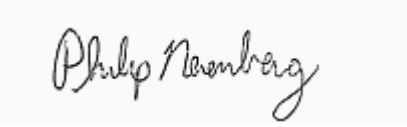

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

ANALYTICAL SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
WRS-R-12 (A810135-12)			**Matrix: Soil**					
Aluminum	**43000**	---	2450	mg/kg dry	200	10/23/08 15:33	EPA 6020	
Antimony	ND	---	1.23	"	10	10/23/08 15:37	"	
Arsenic	**11.8**	---	1.23	"	"	"	"	
Barium	**62.5**	---	1.23	"	"	"	"	
Beryllium	ND	---	2.45	"	"	"	"	
Cadmium	**29.3**	---	1.23	"	"	"	"	
Calcium	**1770**	---	123	"	"	"	"	
Chromium	**33.3**	---	2.45	"	"	"	"	
Cobalt	**21.5**	---	2.45	"	"	"	"	
Copper	**318**	---	4.91	"	"	"	"	
Iron	**58000**	---	2450	"	200	10/23/08 15:33	"	
Lead	**2160**	---	24.5	"	"	"	"	
Magnesium	**11100**	---	123	"	10	10/23/08 15:37	"	
Manganese	**3610**	---	49.1	"	200	10/23/08 15:33	"	
Mercury	**0.429**	---	0.0981	"	10	10/23/08 15:37	"	
Nickel	**27.7**	---	2.45	"	"	"	"	
Potassium	**1640**	---	123	"	"	"	"	
Selenium	**1.51**	---	1.23	"	"	"	"	
Silver	**6.51**	---	2.45	"	"	"	"	
Sodium	ND	---	123	"	"	"	"	
Thallium	ND	---	1.23	"	"	"	"	
Vanadium	**80.7**	---	2.45	"	"	"	"	
Zinc	**7080**	---	98.1	"	200	10/23/08 15:33	"	

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

ANALYTICAL SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
WRS-R-13 (A810135-13)			**Matrix: Soil**					
Aluminum	**30200**	---	1140	mg/kg dry	100	10/23/08 15:46	EPA 6020	
Antimony	**1.71**	---	1.14	"	10	10/22/08 18:24	"	Q-29
Arsenic	**19.6**	---	1.14	"	"	"	"	
Barium	**66.1**	---	1.14	"	"	"	"	
Beryllium	ND	---	2.28	"	"	"	"	
Cadmium	**135**	---	1.14	"	"	"	"	
Calcium	**17300**	---	1140	"	100	10/23/08 17:53	"	
Chromium	**26.7**	---	2.28	"	10	10/22/08 18:24	"	
Cobalt	**25.2**	---	2.28	"	"	"	"	
Copper	**688**	---	45.5	"	100	10/23/08 15:46	"	
Iron	**64500**	---	1140	"	"	"	"	
Lead	**5550**	---	11.4	"	"	"	"	
Magnesium	**14300**	---	1140	"	"	"	"	
Manganese	**7100**	---	228	"	1000	10/23/08 15:43	"	
Mercury	**0.387**	---	0.0911	"	10	10/22/08 18:24	"	
Nickel	**26.4**	---	2.28	"	"	"	"	
Potassium	**3540**	---	114	"	"	"	"	
Selenium	**3.13**	---	1.14	"	"	"	"	
Silver	**11.2**	---	2.28	"	"	"	"	
Sodium	ND	---	114	"	"	"	"	
Thallium	ND	---	1.14	"	"	"	"	
Vanadium	**53.4**	---	2.28	"	"	"	"	
Zinc	**29900**	---	455	"	1000	10/23/08 15:43	"	

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

ANALYTICAL SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
WRS-R-14 (A810135-14)			**Matrix: Soil**					
Aluminum	**34300**	---	1140	mg/kg dry	100	10/23/08 16:01	EPA 6020	
Antimony	**1.53**	---	1.14	"	10	10/22/08 18:27	"	Q-29
Arsenic	**18.0**	---	1.14	"	"	"	"	
Barium	**56.0**	---	1.14	"	"	"	"	
Beryllium	ND	---	2.29	"	"	"	"	
Cadmium	**80.0**	---	1.14	"	"	"	"	
Calcium	**34400**	---	1140	"	100	10/23/08 17:56	"	
Chromium	**33.0**	---	2.29	"	10	10/22/08 18:27	"	
Cobalt	**25.7**	---	2.29	"	"	"	"	
Copper	**1050**	---	45.8	"	100	10/23/08 16:01	"	
Iron	**71700**	---	1140	"	"	"	"	
Lead	**4460**	---	11.4	"	"	"	"	
Magnesium	**16900**	---	1140	"	"	"	"	
Manganese	**9340**	---	114	"	500	10/23/08 15:58	"	
Mercury	**0.217**	---	0.0915	"	10	10/22/08 18:27	"	
Nickel	**27.5**	---	2.29	"	"	"	"	
Potassium	**4280**	---	114	"	"	"	"	
Selenium	**4.07**	---	1.14	"	"	"	"	
Silver	**14.7**	---	2.29	"	"	"	"	
Sodium	ND	---	114	"	"	"	"	
Thallium	ND	---	1.14	"	"	"	"	
Vanadium	**53.0**	---	2.29	"	"	"	"	
Zinc	**19200**	---	229	"	500	10/23/08 15:58	"	

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

ANALYTICAL SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
WRS-R-15 (A810135-15)			**Matrix: Soil**					
Aluminum	**34600**	---	561	mg/kg dry	50	10/22/08 19:49	EPA 6020	
Antimony	**1.85**	---	1.12	"	10	10/22/08 18:30	"	Q-29
Arsenic	**23.0**	---	1.12	"	"	"	"	
Barium	**48.0**	---	1.12	"	"	"	"	
Beryllium	ND	---	2.24	"	"	"	"	
Cadmium	**156**	---	1.12	"	"	"	"	
Calcium	**27200**	---	561	"	50	10/22/08 19:49	"	
Chromium	**27.4**	---	2.24	"	10	10/22/08 18:30	"	
Cobalt	**31.4**	---	2.24	"	"	"	"	
Copper	**6330**	---	449	"	1000	10/23/08 16:04	"	
Iron	**80400**	---	11200	"	"	"	"	
Lead	**5760**	---	112	"	"	"	"	
Magnesium	**16400**	---	561	"	50	10/22/08 19:49	"	
Manganese	**8910**	---	224	"	1000	10/23/08 16:04	"	
Mercury	**0.516**	---	0.0897	"	10	10/22/08 18:30	"	
Nickel	**24.2**	---	2.24	"	"	"	"	
Potassium	**3970**	---	112	"	"	"	"	
Selenium	**7.37**	---	1.12	"	"	"	"	
Silver	**27.0**	---	2.24	"	"	"	"	
Sodium	ND	---	112	"	"	"	"	
Thallium	ND	---	1.12	"	"	"	"	
Vanadium	**52.6**	---	2.24	"	"	"	"	
Zinc	**35800**	---	449	"	1000	10/23/08 16:04	"	

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15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

ANALYTICAL SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
WRS-R-16 (A810135-16)			**Matrix: Soil**					
Aluminum	**38300**	---	599	mg/kg dry	50	10/22/08 19:52	EPA 6020	
Antimony	**1.78**	---	1.20	"	10	10/22/08 18:33	"	Q-29
Arsenic	**21.9**	---	1.20	"	"	"	"	
Barium	**38.8**	---	1.20	"	"	"	"	
Beryllium	ND	---	2.40	"	"	"	"	
Cadmium	**212**	---	1.20	"	"	"	"	
Calcium	**16800**	---	599	"	50	10/22/08 19:52	"	
Chromium	**28.4**	---	2.40	"	10	10/22/08 18:33	"	
Cobalt	**31.0**	---	2.40	"	"	"	"	
Copper	**1790**	---	24.0	"	50	10/22/08 19:52	"	
Iron	**94400**	---	12000	"	1000	10/23/08 16:07	"	
Lead	**8830**	---	120	"	"	"	"	
Magnesium	**18000**	---	599	"	50	10/22/08 19:52	"	
Manganese	**11500**	---	240	"	1000	10/23/08 16:07	"	
Mercury	**0.467**	---	0.0958	"	10	10/22/08 18:33	"	
Nickel	**27.7**	---	2.40	"	"	"	"	
Potassium	**4020**	---	120	"	"	"	"	
Selenium	**4.96**	---	1.20	"	"	"	"	
Silver	**18.8**	---	2.40	"	"	"	"	
Sodium	ND	---	120	"	"	"	"	
Thallium	ND	---	1.20	"	"	"	"	
Vanadium	**54.9**	---	2.40	"	"	"	"	
Zinc	**51400**	---	479	"	1000	10/23/08 16:07	"	

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12232 S.W. Garden Place
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503-718-2323 Phone
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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

ANALYTICAL SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
WRS-R-17 (A810135-17)			**Matrix: Soil**					
Aluminum	**41800**	---	672	mg/kg dry	50	10/22/08 20:07	EPA 6020	
Antimony	**1.64**	---	1.34	"	10	10/22/08 18:48	"	Q-29
Arsenic	**11.2**	---	1.34	"	"	"	"	
Barium	**72.6**	---	1.34	"	"	"	"	
Beryllium	ND	---	2.69	"	"	"	"	
Cadmium	**39.0**	---	1.34	"	"	"	"	
Calcium	**5540**	---	134	"	"	"	"	
Chromium	**29.8**	---	2.69	"	"	"	"	
Cobalt	**19.0**	---	2.69	"	"	"	"	
Copper	**336**	---	5.38	"	"	"	"	
Iron	**48200**	---	672	"	50	10/22/08 20:07	"	
Lead	**1260**	---	6.72	"	"	"	"	
Magnesium	**10300**	---	134	"	10	10/22/08 18:48	"	
Manganese	**2520**	---	13.4	"	50	10/22/08 20:07	"	
Mercury	**0.175**	---	0.108	"	10	10/22/08 18:48	"	
Nickel	**27.9**	---	2.69	"	"	"	"	
Potassium	**1660**	---	134	"	"	"	"	
Selenium	**1.51**	---	1.34	"	"	"	"	
Silver	**3.31**	---	2.69	"	"	"	"	
Sodium	**184**	---	134	"	"	"	"	
Thallium	ND	---	1.34	"	"	"	"	
Vanadium	**69.0**	---	2.69	"	"	"	"	
Zinc	**8940**	---	134	"	250	10/23/08 16:10	"	

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

ANALYTICAL SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
WRS-R-18 (A810135-18)			**Matrix: Soil**					
Aluminum	**34500**	---	558	mg/kg dry	50	10/22/08 20:10	EPA 6020	
Antimony	**1.72**	---	1.12	"	10	10/22/08 18:51	"	Q-29
Arsenic	**19.6**	---	1.12	"	"	"	"	
Barium	**35.6**	---	1.12	"	"	"	"	
Beryllium	ND	---	2.23	"	"	"	"	
Cadmium	**255**	---	1.12	"	"	"	"	
Calcium	**21600**	---	558	"	50	10/22/08 20:10	"	
Chromium	**30.0**	---	2.23	"	10	10/22/08 18:51	"	
Cobalt	**34.2**	---	2.23	"	"	"	"	
Copper	**6500**	---	112	"	250	10/23/08 16:16	"	
Iron	**87000**	---	2790	"	"	"	"	
Lead	**8330**	---	27.9	"	"	"	"	
Magnesium	**16000**	---	558	"	50	10/22/08 20:10	"	
Manganese	**9280**	---	55.8	"	250	10/23/08 16:16	"	
Mercury	**0.592**	---	0.0894	"	10	10/22/08 18:51	"	
Nickel	**26.5**	---	2.23	"	"	"	"	
Potassium	**2970**	---	112	"	"	"	"	
Selenium	**7.03**	---	1.12	"	"	"	"	
Silver	**28.6**	---	2.23	"	"	"	"	
Sodium	ND	---	112	"	"	"	"	
Thallium	ND	---	1.12	"	"	"	"	
Vanadium	**54.1**	---	2.23	"	"	"	"	
Zinc	**60300**	---	1120	"	2500	10/23/08 16:13	"	

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

ANALYTICAL SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
WRS-R-19 (A810135-19)			**Matrix: Soil**					
Aluminum	**31900**	---	605	mg/kg dry	50	10/22/08 20:13	EPA 6020	
Antimony	**1.75**	---	1.21	"	10	10/22/08 18:54	"	Q-29
Arsenic	**20.8**	---	1.21	"	"	"	"	
Barium	**39.5**	---	1.21	"	"	"	"	
Beryllium	ND	---	2.42	"	"	"	"	
Cadmium	**89.1**	---	1.21	"	"	"	"	
Calcium	**16800**	---	605	"	50	10/22/08 20:13	"	
Chromium	**33.0**	---	2.42	"	10	10/22/08 18:54	"	
Cobalt	**25.5**	---	2.42	"	"	"	"	
Copper	**824**	---	24.2	"	50	10/22/08 20:13	"	
Iron	**72900**	---	6050	"	500	10/23/08 16:19	"	
Lead	**4540**	---	60.5	"	"	"	"	
Magnesium	**15300**	---	605	"	50	10/22/08 20:13	"	
Manganese	**8120**	---	121	"	500	10/23/08 16:19	"	
Mercury	**0.314**	---	0.0968	"	10	10/22/08 18:54	"	
Nickel	**27.1**	---	2.42	"	"	"	"	
Potassium	**3380**	---	121	"	"	"	"	
Selenium	**2.66**	---	1.21	"	"	"	"	
Silver	**10.5**	---	2.42	"	"	"	"	
Sodium	**138**	---	121	"	"	"	"	
Thallium	ND	---	1.21	"	"	"	"	
Vanadium	**50.7**	---	2.42	"	"	"	"	
Zinc	**22200**	---	242	"	500	10/23/08 16:19	"	

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

ANALYTICAL SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
WRS-R-20 (A810135-20)			**Matrix: Soil**					
Aluminum	**36400**	---	587	mg/kg dry	50	10/24/08 12:14	EPA 6020	
Antimony	**1.89**	---	1.17	"	10	10/22/08 20:25	"	Q-29
Arsenic	**24.9**	---	1.17	"	"	"	"	
Barium	**53.6**	---	1.17	"	"	"	"	
Beryllium	ND	---	2.35	"	"	"	"	
Cadmium	**226**	---	1.17	"	"	"	"	
Calcium	**16100**	---	587	"	50	10/24/08 12:14	"	
Chromium	**30.3**	---	2.35	"	10	10/22/08 20:25	"	
Cobalt	**31.9**	---	2.35	"	"	"	"	
Copper	**2170**	---	23.5	"	50	10/22/08 22:16	"	
Iron	**81800**	---	11700	"	1000	10/24/08 10:38	"	
Lead	**7460**	---	117	"	"	"	"	
Magnesium	**15900**	---	587	"	50	10/24/08 12:14	"	
Manganese	**9130**	---	235	"	1000	10/24/08 10:38	"	
Mercury	**0.446**	---	0.0939	"	10	10/22/08 20:25	"	
Nickel	**26.7**	---	2.35	"	"	"	"	
Potassium	**5280**	---	117	"	"	"	"	
Selenium	**4.86**	---	1.17	"	"	"	"	
Silver	**17.8**	---	2.35	"	"	"	"	
Sodium	ND	---	117	"	"	"	"	
Thallium	ND	---	1.17	"	"	"	"	
Vanadium	**53.5**	---	2.35	"	"	"	"	
Zinc	**54200**	---	470	"	1000	10/24/08 10:38	"	

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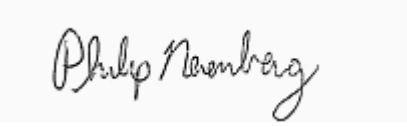

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

ANALYTICAL SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
WRS-R-21 (A810135-21)			**Matrix: Soil**					
Aluminum	**38400**	---	557	mg/kg dry	50	10/24/08 12:23	EPA 6020	
Antimony	**1.75**	---	1.11	"	10	10/22/08 20:49	"	Q-29
Arsenic	**23.5**	---	1.11	"	"	"	"	
Barium	**59.0**	---	1.11	"	"	"	"	
Beryllium	ND	---	2.23	"	"	"	"	
Cadmium	**188**	---	1.11	"	"	"	"	
Calcium	**17200**	---	557	"	50	10/24/08 12:23	"	
Chromium	**28.4**	---	2.23	"	10	10/22/08 20:49	"	
Cobalt	**32.6**	---	2.23	"	"	"	"	
Copper	**1470**	---	22.3	"	50	10/22/08 22:25	"	
Iron	**94600**	---	11100	"	1000	10/24/08 10:53	"	
Lead	**6400**	---	111	"	"	"	"	
Magnesium	**17400**	---	557	"	50	10/24/08 12:23	"	
Manganese	**12500**	---	223	"	1000	10/24/08 10:53	"	
Mercury	**0.357**	---	0.0892	"	10	10/22/08 20:49	"	
Nickel	**27.2**	---	2.23	"	"	"	"	
Potassium	**5490**	---	111	"	"	"	"	
Selenium	**4.86**	---	1.11	"	"	"	"	
Silver	**17.5**	---	2.23	"	"	"	"	
Sodium	ND	---	111	"	"	"	"	
Thallium	ND	---	1.11	"	"	"	"	
Vanadium	**50.3**	---	2.23	"	"	"	"	
Zinc	**46000**	---	446	"	1000	10/24/08 10:53	"	

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

ANALYTICAL SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
WRS-MS-1 (A810135-22)			**Matrix: Soil**					
Aluminum	**20400**	---	588	mg/kg dry	50	10/24/08 12:29	EPA 6020	
Antimony	**2.25**	---	1.18	"	10	10/22/08 21:01	"	Q-29
Arsenic	**25.3**	---	1.18	"	"	"	"	
Barium	**29.1**	---	1.18	"	"	"	"	
Beryllium	ND	---	2.35	"	"	"	"	
Cadmium	**171**	---	1.18	"	"	"	"	
Calcium	**11600**	---	118	"	"	"	"	
Chromium	**15.4**	---	2.35	"	"	"	"	
Cobalt	**17.8**	---	2.35	"	"	"	"	
Copper	**2210**	---	23.5	"	50	10/22/08 22:28	"	
Iron	**49800**	---	588	"	"	"	"	
Lead	**5310**	---	118	"	1000	10/24/08 11:52	"	
Magnesium	**9620**	---	118	"	10	10/22/08 21:01	"	
Manganese	**4150**	---	235	"	1000	10/24/08 11:52	"	
Mercury	**0.471**	---	0.0941	"	10	10/22/08 21:01	"	
Nickel	**16.3**	---	2.35	"	"	"	"	
Potassium	**3450**	---	118	"	"	"	"	
Selenium	**1.45**	---	1.18	"	"	"	"	
Silver	**21.9**	---	2.35	"	"	"	"	
Sodium	ND	---	118	"	"	"	"	
Thallium	ND	---	1.18	"	"	"	"	
Vanadium	**30.1**	---	2.35	"	"	"	"	
Zinc	**42800**	---	471	"	1000	10/24/08 11:52	"	

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

ANALYTICAL SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
WRS-MS-2 (A810135-23)			**Matrix: Soil**					
Aluminum	**16000**	---	1170	mg/kg dry	100	10/24/08 12:41	EPA 6020	
Antimony	**1.42**	---	1.17	"	10	10/22/08 21:04	"	Q-29
Arsenic	**18.6**	---	1.17	"	"	"	"	
Barium	**19.8**	---	1.17	"	"	"	"	
Beryllium	ND	---	2.35	"	"	"	"	
Cadmium	**144**	---	1.17	"	"	"	"	
Calcium	**7620**	---	117	"	"	"	"	
Chromium	**14.1**	---	2.35	"	"	"	"	
Cobalt	**21.5**	---	2.35	"	"	"	"	
Copper	**4040**	---	47.0	"	100	10/24/08 12:41	"	
Iron	**44200**	---	587	"	50	10/22/08 22:43	"	
Lead	**2050**	---	11.7	"	100	10/24/08 12:41	"	
Magnesium	**7460**	---	117	"	10	10/22/08 21:04	"	
Manganese	**2360**	---	11.7	"	50	10/22/08 22:43	"	
Mercury	**0.458**	---	0.0940	"	10	10/22/08 21:04	"	
Nickel	**19.2**	---	2.35	"	"	"	"	
Potassium	**2490**	---	117	"	"	"	"	
Selenium	**1.20**	---	1.17	"	"	"	"	
Silver	**15.6**	---	2.35	"	"	"	"	
Sodium	ND	---	117	"	"	"	"	
Thallium	ND	---	1.17	"	"	"	"	
Vanadium	**21.8**	---	2.35	"	"	"	"	
Zinc	**35100**	---	470	"	1000	10/24/08 11:03	"	

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

ANALYTICAL SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
WRS-MS-3 (A810135-24)			**Matrix: Soil**					
Aluminum	**18200**	---	2800	mg/kg dry	250	10/24/08 11:06	EPA 6020	
Antimony	ND	---	1.12	"	10	10/22/08 21:07	"	
Arsenic	**7.54**	---	1.12	"	"	"	"	
Barium	**25.5**	---	1.12	"	"	"	"	
Beryllium	ND	---	2.24	"	"	"	"	
Cadmium	**37.6**	---	1.12	"	"	"	"	
Calcium	**34300**	---	560	"	50	10/22/08 22:46	"	
Chromium	**18.7**	---	2.24	"	10	10/22/08 21:07	"	
Cobalt	**16.1**	---	2.24	"	"	"	"	
Copper	**806**	---	22.4	"	50	10/22/08 22:46	"	
Iron	**33800**	---	560	"	"	"	"	
Lead	**2940**	---	28.0	"	250	10/24/08 11:06	"	
Magnesium	**9880**	---	112	"	10	10/22/08 21:07	"	
Manganese	**3000**	---	56.0	"	250	10/24/08 11:06	"	
Mercury	**0.470**	---	0.0895	"	10	10/22/08 21:07	"	
Nickel	**21.2**	---	2.24	"	"	"	"	
Potassium	**3030**	---	112	"	"	"	"	
Selenium	ND	---	1.12	"	"	"	"	
Silver	**5.91**	---	2.24	"	"	"	"	
Sodium	ND	---	112	"	"	"	"	
Thallium	ND	---	1.12	"	"	"	"	
Vanadium	**26.8**	---	2.24	"	"	"	"	
Zinc	**11800**	---	112	"	250	10/24/08 11:06	"	

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

ANALYTICAL SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
WRS-MS-4 (A810135-25)			**Matrix: Soil**					
Aluminum	**19200**	---	1190	mg/kg dry	100	10/24/08 12:44	EPA 6020	
Antimony	**1.52**	---	1.19	"	10	10/22/08 21:10	"	Q-29
Arsenic	**14.7**	---	1.19	"	"	"	"	
Barium	**25.4**	---	1.19	"	"	"	"	
Beryllium	ND	---	2.38	"	"	"	"	
Cadmium	**49.9**	---	1.19	"	"	"	"	
Calcium	**8640**	---	119	"	"	"	"	
Chromium	**18.7**	---	2.38	"	"	"	"	
Cobalt	**16.0**	---	2.38	"	"	"	"	
Copper	**1030**	---	23.8	"	50	10/22/08 22:49	"	
Iron	**38500**	---	595	"	"	"	"	
Lead	**3100**	---	11.9	"	100	10/24/08 12:44	"	
Magnesium	**10300**	---	119	"	10	10/22/08 21:10	"	
Manganese	**3550**	---	23.8	"	100	10/24/08 12:44	"	
Mercury	**0.429**	---	0.0952	"	10	10/22/08 21:10	"	
Nickel	**19.7**	---	2.38	"	"	"	"	
Potassium	**2780**	---	119	"	"	"	"	
Selenium	ND	---	1.19	"	"	"	"	
Silver	**7.31**	---	2.38	"	"	"	"	
Sodium	ND	---	119	"	"	"	"	
Thallium	ND	---	1.19	"	"	"	"	
Vanadium	**27.3**	---	2.38	"	"	"	"	
Zinc	**15400**	---	238	"	500	10/24/08 11:09	"	

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

ANALYTICAL SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
WRS-MS-5 (A810135-26)			**Matrix: Soil**					
Aluminum	**22600**	---	550	mg/kg dry	50	10/24/08 12:47	EPA 6020	
Antimony	**3.98**	---	1.10	"	10	10/22/08 21:25	"	Q-29
Arsenic	**30.0**	---	1.10	"	"	"	"	
Barium	**20.5**	---	1.10	"	"	"	"	
Beryllium	ND	---	2.20	"	"	"	"	
Cadmium	**112**	---	1.10	"	"	"	"	
Calcium	**29300**	---	550	"	50	10/24/08 12:47	"	
Chromium	**15.3**	---	2.20	"	10	10/22/08 21:25	"	
Cobalt	**16.8**	---	2.20	"	"	"	"	
Copper	**679**	---	22.0	"	50	10/22/08 22:52	"	
Iron	**46100**	---	550	"	"	"	"	
Lead	**8390**	---	110	"	1000	10/24/08 11:12	"	
Magnesium	**11300**	---	550	"	50	10/22/08 22:52	"	
Manganese	**5300**	---	220	"	1000	10/24/08 11:12	"	
Mercury	**0.627**	---	0.0880	"	10	10/22/08 21:25	"	
Nickel	**16.5**	---	2.20	"	"	"	"	
Potassium	**2550**	---	550	"	50	10/24/08 12:47	"	
Selenium	**2.11**	---	1.10	"	10	10/22/08 21:25	"	
Silver	**20.8**	---	2.20	"	"	"	"	
Sodium	ND	---	110	"	"	"	"	
Thallium	ND	---	1.10	"	"	"	"	
Vanadium	**32.0**	---	2.20	"	"	"	"	
Zinc	**30300**	---	440	"	1000	10/24/08 11:12	"	

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

ANALYTICAL SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
WRS-MS-6 (A810135-27)			**Matrix: Soil**					
Aluminum	**19600**	---	605	mg/kg dry	50	10/24/08 12:50	EPA 6020	
Antimony	**3.28**	---	1.21	"	10	10/22/08 21:28	"	Q-29
Arsenic	**24.7**	---	1.21	"	"	"	"	
Barium	**27.6**	---	1.21	"	"	"	"	
Beryllium	ND	---	2.42	"	"	"	"	
Cadmium	**215**	---	1.21	"	"	"	"	
Calcium	**23000**	---	605	"	50	10/24/08 12:50	"	
Chromium	**14.9**	---	2.42	"	10	10/22/08 21:28	"	
Cobalt	**16.7**	---	2.42	"	"	"	"	
Copper	**668**	---	24.2	"	50	10/22/08 22:55	"	
Iron	**48400**	---	605	"	"	"	"	
Lead	**11700**	---	121	"	1000	10/24/08 11:15	"	
Magnesium	**9600**	---	121	"	10	10/22/08 21:28	"	
Manganese	**5080**	---	242	"	1000	10/24/08 11:15	"	
Mercury	**0.617**	---	0.0968	"	10	10/22/08 21:28	"	
Nickel	**16.4**	---	2.42	"	"	"	"	
Potassium	**2410**	---	605	"	50	10/24/08 12:50	"	
Selenium	**1.57**	---	1.21	"	10	10/22/08 21:28	"	
Silver	**12.6**	---	2.42	"	"	"	"	
Sodium	ND	---	121	"	"	"	"	
Thallium	ND	---	1.21	"	"	"	"	
Vanadium	**30.1**	---	2.42	"	"	"	"	
Zinc	**51900**	---	484	"	1000	10/24/08 11:15	"	

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

ANALYTICAL SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
WRS-MS-7 (A810135-28)			**Matrix: Soil**					
Aluminum	**28400**	---	621	mg/kg dry	50	10/24/08 12:53	EPA 6020	
Antimony	**1.53**	---	1.24	"	10	10/22/08 21:31	"	Q-29
Arsenic	**13.4**	---	1.24	"	"	"	"	
Barium	**68.0**	---	1.24	"	"	"	"	
Beryllium	ND	---	2.49	"	"	"	"	
Cadmium	**105**	---	1.24	"	"	"	"	
Calcium	**4070**	---	621	"	50	10/24/08 12:53	"	
Chromium	**21.7**	---	2.49	"	10	10/22/08 21:31	"	
Cobalt	**16.0**	---	2.49	"	"	"	"	
Copper	**408**	---	4.97	"	"	"	"	
Iron	**37200**	---	621	"	50	10/24/08 12:53	"	
Lead	**3600**	---	62.1	"	500	10/24/08 11:24	"	
Magnesium	**10800**	---	124	"	10	10/22/08 21:31	"	
Manganese	**2510**	---	12.4	"	50	10/24/08 12:53	"	
Mercury	**0.460**	---	0.0994	"	10	10/22/08 21:31	"	
Nickel	**21.2**	---	2.49	"	"	"	"	
Potassium	**3100**	---	621	"	50	10/24/08 12:53	"	
Selenium	ND	---	1.24	"	10	10/22/08 21:31	"	
Silver	**10.2**	---	2.49	"	"	"	"	
Sodium	**174**	---	124	"	"	"	"	
Thallium	ND	---	1.24	"	"	"	"	
Vanadium	**47.5**	---	2.49	"	"	"	"	
Zinc	**23700**	---	249	"	500	10/24/08 11:24	"	

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

ANALYTICAL SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
WRS-MS-8 (A810135-29)			**Matrix: Soil**					
Aluminum	**33100**	---	666	mg/kg dry	50	10/24/08 11:27	EPA 6020	
Antimony	ND	---	1.33	"	10	10/22/08 21:34	"	
Arsenic	**5.89**	---	1.33	"	"	"	"	
Barium	**73.6**	---	1.33	"	"	"	"	
Beryllium	ND	---	2.67	"	"	"	"	
Cadmium	**4.30**	---	1.33	"	"	"	"	
Calcium	**4950**	---	133	"	"	10/24/08 12:56	"	
Chromium	**24.0**	---	2.67	"	"	10/22/08 21:34	"	
Cobalt	**15.2**	---	2.67	"	"	"	"	
Copper	**173**	---	5.33	"	"	"	"	
Iron	**33200**	---	666	"	50	10/22/08 23:01	"	
Lead	**279**	---	1.33	"	10	10/22/08 21:34	"	
Magnesium	**11100**	---	133	"	"	"	"	
Manganese	**771**	---	13.3	"	50	10/22/08 23:01	"	
Mercury	**0.213**	---	0.107	"	10	10/22/08 21:34	"	
Nickel	**27.0**	---	2.67	"	"	"	"	
Potassium	**1650**	---	133	"	"	10/24/08 12:56	"	
Selenium	ND	---	1.33	"	"	10/22/08 21:34	"	
Silver	ND	---	2.67	"	"	"	"	
Sodium	**171**	---	133	"	"	"	"	
Thallium	ND	---	1.33	"	"	"	"	
Vanadium	**46.7**	---	2.67	"	"	"	"	
Zinc	**884**	---	26.7	"	50	10/24/08 11:27	"	

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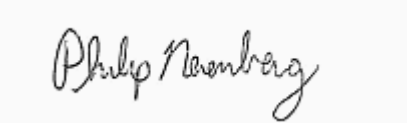

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

ANALYTICAL SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
WRS-MS-9 (A810135-30)			**Matrix: Soil**					
Aluminum	**27200**	---	601	mg/kg dry	50	10/24/08 11:30	EPA 6020	
Antimony	ND	---	1.20	"	10	10/22/08 21:37	"	
Arsenic	**7.23**	---	1.20	"	"	"	"	
Barium	**60.4**	---	1.20	"	"	"	"	
Beryllium	ND	---	2.40	"	"	"	"	
Cadmium	**3.33**	---	1.20	"	"	"	"	
Calcium	**4370**	---	120	"	"	10/24/08 12:59	"	
Chromium	**24.2**	---	2.40	"	"	10/22/08 21:37	"	
Cobalt	**17.3**	---	2.40	"	"	"	"	
Copper	**96.9**	---	4.80	"	"	"	"	
Iron	**34300**	---	601	"	50	10/22/08 23:04	"	
Lead	**409**	---	1.20	"	10	10/22/08 21:37	"	
Magnesium	**12300**	---	601	"	50	10/24/08 11:30	"	
Manganese	**997**	---	12.0	"	"	10/22/08 23:04	"	
Mercury	**0.132**	---	0.0961	"	10	10/22/08 21:37	"	
Nickel	**26.7**	---	2.40	"	"	"	"	
Potassium	**921**	---	120	"	"	10/24/08 12:59	"	
Selenium	ND	---	1.20	"	"	10/22/08 21:37	"	
Silver	ND	---	2.40	"	"	"	"	
Sodium	**190**	---	120	"	"	"	"	
Thallium	ND	---	1.20	"	"	"	"	
Vanadium	**48.9**	---	2.40	"	"	"	"	
Zinc	**718**	---	24.0	"	50	10/24/08 11:30	"	

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

ANALYTICAL SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
WRS-MS-10 (A810135-31)			**Matrix: Soil**					
Aluminum	**20000**	---	5730	mg/kg dry	500	10/24/08 11:33	EPA 6020	
Antimony	**2.07**	---	1.15	"	10	10/22/08 21:40	"	Q-29
Arsenic	**24.3**	---	1.15	"	"	"	"	
Barium	**21.2**	---	1.15	"	"	"	"	
Beryllium	ND	---	2.29	"	"	"	"	
Cadmium	**39.0**	---	1.15	"	"	"	"	
Calcium	**5470**	---	115	"	"	10/24/08 13:02	"	
Chromium	**12.5**	---	2.29	"	"	10/22/08 21:40	"	
Cobalt	**14.2**	---	2.29	"	"	"	"	
Copper	**696**	---	22.9	"	50	10/22/08 23:07	"	
Iron	**41900**	---	573	"	"	"	"	
Lead	**7790**	---	57.3	"	500	10/24/08 11:33	"	
Magnesium	**9530**	---	115	"	10	10/22/08 21:40	"	
Manganese	**5020**	---	115	"	500	10/24/08 11:33	"	
Mercury	**0.229**	---	0.0917	"	10	10/22/08 21:40	"	
Nickel	**16.3**	---	2.29	"	"	"	"	
Potassium	**2350**	---	115	"	"	10/24/08 13:02	"	
Selenium	**1.30**	---	1.15	"	"	10/22/08 21:40	"	
Silver	**8.45**	---	2.29	"	"	"	"	
Sodium	ND	---	115	"	"	"	"	
Thallium	ND	---	1.15	"	"	"	"	
Vanadium	**27.9**	---	2.29	"	"	"	"	
Zinc	**15700**	---	229	"	500	10/24/08 11:33	"	

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

ANALYTICAL SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
WRS-MS-11 (A810135-32)			**Matrix: Soil**					
Aluminum	**34800**	---	675	mg/kg dry	50	10/24/08 13:05	EPA 6020	
Antimony	**2.11**	---	1.35	"	10	10/22/08 21:43	"	Q-29
Arsenic	**25.8**	---	1.35	"	"	"	"	
Barium	**45.2**	---	1.35	"	"	"	"	
Beryllium	ND	---	2.70	"	"	"	"	
Cadmium	**33.7**	---	1.35	"	"	"	"	
Calcium	**8650**	---	675	"	50	10/24/08 13:05	"	
Chromium	**19.0**	---	2.70	"	10	10/22/08 21:43	"	
Cobalt	**20.3**	---	2.70	"	"	"	"	
Copper	**412**	---	5.40	"	"	"	"	
Iron	**71900**	---	3370	"	250	10/24/08 11:36	"	
Lead	**6470**	---	33.7	"	"	"	"	
Magnesium	**14100**	---	675	"	50	10/24/08 13:05	"	
Manganese	**7810**	---	67.5	"	250	10/24/08 11:36	"	
Mercury	**0.364**	---	0.108	"	10	10/22/08 21:43	"	
Nickel	**21.0**	---	2.70	"	"	"	"	
Potassium	**3220**	---	675	"	50	10/24/08 13:05	"	
Selenium	**1.39**	---	1.35	"	10	10/22/08 21:43	"	
Silver	**8.89**	---	2.70	"	"	"	"	
Sodium	ND	---	135	"	"	"	"	
Thallium	ND	---	1.35	"	"	"	"	
Vanadium	**50.3**	---	2.70	"	"	"	"	
Zinc	**9220**	---	135	"	250	10/24/08 11:36	"	

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

ANALYTICAL SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
WRS-R-22 (A810135-33)			**Matrix: Soil**					
Aluminum	**21200**	---	1130	mg/kg dry	100	10/24/08 13:17	EPA 6020	
Antimony	ND	---	1.13	"	10	10/22/08 21:46	"	
Arsenic	**16.8**	---	1.13	"	"	"	"	
Barium	**50.5**	---	1.13	"	"	"	"	
Beryllium	ND	---	2.26	"	"	"	"	
Cadmium	**19.3**	---	1.13	"	"	"	"	
Calcium	**11800**	---	1130	"	100	10/24/08 13:17	"	
Chromium	**29.8**	---	2.26	"	10	10/22/08 21:46	"	
Cobalt	**13.4**	---	2.26	"	"	"	"	
Copper	**152**	---	4.51	"	"	"	"	
Iron	**31400**	---	1130	"	100	10/24/08 13:17	"	
Lead	**1190**	---	11.3	"	"	"	"	
Magnesium	**12400**	---	564	"	50	10/22/08 23:26	"	
Manganese	**4020**	---	22.6	"	100	10/24/08 13:17	"	
Mercury	**0.0902**	---	0.0902	"	10	10/22/08 21:46	"	
Nickel	**24.3**	---	2.26	"	"	"	"	
Potassium	**3500**	---	1130	"	100	10/24/08 13:17	"	
Selenium	ND	---	1.13	"	10	10/22/08 21:46	"	
Silver	**2.49**	---	2.26	"	"	"	"	
Sodium	ND	---	113	"	"	"	"	
Thallium	ND	---	1.13	"	"	"	"	
Vanadium	**30.0**	---	2.26	"	"	"	"	
Zinc	**5000**	---	45.1	"	100	10/24/08 13:17	"	

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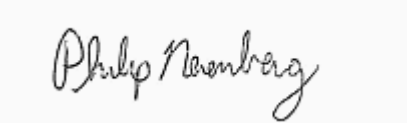

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

ANALYTICAL SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
WRS-R-23 (A810135-34)			**Matrix: Soil**					
Aluminum	**19500**	---	1120	mg/kg dry	100	10/24/08 13:20	EPA 6020	
Antimony	ND	---	1.12	"	10	10/22/08 21:49	"	
Arsenic	**8.16**	---	1.12	"	"	"	"	
Barium	**59.6**	---	1.12	"	"	"	"	
Beryllium	ND	---	2.25	"	"	"	"	
Cadmium	**16.9**	---	1.12	"	"	"	"	
Calcium	**16500**	---	1120	"	100	10/24/08 13:20	"	
Chromium	**31.5**	---	2.25	"	10	10/22/08 21:49	"	
Cobalt	**14.4**	---	2.25	"	"	"	"	
Copper	**102**	---	4.49	"	"	"	"	
Iron	**29100**	---	562	"	50	10/22/08 23:29	"	
Lead	**682**	---	11.2	"	100	10/24/08 13:20	"	
Magnesium	**10100**	---	112	"	10	10/22/08 21:49	"	
Manganese	**3270**	---	22.5	"	100	10/24/08 13:20	"	
Mercury	ND	---	0.0899	"	10	10/22/08 21:49	"	
Nickel	**27.9**	---	2.25	"	"	"	"	
Potassium	**2750**	---	1120	"	100	10/24/08 13:20	"	
Selenium	ND	---	1.12	"	10	10/22/08 21:49	"	
Silver	ND	---	2.25	"	"	"	"	
Sodium	ND	---	112	"	"	"	"	
Thallium	ND	---	1.12	"	"	"	"	
Vanadium	**31.2**	---	2.25	"	"	"	"	
Zinc	**4170**	---	44.9	"	100	10/24/08 13:20	"	

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Philip Nerenberg, Lab Director

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Apex Labs

12232 S.W. Garden Place
Tigard, OR 97223
503-718-2323 Phone
503-718-0333 Fax

GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

ANALYTICAL SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
WRS-R-24 (A810135-35)			**Matrix: Soil**					
Aluminum	**24700**	---	1190	mg/kg dry	100	10/24/08 11:46	EPA 6020	
Antimony	ND	---	1.19	"	10	10/24/08 14:56	"	
Arsenic	**5.39**	---	1.19	"	"	"	"	
Barium	**42.5**	---	1.19	"	"	"	"	
Beryllium	ND	---	2.38	"	"	"	"	
Cadmium	**16.4**	---	1.19	"	"	"	"	
Calcium	**14200**	---	1190	"	100	10/24/08 11:46	"	
Chromium	**25.6**	---	2.38	"	10	10/24/08 14:56	"	
Cobalt	**16.9**	---	2.38	"	"	"	"	
Copper	**1190**	---	47.6	"	100	10/24/08 11:46	"	
Iron	**39100**	---	1190	"	"	"	"	
Lead	**1130**	---	11.9	"	"	"	"	
Magnesium	**13300**	---	1190	"	"	"	"	
Manganese	**3480**	---	23.8	"	"	"	"	
Mercury	**0.131**	---	0.0951	"	10	10/24/08 14:56	"	
Nickel	**24.7**	---	2.38	"	"	"	"	
Potassium	**2140**	---	119	"	"	"	"	
Selenium	ND	---	1.19	"	"	"	"	
Silver	**5.16**	---	2.38	"	"	"	"	
Sodium	**150**	---	119	"	"	"	"	
Thallium	ND	---	1.19	"	"	"	"	
Vanadium	**47.4**	---	2.38	"	"	"	"	
Zinc	**3510**	---	47.6	"	100	10/24/08 11:46	"	

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15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

ANALYTICAL SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
WRS-R-25 (A810135-36)			**Matrix: Soil**					
Aluminum	**23400**	---	2280	mg/kg dry	200	10/24/08 11:49	EPA 6020	
Antimony	**1.36**	---	1.14	"	10	10/24/08 13:26	"	Q-29
Arsenic	**10.7**	---	1.14	"	"	"	"	
Barium	**95.3**	---	1.14	"	"	"	"	
Beryllium	ND	---	2.28	"	"	"	"	
Cadmium	**32.3**	---	1.14	"	"	"	"	
Calcium	**23300**	---	2280	"	200	10/24/08 11:49	"	
Chromium	**33.5**	---	2.28	"	10	10/24/08 13:26	"	
Cobalt	**14.8**	---	2.28	"	"	"	"	
Copper	**128**	---	4.56	"	"	"	"	
Iron	**34700**	---	2280	"	200	10/24/08 11:49	"	
Lead	**1450**	---	22.8	"	"	"	"	
Magnesium	**8870**	---	114	"	10	10/24/08 13:26	"	
Manganese	**5040**	---	45.6	"	200	10/24/08 11:49	"	
Mercury	**0.388**	---	0.0912	"	10	10/24/08 13:26	"	
Nickel	**28.5**	---	2.28	"	"	"	"	
Potassium	**3000**	---	114	"	"	"	"	
Selenium	ND	---	1.14	"	"	"	"	
Silver	**3.13**	---	2.28	"	"	"	"	
Sodium	ND	---	114	"	"	"	"	
Thallium	ND	---	1.14	"	"	"	"	
Vanadium	**37.8**	---	2.28	"	"	"	"	
Zinc	**7510**	---	91.2	"	200	10/24/08 11:49	"	

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

ANALYTICAL SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
WRS-R-26 (A810135-37)			**Matrix: Soil**					
Aluminum	**34600**	---	1230	mg/kg dry	100	10/24/08 12:08	EPA 6020	
Antimony	ND	---	1.23	"	10	10/24/08 13:29	"	
Arsenic	**9.14**	---	1.23	"	"	"	"	
Barium	**124**	---	1.23	"	"	"	"	
Beryllium	ND	---	2.47	"	"	"	"	
Cadmium	**8.02**	---	1.23	"	"	"	"	
Calcium	**5510**	---	123	"	"	"	"	
Chromium	**32.3**	---	2.47	"	"	"	"	
Cobalt	**21.5**	---	2.47	"	"	"	"	
Copper	**198**	---	4.94	"	"	"	"	
Iron	**42700**	---	1230	"	100	10/24/08 12:08	"	
Lead	**1130**	---	12.3	"	"	"	"	
Magnesium	**13600**	---	1230	"	"	"	"	
Manganese	**3890**	---	24.7	"	"	"	"	
Mercury	**0.111**	---	0.0987	"	10	10/24/08 13:29	"	
Nickel	**25.8**	---	2.47	"	"	"	"	
Potassium	**2610**	---	123	"	"	"	"	
Selenium	ND	---	1.23	"	"	"	"	
Silver	ND	---	2.47	"	"	"	"	
Sodium	**161**	---	123	"	"	"	"	
Thallium	ND	---	1.23	"	"	"	"	
Vanadium	**65.7**	---	2.47	"	"	"	"	
Zinc	**2020**	---	49.4	"	100	10/24/08 12:08	"	

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

ANALYTICAL SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
WRS-R-27 (A810135-38)			**Matrix: Soil**					
Aluminum	**25300**	---	2430	mg/kg dry	200	10/24/08 12:11	EPA 6020	
Antimony	ND	---	1.21	"	10	10/24/08 13:32	"	
Arsenic	**37.2**	---	1.21	"	"	"	"	
Barium	**42.8**	---	1.21	"	"	"	"	
Beryllium	ND	---	2.43	"	"	"	"	
Cadmium	**43.5**	---	1.21	"	"	"	"	
Calcium	**18500**	---	2430	"	200	10/24/08 12:11	"	
Chromium	**26.9**	---	2.43	"	10	10/24/08 13:32	"	
Cobalt	**24.3**	---	2.43	"	"	"	"	
Copper	**272**	---	4.86	"	"	"	"	
Iron	**59700**	---	2430	"	200	10/24/08 12:11	"	
Lead	**1850**	---	24.3	"	"	"	"	
Magnesium	**13600**	---	2430	"	"	"	"	
Manganese	**6700**	---	48.6	"	"	"	"	
Mercury	**0.911**	---	0.0971	"	10	10/24/08 13:32	"	
Nickel	**26.9**	---	2.43	"	"	"	"	
Potassium	**3570**	---	121	"	"	"	"	
Selenium	**2.73**	---	1.21	"	"	"	"	
Silver	**7.84**	---	2.43	"	"	"	"	
Sodium	ND	---	121	"	"	"	"	
Thallium	ND	---	1.21	"	"	"	"	
Vanadium	**30.3**	---	2.43	"	"	"	"	
Zinc	**10500**	---	97.1	"	200	10/24/08 12:11	"	

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

ANALYTICAL SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
WRS-R-28 (A810135-39)			**Matrix: Soil**					
Aluminum	**23200**	---	1100	mg/kg dry	100	10/27/08 11:57	EPA 6020	
Antimony	ND	---	1.10	"	10	10/24/08 17:54	"	
Arsenic	**13.2**	---	1.10	"	"	"	"	
Barium	**61.2**	---	1.10	"	"	"	"	
Beryllium	ND	---	2.21	"	"	"	"	
Cadmium	**17.6**	---	1.10	"	"	"	"	
Calcium	**18300**	---	1100	"	100	10/27/08 11:57	"	
Chromium	**31.4**	---	2.21	"	10	10/24/08 17:54	"	
Cobalt	**15.7**	---	2.21	"	"	"	"	
Copper	**155**	---	4.41	"	"	"	"	
Iron	**36900**	---	1100	"	100	10/27/08 11:57	"	
Lead	**1230**	---	11.0	"	"	"	"	
Magnesium	**13400**	---	1100	"	"	"	"	
Manganese	**4460**	---	22.1	"	"	"	"	
Mercury	**0.132**	---	0.0882	"	10	10/24/08 17:54	"	
Nickel	**26.1**	---	2.21	"	"	"	"	
Potassium	**2750**	---	110	"	"	"	"	
Selenium	**1.44**	---	1.10	"	"	"	"	
Silver	**4.15**	---	2.21	"	"	"	"	
Sodium	ND	---	110	"	"	"	"	
Thallium	ND	---	1.10	"	"	"	"	
Vanadium	**35.5**	---	2.21	"	"	"	"	
Zinc	**4690**	---	44.1	"	100	10/27/08 11:57	"	

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

ANALYTICAL SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
WRS-R-29 (A810135-40)			**Matrix: Soil**					
Aluminum	**23100**	---	2140	mg/kg dry	200	10/27/08 12:00	EPA 6020	
Antimony	**1.13**	---	1.07	"	10	10/24/08 17:57	"	Q-29
Arsenic	**11.6**	---	1.07	"	"	"	"	
Barium	**40.2**	---	1.07	"	"	"	"	
Beryllium	ND	---	2.14	"	"	"	"	
Cadmium	**47.5**	---	1.07	"	"	"	"	
Calcium	**17500**	---	2140	"	200	10/27/08 12:00	"	
Chromium	**24.3**	---	2.14	"	10	10/24/08 17:57	"	
Cobalt	**16.7**	---	2.14	"	"	"	"	
Copper	**437**	---	4.27	"	"	"	"	
Iron	**35400**	---	2140	"	200	10/27/08 12:00	"	
Lead	**1210**	---	21.4	"	"	"	"	
Magnesium	**13100**	---	2140	"	"	"	"	
Manganese	**5270**	---	42.7	"	"	"	"	
Mercury	ND	---	0.0854	"	10	10/24/08 17:57	"	
Nickel	**22.1**	---	2.14	"	"	"	"	
Potassium	**2320**	---	107	"	"	"	"	
Selenium	**2.07**	---	1.07	"	"	"	"	
Silver	**5.50**	---	2.14	"	"	"	"	
Sodium	ND	---	107	"	"	"	"	
Thallium	ND	---	1.07	"	"	"	"	
Vanadium	**33.5**	---	2.14	"	"	"	"	
Zinc	**10600**	---	85.4	"	200	10/27/08 12:00	"	

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15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

ANALYTICAL SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
WRS-R-DUP (A810135-41)			**Matrix: Soil**					
Aluminum	**27200**	---	1070	mg/kg dry	100	10/27/08 12:09	EPA 6020	
Antimony	**1.23**	---	1.07	"	10	10/24/08 18:06	"	Q-29
Arsenic	**3.88**	---	1.07	"	"	"	"	
Barium	**102**	---	1.07	"	"	"	"	
Beryllium	ND	---	2.14	"	"	"	"	
Cadmium	**12.8**	---	1.07	"	"	"	"	
Calcium	**38500**	---	1070	"	100	10/27/08 12:09	"	
Chromium	**21.5**	---	2.14	"	10	10/24/08 18:06	"	
Cobalt	**13.6**	---	2.14	"	"	"	"	
Copper	**100**	---	4.28	"	"	"	"	
Iron	**31500**	---	1070	"	100	10/27/08 12:09	"	
Lead	**905**	---	10.7	"	"	"	"	
Magnesium	**13500**	---	1070	"	"	"	"	
Manganese	**4640**	---	21.4	"	"	"	"	
Mercury	ND	---	0.0856	"	10	10/24/08 18:06	"	
Nickel	**19.3**	---	2.14	"	"	"	"	
Potassium	**2780**	---	107	"	"	"	"	
Selenium	**1.34**	---	1.07	"	"	"	"	
Silver	ND	---	2.14	"	"	"	"	
Sodium	ND	---	107	"	"	"	"	
Thallium	ND	---	1.07	"	"	"	"	
Vanadium	**42.1**	---	2.14	"	"	"	"	
Zinc	**2730**	---	42.8	"	100	10/27/08 12:09	"	

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15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

ANALYTICAL SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
WRS-R-30 (A810135-42)			**Matrix: Soil**					
Aluminum	**27000**	---	2230	mg/kg dry	200	10/27/08 12:27	EPA 6020	
Antimony	ND	---	1.11	"	10	10/24/08 18:24	"	
Arsenic	**30.3**	---	1.11	"	"	"	"	
Barium	**66.3**	---	1.11	"	"	"	"	
Beryllium	ND	---	2.23	"	"	"	"	
Cadmium	**34.0**	---	1.11	"	"	"	"	
Calcium	**24900**	---	2230	"	200	10/27/08 12:27	"	
Chromium	**24.4**	---	2.23	"	10	10/24/08 18:24	"	
Cobalt	**14.5**	---	2.23	"	"	"	"	
Copper	**223**	---	4.46	"	"	"	"	
Iron	**38700**	---	2230	"	200	10/27/08 12:27	"	
Lead	**3230**	---	22.3	"	"	"	"	
Magnesium	**12300**	---	2230	"	"	"	"	
Manganese	**4670**	---	44.6	"	"	"	"	
Mercury	**0.145**	---	0.0891	"	10	10/24/08 18:24	"	
Nickel	**22.4**	---	2.23	"	"	"	"	
Potassium	**6770**	---	111	"	"	"	"	
Selenium	**2.03**	---	1.11	"	"	"	"	
Silver	**7.40**	---	2.23	"	"	"	"	
Sodium	ND	---	111	"	"	"	"	
Thallium	ND	---	1.11	"	"	"	"	
Vanadium	**34.0**	---	2.23	"	"	"	"	
Zinc	**8100**	---	89.1	"	200	10/27/08 12:27	"	

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15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

ANALYTICAL SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
AW-MA-1 (A810135-43)			**Matrix: Water**					
Aluminum	ND	---	100	ug/L	1	10/17/08 17:48	EPA 6020	
Antimony	ND	---	1.00	"	"	"	"	
Arsenic	**4.76**	---	1.00	"	"	"	"	
Barium	ND	---	1.00	"	"	"	"	
Beryllium	ND	---	1.00	"	"	"	"	
Cadmium	ND	---	1.00	"	"	"	"	
Calcium	**12100**	---	500	"	5	10/21/08 09:54	"	
Chromium	ND	---	1.00	"	1	10/17/08 17:48	"	
Cobalt	ND	---	2.00	"	"	"	"	
Copper	ND	---	4.00	"	"	"	"	
Iron	ND	---	100	"	"	"	"	
Lead	**2.23**	---	1.00	"	"	"	"	
Magnesium	**263**	---	100	"	"	"	"	
Manganese	ND	---	1.00	"	"	"	"	
Mercury	ND	---	0.100	"	"	10/23/08 18:14	"	
Nickel	ND	---	1.00	"	"	10/17/08 17:48	"	
Potassium	**240**	---	100	"	"	"	"	
Selenium	ND	---	1.00	"	"	"	"	
Silver	ND	---	2.00	"	"	"	"	
Sodium	**6870**	---	100	"	"	"	"	
Thallium	ND	---	1.00	"	"	"	"	
Vanadium	ND	---	2.00	"	"	"	"	
Zinc	**56.5**	---	4.00	"	"	"	"	

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15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

ANALYTICAL SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
SW-MS-11 (A810135-44)			**Matrix: Water**					
Aluminum	ND	---	100	ug/L	1	10/17/08 18:10	EPA 6020	
Antimony	ND	---	1.00	"	"	"	"	
Arsenic	ND	---	1.00	"	"	"	"	
Barium	**1.73**	---	1.00	"	"	"	"	
Beryllium	ND	---	1.00	"	"	"	"	
Cadmium	ND	---	1.00	"	"	"	"	
Calcium	**3300**	---	100	"	"	"	"	
Chromium	ND	---	1.00	"	"	"	"	
Cobalt	ND	---	2.00	"	"	"	"	
Copper	ND	---	4.00	"	"	"	"	
Iron	ND	---	100	"	"	"	"	
Lead	**1.71**	---	1.00	"	"	"	"	
Magnesium	**337**	---	100	"	"	"	"	
Manganese	ND	---	1.00	"	"	"	"	
Mercury	ND	---	0.100	"	"	10/21/08 11:04	"	
Nickel	ND	---	1.00	"	"	10/17/08 18:10	"	
Potassium	**127**	---	100	"	"	"	"	
Selenium	ND	---	1.00	"	"	"	"	
Silver	ND	---	2.00	"	"	"	"	
Sodium	**1110**	---	100	"	"	"	"	
Thallium	ND	---	1.00	"	"	"	"	
Vanadium	ND	---	2.00	"	"	"	"	
Zinc	**22.9**	---	4.00	"	"	"	"	

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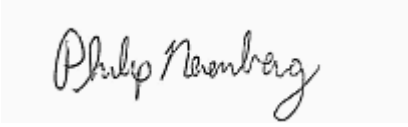

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503-718-2323 Phone
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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

ANALYTICAL SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
SW-MS-12 (A810135-45)			**Matrix: Water**					
Aluminum	ND	---	100	ug/L	1	10/17/08 18:01	EPA 6020	
Antimony	ND	---	1.00	"	"	"	"	
Arsenic	**1.10**	---	1.00	"	"	"	"	
Barium	ND	---	1.00	"	"	"	"	
Beryllium	ND	---	1.00	"	"	"	"	
Cadmium	ND	---	1.00	"	"	"	"	
Calcium	**4980**	---	100	"	"	"	"	
Chromium	ND	---	1.00	"	"	"	"	
Cobalt	ND	---	2.00	"	"	"	"	
Copper	ND	---	4.00	"	"	"	"	
Iron	ND	---	100	"	"	"	"	
Lead	**2.48**	---	1.00	"	"	"	"	
Magnesium	**280**	---	100	"	"	"	"	
Manganese	ND	---	1.00	"	"	"	"	
Mercury	ND	---	0.100	"	"	10/23/08 18:17	"	
Nickel	ND	---	1.00	"	"	10/17/08 18:01	"	
Potassium	**141**	---	100	"	"	"	"	
Selenium	ND	---	1.00	"	"	"	"	
Silver	ND	---	2.00	"	"	"	"	
Sodium	**2160**	---	100	"	"	"	"	
Thallium	ND	---	1.00	"	"	"	"	
Vanadium	ND	---	2.00	"	"	"	"	
Zinc	**41.5**	---	4.00	"	"	"	"	

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

ANALYTICAL SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
SW-MS-13 (A810135-46)			**Matrix: Water**					
Aluminum	ND	---	100	ug/L	1	10/17/08 18:19	EPA 6020	
Antimony	ND	---	1.00	"	"	"	"	
Arsenic	**1.34**	---	1.00	"	"	"	"	
Barium	ND	---	1.00	"	"	"	"	
Beryllium	ND	---	1.00	"	"	"	"	
Cadmium	ND	---	1.00	"	"	"	"	
Calcium	**5250**	---	100	"	"	"	"	
Chromium	ND	---	1.00	"	"	"	"	
Cobalt	ND	---	2.00	"	"	"	"	
Copper	ND	---	4.00	"	"	"	"	
Iron	ND	---	100	"	"	"	"	
Lead	**3.44**	---	1.00	"	"	"	"	
Magnesium	**258**	---	100	"	"	"	"	
Manganese	ND	---	1.00	"	"	"	"	
Mercury	ND	---	0.100	"	"	10/23/08 18:20	"	
Nickel	ND	---	1.00	"	"	10/17/08 18:19	"	
Potassium	**137**	---	100	"	"	"	"	
Selenium	ND	---	1.00	"	"	"	"	
Silver	ND	---	2.00	"	"	"	"	
Sodium	**2180**	---	100	"	"	"	"	
Thallium	ND	---	1.00	"	"	"	"	
Vanadium	ND	---	2.00	"	"	"	"	
Zinc	**64.6**	---	4.00	"	"	"	"	

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

ANALYTICAL SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
SED-MS-12 (A810135-47)			**Matrix: Soil**					
Aluminum	**17400**	---	1160	mg/kg dry	100	10/27/08 12:30	EPA 6020	
Antimony	ND	---	1.16	"	10	10/24/08 18:27	"	
Arsenic	**41.4**	---	1.16	"	"	"	"	
Barium	**15.3**	---	1.16	"	"	"	"	
Beryllium	ND	---	2.32	"	"	"	"	
Cadmium	**9.86**	---	1.16	"	"	"	"	
Calcium	**3750**	---	116	"	"	"	"	
Chromium	**18.4**	---	2.32	"	"	"	"	
Cobalt	**16.0**	---	2.32	"	"	"	"	
Copper	**231**	---	4.64	"	"	"	"	
Iron	**37600**	---	1160	"	100	10/27/08 12:30	"	
Lead	**1370**	---	11.6	"	"	"	"	
Magnesium	**11500**	---	116	"	10	10/24/08 18:27	"	
Manganese	**2820**	---	23.2	"	100	10/27/08 12:30	"	
Mercury	**0.162**	---	0.0928	"	10	10/24/08 18:27	"	
Nickel	**20.5**	---	2.32	"	"	"	"	
Potassium	**1410**	---	116	"	"	"	"	
Selenium	ND	---	1.16	"	"	"	"	
Silver	**2.60**	---	2.32	"	"	"	"	
Sodium	ND	---	116	"	"	"	"	
Thallium	ND	---	1.16	"	"	"	"	
Vanadium	**29.2**	---	2.32	"	"	"	"	
Zinc	**2920**	---	46.4	"	100	10/27/08 12:30	"	

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

ANALYTICAL SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
SED-MS-13 (A810135-48)			**Matrix: Soil**					
Aluminum	**10300**	---	109	mg/kg dry	10	10/27/08 13:33	EPA 6020	
Antimony	ND	---	1.09	"	"	"	"	
Arsenic	**5.91**	---	1.09	"	"	"	"	
Barium	**20.1**	---	1.09	"	"	"	"	
Beryllium	ND	---	2.19	"	"	"	"	
Cadmium	**3.54**	---	1.09	"	"	"	"	
Calcium	**4740**	---	109	"	"	"	"	
Chromium	**19.3**	---	2.19	"	"	"	"	
Cobalt	**13.1**	---	2.19	"	"	"	"	
Copper	**140**	---	4.37	"	"	"	"	
Iron	**26500**	---	546	"	50	10/27/08 12:34	"	
Lead	**660**	---	5.46	"	"	"	"	
Magnesium	**10300**	---	109	"	10	10/27/08 13:33	"	
Manganese	**1340**	---	10.9	"	50	10/27/08 12:34	"	
Mercury	ND	---	0.0874	"	10	10/27/08 13:33	"	
Nickel	**18.7**	---	2.19	"	"	"	"	
Potassium	**1300**	---	109	"	"	"	"	
Selenium	ND	---	1.09	"	"	"	"	
Silver	ND	---	2.19	"	"	"	"	
Sodium	**135**	---	109	"	"	"	"	
Thallium	ND	---	1.09	"	"	"	"	
Vanadium	**31.4**	---	2.19	"	"	"	"	
Zinc	**1480**	---	21.9	"	50	10/27/08 12:34	"	

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

ANALYTICAL SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
SW-MS-14 (A810135-49)			**Matrix: Water**					
Aluminum	ND	---	100	ug/L	1	10/17/08 18:22	EPA 6020	
Antimony	ND	---	1.00	"	"	"	"	
Arsenic	ND	---	1.00	"	"	"	"	
Barium	ND	---	1.00	"	"	"	"	
Beryllium	ND	---	1.00	"	"	"	"	
Cadmium	ND	---	1.00	"	"	"	"	
Calcium	**4050**	---	100	"	"	"	"	
Chromium	ND	---	1.00	"	"	"	"	
Cobalt	ND	---	2.00	"	"	"	"	
Copper	ND	---	4.00	"	"	"	"	
Iron	ND	---	100	"	"	"	"	
Lead	ND	---	1.00	"	"	"	"	
Magnesium	**483**	---	100	"	"	"	"	
Manganese	ND	---	1.00	"	"	"	"	
Mercury	ND	---	0.100	"	"	10/23/08 18:23	"	
Nickel	ND	---	1.00	"	"	10/17/08 18:22	"	
Potassium	**110**	---	100	"	"	"	"	
Selenium	ND	---	1.00	"	"	"	"	
Silver	ND	---	2.00	"	"	"	"	
Sodium	**1320**	---	100	"	"	"	"	
Thallium	ND	---	1.00	"	"	"	"	
Vanadium	ND	---	2.00	"	"	"	"	
Zinc	**6.89**	---	4.00	"	"	"	"	

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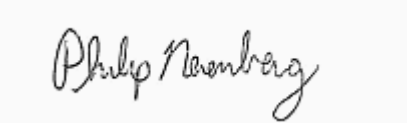

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

ANALYTICAL SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
SED-MS-14 (A810135-50)			**Matrix: Soil**					
Aluminum	**17900**	---	263	mg/kg dry	20	10/27/08 12:37	EPA 6020	
Antimony	ND	---	1.32	"	10	10/24/08 18:33	"	
Arsenic	**1.42**	---	1.32	"	"	"	"	
Barium	**32.8**	---	1.32	"	"	"	"	
Beryllium	ND	---	2.63	"	"	"	"	
Cadmium	ND	---	1.32	"	"	"	"	
Calcium	**7490**	---	132	"	"	"	"	
Chromium	**11.4**	---	2.63	"	"	"	"	
Cobalt	**9.61**	---	2.63	"	"	"	"	
Copper	**15.5**	---	5.26	"	"	"	"	
Iron	**16000**	---	263	"	20	10/27/08 12:37	"	
Lead	**2.97**	---	1.32	"	10	10/24/08 18:33	"	
Magnesium	**7330**	---	132	"	"	"	"	
Manganese	**424**	---	2.63	"	"	"	"	
Mercury	ND	---	0.105	"	"	"	"	
Nickel	**16.3**	---	2.63	"	"	"	"	
Potassium	**844**	---	132	"	"	"	"	
Selenium	ND	---	1.32	"	"	"	"	
Silver	ND	---	2.63	"	"	"	"	
Sodium	**267**	---	132	"	"	"	"	
Thallium	ND	---	1.32	"	"	"	"	
Vanadium	**28.8**	---	2.63	"	"	"	"	
Zinc	**36.1**	---	5.26	"	"	"	"	

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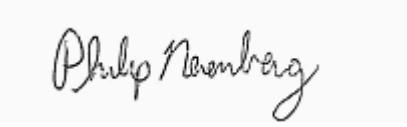

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

ANALYTICAL SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
SW-MS-15 (A810135-52)			**Matrix: Water**					
Aluminum	ND	---	100	ug/L	1	10/17/08 18:25	EPA 6020	
Antimony	ND	---	1.00	"	"	"	"	
Arsenic	ND	---	1.00	"	"	"	"	
Barium	ND	---	1.00	"	"	"	"	
Beryllium	ND	---	1.00	"	"	"	"	
Cadmium	ND	---	1.00	"	"	"	"	
Calcium	**4030**	---	100	"	"	"	"	
Chromium	ND	---	1.00	"	"	"	"	
Cobalt	ND	---	2.00	"	"	"	"	
Copper	ND	---	4.00	"	"	"	"	
Iron	ND	---	100	"	"	"	"	
Lead	ND	---	1.00	"	"	"	"	
Magnesium	**473**	---	100	"	"	"	"	
Manganese	ND	---	1.00	"	"	"	"	
Mercury	ND	---	0.100	"	"	10/23/08 18:33	"	
Nickel	ND	---	1.00	"	"	10/17/08 18:25	"	
Potassium	**108**	---	100	"	"	"	"	
Selenium	ND	---	1.00	"	"	"	"	
Silver	ND	---	2.00	"	"	"	"	
Sodium	**1290**	---	100	"	"	"	"	
Thallium	ND	---	1.00	"	"	"	"	
Vanadium	ND	---	2.00	"	"	"	"	
Zinc	**10.7**	---	4.00	"	"	"	"	

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

ANALYTICAL SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
SED-MS-15 (A810135-53)			**Matrix: Soil**					
Aluminum	**24100**	---	601	mg/kg dry	50	10/27/08 12:40	EPA 6020	
Antimony	ND	---	1.20	"	10	10/24/08 18:36	"	
Arsenic	**1.25**	---	1.20	"	"	"	"	
Barium	**51.6**	---	1.20	"	"	"	"	
Beryllium	ND	---	2.40	"	"	"	"	
Cadmium	ND	---	1.20	"	"	"	"	
Calcium	**6460**	---	120	"	"	"	"	
Chromium	**22.3**	---	2.40	"	"	"	"	
Cobalt	**12.5**	---	2.40	"	"	"	"	
Copper	**24.3**	---	4.81	"	"	"	"	
Iron	**25000**	---	601	"	50	10/27/08 12:40	"	
Lead	**3.44**	---	1.20	"	10	10/24/08 18:36	"	
Magnesium	**10600**	---	120	"	"	"	"	
Manganese	**466**	---	2.40	"	"	"	"	
Mercury	ND	---	0.0962	"	"	"	"	
Nickel	**28.7**	---	2.40	"	"	"	"	
Potassium	**843**	---	120	"	"	"	"	
Selenium	ND	---	1.20	"	"	"	"	
Silver	ND	---	2.40	"	"	"	"	
Sodium	**396**	---	120	"	"	"	"	
Thallium	ND	---	1.20	"	"	"	"	
Vanadium	**43.4**	---	2.40	"	"	"	"	
Zinc	**50.5**	---	4.81	"	"	"	"	

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

ANALYTICAL SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
SW-MS-16 (A810135-55)			**Matrix: Water**					
Aluminum	ND	---	100	ug/L	1	10/17/08 18:28	EPA 6020	
Antimony	ND	---	1.00	"	"	"	"	
Arsenic	ND	---	1.00	"	"	"	"	
Barium	ND	---	1.00	"	"	"	"	
Beryllium	ND	---	1.00	"	"	"	"	
Cadmium	ND	---	1.00	"	"	"	"	
Calcium	**3910**	---	100	"	"	"	"	
Chromium	ND	---	1.00	"	"	"	"	
Cobalt	ND	---	2.00	"	"	"	"	
Copper	ND	---	4.00	"	"	"	"	
Iron	ND	---	100	"	"	"	"	
Lead	ND	---	1.00	"	"	"	"	
Magnesium	**466**	---	100	"	"	"	"	
Manganese	ND	---	1.00	"	"	"	"	
Mercury	ND	---	0.100	"	"	10/23/08 18:45	"	
Nickel	ND	---	1.00	"	"	10/17/08 18:28	"	
Potassium	**117**	---	100	"	"	"	"	
Selenium	ND	---	1.00	"	"	"	"	
Silver	ND	---	2.00	"	"	"	"	
Sodium	**1300**	---	100	"	"	"	"	
Thallium	ND	---	1.00	"	"	"	"	
Vanadium	ND	---	2.00	"	"	"	"	
Zinc	**9.78**	---	4.00	"	"	"	"	

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

ANALYTICAL SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
SED-MS-16 (A810135-56)			**Matrix: Soil**					
Aluminum	**19600**	---	261	mg/kg dry	20	10/27/08 12:43	EPA 6020	
Antimony	ND	---	1.31	"	10	10/24/08 18:39	"	
Arsenic	ND	---	1.31	"	"	"	"	
Barium	**39.9**	---	1.31	"	"	"	"	
Beryllium	ND	---	2.61	"	"	"	"	
Cadmium	ND	---	1.31	"	"	"	"	
Calcium	**6090**	---	131	"	"	"	"	
Chromium	**10.7**	---	2.61	"	"	"	"	
Cobalt	**10.3**	---	2.61	"	"	"	"	
Copper	**20.8**	---	5.23	"	"	"	"	
Iron	**19100**	---	261	"	20	10/27/08 12:43	"	
Lead	**2.27**	---	1.31	"	10	10/24/08 18:39	"	
Magnesium	**9640**	---	131	"	"	"	"	
Manganese	**359**	---	2.61	"	"	"	"	
Mercury	ND	---	0.105	"	"	"	"	
Nickel	**21.2**	---	2.61	"	"	"	"	
Potassium	**547**	---	131	"	"	"	"	
Selenium	ND	---	1.31	"	"	"	"	
Silver	ND	---	2.61	"	"	"	"	
Sodium	**445**	---	131	"	"	"	"	
Thallium	ND	---	1.31	"	"	"	"	
Vanadium	**36.3**	---	2.61	"	"	"	"	
Zinc	**39.6**	---	5.23	"	"	"	"	

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503-718-2323 Phone
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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

ANALYTICAL SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
SW-MS-17 (A810135-58)			**Matrix: Water**					
Aluminum	**101**	---	100	ug/L	1	10/21/08 10:06	EPA 6020	
Antimony	ND	---	1.00	"	"	"	"	
Arsenic	**1.30**	---	1.00	"	"	"	"	
Barium	ND	---	1.00	"	"	"	"	
Beryllium	ND	---	1.00	"	"	"	"	
Cadmium	ND	---	1.00	"	"	"	"	
Calcium	**5300**	---	100	"	"	"	"	
Chromium	ND	---	1.00	"	"	"	"	
Cobalt	ND	---	2.00	"	"	"	"	
Copper	ND	---	4.00	"	"	"	"	
Iron	ND	---	100	"	"	"	"	
Lead	**12.7**	---	1.00	"	"	"	"	
Magnesium	**270**	---	100	"	"	"	"	
Manganese	**4.93**	---	1.00	"	"	"	"	
Mercury	ND	---	0.100	"	"	10/23/08 18:48	"	
Nickel	ND	---	1.00	"	"	10/21/08 10:06	"	
Potassium	**137**	---	100	"	"	"	"	
Selenium	ND	---	1.00	"	"	"	"	
Silver	ND	---	2.00	"	"	"	"	
Sodium	**2340**	---	100	"	"	"	"	
Thallium	ND	---	1.00	"	"	"	"	
Vanadium	ND	---	2.00	"	"	"	"	
Zinc	**81.7**	---	4.00	"	"	"	"	

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

ANALYTICAL SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
SED-MS-17 (A810135-59)			**Matrix: Soil**					
Aluminum	**18600**	---	651	mg/kg dry	50	10/27/08 12:52	EPA 6020	
Antimony	ND	---	1.30	"	10	10/24/08 18:55	"	
Arsenic	**2.31**	---	1.30	"	"	"	"	
Barium	**56.0**	---	1.30	"	"	"	"	
Beryllium	ND	---	2.61	"	"	"	"	
Cadmium	**2.11**	---	1.30	"	"	"	"	
Calcium	**5960**	---	130	"	"	"	"	
Chromium	**18.5**	---	2.61	"	"	"	"	
Cobalt	**15.7**	---	2.61	"	"	"	"	
Copper	**32.8**	---	5.21	"	"	"	"	
Iron	**35700**	---	651	"	50	10/27/08 12:52	"	
Lead	**50.8**	---	1.30	"	10	10/24/08 18:55	"	
Magnesium	**15200**	---	651	"	50	10/27/08 12:52	"	
Manganese	**525**	---	2.61	"	10	10/24/08 18:55	"	
Mercury	ND	---	0.104	"	"	"	"	
Nickel	**89.1**	---	2.61	"	"	"	"	
Potassium	**839**	---	130	"	"	"	"	
Selenium	ND	---	1.30	"	"	"	"	
Silver	ND	---	2.61	"	"	"	"	
Sodium	**355**	---	130	"	"	"	"	
Thallium	ND	---	1.30	"	"	"	"	
Vanadium	**47.2**	---	2.61	"	"	"	"	
Zinc	**608**	---	5.21	"	"	"	"	

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

ANALYTICAL SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
SW-MS-18 (A810135-60)			**Matrix: Water**					
Aluminum	ND	---	100	ug/L	1	10/17/08 18:35	EPA 6020	
Antimony	ND	---	1.00	"	"	"	"	
Arsenic	ND	---	1.00	"	"	"	"	
Barium	ND	---	1.00	"	"	"	"	
Beryllium	ND	---	1.00	"	"	"	"	
Cadmium	ND	---	1.00	"	"	"	"	
Calcium	**4050**	---	100	"	"	"	"	
Chromium	ND	---	1.00	"	"	"	"	
Cobalt	ND	---	2.00	"	"	"	"	
Copper	ND	---	4.00	"	"	"	"	
Iron	ND	---	100	"	"	"	"	
Lead	ND	---	1.00	"	"	"	"	
Magnesium	**481**	---	100	"	"	"	"	
Manganese	ND	---	1.00	"	"	"	"	
Mercury	ND	---	0.100	"	"	10/23/08 18:51	"	
Nickel	ND	---	1.00	"	"	10/17/08 18:35	"	
Potassium	**110**	---	100	"	"	"	"	
Selenium	ND	---	1.00	"	"	"	"	
Silver	ND	---	2.00	"	"	"	"	
Sodium	**1370**	---	100	"	"	"	"	
Thallium	ND	---	1.00	"	"	"	"	
Vanadium	ND	---	2.00	"	"	"	"	
Zinc	**19.6**	---	4.00	"	"	"	"	

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

ANALYTICAL SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
SED-MS-18 (A810135-61)			**Matrix: Soil**					
Aluminum	**21600**	---	280	mg/kg dry	20	10/27/08 13:04	EPA 6020	
Antimony	ND	---	1.40	"	10	10/27/08 13:54	"	
Arsenic	ND	---	1.40	"	"	"	"	
Barium	**46.5**	---	1.40	"	"	"	"	
Beryllium	ND	---	2.80	"	"	"	"	
Cadmium	ND	---	1.40	"	"	"	"	
Calcium	**7280**	---	140	"	"	"	"	
Chromium	**16.0**	---	2.80	"	"	"	"	
Cobalt	**13.4**	---	2.80	"	"	"	"	
Copper	**40.7**	---	5.60	"	"	"	"	
Iron	**23700**	---	280	"	20	10/27/08 13:04	"	
Lead	**6.69**	---	1.40	"	10	10/27/08 13:54	"	
Magnesium	**10400**	---	140	"	"	"	"	
Manganese	**484**	---	2.80	"	"	"	"	
Mercury	ND	---	0.112	"	"	"	"	
Nickel	**47.6**	---	2.80	"	"	"	"	
Potassium	**860**	---	140	"	"	"	"	
Selenium	ND	---	1.40	"	"	"	"	
Silver	ND	---	2.80	"	"	"	"	
Sodium	**374**	---	140	"	"	"	"	
Thallium	ND	---	1.40	"	"	"	"	
Vanadium	**38.3**	---	2.80	"	"	"	"	
Zinc	**68.5**	---	5.60	"	"	"	"	

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

ANALYTICAL SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
SW-R-19 (A810135-63)			**Matrix: Water**					
Aluminum	**375**	---	100	ug/L	1	10/17/08 18:38	EPA 6020	
Antimony	ND	---	1.00	"	"	"	"	
Arsenic	ND	---	1.00	"	"	"	"	
Barium	**2.08**	---	1.00	"	"	"	"	
Beryllium	ND	---	1.00	"	"	"	"	
Cadmium	ND	---	1.00	"	"	"	"	
Calcium	**4290**	---	100	"	"	"	"	
Chromium	**1.03**	---	1.00	"	"	"	"	
Cobalt	ND	---	2.00	"	"	"	"	
Copper	ND	---	4.00	"	"	"	"	
Iron	**187**	---	100	"	"	"	"	
Lead	ND	---	1.00	"	"	"	"	
Magnesium	**559**	---	100	"	"	"	"	
Manganese	**6.82**	---	1.00	"	"	"	"	
Mercury	ND	---	0.100	"	"	10/23/08 18:54	"	
Nickel	ND	---	1.00	"	"	10/17/08 18:38	"	
Potassium	**167**	---	100	"	"	"	"	
Selenium	ND	---	1.00	"	"	"	"	
Silver	ND	---	2.00	"	"	"	"	
Sodium	**1420**	---	100	"	"	"	"	
Thallium	ND	---	1.00	"	"	"	"	
Vanadium	ND	---	2.00	"	"	"	"	
Zinc	**8.61**	---	4.00	"	"	"	"	

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

ANALYTICAL SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
SED-R-19 (A810135-64)			**Matrix: Soil**					
Aluminum	**17300**	---	284	mg/kg dry	20	10/27/08 13:14	EPA 6020	
Antimony	ND	---	1.42	"	10	10/24/08 19:01	"	
Arsenic	ND	---	1.42	"	"	"	"	
Barium	**30.4**	---	1.42	"	"	"	"	
Beryllium	ND	---	2.84	"	"	"	"	
Cadmium	ND	---	1.42	"	"	"	"	
Calcium	**5010**	---	142	"	"	"	"	
Chromium	**13.1**	---	2.84	"	"	"	"	
Cobalt	**10.0**	---	2.84	"	"	"	"	
Copper	**21.5**	---	5.68	"	"	"	"	
Iron	**20500**	---	284	"	20	10/27/08 13:14	"	
Lead	**8.58**	---	1.42	"	10	10/24/08 19:01	"	
Magnesium	**8480**	---	142	"	"	"	"	
Manganese	**383**	---	2.84	"	"	"	"	
Mercury	ND	---	0.114	"	"	"	"	
Nickel	**26.9**	---	2.84	"	"	"	"	
Potassium	**630**	---	142	"	"	"	"	
Selenium	ND	---	1.42	"	"	"	"	
Silver	ND	---	2.84	"	"	"	"	
Sodium	**283**	---	142	"	"	"	"	
Thallium	ND	---	1.42	"	"	"	"	
Vanadium	**36.7**	---	2.84	"	"	"	"	
Zinc	**67.9**	---	5.68	"	"	"	"	

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

ANALYTICAL SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
SW-R-20 (A810135-66)			**Matrix: Water**					
Aluminum	ND	---	100	ug/L	1	10/17/08 18:41	EPA 6020	
Antimony	ND	---	1.00	"	"	"	"	
Arsenic	ND	---	1.00	"	"	"	"	
Barium	ND	---	1.00	"	"	"	"	
Beryllium	ND	---	1.00	"	"	"	"	
Cadmium	ND	---	1.00	"	"	"	"	
Calcium	**4080**	---	100	"	"	"	"	
Chromium	ND	---	1.00	"	"	"	"	
Cobalt	ND	---	2.00	"	"	"	"	
Copper	ND	---	4.00	"	"	"	"	
Iron	ND	---	100	"	"	"	"	
Lead	ND	---	1.00	"	"	"	"	
Magnesium	**482**	---	100	"	"	"	"	
Manganese	ND	---	1.00	"	"	"	"	
Mercury	ND	---	0.100	"	"	10/23/08 18:57	"	
Nickel	ND	---	1.00	"	"	10/17/08 18:41	"	
Potassium	**113**	---	100	"	"	"	"	
Selenium	ND	---	1.00	"	"	"	"	
Silver	ND	---	2.00	"	"	"	"	
Sodium	**1370**	---	100	"	"	"	"	
Thallium	ND	---	1.00	"	"	"	"	
Vanadium	ND	---	2.00	"	"	"	"	
Zinc	**6.67**	---	4.00	"	"	"	"	

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

ANALYTICAL SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
SED-R-20 (A810135-67)			**Matrix: Soil**					
Aluminum	**22400**	---	268	mg/kg dry	20	10/27/08 13:17	EPA 6020	
Antimony	ND	---	1.34	"	10	10/24/08 19:04	"	
Arsenic	**2.39**	---	1.34	"	"	"	"	
Barium	**27.2**	---	1.34	"	"	"	"	
Beryllium	ND	---	2.68	"	"	"	"	
Cadmium	ND	---	1.34	"	"	"	"	
Calcium	**7170**	---	134	"	"	"	"	
Chromium	**11.6**	---	2.68	"	"	"	"	
Cobalt	**11.2**	---	2.68	"	"	"	"	
Copper	**29.9**	---	5.36	"	"	"	"	
Iron	**25000**	---	268	"	20	10/27/08 13:17	"	
Lead	**4.75**	---	1.34	"	10	10/24/08 19:04	"	
Magnesium	**9060**	---	134	"	"	"	"	
Manganese	**439**	---	2.68	"	"	"	"	
Mercury	ND	---	0.107	"	"	"	"	
Nickel	**17.5**	---	2.68	"	"	"	"	
Potassium	**643**	---	134	"	"	"	"	
Selenium	ND	---	1.34	"	"	"	"	
Silver	ND	---	2.68	"	"	"	"	
Sodium	**167**	---	134	"	"	"	"	
Thallium	ND	---	1.34	"	"	"	"	
Vanadium	**38.9**	---	2.68	"	"	"	"	
Zinc	**62.2**	---	5.36	"	"	"	"	

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

ANALYTICAL SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
SW-R-21 (A810135-69)			**Matrix: Water**					
Aluminum	ND	---	100	ug/L	1	10/17/08 18:44	EPA 6020	
Antimony	ND	---	1.00	"	"	"	"	
Arsenic	ND	---	1.00	"	"	"	"	
Barium	ND	---	1.00	"	"	"	"	
Beryllium	ND	---	1.00	"	"	"	"	
Cadmium	ND	---	1.00	"	"	"	"	
Calcium	**4010**	---	100	"	"	"	"	
Chromium	ND	---	1.00	"	"	"	"	
Cobalt	ND	---	2.00	"	"	"	"	
Copper	ND	---	4.00	"	"	"	"	
Iron	ND	---	100	"	"	"	"	
Lead	ND	---	1.00	"	"	"	"	
Magnesium	**467**	---	100	"	"	"	"	
Manganese	ND	---	1.00	"	"	"	"	
Mercury	ND	---	0.100	"	"	10/23/08 19:09	"	
Nickel	ND	---	1.00	"	"	10/17/08 18:44	"	
Potassium	ND	---	100	"	"	"	"	
Selenium	ND	---	1.00	"	"	"	"	
Silver	ND	---	2.00	"	"	"	"	
Sodium	**1310**	---	100	"	"	"	"	
Thallium	ND	---	1.00	"	"	"	"	
Vanadium	ND	---	2.00	"	"	"	"	
Zinc	**14.8**	---	4.00	"	"	"	"	

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

ANALYTICAL SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
SED-R-21 (A810135-70)			**Matrix: Soil**					
Aluminum	**19500**	---	667	mg/kg dry	50	10/27/08 13:20	EPA 6020	
Antimony	ND	---	1.33	"	10	10/24/08 19:07	"	
Arsenic	**1.53**	---	1.33	"	"	"	"	
Barium	**35.9**	---	1.33	"	"	"	"	
Beryllium	ND	---	2.67	"	"	"	"	
Cadmium	ND	---	1.33	"	"	"	"	
Calcium	**6060**	---	133	"	"	"	"	
Chromium	**16.5**	---	2.67	"	"	"	"	
Cobalt	**12.6**	---	2.67	"	"	"	"	
Copper	**30.8**	---	5.33	"	"	"	"	
Iron	**25300**	---	667	"	50	10/27/08 13:20	"	
Lead	**55.5**	---	1.33	"	10	10/24/08 19:07	"	
Magnesium	**10300**	---	133	"	"	"	"	
Manganese	**728**	---	13.3	"	50	10/27/08 13:20	"	
Mercury	ND	---	0.107	"	10	10/24/08 19:07	"	
Nickel	**23.8**	---	2.67	"	"	"	"	
Potassium	**715**	---	133	"	"	"	"	
Selenium	ND	---	1.33	"	"	"	"	
Silver	ND	---	2.67	"	"	"	"	
Sodium	**372**	---	133	"	"	"	"	
Thallium	ND	---	1.33	"	"	"	"	
Vanadium	**48.2**	---	2.67	"	"	"	"	
Zinc	**174**	---	5.33	"	"	"	"	

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

ANALYTICAL SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
SW-R-22 (A810135-71)			**Matrix: Water**					
Aluminum	ND	---	100	ug/L	1	10/17/08 18:47	EPA 6020	
Antimony	ND	---	1.00	"	"	"	"	
Arsenic	ND	---	1.00	"	"	"	"	
Barium	ND	---	1.00	"	"	"	"	
Beryllium	ND	---	1.00	"	"	"	"	
Cadmium	ND	---	1.00	"	"	"	"	
Calcium	**4120**	---	100	"	"	"	"	
Chromium	ND	---	1.00	"	"	"	"	
Cobalt	ND	---	2.00	"	"	"	"	
Copper	ND	---	4.00	"	"	"	"	
Iron	ND	---	100	"	"	"	"	
Lead	ND	---	1.00	"	"	"	"	
Magnesium	**480**	---	100	"	"	"	"	
Manganese	**1.36**	---	1.00	"	"	"	"	
Mercury	ND	---	0.100	"	"	10/23/08 19:21	"	
Nickel	ND	---	1.00	"	"	10/17/08 18:47	"	
Potassium	**105**	---	100	"	"	"	"	
Selenium	ND	---	1.00	"	"	"	"	
Silver	ND	---	2.00	"	"	"	"	
Sodium	**1390**	---	100	"	"	"	"	
Thallium	ND	---	1.00	"	"	"	"	
Vanadium	ND	---	2.00	"	"	"	"	
Zinc	**18.7**	---	4.00	"	"	"	"	

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12232 S.W. Garden Place
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503-718-2323 Phone
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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

ANALYTICAL SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
SED-R-22 (A810135-72)			**Matrix: Soil**					
Aluminum	**23000**	---	716	mg/kg dry	50	10/27/08 13:23	EPA 6020	
Antimony	ND	---	1.43	"	10	10/24/08 19:10	"	
Arsenic	**15.7**	---	1.43	"	"	"	"	
Barium	**54.0**	---	1.43	"	"	"	"	
Beryllium	ND	---	2.86	"	"	"	"	
Cadmium	**5.59**	---	1.43	"	"	"	"	
Calcium	**6700**	---	143	"	"	"	"	
Chromium	**20.8**	---	2.86	"	"	"	"	
Cobalt	**16.1**	---	2.86	"	"	"	"	
Copper	**34.6**	---	5.73	"	"	"	"	
Iron	**33400**	---	716	"	50	10/27/08 13:23	"	
Lead	**83.2**	---	1.43	"	10	10/24/08 19:10	"	
Magnesium	**13000**	---	143	"	"	"	"	
Manganese	**2110**	---	14.3	"	50	10/27/08 13:23	"	
Mercury	ND	---	0.115	"	10	10/24/08 19:10	"	
Nickel	**50.2**	---	2.86	"	"	"	"	
Potassium	**973**	---	143	"	"	"	"	
Selenium	ND	---	1.43	"	"	"	"	
Silver	ND	---	2.86	"	"	"	"	
Sodium	**354**	---	143	"	"	"	"	
Thallium	ND	---	1.43	"	"	"	"	
Vanadium	**55.6**	---	2.86	"	"	"	"	
Zinc	**1390**	---	28.6	"	50	10/27/08 13:23	"	

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

ANALYTICAL SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
SW-R-23 (A810135-74)			**Matrix: Water**					
Aluminum	ND	---	100	ug/L	1	10/17/08 18:56	EPA 6020	
Antimony	ND	---	1.00	"	"	"	"	
Arsenic	ND	---	1.00	"	"	"	"	
Barium	ND	---	1.00	"	"	"	"	
Beryllium	ND	---	1.00	"	"	"	"	
Cadmium	ND	---	1.00	"	"	"	"	
Calcium	**4110**	---	100	"	"	"	"	
Chromium	**1.10**	---	1.00	"	"	"	"	
Cobalt	ND	---	2.00	"	"	"	"	
Copper	ND	---	4.00	"	"	"	"	
Iron	ND	---	100	"	"	"	"	
Lead	ND	---	1.00	"	"	"	"	
Magnesium	**467**	---	100	"	"	"	"	
Manganese	ND	---	1.00	"	"	"	"	
Mercury	ND	---	0.100	"	"	10/23/08 19:24	"	
Nickel	ND	---	1.00	"	"	10/17/08 18:56	"	
Potassium	**108**	---	100	"	"	"	"	
Selenium	ND	---	1.00	"	"	"	"	
Silver	ND	---	2.00	"	"	"	"	
Sodium	**1330**	---	100	"	"	"	"	
Thallium	ND	---	1.00	"	"	"	"	
Vanadium	ND	---	2.00	"	"	"	"	
Zinc	**16.7**	---	4.00	"	"	"	"	

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

ANALYTICAL SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
SED-R-23 (A810135-75)			**Matrix: Soil**					
Aluminum	**30100**	---	661	mg/kg dry	50	10/27/08 13:26	EPA 6020	
Antimony	ND	---	1.32	"	10	10/24/08 19:13	"	
Arsenic	**1.85**	---	1.32	"	"	"	"	
Barium	**59.2**	---	1.32	"	"	"	"	
Beryllium	ND	---	2.64	"	"	"	"	
Cadmium	ND	---	1.32	"	"	"	"	
Calcium	**8700**	---	132	"	"	"	"	
Chromium	**22.6**	---	2.64	"	"	"	"	
Cobalt	**15.8**	---	2.64	"	"	"	"	
Copper	**109**	---	5.29	"	"	"	"	
Iron	**32100**	---	661	"	50	10/27/08 13:26	"	
Lead	**43.8**	---	1.32	"	10	10/24/08 19:13	"	
Magnesium	**12100**	---	132	"	"	"	"	
Manganese	**567**	---	2.64	"	"	"	"	
Mercury	ND	---	0.106	"	"	"	"	
Nickel	**45.5**	---	2.64	"	"	"	"	
Potassium	**1230**	---	132	"	"	"	"	
Selenium	ND	---	1.32	"	"	"	"	
Silver	ND	---	2.64	"	"	"	"	
Sodium	**572**	---	132	"	"	"	"	
Thallium	ND	---	1.32	"	"	"	"	
Vanadium	**66.5**	---	2.64	"	"	"	"	
Zinc	**299**	---	5.29	"	"	"	"	

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

ANALYTICAL SAMPLE RESULTS

Dissolved Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
PW-MS-14 (A810135-51)			**Matrix: Water**					
Aluminum	ND	---	100	ug/L	1	10/23/08 14:08	EPA 6020 (Diss)	
Antimony	ND	---	1.00	"	"	"	"	
Arsenic	ND	---	1.00	"	"	"	"	
Barium	**1.50**	---	1.00	"	"	"	"	
Beryllium	ND	---	1.00	"	"	"	"	
Cadmium	ND	---	1.00	"	"	"	"	
Calcium	**3900**	---	100	"	"	"	"	
Chromium	ND	---	1.00	"	"	"	"	
Cobalt	ND	---	2.00	"	"	"	"	
Copper	ND	---	5.00	"	"	"	"	
Iron	ND	---	100	"	"	"	"	
Lead	ND	---	1.00	"	"	"	"	
Magnesium	**502**	---	100	"	"	"	"	
Manganese	**5.21**	---	1.00	"	"	"	"	
Mercury	ND	---	0.100	"	"	10/27/08 14:34	"	
Nickel	**2.27**	---	1.00	"	"	10/23/08 14:08	"	
Potassium	**175**	---	100	"	"	"	"	
Selenium	ND	---	1.00	"	"	"	"	
Silver	ND	---	2.00	"	"	"	"	
Sodium	**1520**	---	100	"	"	"	"	
Thallium	ND	---	1.00	"	"	"	"	
Vanadium	ND	---	2.00	"	"	"	"	
Zinc	**5.47**	---	4.00	"	"	"	"	

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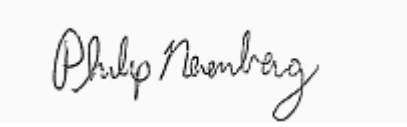

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

ANALYTICAL SAMPLE RESULTS

Dissolved Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
PW-MS-15 (A810135-54)			**Matrix: Water**					
Aluminum	ND	---	100	ug/L	1	10/23/08 14:17	EPA 6020 (Diss)	
Antimony	ND	---	1.00	"	"	"	"	
Arsenic	ND	---	1.00	"	"	"	"	
Barium	**1.06**	---	1.00	"	"	"	"	
Beryllium	ND	---	1.00	"	"	"	"	
Cadmium	ND	---	1.00	"	"	"	"	
Calcium	**3830**	---	100	"	"	"	"	
Chromium	ND	---	1.00	"	"	"	"	
Cobalt	ND	---	2.00	"	"	"	"	
Copper	ND	---	5.00	"	"	"	"	
Iron	ND	---	100	"	"	"	"	
Lead	ND	---	1.00	"	"	"	"	
Magnesium	**494**	---	100	"	"	"	"	
Manganese	**4.47**	---	1.00	"	"	"	"	
Mercury	ND	---	0.100	"	"	10/27/08 14:37	"	
Nickel	**2.13**	---	1.00	"	"	10/23/08 14:17	"	
Potassium	**138**	---	100	"	"	"	"	
Selenium	ND	---	1.00	"	"	"	"	
Silver	ND	---	2.00	"	"	"	"	
Sodium	**1370**	---	100	"	"	"	"	
Thallium	ND	---	1.00	"	"	"	"	
Vanadium	ND	---	2.00	"	"	"	"	
Zinc	**5.13**	---	4.00	"	"	"	"	

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

ANALYTICAL SAMPLE RESULTS

Dissolved Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
PW-MS-16 (A810135-57)			**Matrix: Water**					
Aluminum	ND	---	100	ug/L	1	10/23/08 14:20	EPA 6020 (Diss)	
Antimony	ND	---	1.00	"	"	"	"	
Arsenic	ND	---	1.00	"	"	"	"	
Barium	ND	---	1.00	"	"	"	"	
Beryllium	ND	---	1.00	"	"	"	"	
Cadmium	ND	---	1.00	"	"	"	"	
Calcium	**3800**	---	100	"	"	"	"	
Chromium	ND	---	1.00	"	"	"	"	
Cobalt	ND	---	2.00	"	"	"	"	
Copper	ND	---	5.00	"	"	"	"	
Iron	ND	---	100	"	"	"	"	
Lead	ND	---	1.00	"	"	"	"	
Magnesium	**478**	---	100	"	"	"	"	
Manganese	**1.91**	---	1.00	"	"	"	"	
Mercury	ND	---	0.100	"	"	10/27/08 14:40	"	
Nickel	ND	---	1.00	"	"	10/23/08 14:20	"	
Potassium	**101**	---	100	"	"	"	"	
Selenium	ND	---	1.00	"	"	"	"	
Silver	ND	---	2.00	"	"	"	"	
Sodium	**1350**	---	100	"	"	"	"	
Thallium	ND	---	1.00	"	"	"	"	
Vanadium	ND	---	2.00	"	"	"	"	
Zinc	ND	---	4.00	"	"	"	"	

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

ANALYTICAL SAMPLE RESULTS

Dissolved Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
PW-MS-18 (A810135-62)			**Matrix: Water**					
Aluminum	ND	---	100	ug/L	1	10/23/08 14:29	EPA 6020 (Diss)	
Antimony	ND	---	1.00	"	"	"	"	
Arsenic	ND	---	1.00	"	"	"	"	
Barium	ND	---	1.00	"	"	"	"	
Beryllium	ND	---	1.00	"	"	"	"	
Cadmium	ND	---	1.00	"	"	"	"	
Calcium	**3760**	---	100	"	"	"	"	
Chromium	ND	---	1.00	"	"	"	"	
Cobalt	ND	---	2.00	"	"	"	"	
Copper	ND	---	5.00	"	"	"	"	
Iron	ND	---	100	"	"	"	"	
Lead	ND	---	1.00	"	"	"	"	
Magnesium	**470**	---	100	"	"	"	"	
Manganese	**2.57**	---	1.00	"	"	"	"	
Mercury	ND	---	0.100	"	"	10/27/08 14:43	"	
Nickel	ND	---	1.00	"	"	10/23/08 14:29	"	
Potassium	**103**	---	100	"	"	"	"	
Selenium	ND	---	1.00	"	"	"	"	
Silver	ND	---	2.00	"	"	"	"	
Sodium	**1370**	---	100	"	"	"	"	
Thallium	ND	---	1.00	"	"	"	"	
Vanadium	ND	---	2.00	"	"	"	"	
Zinc	ND	---	4.00	"	"	"	"	

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

ANALYTICAL SAMPLE RESULTS

Dissolved Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
PW-R-19 (A810135-65)			**Matrix: Water**					
Aluminum	ND	---	100	ug/L	1	10/23/08 14:32	EPA 6020 (Diss)	
Antimony	ND	---	1.00	"	"	"	"	
Arsenic	ND	---	1.00	"	"	"	"	
Barium	**1.04**	---	1.00	"	"	"	"	
Beryllium	ND	---	1.00	"	"	"	"	
Cadmium	ND	---	1.00	"	"	"	"	
Calcium	**3700**	---	100	"	"	"	"	
Chromium	ND	---	1.00	"	"	"	"	
Cobalt	ND	---	2.00	"	"	"	"	
Copper	ND	---	5.00	"	"	"	"	
Iron	ND	---	100	"	"	"	"	
Lead	ND	---	1.00	"	"	"	"	
Magnesium	**465**	---	100	"	"	"	"	
Manganese	**1.91**	---	1.00	"	"	"	"	
Mercury	ND	---	0.100	"	"	10/27/08 14:46	"	
Nickel	ND	---	1.00	"	"	10/23/08 14:32	"	
Potassium	**111**	---	100	"	"	"	"	
Selenium	ND	---	1.00	"	"	"	"	
Silver	ND	---	2.00	"	"	"	"	
Sodium	**1410**	---	100	"	"	"	"	
Thallium	ND	---	1.00	"	"	"	"	
Vanadium	ND	---	2.00	"	"	"	"	
Zinc	**7.12**	---	4.00	"	"	"	"	

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

ANALYTICAL SAMPLE RESULTS

Dissolved Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
PW-R-20 (A810135-68)			**Matrix: Water**					
Aluminum	ND	---	100	ug/L	1	10/23/08 14:45	EPA 6020 (Diss)	
Antimony	ND	---	1.00	"	"	"	"	
Arsenic	ND	---	1.00	"	"	"	"	
Barium	**1.17**	---	1.00	"	"	"	"	
Beryllium	ND	---	1.00	"	"	"	"	
Cadmium	ND	---	1.00	"	"	"	"	
Calcium	**4400**	---	100	"	"	10/23/08 17:44	"	
Chromium	ND	---	1.00	"	"	10/23/08 14:45	"	
Cobalt	ND	---	2.00	"	"	"	"	
Copper	ND	---	5.00	"	"	"	"	
Iron	ND	---	100	"	"	"	"	
Lead	ND	---	1.00	"	"	"	"	
Magnesium	**491**	---	100	"	"	"	"	
Manganese	**4.10**	---	1.00	"	"	"	"	
Mercury	ND	---	0.100	"	"	10/27/08 14:50	"	
Nickel	ND	---	1.00	"	"	10/23/08 14:45	"	
Potassium	**138**	---	100	"	"	10/23/08 17:44	"	
Selenium	ND	---	1.00	"	"	10/23/08 14:45	"	
Silver	ND	---	2.00	"	"	"	"	
Sodium	**1410**	---	100	"	"	"	"	
Thallium	ND	---	1.00	"	"	"	"	
Vanadium	ND	---	2.00	"	"	"	"	
Zinc	**5.89**	---	4.00	"	"	"	"	

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

ANALYTICAL SAMPLE RESULTS

Dissolved Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
PW-R-22 (A810135-73)			**Matrix: Water**					
Aluminum	ND	---	100	ug/L	1	10/23/08 14:48	EPA 6020 (Diss)	
Antimony	ND	---	1.00	"	"	"	"	
Arsenic	ND	---	1.00	"	"	"	"	
Barium	**1.36**	---	1.00	"	"	"	"	
Beryllium	ND	---	1.00	"	"	"	"	
Cadmium	ND	---	1.00	"	"	"	"	
Calcium	**4050**	---	100	"	"	10/23/08 17:47	"	
Chromium	ND	---	1.00	"	"	10/23/08 14:48	"	
Cobalt	ND	---	2.00	"	"	"	"	
Copper	ND	---	5.00	"	"	"	"	
Iron	ND	---	100	"	"	"	"	
Lead	**1.53**	---	1.00	"	"	"	"	
Magnesium	**452**	---	100	"	"	"	"	
Manganese	**4.34**	---	1.00	"	"	"	"	
Mercury	ND	---	0.100	"	"	10/27/08 14:53	"	
Nickel	ND	---	1.00	"	"	10/23/08 14:48	"	
Potassium	**144**	---	100	"	"	10/23/08 17:47	"	
Selenium	ND	---	1.00	"	"	10/23/08 14:48	"	
Silver	ND	---	2.00	"	"	"	"	
Sodium	**1370**	---	100	"	"	"	"	
Thallium	ND	---	1.00	"	"	"	"	
Vanadium	ND	---	2.00	"	"	"	"	
Zinc	**103**	---	4.00	"	"	"	"	

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

ANALYTICAL SAMPLE RESULTS

Dissolved Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
PW-R-23 (A810135-76)			**Matrix: Water**					
Aluminum	ND	---	100	ug/L	1	10/23/08 14:51	EPA 6020 (Diss)	
Antimony	ND	---	1.00	"	"	"	"	
Arsenic	ND	---	1.00	"	"	"	"	
Barium	**2.36**	---	1.00	"	"	"	"	
Beryllium	ND	---	1.00	"	"	"	"	
Cadmium	ND	---	1.00	"	"	"	"	
Calcium	**8410**	---	100	"	"	10/23/08 17:50	"	
Chromium	ND	---	1.00	"	"	10/23/08 14:51	"	
Cobalt	ND	---	2.00	"	"	"	"	
Copper	ND	---	5.00	"	"	"	"	
Iron	ND	---	100	"	"	"	"	
Lead	ND	---	1.00	"	"	"	"	
Magnesium	**648**	---	100	"	"	"	"	
Manganese	**4.84**	---	1.00	"	"	"	"	
Mercury	ND	---	0.100	"	"	10/27/08 14:56	"	
Nickel	ND	---	1.00	"	"	10/23/08 14:51	"	
Potassium	**159**	---	100	"	"	10/23/08 17:50	"	
Selenium	ND	---	1.00	"	"	10/23/08 14:51	"	
Silver	ND	---	2.00	"	"	"	"	
Sodium	**1950**	---	100	"	"	"	"	
Thallium	ND	---	1.00	"	"	"	"	
Vanadium	ND	---	2.00	"	"	"	"	
Zinc	**78.3**	---	4.00	"	"	"	"	

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

ANALYTICAL SAMPLE RESULTS

Percent Dry Weight by D2216

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
BG-11 (A810135-01)			**Matrix: Soil**					
% Solids	**65.5**	---	1.00	% by Weight	1	10/20/08 08:57	D2216	
BG-12 (A810135-02)			**Matrix: Soil**					
% Solids	**79.9**	---	1.00	% by Weight	1	10/20/08 08:57	D2216	
BG-13 (A810135-03)			**Matrix: Soil**					
% Solids	**72.4**	---	1.00	% by Weight	1	10/20/08 08:57	D2216	
BG-14 (A810135-04)			**Matrix: Soil**					
% Solids	**66.6**	---	1.00	% by Weight	1	10/20/08 08:57	D2216	
BG-15 (A810135-05)			**Matrix: Soil**					
% Solids	**58.8**	---	1.00	% by Weight	1	10/20/08 08:57	D2216	
BG-16 (A810135-06)			**Matrix: Soil**					
% Solids	**81.6**	---	1.00	% by Weight	1	10/20/08 08:57	D2216	
BG-17 (A810135-07)			**Matrix: Soil**					
% Solids	**86.8**	---	1.00	% by Weight	1	10/20/08 08:57	D2216	
BG-18 (A810135-08)			**Matrix: Soil**					
% Solids	**80.8**	---	1.00	% by Weight	1	10/20/08 08:57	D2216	
BG-19 (A810135-09)			**Matrix: Soil**					
% Solids	**64.6**	---	1.00	% by Weight	1	10/20/08 08:57	D2216	
BG-20 (A810135-10)			**Matrix: Soil**					
% Solids	**73.5**	---	1.00	% by Weight	1	10/20/08 08:57	D2216	
WRS-R-11 (A810135-11)			**Matrix: Soil**					
% Solids	**75.3**	---	1.00	% by Weight	1	10/20/08 08:57	D2216	
WRS-R-12 (A810135-12)			**Matrix: Soil**					
% Solids	**82.0**	---	1.00	% by Weight	1	10/20/08 08:57	D2216	

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15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

ANALYTICAL SAMPLE RESULTS

Percent Dry Weight by D2216

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
WRS-R-13 (A810135-13)			**Matrix: Soil**					
% Solids	**87.3**	---	1.00	% by Weight	1	10/20/08 08:57	D2216	
WRS-R-14 (A810135-14)			**Matrix: Soil**					
% Solids	**88.1**	---	1.00	% by Weight	1	10/20/08 08:57	D2216	
WRS-R-15 (A810135-15)			**Matrix: Soil**					
% Solids	**89.0**	---	1.00	% by Weight	1	10/20/08 08:57	D2216	
WRS-R-16 (A810135-16)			**Matrix: Soil**					
% Solids	**87.5**	---	1.00	% by Weight	1	10/20/08 08:57	D2216	
WRS-R-17 (A810135-17)			**Matrix: Soil**					
% Solids	**74.8**	---	1.00	% by Weight	1	10/20/08 08:57	D2216	
WRS-R-18 (A810135-18)			**Matrix: Soil**					
% Solids	**89.0**	---	1.00	% by Weight	1	10/20/08 08:57	D2216	
WRS-R-19 (A810135-19)			**Matrix: Soil**					
% Solids	**86.3**	---	1.00	% by Weight	1	10/20/08 08:57	D2216	
WRS-R-20 (A810135-20)			**Matrix: Soil**					
% Solids	**87.8**	---	1.00	% by Weight	1	10/20/08 08:57	D2216	
WRS-R-21 (A810135-21)			**Matrix: Soil**					
% Solids	**88.3**	---	1.00	% by Weight	1	10/20/08 08:57	D2216	
WRS-MS-1 (A810135-22)			**Matrix: Soil**					
% Solids	**85.7**	---	1.00	% by Weight	1	10/20/08 08:57	D2216	
WRS-MS-2 (A810135-23)			**Matrix: Soil**					
% Solids	**87.2**	---	1.00	% by Weight	1	10/20/08 08:57	D2216	
WRS-MS-3 (A810135-24)			**Matrix: Soil**					
% Solids	**91.0**	---	1.00	% by Weight	1	10/20/08 08:57	D2216	

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15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

ANALYTICAL SAMPLE RESULTS

Percent Dry Weight by D2216

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
WRS-MS-4 (A810135-25)			**Matrix: Soil**					
% Solids	**87.5**	---	1.00	% by Weight	1	10/20/08 08:57	D2216	
WRS-MS-5 (A810135-26)			**Matrix: Soil**					
% Solids	**89.5**	---	1.00	% by Weight	1	10/20/08 08:57	D2216	
WRS-MS-6 (A810135-27)			**Matrix: Soil**					
% Solids	**85.4**	---	1.00	% by Weight	1	10/20/08 08:57	D2216	
WRS-MS-7 (A810135-28)			**Matrix: Soil**					
% Solids	**84.0**	---	1.00	% by Weight	1	10/20/08 08:57	D2216	
WRS-MS-8 (A810135-29)			**Matrix: Soil**					
% Solids	**78.5**	---	1.00	% by Weight	1	10/20/08 08:57	D2216	
WRS-MS-9 (A810135-30)			**Matrix: Soil**					
% Solids	**82.6**	---	1.00	% by Weight	1	10/20/08 08:57	D2216	
WRS-MS-10 (A810135-31)			**Matrix: Soil**					
% Solids	**89.2**	---	1.00	% by Weight	1	10/20/08 08:57	D2216	
WRS-MS-11 (A810135-32)			**Matrix: Soil**					
% Solids	**76.4**	---	1.00	% by Weight	1	10/20/08 08:57	D2216	
WRS-R-22 (A810135-33)			**Matrix: Soil**					
% Solids	**88.3**	---	1.00	% by Weight	1	10/20/08 08:57	D2216	
WRS-R-23 (A810135-34)			**Matrix: Soil**					
% Solids	**89.9**	---	1.00	% by Weight	1	10/20/08 08:57	D2216	
WRS-R-24 (A810135-35)			**Matrix: Soil**					
% Solids	**87.6**	---	1.00	% by Weight	1	10/20/08 08:57	D2216	
WRS-R-25 (A810135-36)			**Matrix: Soil**					
% Solids	**90.2**	---	1.00	% by Weight	1	10/20/08 08:57	D2216	

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

ANALYTICAL SAMPLE RESULTS

Percent Dry Weight by D2216

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
WRS-R-26 (A810135-37)			**Matrix: Soil**					
% Solids	**83.9**	---	1.00	% by Weight	1	10/20/08 08:57	D2216	
WRS-R-27 (A810135-38)			**Matrix: Soil**					
% Solids	**88.0**	---	1.00	% by Weight	1	10/20/08 08:57	D2216	
WRS-R-28 (A810135-39)			**Matrix: Soil**					
% Solids	**91.6**	---	1.00	% by Weight	1	10/20/08 08:57	D2216	
WRS-R-29 (A810135-40)			**Matrix: Soil**					
% Solids	**93.1**	---	1.00	% by Weight	1	10/20/08 08:57	D2216	
WRS-R-DUP (A810135-41)			**Matrix: Soil**					
% Solids	**93.5**	---	1.00	% by Weight	1	10/20/08 08:57	D2216	
WRS-R-30 (A810135-42)			**Matrix: Soil**					
% Solids	**90.3**	---	1.00	% by Weight	1	10/20/08 08:57	D2216	
SED-MS-12 (A810135-47)			**Matrix: Soil**					
% Solids	**86.0**	---	1.00	% by Weight	1	10/20/08 08:57	D2216	
SED-MS-13 (A810135-48)			**Matrix: Soil**					
% Solids	**93.4**	---	1.00	% by Weight	1	10/20/08 08:57	D2216	
SED-MS-14 (A810135-50)			**Matrix: Soil**					
% Solids	**79.2**	---	1.00	% by Weight	1	10/20/08 08:57	D2216	
SED-MS-15 (A810135-53)			**Matrix: Soil**					
% Solids	**83.2**	---	1.00	% by Weight	1	10/20/08 08:57	D2216	
SED-MS-16 (A810135-56)			**Matrix: Soil**					
% Solids	**78.9**	---	1.00	% by Weight	1	10/20/08 08:57	D2216	
SED-MS-17 (A810135-59)			**Matrix: Soil**					
% Solids	**76.0**	---	1.00	% by Weight	1	10/20/08 08:57	D2216	

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

ANALYTICAL SAMPLE RESULTS

Percent Dry Weight by D2216

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
SED-MS-18 (A810135-61)			**Matrix: Soil**					
% Solids	**72.6**	---	1.00	% by Weight	1	10/20/08 08:57	D2216	
SED-R-19 (A810135-64)			**Matrix: Soil**					
% Solids	**72.9**	---	1.00	% by Weight	1	10/20/08 08:57	D2216	
SED-R-20 (A810135-67)			**Matrix: Soil**					
% Solids	**78.0**	---	1.00	% by Weight	1	10/20/08 08:57	D2216	
SED-R-21 (A810135-70)			**Matrix: Soil**					
% Solids	**75.9**	---	1.00	% by Weight	1	10/20/08 08:57	D2216	
SED-R-22 (A810135-72)			**Matrix: Soil**					
% Solids	**71.4**	---	1.00	% by Weight	1	10/20/08 08:57	D2216	
SED-R-23 (A810135-75)			**Matrix: Soil**					
% Solids	**77.5**	---	1.00	% by Weight	1	10/20/08 08:57	D2216	

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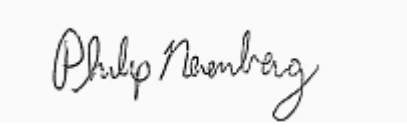

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

QUALITY CONTROL (QC) SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 8100253 - EPA 3015							**Water**					
Blank (8100253-BLK1)						**Analyzed: 10/17/08 17:42**						
EPA 6020												
Aluminum	ND	---	100	ug/L	1	---	---	---	---	---	---	
Antimony	ND	---	1.00	"	"	---	---	---	---	---	---	
Arsenic	ND	---	1.00	"	"	---	---	---	---	---	---	
Barium	ND	---	1.00	"	"	---	---	---	---	---	---	
Beryllium	ND	---	1.00	"	"	---	---	---	---	---	---	
Cadmium	ND	---	1.00	"	"	---	---	---	---	---	---	
Calcium	ND	---	100	"	"	---	---	---	---	---	---	
Chromium	ND	---	1.00	"	"	---	---	---	---	---	---	B-02
Cobalt	ND	---	2.00	"	"	---	---	---	---	---	---	
Copper	ND	---	4.00	"	"	---	---	---	---	---	---	
Iron	ND	---	100	"	"	---	---	---	---	---	---	
Lead	ND	---	1.00	"	"	---	---	---	---	---	---	
Magnesium	ND	---	100	"	"	---	---	---	---	---	---	
Manganese	ND	---	1.00	"	"	---	---	---	---	---	---	
Nickel	ND	---	1.00	"	"	---	---	---	---	---	---	
Potassium	ND	---	100	"	"	---	---	---	---	---	---	
Selenium	ND	---	1.00	"	"	---	---	---	---	---	---	
Silver	ND	---	2.00	"	"	---	---	---	---	---	---	
Sodium	ND	---	100	"	"	---	---	---	---	---	---	
Thallium	ND	---	1.00	"	"	---	---	---	---	---	---	
Vanadium	ND	---	2.00	"	"	---	---	---	---	---	---	
Zinc	ND	---	4.00	"	"	---	---	---	---	---	---	
LCS (8100253-BS1)						**Analyzed: 10/17/08 17:45**						
EPA 6020												
Aluminum	5570	---	100	ug/L	1	5560	---	100	80-120%	---	---	
Antimony	34.4	---	1.00	"	"	27.8	---	124	"	---	---	Q-08
Arsenic	56.2	---	1.00	"	"	55.6	---	101	"	---	---	
Barium	58.6	---	1.00	"	"	"	---	105	"	---	---	
Beryllium	27.2	---	1.00	"	"	27.8	---	98	"	---	---	
Cadmium	55.3	---	1.00	"	"	55.6	---	100	"	---	---	
Calcium	5460	---	100	"	"	5560	---	98	"	---	---	
Chromium	58.1	---	1.00	"	"	55.6	---	105	"	---	---	
Cobalt	55.9	---	2.00	"	"	"	---	101	"	---	---	

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

QUALITY CONTROL (QC) SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 8100253 - EPA 3015							**Water**					
LCS (8100253-BS1)						**Analyzed: 10/17/08 17:45**						
Copper	56.2	---	4.00	ug/L	"	"	---	101	"	---	---	
Iron	5550	---	100	"	"	5560	---	100	"	---	---	
Lead	53.6	---	1.00	"	"	55.6	---	96	"	---	---	
Magnesium	5680	---	100	"	"	5560	---	102	"	---	---	
Manganese	56.8	---	1.00	"	"	55.6	---	102	"	---	---	
Nickel	55.5	---	1.00	"	"	"	---	100	"	---	---	
Potassium	5540	---	100	"	"	5560	---	100	"	---	---	
Selenium	27.9	---	1.00	"	"	27.8	---	101	"	---	---	
Silver	27.8	---	2.00	"	"	"	---	100	"	---	---	
Sodium	5600	---	100	"	"	5560	---	101	"	---	---	
Thallium	28.3	---	1.00	"	"	27.8	---	102	"	---	---	
Vanadium	56.0	---	2.00	"	"	55.6	---	101	"	---	---	
Zinc	55.4	---	4.00	"	"	"	---	100	"	---	---	
Duplicate (8100253-DUP1)			**Source: A810135-43**			**Analyzed: 10/17/08 17:51**						
EPA 6020												
Aluminum	ND	---	100	ug/L	1	---	ND	---	---	---	20%	Q-05
Antimony	ND	---	1.00	"	"	---	ND	---	---	---	20%	
Arsenic	**4.73**	---	1.00	"	"	---	4.76	---	---	0.5	20%	
Barium	ND	---	1.00	"	"	---	ND	---	---	---	20%	
Beryllium	ND	---	1.00	"	"	---	ND	---	---	---	20%	
Cadmium	ND	---	1.00	"	"	---	ND	---	---	---	20%	
Chromium	ND	---	1.00	"	"	---	ND	---	---	---	20%	
Cobalt	ND	---	2.00	"	"	---	ND	---	---	---	20%	
Copper	ND	---	4.00	"	"	---	ND	---	---	---	20%	
Iron	ND	---	100	"	"	---	ND	---	---	---	20%	
Lead	**2.23**	---	1.00	"	"	---	2.23	---	---	0	20%	
Magnesium	**269**	---	100	"	"	---	263	---	---	3	20%	
Manganese	ND	---	1.00	"	"	---	ND	---	---	---	20%	
Nickel	ND	---	1.00	"	"	---	ND	---	---	---	20%	
Potassium	**249**	---	100	"	"	---	240	---	---	4	20%	
Selenium	ND	---	1.00	"	"	---	ND	---	---	---	20%	
Silver	ND	---	2.00	"	"	---	ND	---	---	---	20%	
Sodium	**7110**	---	100	"	"	---	6870	---	---	3	20%	
Thallium	ND	---	1.00	"	"	---	ND	---	---	---	20%	

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503-718-2323 Phone
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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

QUALITY CONTROL (QC) SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 8100253 - EPA 3015							**Water**					
Duplicate (8100253-DUP1)			**Source: A810135-43**			**Analyzed: 10/17/08 17:51**						
Vanadium	ND	---	2.00	ug/L	"	---	ND	---	---	---	20%	
Zinc	**57.2**	---	4.00	"	"	---	56.5	---	---	1	20%	
						Analyzed: 10/21/08 10:00						
EPA 6020												
Calcium	**12400**	---	500	"	5	---	12100	---	---	2	20%	
Matrix Spike (8100253-MS1)			**Source: A810135-43**			**Analyzed: 10/17/08 17:55**						
EPA 6020												
Aluminum	5460	---	100	ug/L	1	5560	5.73	98	75-125%	---	---	
Antimony	34.8	---	1.00	"	"	27.8	ND	126	"	---	---	Q-29
Arsenic	59.9	---	1.00	"	"	55.6	4.76	99	"	---	---	
Barium	58.7	---	1.00	"	"	"	0.633	104	"	---	---	
Beryllium	26.8	---	1.00	"	"	27.8	ND	97	"	---	---	
Cadmium	55.9	---	1.00	"	"	55.6	0.433	100	"	---	---	
Chromium	56.8	---	1.00	"	"	"	0.800	101	"	---	---	
Cobalt	55.5	---	2.00	"	"	"	ND	100	"	---	---	
Copper	55.0	---	4.00	"	"	"	0.433	98	"	---	---	
Iron	5510	---	100	"	"	5560	21.5	99	"	---	---	
Lead	55.5	---	1.00	"	"	55.6	2.23	96	"	---	---	
Magnesium	5790	---	100	"	"	5560	263	100	"	---	---	
Manganese	56.5	---	1.00	"	"	55.6	0.233	101	"	---	---	
Nickel	53.9	---	1.00	"	"	"	ND	97	"	---	---	
Potassium	5750	---	100	"	"	5560	240	99	"	---	---	
Selenium	27.3	---	1.00	"	"	27.8	ND	98	"	---	---	
Silver	27.6	---	2.00	"	"	"	ND	99	"	---	---	
Thallium	28.0	---	1.00	"	"	"	ND	101	"	---	---	
Vanadium	55.5	---	2.00	"	"	55.6	0.622	99	"	---	---	
Zinc	107	---	4.00	"	"	"	56.5	91	"	---	---	
						Analyzed: 10/21/08 10:03						
EPA 6020												
Calcium	18000	---	500	"	5	5560	12100	106	"	---	---	
Sodium	12900	---	500	"	"	"	6870	109	"	---	---	
Matrix Spike (8100253-MS2)			**Source: A810135-45**			**Analyzed: 10/17/08 18:04**						

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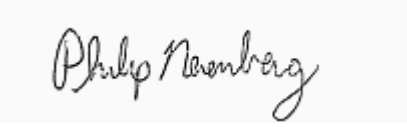

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

QUALITY CONTROL (QC) SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 8100253 - EPA 3015							**Water**					
Matrix Spike (8100253-MS2)			**Source: A810135-45**			**Analyzed: 10/17/08 18:04**						
EPA 6020												
Aluminum	5560	---	100	ug/L	1	5560	15.3	100	75-125%	---	---	
Antimony	34.6	---	1.00	"	"	27.8	ND	125	"	---	---	Q-29
Arsenic	56.8	---	1.00	"	"	55.6	1.10	100	"	---	---	
Barium	58.8	---	1.00	"	"	"	0.522	105	"	---	---	
Beryllium	27.2	---	1.00	"	"	27.8	ND	98	"	---	---	
Cadmium	54.9	---	1.00	"	"	55.6	0.333	98	"	---	---	
Chromium	56.9	---	1.00	"	"	"	0.756	101	"	---	---	
Cobalt	55.6	---	2.00	"	"	"	ND	100	"	---	---	
Copper	56.7	---	4.00	"	"	"	1.22	100	"	---	---	
Iron	5530	---	100	"	"	5560	11.4	99	"	---	---	
Lead	56.1	---	1.00	"	"	55.6	2.48	96	"	---	---	
Magnesium	5930	---	100	"	"	5560	280	102	"	---	---	
Manganese	56.8	---	1.00	"	"	55.6	0.267	102	"	---	---	
Nickel	54.5	---	1.00	"	"	"	ND	98	"	---	---	
Potassium	5690	---	100	"	"	5560	141	100	"	---	---	
Selenium	27.7	---	1.00	"	"	27.8	ND	100	"	---	---	
Silver	27.8	---	2.00	"	"	"	ND	100	"	---	---	
Sodium	7810	---	100	"	"	5560	2160	102	"	---	---	
Thallium	28.1	---	1.00	"	"	27.8	ND	101	"	---	---	
Vanadium	55.5	---	2.00	"	"	55.6	0.222	100	"	---	---	
Zinc	96.1	---	4.00	"	"	"	41.5	98	"	---	---	
						Analyzed: 10/17/08 18:07						
EPA 6020												
Calcium	10800	---	500	"	5	5560	4980	104	"	---	---	

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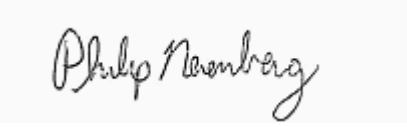

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

QUALITY CONTROL (QC) SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 8100260 - EPA 3015 (Hg Only)							**Water**					
Blank (8100260-BLK1)						**Analyzed: 10/21/08 10:52**						
EPA 6020												
Mercury	ND	---	0.100	ug/L	1	---	---	---	---	---	---	
LCS (8100260-BS1)						**Analyzed: 10/21/08 10:55**						
EPA 6020												
Mercury	2.41	---	0.100	ug/L	1	2.50	---	96	80-120%	---	---	
Matrix Spike (8100260-MS1)			**Source: A810135-44**			**Analyzed: 10/21/08 11:07**						
EPA 6020												
Mercury	2.38	---	0.100	ug/L	1	2.50	ND	95	75-125%	---	---	
Matrix Spike Dup (8100260-MSD1)			**Source: A810135-44**			**Analyzed: 10/21/08 11:11**						
EPA 6020												
Mercury	2.41	---	0.100	ug/L	1	2.50	ND	96	75-125%	---	20%	

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

QUALITY CONTROL (QC) SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 8100267 - EPA 3051							**Soil**					
Blank (8100267-BLK1)						**Analyzed: 10/22/08 16:59**						
EPA 6020												
Aluminum	ND	---	100	mg/kg wet	10	---	---	---	---	---	---	
Antimony	ND	---	1.00	"	"	---	---	---	---	---	---	
Arsenic	ND	---	1.00	"	"	---	---	---	---	---	---	
Barium	ND	---	1.00	"	"	---	---	---	---	---	---	
Beryllium	ND	---	2.00	"	"	---	---	---	---	---	---	
Cadmium	ND	---	1.00	"	"	---	---	---	---	---	---	
Calcium	ND	---	100	"	"	---	---	---	---	---	---	
Chromium	ND	---	2.00	"	"	---	---	---	---	---	---	
Cobalt	ND	---	2.00	"	"	---	---	---	---	---	---	
Copper	ND	---	4.00	"	"	---	---	---	---	---	---	
Iron	ND	---	100	"	"	---	---	---	---	---	---	
Lead	ND	---	1.00	"	"	---	---	---	---	---	---	
Magnesium	ND	---	100	"	"	---	---	---	---	---	---	
Manganese	ND	---	2.00	"	"	---	---	---	---	---	---	
Mercury	ND	---	0.0800	"	"	---	---	---	---	---	---	
Nickel	ND	---	2.00	"	"	---	---	---	---	---	---	
Potassium	ND	---	100	"	"	---	---	---	---	---	---	
Selenium	ND	---	1.00	"	"	---	---	---	---	---	---	
Silver	ND	---	2.00	"	"	---	---	---	---	---	---	
Sodium	ND	---	100	"	"	---	---	---	---	---	---	
Thallium	ND	---	1.00	"	"	---	---	---	---	---	---	
Vanadium	ND	---	2.00	"	"	---	---	---	---	---	---	
Zinc	ND	---	4.00	"	"	---	---	---	---	---	---	
LCS (8100267-BS1)						**Analyzed: 10/22/08 17:02**						
EPA 6020												
Aluminum	5100	---	100	mg/kg wet	10	5000	---	102	80-120%	---	---	
Antimony	35.6	---	1.00	"	"	25.0	---	142	"	---	---	Q-29
Arsenic	52.6	---	1.00	"	"	50.0	---	105	"	---	---	
Barium	53.2	---	1.00	"	"	"	---	106	"	---	---	
Beryllium	25.1	---	2.00	"	"	25.0	---	100	"	---	---	
Cadmium	51.5	---	1.00	"	"	50.0	---	103	"	---	---	
Calcium	5300	---	100	"	"	5000	---	106	"	---	---	
Chromium	52.6	---	2.00	"	"	50.0	---	105	"	---	---	

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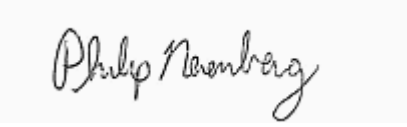

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

QUALITY CONTROL (QC) SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 8100267 - EPA 3051							**Soil**					
LCS (8100267-BS1)						**Analyzed: 10/22/08 17:02**						
Cobalt	50.5	---	2.00	mg/kg wet	"	"	---	101	"	---	---	
Copper	51.6	---	4.00	"	"	"	---	103	"	---	---	
Iron	5220	---	100	"	"	5000	---	104	"	---	---	
Lead	50.2	---	1.00	"	"	50.0	---	100	"	---	---	
Magnesium	5240	---	100	"	"	5000	---	105	"	---	---	
Manganese	52.4	---	2.00	"	"	50.0	---	105	"	---	---	
Mercury	1.84	---	0.0800	"	"	2.00	---	92	"	---	---	
Nickel	51.2	---	2.00	"	"	50.0	---	102	"	---	---	
Potassium	5120	---	100	"	"	5000	---	102	"	---	---	
Selenium	26.8	---	1.00	"	"	25.0	---	107	"	---	---	
Silver	25.3	---	2.00	"	"	"	---	101	"	---	---	
Sodium	5100	---	100	"	"	5000	---	102	"	---	---	
Thallium	25.4	---	1.00	"	"	25.0	---	101	"	---	---	
Vanadium	51.2	---	2.00	"	"	50.0	---	102	"	---	---	
Zinc	54.5	---	4.00	"	"	"	---	109	"	---	---	
Duplicate (8100267-DUP1)			**Source: A810135-01**			**Analyzed: 10/22/08 17:39**						
EPA 6020												
Antimony	ND	---	1.54	mg/kg dry	10	---	ND	---	---	---	40%	Q-05
Arsenic	**8.33**	---	1.54	"	"	---	7.37	---	---	12	40%	
Barium	**54.2**	---	1.54	"	"	---	55.2	---	---	2	40%	
Beryllium	ND	---	3.08	"	"	---	ND	---	---	---	40%	
Cadmium	ND	---	1.54	"	"	---	ND	---	---	---	40%	
Calcium	**2720**	---	154	"	"	---	2690	---	---	1	40%	
Chromium	**25.2**	---	3.08	"	"	---	22.8	---	---	10	40%	
Cobalt	**7.11**	---	3.08	"	"	---	7.03	---	---	1	40%	
Copper	**26.1**	---	6.16	"	"	---	25.3	---	---	3	40%	
Lead	**13.6**	---	1.54	"	"	---	13.5	---	---	0.5	40%	
Magnesium	**4620**	---	154	"	"	---	4270	---	---	8	40%	
Manganese	**241**	---	3.08	"	"	---	234	---	---	3	40%	
Mercury	**0.154**	---	0.123	"	"	---	0.140	---	---	10	40%	
Nickel	**14.6**	---	3.08	"	"	---	14.1	---	---	4	40%	
Potassium	**870**	---	154	"	"	---	944	---	---	8	40%	
Selenium	ND	---	1.54	"	"	---	ND	---	---	---	40%	
Silver	ND	---	3.08	"	"	---	ND	---	---	---	40%	

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

QUALITY CONTROL (QC) SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 8100267 - EPA 3051							**Soil**					
Duplicate (8100267-DUP1)			**Source: A810135-01**			**Analyzed: 10/22/08 17:39**						
Sodium	ND	---	154	mg/kg dry	"	---	ND	---	---	---	40%	
Thallium	ND	---	1.54	"	"	---	ND	---	---	---	40%	
Vanadium	**96.7**	---	3.08	"	"	---	81.8	---	---	17	40%	
Zinc	**52.7**	---	6.16	"	"	---	52.4	---	---	0.5	40%	
						Analyzed: 10/22/08 19:00						
EPA 6020												
Aluminum	**34400**	---	770	"	50	---	33200	---	---	4	40%	
Iron	**36800**	---	770	"	"	---	33800	---	---	8	40%	
Matrix Spike (8100267-MS1)			**Source: A810135-01**			**Analyzed: 10/22/08 17:14**						
EPA 6020												
Antimony	46.7	---	1.53	mg/kg dry	10	38.3	0.653	120	75-125%	---	---	Q-29
Arsenic	87.1	---	1.53	"	"	76.6	7.37	104	"	---	---	
Barium	134	---	1.53	"	"	"	55.2	103	"	---	---	
Beryllium	37.3	---	3.07	"	"	38.3	ND	97	"	---	---	
Cadmium	77.4	---	1.53	"	"	76.6	ND	101	"	---	---	
Calcium	11000	---	153	"	"	7660	2690	108	"	---	---	
Chromium	105	---	3.07	"	"	76.6	22.8	107	"	---	---	
Cobalt	85.4	---	3.07	"	"	"	7.03	102	"	---	---	
Copper	107	---	6.13	"	"	"	25.3	106	"	---	---	
Lead	87.9	---	1.53	"	"	"	13.5	97	"	---	---	
Magnesium	12400	---	153	"	"	7660	4270	106	"	---	---	
Manganese	325	---	3.07	"	"	76.6	234	118	"	---	---	
Mercury	2.85	---	0.123	"	"	3.07	0.140	88	"	---	---	
Nickel	92.8	---	3.07	"	"	76.6	14.1	103	"	---	---	
Potassium	8460	---	153	"	"	7660	944	98	"	---	---	
Selenium	39.4	---	1.53	"	"	38.3	0.793	101	"	---	---	
Silver	37.9	---	3.07	"	"	"	0.249	98	"	---	---	
Sodium	7810	---	153	"	"	7660	134	100	"	---	---	
Thallium	38.0	---	1.53	"	"	38.3	ND	99	"	---	---	
Vanadium	164	---	3.07	"	"	76.6	81.8	107	"	---	---	
Zinc	133	---	6.13	"	"	"	52.4	106	"	---	---	
						Analyzed: 10/22/08 19:03						
EPA 6020												

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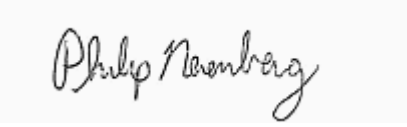

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

QUALITY CONTROL (QC) SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 8100267 - EPA 3051							**Soil**					
Matrix Spike (8100267-MS1)			**Source: A810135-01**			**Analyzed: 10/22/08 19:03**						
Aluminum	42100	---	766	mg/kg dry	50	7660	33200	116	"	---	---	
Iron	42300	---	766	"	"	"	33800	111	"	---	---	
Matrix Spike (8100267-MS2)			**Source: A810135-02**			**Analyzed: 10/22/08 17:33**						
EPA 6020												
Antimony	37.4	---	1.24	mg/kg dry	10	31.0	1.53	116	75-125%	---	---	Q-29
Arsenic	62.5	---	1.24	"	"	62.1	4.97	93	"	---	---	
Barium	183	---	1.24	"	"	"	121	99	"	---	---	
Beryllium	29.8	---	2.48	"	"	31.0	ND	96	"	---	---	
Cadmium	61.0	---	1.24	"	"	62.1	ND	98	"	---	---	
Calcium	8180	---	124	"	"	6210	2170	97	"	---	---	
Chromium	71.7	---	2.48	"	"	62.1	11.1	97	"	---	---	
Cobalt	67.9	---	2.48	"	"	"	11.3	91	"	---	---	
Copper	72.9	---	4.97	"	"	"	15.0	93	"	---	---	
Lead	66.7	---	1.24	"	"	"	8.53	94	"	---	---	
Magnesium	8500	---	124	"	"	6210	4680	62	"	---	---	Q-01
Mercury	2.16	---	0.0993	"	"	2.48	0.0892	83	"	---	---	
Nickel	66.0	---	2.48	"	"	62.1	7.49	94	"	---	---	
Potassium	6590	---	124	"	"	6210	1300	85	"	---	---	
Selenium	30.3	---	1.24	"	"	31.0	ND	98	"	---	---	
Silver	29.9	---	2.48	"	"	"	ND	96	"	---	---	
Sodium	6210	---	124	"	"	6210	295	95	"	---	---	
Thallium	29.5	---	1.24	"	"	31.0	ND	95	"	---	---	
Vanadium	119	---	2.48	"	"	62.1	73.6	73	"	---	---	Q-01
Zinc	116	---	4.97	"	"	"	69.5	74	"	---	---	Q-01
						Analyzed: 10/22/08 17:36						
EPA 6020												
Aluminum	26300	---	621	"	50	6210	28800	-40	"	---	---	Q-11
Iron	31900	---	621	"	"	"	32800	-15	"	---	---	Q-11
Manganese	1110	---	12.4	"	"	62.1	1050	91	"	---	---	

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12232 S.W. Garden Place
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503-718-2323 Phone
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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

QUALITY CONTROL (QC) SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 8100285 - EPA 3051							**Soil**					
Blank (8100285-BLK1)						**Analyzed: 10/22/08 20:16**						
EPA 6020												
Aluminum	ND	---	100	mg/kg wet	10	---	---	---	---	---	---	
Antimony	ND	---	1.00	"	"	---	---	---	---	---	---	
Arsenic	ND	---	1.00	"	"	---	---	---	---	---	---	
Barium	ND	---	1.00	"	"	---	---	---	---	---	---	
Beryllium	ND	---	2.00	"	"	---	---	---	---	---	---	
Cadmium	ND	---	1.00	"	"	---	---	---	---	---	---	
Calcium	ND	---	100	"	"	---	---	---	---	---	---	
Chromium	ND	---	2.00	"	"	---	---	---	---	---	---	
Cobalt	ND	---	2.00	"	"	---	---	---	---	---	---	
Copper	ND	---	4.00	"	"	---	---	---	---	---	---	
Iron	ND	---	100	"	"	---	---	---	---	---	---	
Lead	ND	---	1.00	"	"	---	---	---	---	---	---	
Magnesium	ND	---	100	"	"	---	---	---	---	---	---	
Manganese	ND	---	2.00	"	"	---	---	---	---	---	---	
Mercury	ND	---	0.0800	"	"	---	---	---	---	---	---	
Nickel	ND	---	2.00	"	"	---	---	---	---	---	---	
Potassium	ND	---	100	"	"	---	---	---	---	---	---	
Selenium	ND	---	1.00	"	"	---	---	---	---	---	---	
Silver	ND	---	2.00	"	"	---	---	---	---	---	---	
Sodium	ND	---	100	"	"	---	---	---	---	---	---	
Thallium	ND	---	1.00	"	"	---	---	---	---	---	---	
Vanadium	ND	---	2.00	"	"	---	---	---	---	---	---	
						Analyzed: 10/24/08 10:32						
EPA 6020												
Zinc	ND	---	4.00	"	"	---	---	---	---	---	---	
LCS (8100285-BS1)						**Analyzed: 10/22/08 20:19**						
EPA 6020												
Aluminum	4970	---	100	mg/kg wet	10	5400	---	92	80-120%	---	---	
Antimony	34.2	---	1.00	"	"	27.0	---	127	"	---	---	Q-29
Arsenic	51.3	---	1.00	"	"	54.0	---	95	"	---	---	
Barium	50.9	---	1.00	"	"	"	---	94	"	---	---	
Beryllium	24.3	---	2.00	"	"	27.0	---	90	"	---	---	
Cadmium	50.7	---	1.00	"	"	54.0	---	94	"	---	---	

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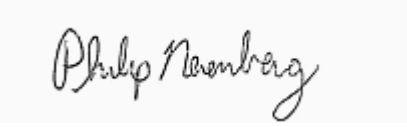

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

QUALITY CONTROL (QC) SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 8100285 - EPA 3051							**Soil**					
LCS (8100285-BS1)						**Analyzed: 10/22/08 20:19**						
Calcium	5400	---	100	mg/kg wet	"	5400	---	100	"	---	---	
Chromium	51.2	---	2.00	"	"	54.0	---	95	"	---	---	
Cobalt	49.5	---	2.00	"	"	"	---	92	"	---	---	
Copper	50.4	---	4.00	"	"	"	---	93	"	---	---	
Iron	5060	---	100	"	"	5400	---	94	"	---	---	
Lead	47.8	---	1.00	"	"	54.0	---	89	"	---	---	
Magnesium	5140	---	100	"	"	5400	---	95	"	---	---	
Manganese	51.5	---	2.00	"	"	54.0	---	95	"	---	---	
Mercury	1.74	---	0.0800	"	"	2.00	---	87	"	---	---	
Nickel	50.0	---	2.00	"	"	54.0	---	93	"	---	---	
Potassium	5140	---	100	"	"	5400	---	95	"	---	---	
Selenium	25.6	---	1.00	"	"	27.0	---	95	"	---	---	
Silver	24.6	---	2.00	"	"	"	---	91	"	---	---	
Sodium	5020	---	100	"	"	5400	---	93	"	---	---	
Thallium	24.0	---	1.00	"	"	27.0	---	89	"	---	---	
Vanadium	49.9	---	2.00	"	"	54.0	---	92	"	---	---	
						Analyzed: 10/24/08 10:35						
EPA 6020												
Zinc	50.7	---	4.00	"	"	"	---	94	"	---	---	
Duplicate (8100285-DUP1)			**Source: A810135-20**			**Analyzed: 10/22/08 20:28**						
EPA 6020												
Antimony	**1.83**	---	1.13	mg/kg dry	10	---	1.89	---	---	3	40%	Q-29
Arsenic	**21.7**	---	1.13	"	"	---	24.9	---	---	14	40%	
Barium	**53.6**	---	1.13	"	"	---	53.6	---	---	0.08	40%	
Beryllium	ND	---	2.26	"	"	---	ND	---	---	---	40%	
Cadmium	**198**	---	1.13	"	"	---	226	---	---	13	40%	
Chromium	**41.6**	---	2.26	"	"	---	30.3	---	---	31	40%	
Cobalt	**36.6**	---	2.26	"	"	---	31.9	---	---	14	40%	
Mercury	**0.521**	---	0.0906	"	"	---	0.446	---	---	15	40%	
Nickel	**33.4**	---	2.26	"	"	---	26.7	---	---	23	40%	
Potassium	**4350**	---	113	"	"	---	5280	---	---	19	40%	
Selenium	**4.39**	---	1.13	"	"	---	4.86	---	---	10	40%	
Silver	**15.1**	---	2.26	"	"	---	17.8	---	---	16	40%	
Sodium	ND	---	113	"	"	---	ND	---	---	---	40%	

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

QUALITY CONTROL (QC) SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 8100285 - EPA 3051							**Soil**					
Duplicate (8100285-DUP1)			**Source: A810135-20**			**Analyzed: 10/22/08 20:28**						
Thallium	ND	---	1.13	mg/kg dry	"	---	ND	---	---	---	40%	
Vanadium	**62.5**	---	2.26	"	"	---	53.5	---	---	15	40%	
						Analyzed: 10/22/08 22:19						
EPA 6020												
Copper	**1800**	---	22.6	"	50	---	2170	---	---	19	40%	
						Analyzed: 10/24/08 10:47						
EPA 6020												
Iron	**82000**	---	11300	"	1000	---	81800	---	---	0.2	40%	
Lead	**6200**	---	113	"	"	---	7460	---	---	19	40%	
Manganese	**10400**	---	226	"	"	---	9130	---	---	13	40%	
Zinc	**45600**	---	453	"	"	---	54200	---	---	17	40%	
						Analyzed: 10/24/08 12:17						
EPA 6020												
Aluminum	**37600**	---	566	"	50	---	36400	---	---	3	40%	
Calcium	**14300**	---	566	"	"	---	16100	---	---	12	40%	
Magnesium	**18100**	---	566	"	"	---	15900	---	---	13	40%	
Matrix Spike (8100285-MS1)			**Source: A810135-20**			**Analyzed: 10/22/08 20:31**						
EPA 6020												
Antimony	29.4	---	1.16	mg/kg dry	10	31.3	1.89	88	75-125%	---	---	Q-29
Arsenic	76.0	---	1.16	"	"	62.5	24.9	82	"	---	---	
Barium	91.5	---	1.16	"	"	"	53.6	61	"	---	---	Q-04
Beryllium	27.9	---	2.31	"	"	31.3	ND	89	"	---	---	
Cadmium	302	---	1.16	"	"	62.5	226	122	"	---	---	
Chromium	84.3	---	2.31	"	"	"	30.3	86	"	---	---	
Cobalt	85.6	---	2.31	"	"	"	31.9	86	"	---	---	
Mercury	2.45	---	0.0926	"	"	2.31	0.446	87	"	---	---	
Nickel	80.2	---	2.31	"	"	62.5	26.7	86	"	---	---	
Potassium	8870	---	116	"	"	6250	5280	58	"	---	---	Q-04
Selenium	32.5	---	1.16	"	"	31.3	4.86	89	"	---	---	
Silver	46.1	---	2.31	"	"	"	17.8	91	"	---	---	
Sodium	5890	---	116	"	"	6250	106	93	"	---	---	
Thallium	26.1	---	1.16	"	"	31.3	0.387	82	"	---	---	
Vanadium	104	---	2.31	"	"	62.5	53.5	80	"	---	---	

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

QUALITY CONTROL (QC) SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 8100285 - EPA 3051							**Soil**					
Matrix Spike (8100285-MS1)			**Source: A810135-20**			**Analyzed: 10/22/08 22:22**						
EPA 6020												
Copper	2400	---	23.1	mg/kg dry	50	"	2170	364	"	---	---	Q-04
						Analyzed: 10/24/08 10:50						
EPA 6020												
Iron	89700	---	11600	"	1000	6250	81800	126	"	---	---	Q-03
Lead	7140	---	116	"	"	62.5	7460	-522	"	---	---	Q-03
Manganese	10100	---	231	"	"	"	9130	1470	"	---	---	Q-03
						Analyzed: 10/24/08 12:05						
EPA 6020												
Zinc	59900	---	926	"	2000	"	54200	9120	"	---	---	Q-03
						Analyzed: 10/24/08 12:20						
EPA 6020												
Aluminum	38600	---	579	"	50	6250	36400	34	"	---	---	Q-04
Calcium	23300	---	579	"	"	"	16100	116	"	---	---	
Magnesium	21800	---	579	"	"	"	15900	94	"	---	---	
Matrix Spike (8100285-MS2)			**Source: A810135-21**			**Analyzed: 10/24/08 13:39**						
EPA 6020												
Lead	18900	---	113	mg/kg dry	1000	61.2	6400	20400	75-125%	---	---	Q-03
Manganese	11400	---	227	"	"	"	12500	-1710	"	---	---	Q-03
Zinc	44600	---	453	"	"	"	46000	-2300	"	---	---	Q-03
						Analyzed: 10/24/08 13:42						
EPA 6020												
Aluminum	35800	---	1130	"	100	6120	38400	-43	"	---	---	Q-04
Calcium	55400	---	1130	"	"	"	17200	625	"	---	---	Q-04
Copper	1400	---	45.3	"	"	61.2	1470	-114	"	---	---	Q-04
Iron	94100	---	1130	"	"	6120	94600	-9	"	---	---	Q-04
Magnesium	20200	---	1130	"	"	"	17400	46	"	---	---	Q-04
						Analyzed: 10/24/08 13:45						
EPA 6020												
Antimony	26.0	---	1.13	"	10	30.6	1.75	79	"	---	---	Q-29
Arsenic	78.7	---	1.13	"	"	61.2	23.5	90	"	---	---	
Barium	104	---	1.13	"	"	"	59.0	73	"	---	---	Q-04

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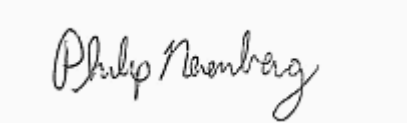

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

QUALITY CONTROL (QC) SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 8100285 - EPA 3051							**Soil**					
Matrix Spike (8100285-MS2)			**Source: A810135-21**			**Analyzed: 10/24/08 13:45**						
Beryllium	26.1	---	2.27	mg/kg dry	"	30.6	0.691	83	"	---	---	
Cadmium	240	---	1.13	"	"	61.2	188	84	"	---	---	
Chromium	80.4	---	2.27	"	"	"	28.4	85	"	---	---	
Cobalt	83.1	---	2.27	"	"	"	32.6	83	"	---	---	
Mercury	2.41	---	0.0906	"	"	2.27	0.357	91	"	---	---	
Nickel	73.0	---	2.27	"	"	61.2	27.2	75	"	---	---	
Potassium	8910	---	113	"	"	6120	5490	56	"	---	---	Q-04
Selenium	35.2	---	1.13	"	"	30.6	4.86	99	"	---	---	
Silver	48.5	---	2.27	"	"	"	17.5	101	"	---	---	
Sodium	5630	---	113	"	"	6120	70.7	91	"	---	---	
Thallium	27.1	---	1.13	"	"	30.6	0.379	87	"	---	---	
Vanadium	101	---	2.27	"	"	61.2	50.3	83	"	---	---	

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

QUALITY CONTROL (QC) SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 8100321 - EPA 3051							**Soil**					
Blank (8100321-BLK1)						**Analyzed: 10/24/08 17:39**						
EPA 6020												
Aluminum	ND	---	100	mg/kg wet	10	---	---	---	---	---	---	
Antimony	ND	---	1.00	"	"	---	---	---	---	---	---	
Arsenic	ND	---	1.00	"	"	---	---	---	---	---	---	
Barium	ND	---	1.00	"	"	---	---	---	---	---	---	
Beryllium	ND	---	2.00	"	"	---	---	---	---	---	---	
Cadmium	ND	---	1.00	"	"	---	---	---	---	---	---	
Calcium	ND	---	100	"	"	---	---	---	---	---	---	
Chromium	ND	---	2.00	"	"	---	---	---	---	---	---	
Cobalt	ND	---	2.00	"	"	---	---	---	---	---	---	
Copper	ND	---	4.00	"	"	---	---	---	---	---	---	
Iron	ND	---	100	"	"	---	---	---	---	---	---	
Lead	ND	---	1.00	"	"	---	---	---	---	---	---	
Magnesium	ND	---	100	"	"	---	---	---	---	---	---	
Manganese	ND	---	2.00	"	"	---	---	---	---	---	---	
Mercury	ND	---	0.0800	"	"	---	---	---	---	---	---	
Nickel	ND	---	2.00	"	"	---	---	---	---	---	---	
Potassium	ND	---	100	"	"	---	---	---	---	---	---	
Selenium	ND	---	1.00	"	"	---	---	---	---	---	---	
Silver	ND	---	2.00	"	"	---	---	---	---	---	---	
Sodium	ND	---	100	"	"	---	---	---	---	---	---	
Thallium	ND	---	1.00	"	"	---	---	---	---	---	---	
Vanadium	ND	---	2.00	"	"	---	---	---	---	---	---	
Zinc	ND	---	4.00	"	"	---	---	---	---	---	---	
LCS (8100321-BS1)						**Analyzed: 10/24/08 17:42**						
EPA 6020												
Aluminum	5160	---	100	mg/kg wet	10	5000	---	103	80-120%	---	---	
Antimony	31.3	---	1.00	"	"	25.0	---	125	"	---	---	Q-29
Arsenic	51.3	---	1.00	"	"	50.0	---	103	"	---	---	
Barium	50.7	---	1.00	"	"	"	---	101	"	---	---	
Beryllium	24.2	---	2.00	"	"	25.0	---	97	"	---	---	
Cadmium	50.3	---	1.00	"	"	50.0	---	101	"	---	---	
Calcium	5190	---	100	"	"	5000	---	104	"	---	---	
Chromium	51.0	---	2.00	"	"	50.0	---	102	"	---	---	

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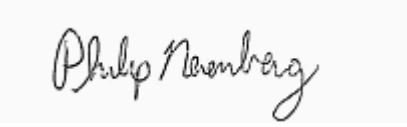

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

QUALITY CONTROL (QC) SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 8100321 - EPA 3051							**Soil**					
LCS (8100321-BS1)						**Analyzed: 10/24/08 17:42**						
Cobalt	49.4	---	2.00	mg/kg wet	"	"	---	99	"	---	---	
Copper	50.1	---	4.00	"	"	"	---	100	"	---	---	
Iron	5040	---	100	"	"	5000	---	101	"	---	---	
Lead	50.6	---	1.00	"	"	50.0	---	101	"	---	---	
Magnesium	5330	---	100	"	"	5000	---	107	"	---	---	
Manganese	50.1	---	2.00	"	"	50.0	---	100	"	---	---	
Mercury	1.84	---	0.0800	"	"	2.00	---	92	"	---	---	
Nickel	48.4	---	2.00	"	"	50.0	---	97	"	---	---	
Potassium	5220	---	100	"	"	5000	---	104	"	---	---	
Selenium	25.3	---	1.00	"	"	25.0	---	101	"	---	---	
Silver	25.0	---	2.00	"	"	"	---	100	"	---	---	
Sodium	5150	---	100	"	"	5000	---	103	"	---	---	
Thallium	25.0	---	1.00	"	"	25.0	---	100	"	---	---	
Vanadium	49.6	---	2.00	"	"	50.0	---	99	"	---	---	
Zinc	51.2	---	4.00	"	"	"	---	102	"	---	---	
Duplicate (8100321-DUP1)			**Source: A810135-40**			**Analyzed: 10/27/08 12:03**						
EPA 6020												
Aluminum	**28500**	---	2170	mg/kg dry	200	---	23100	---	---	21	40%	
Calcium	**22000**	---	2170	"	"	---	17500	---	---	23	40%	
Iron	**41100**	---	2170	"	"	---	35400	---	---	15	40%	
Lead	**1520**	---	21.7	"	"	---	1210	---	---	23	40%	
Magnesium	**14300**	---	2170	"	"	---	13100	---	---	9	40%	
Manganese	**5530**	---	43.4	"	"	---	5270	---	---	5	40%	
Zinc	**7810**	---	86.8	"	"	---	10600	---	---	30	40%	
						Analyzed: 10/27/08 13:30						
EPA 6020												
Antimony	**1.29**	---	1.08	"	10	---	1.13	---	---	13	40%	Q-29
Arsenic	**9.63**	---	1.08	"	"	---	11.6	---	---	19	40%	
Barium	**54.5**	---	1.08	"	"	---	40.2	---	---	30	40%	
Beryllium	ND	---	2.17	"	"	---	ND	---	---	---	40%	
Cadmium	**31.6**	---	1.08	"	"	---	47.5	---	---	40	40%	
Chromium	**29.7**	---	2.17	"	"	---	24.3	---	---	20	40%	
Cobalt	**15.8**	---	2.17	"	"	---	16.7	---	---	6	40%	
Copper	**193**	---	4.34	"	"	---	437	---	---	77	40%	Q-04

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503-718-2323 Phone
503-718-0333 Fax

GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

QUALITY CONTROL (QC) SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 8100321 - EPA 3051							**Soil**					
Duplicate (8100321-DUP1)			**Source: A810135-40**			**Analyzed: 10/27/08 13:30**						
Mercury	ND	---	0.0868	mg/kg dry	"	---	ND	---	---	---	40%	
Nickel	**23.4**	---	2.17	"	"	---	22.1	---	---	5	40%	
Potassium	**2680**	---	108	"	"	---	2320	---	---	14	40%	
Selenium	**1.67**	---	1.08	"	"	---	2.07	---	---	21	40%	
Silver	**2.85**	---	2.17	"	"	---	5.50	---	---	63	40%	Q-04
Sodium	ND	---	108	"	"	---	ND	---	---	---	40%	Q-04
Thallium	ND	---	1.08	"	"	---	ND	---	---	---	40%	
Vanadium	**41.1**	---	2.17	"	"	---	33.5	---	---	20	40%	
Matrix Spike (8100321-MS1)			**Source: A810135-40**			**Analyzed: 10/24/08 18:03**						
EPA 6020												
Antimony	28.7	---	1.07	mg/kg dry	10	26.9	1.13	103	75-125%	---	---	Q-29
Arsenic	61.4	---	1.07	"	"	53.7	11.6	93	"	---	---	
Barium	118	---	1.07	"	"	"	40.2	144	"	---	---	Q-04
Beryllium	26.6	---	2.15	"	"	26.9	ND	99	"	---	---	
Cadmium	69.9	---	1.07	"	"	53.7	47.5	42	"	---	---	Q-04
Chromium	77.8	---	2.15	"	"	"	24.3	100	"	---	---	
Cobalt	67.4	---	2.15	"	"	"	16.7	94	"	---	---	
Copper	153	---	4.30	"	"	"	437	-530	"	---	---	Q-04
Mercury	1.93	---	0.0859	"	"	2.15	0.0747	87	"	---	---	
Nickel	72.8	---	2.15	"	"	53.7	22.1	94	"	---	---	
Potassium	7620	---	107	"	"	5370	2320	99	"	---	---	
Selenium	27.0	---	1.07	"	"	26.9	2.07	93	"	---	---	
Silver	28.0	---	2.15	"	"	"	5.50	84	"	---	---	
Sodium	5540	---	107	"	"	5370	50.2	102	"	---	---	
Thallium	25.6	---	1.07	"	"	26.9	0.203	95	"	---	---	
Vanadium	92.3	---	2.15	"	"	53.7	33.5	109	"	---	---	
						Analyzed: 10/27/08 12:06						
EPA 6020												
Aluminum	31700	---	1070	"	100	5370	23100	159	"	---	---	Q-04
Calcium	26700	---	1070	"	"	"	17500	171	"	---	---	Q-04
Iron	42700	---	1070	"	"	"	35400	134	"	---	---	Q-04
Lead	598	---	10.7	"	"	53.7	1210	-1140	"	---	---	Q-04
Magnesium	19700	---	1070	"	"	5370	13100	122	"	---	---	
Manganese	4750	---	21.5	"	"	53.7	5270	-957	"	---	---	Q-04

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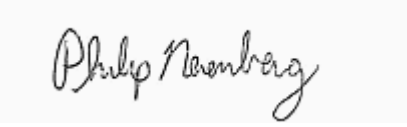

Philip Nerenberg, Lab Director

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

QUALITY CONTROL (QC) SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 8100321 - EPA 3051							**Soil**					
Matrix Spike (8100321-MS1)			**Source: A810135-40**			**Analyzed: 10/27/08 12:06**						
Zinc	3570	---	43.0	mg/kg dry	"	"	10600	-13100	"	---	---	Q-04
Matrix Spike (8100321-MS2)			**Source: A810135-41**			**Analyzed: 10/24/08 18:21**						
EPA 6020												
Antimony	31.1	---	1.06	mg/kg dry	10	26.5	1.23	113	75-125%	---	---	Q-29
Arsenic	58.4	---	1.06	"	"	53.1	3.88	103	"	---	---	
Barium	237	---	1.06	"	"	"	102	255	"	---	---	Q-04
Beryllium	25.7	---	2.12	"	"	26.5	0.695	94	"	---	---	
Cadmium	65.1	---	1.06	"	"	53.1	12.8	99	"	---	---	
Chromium	75.3	---	2.12	"	"	"	21.5	101	"	---	---	
Cobalt	65.6	---	2.12	"	"	"	13.6	98	"	---	---	
Mercury	1.91	---	0.0849	"	"	2.12	0.0428	88	"	---	---	
Nickel	69.1	---	2.12	"	"	53.1	19.3	94	"	---	---	
Potassium	7540	---	106	"	"	5310	2780	90	"	---	---	
Selenium	27.6	---	1.06	"	"	26.5	1.34	99	"	---	---	
Silver	27.8	---	2.12	"	"	"	2.00	97	"	---	---	
Sodium	5490	---	106	"	"	5310	91.9	102	"	---	---	
Thallium	25.8	---	1.06	"	"	26.5	0.171	96	"	---	---	
Vanadium	91.2	---	2.12	"	"	53.1	42.1	93	"	---	---	
						Analyzed: 10/27/08 12:12						
EPA 6020												
Copper	11500	---	212	"	500	"	100	21500	"	---	---	Q-04
						Analyzed: 10/27/08 12:15						
EPA 6020												
Aluminum	31000	---	1060	"	100	5310	27200	72	"	---	---	Q-04
Calcium	51800	---	1060	"	"	"	38500	251	"	---	---	Q-04
Iron	38200	---	1060	"	"	"	31500	127	"	---	---	Q-04
Lead	1890	---	10.6	"	"	53.1	905	1850	"	---	---	Q-04
Magnesium	19400	---	1060	"	"	5310	13500	111	"	---	---	
Manganese	4970	---	21.2	"	"	53.1	4640	609	"	---	---	Q-04
Zinc	2940	---	42.4	"	"	"	2730	393	"	---	---	Q-04

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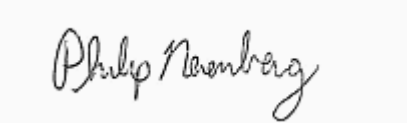

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

QUALITY CONTROL (QC) SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 8100330 - EPA 3015 (Hg Only)							**Water**					
Blank (8100330-BLK1)						**Analyzed: 10/23/08 18:08**						
EPA 6020												
Mercury	ND	---	0.100	ug/L	1	---	---	---	---	---	---	
LCS (8100330-BS1)						**Analyzed: 10/23/08 18:11**						
EPA 6020												
Mercury	2.30	---	0.100	ug/L	1	2.50	---	92	80-120%	---	---	
Matrix Spike (8100330-MS1)			**Source: A810135-49**			**Analyzed: 10/23/08 18:26**						
EPA 6020												
Mercury	2.29	---	0.100	ug/L	1	2.50	ND	92	75-125%	---	---	
Matrix Spike (8100330-MS2)			**Source: A810135-66**			**Analyzed: 10/23/08 19:00**						
EPA 6020												
Mercury	2.26	---	0.100	ug/L	1	2.50	ND	90	75-125%	---	---	
Matrix Spike Dup (8100330-MSD1)			**Source: A810135-49**			**Analyzed: 10/23/08 18:29**						
EPA 6020												
Mercury	2.26	---	0.100	ug/L	1	2.50	ND	90	75-125%	---	20%	
Matrix Spike Dup (8100330-MSD2)			**Source: A810135-66**			**Analyzed: 10/23/08 19:03**						
EPA 6020												
Mercury	2.32	---	0.100	ug/L	1	2.50	ND	93	75-125%	---	20%	

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

QUALITY CONTROL (QC) SAMPLE RESULTS

Dissolved Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 8100315 - EPA 3015 - Dissolved							**Water**					
Blank (8100315-BLK1)						**Analyzed: 10/23/08 13:56**						
EPA 6020 (Diss)												
Aluminum	ND	---	100	ug/L	1	---	---	---	---	---	---	
Antimony	ND	---	1.00	"	"	---	---	---	---	---	---	
Arsenic	ND	---	1.00	"	"	---	---	---	---	---	---	
Barium	ND	---	1.00	"	"	---	---	---	---	---	---	
Beryllium	ND	---	1.00	"	"	---	---	---	---	---	---	
Cadmium	ND	---	1.00	"	"	---	---	---	---	---	---	
Calcium	ND	---	100	"	"	---	---	---	---	---	---	
Chromium	ND	---	1.00	"	"	---	---	---	---	---	---	B-02
Cobalt	ND	---	2.00	"	"	---	---	---	---	---	---	
Copper	ND	---	5.00	"	"	---	---	---	---	---	---	
Iron	ND	---	100	"	"	---	---	---	---	---	---	
Lead	ND	---	1.00	"	"	---	---	---	---	---	---	
Magnesium	ND	---	100	"	"	---	---	---	---	---	---	
Manganese	ND	---	1.00	"	"	---	---	---	---	---	---	
Nickel	ND	---	1.00	"	"	---	---	---	---	---	---	
Potassium	ND	---	100	"	"	---	---	---	---	---	---	
Selenium	ND	---	1.00	"	"	---	---	---	---	---	---	
Silver	ND	---	2.00	"	"	---	---	---	---	---	---	
Sodium	ND	---	100	"	"	---	---	---	---	---	---	
Thallium	ND	---	1.00	"	"	---	---	---	---	---	---	
Vanadium	ND	---	2.00	"	"	---	---	---	---	---	---	
Zinc	ND	---	4.00	"	"	---	---	---	---	---	---	
LCS (8100315-BS1)						**Analyzed: 10/23/08 13:53**						
EPA 6020 (Diss)												
Aluminum	5340	---	100	ug/L	1	6000	---	89	80-120%	---	---	
Antimony	38.3	---	1.00	"	"	30.0	---	128	"	---	---	Q-08
Arsenic	53.6	---	1.00	"	"	60.0	---	89	"	---	---	
Barium	57.3	---	1.00	"	"	"	---	96	"	---	---	
Beryllium	26.6	---	1.00	"	"	30.0	---	89	"	---	---	
Cadmium	54.7	---	1.00	"	"	60.0	---	91	"	---	---	
Calcium	5300	---	100	"	"	6000	---	88	"	---	---	
Chromium	56.5	---	1.00	"	"	60.0	---	94	"	---	---	
Cobalt	55.1	---	2.00	"	"	"	---	92	"	---	---	

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

QUALITY CONTROL (QC) SAMPLE RESULTS

Dissolved Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 8100315 - EPA 3015 - Dissolved							**Water**					
LCS (8100315-BS1)						**Analyzed: 10/23/08 13:53**						
Copper	54.8	---	5.00	ug/L	"	"	---	91	"	---	---	
Iron	5530	---	100	"	"	6000	---	92	"	---	---	
Lead	55.6	---	1.00	"	"	60.0	---	93	"	---	---	
Magnesium	5440	---	100	"	"	6000	---	91	"	---	---	
Manganese	56.4	---	1.00	"	"	60.0	---	94	"	---	---	
Nickel	54.1	---	1.00	"	"	"	---	90	"	---	---	
Potassium	5280	---	100	"	"	6000	---	88	"	---	---	
Selenium	26.0	---	1.00	"	"	30.0	---	87	"	---	---	
Silver	28.7	---	2.00	"	"	"	---	96	"	---	---	
Sodium	5380	---	100	"	"	6000	---	90	"	---	---	
Thallium	28.9	---	1.00	"	"	30.0	---	96	"	---	---	
Vanadium	55.1	---	2.00	"	"	60.0	---	92	"	---	---	
Zinc	52.6	---	4.00	"	"	"	---	88	"	---	---	
Duplicate (8100315-DUP1)			**Source: A810135-51**			**Analyzed: 10/23/08 14:11**						
EPA 6020 (Diss)												
Aluminum	ND	---	100	ug/L	1	---	ND	---	---	---	20%	
Antimony	ND	---	1.00	"	"	---	ND	---	---	---	20%	
Arsenic	ND	---	1.00	"	"	---	ND	---	---	---	20%	
Barium	**1.27**	---	1.00	"	"	---	1.50	---	---	17	20%	
Beryllium	ND	---	1.00	"	"	---	ND	---	---	---	20%	
Cadmium	ND	---	1.00	"	"	---	ND	---	---	---	20%	
Calcium	**3900**	---	100	"	"	---	3900	---	---	0.06	20%	
Chromium	ND	---	1.00	"	"	---	ND	---	---	---	20%	
Cobalt	ND	---	2.00	"	"	---	ND	---	---	---	20%	
Copper	ND	---	5.00	"	"	---	ND	---	---	---	20%	
Iron	ND	---	100	"	"	---	ND	---	---	---	20%	
Lead	ND	---	1.00	"	"	---	ND	---	---	---	20%	
Magnesium	**507**	---	100	"	"	---	502	---	---	0.9	20%	
Manganese	**5.01**	---	1.00	"	"	---	5.21	---	---	4	20%	
Nickel	**2.37**	---	1.00	"	"	---	2.27	---	---	4	20%	
Potassium	**179**	---	100	"	"	---	175	---	---	2	20%	
Selenium	ND	---	1.00	"	"	---	ND	---	---	---	20%	
Silver	ND	---	2.00	"	"	---	ND	---	---	---	20%	
Sodium	**1500**	---	100	"	"	---	1520	---	---	1	20%	

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

QUALITY CONTROL (QC) SAMPLE RESULTS

Dissolved Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 8100315 - EPA 3015 - Dissolved							**Water**					
Duplicate (8100315-DUP1)			**Source: A810135-51**			**Analyzed: 10/23/08 14:11**						
Thallium	ND	---	1.00	ug/L	"	---	ND	---	---	---	20%	
Vanadium	ND	---	2.00	"	"	---	ND	---	---	---	20%	
Zinc	**4.24**	---	4.00	"	"	---	5.47	---	---	25	20%	Q-05
Matrix Spike (8100315-MS1)			**Source: A810135-51**			**Analyzed: 10/23/08 14:14**						
EPA 6020 (Diss)												
Aluminum	5330	---	100	ug/L	1	6000	36.9	88	75-125%	---	---	
Antimony	37.6	---	1.00	"	"	30.0	ND	125	"	---	---	Q-29
Arsenic	53.9	---	1.00	"	"	60.0	ND	90	"	---	---	
Barium	59.3	---	1.00	"	"	"	1.50	96	"	---	---	
Beryllium	25.7	---	1.00	"	"	30.0	ND	86	"	---	---	
Cadmium	56.3	---	1.00	"	"	60.0	ND	94	"	---	---	
Calcium	9080	---	100	"	"	6000	3900	86	"	---	---	
Chromium	57.6	---	1.00	"	"	60.0	0.811	95	"	---	---	
Cobalt	57.0	---	2.00	"	"	"	0.678	94	"	---	---	
Copper	56.1	---	5.00	"	"	"	1.40	91	"	---	---	
Iron	5600	---	100	"	"	6000	34.2	93	"	---	---	
Lead	55.7	---	1.00	"	"	60.0	ND	93	"	---	---	
Magnesium	5860	---	100	"	"	6000	502	89	"	---	---	
Manganese	60.8	---	1.00	"	"	60.0	5.21	93	"	---	---	
Nickel	56.5	---	1.00	"	"	"	2.27	90	"	---	---	
Potassium	5340	---	100	"	"	6000	175	86	"	---	---	
Selenium	25.6	---	1.00	"	"	30.0	ND	85	"	---	---	
Silver	28.6	---	2.00	"	"	"	ND	95	"	---	---	
Sodium	6690	---	100	"	"	6000	1520	86	"	---	---	
Thallium	28.4	---	1.00	"	"	30.0	ND	95	"	---	---	
Vanadium	55.9	---	2.00	"	"	60.0	0.456	92	"	---	---	
Zinc	56.5	---	4.00	"	"	"	5.47	85	"	---	---	
Matrix Spike (8100315-MS2)			**Source: A810135-57**			**Analyzed: 10/23/08 15:24**						
EPA 6020 (Diss)												
Aluminum	5300	---	100	ug/L	1	6000	14.0	88	75-125%	---	---	
Antimony	38.1	---	1.00	"	"	30.0	ND	127	"	---	---	Q-29
Arsenic	53.9	---	1.00	"	"	60.0	ND	90	"	---	---	
Barium	60.1	---	1.00	"	"	"	0.856	99	"	---	---	

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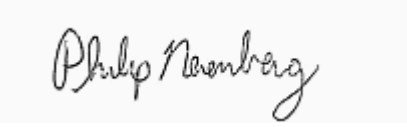

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Tigard, OR 97223
503-718-2323 Phone
503-718-0333 Fax

GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

QUALITY CONTROL (QC) SAMPLE RESULTS

Dissolved Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 8100315 - EPA 3015 - Dissolved							**Water**					
Matrix Spike (8100315-MS2)			**Source: A810135-57**			**Analyzed: 10/23/08 15:24**						
Beryllium	25.8	---	1.00	ug/L	"	30.0	ND	86	"	---	---	
Cadmium	56.1	---	1.00	"	"	60.0	ND	93	"	---	---	
Chromium	57.3	---	1.00	"	"	"	0.678	94	"	---	---	
Cobalt	56.0	---	2.00	"	"	"	0.444	93	"	---	---	
Copper	55.0	---	5.00	"	"	"	0.211	91	"	---	---	
Iron	5580	---	100	"	"	6000	22.0	93	"	---	---	
Lead	55.6	---	1.00	"	"	60.0	ND	93	"	---	---	
Magnesium	5880	---	100	"	"	6000	478	90	"	---	---	
Manganese	58.7	---	1.00	"	"	60.0	1.91	95	"	---	---	
Nickel	54.8	---	1.00	"	"	"	0.411	91	"	---	---	
Selenium	26.0	---	1.00	"	"	30.0	ND	87	"	---	---	
Silver	28.6	---	2.00	"	"	"	ND	95	"	---	---	
Sodium	6610	---	100	"	"	6000	1350	88	"	---	---	
Thallium	27.8	---	1.00	"	"	30.0	ND	93	"	---	---	
Vanadium	55.3	---	2.00	"	"	60.0	0.567	91	"	---	---	
Zinc	55.4	---	4.00	"	"	"	3.79	86	"	---	---	
						Analyzed: 10/23/08 17:41						
EPA 6020 (Diss)												
Calcium	10100	---	100	"	"	6000	3800	104	"	---	---	
Potassium	5810	---	100	"	"	"	101	95	"	---	---	

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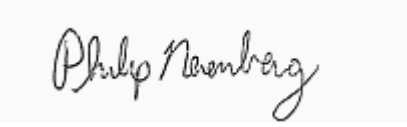

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

QUALITY CONTROL (QC) SAMPLE RESULTS

Dissolved Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 8100348 - EPA 3015 (Hg Only)							**Water**					
Blank (8100348-BLK1)						**Analyzed: 10/24/08 20:44**						
EPA 6020 (Diss)												
Mercury	ND	---	0.100	ug/L	1	---	---	---	---	---	---	
LCS (8100348-BS1)						**Analyzed: 10/24/08 20:48**						
EPA 6020 (Diss)												
Mercury	2.30	---	0.100	ug/L	1	2.50	---	92	80-120%	---	---	

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

QUALITY CONTROL (QC) SAMPLE RESULTS

Percent Dry Weight by D2216

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 8100246 - Dry Weight							**Soil**					
Duplicate (8100246-DUP5)			**Source: A810135-12**			**Analyzed: 10/20/08 08:57**						
D2216												
% Solids	**82.2**	---	1.00	% by Weight	1	---	82.0	---	---	0.2	20%	
Duplicate (8100246-DUP6)			**Source: A810135-25**			**Analyzed: 10/20/08 08:57**						
D2216												
% Solids	**89.2**	---	1.00	% by Weight	1	---	87.5	---	---	2	20%	
Duplicate (8100246-DUP8)			**Source: A810135-33**			**Analyzed: 10/20/08 08:57**						
D2216												
% Solids	**88.1**	---	1.00	% by Weight	1	---	88.3	---	---	0.2	20%	
Duplicate (8100246-DUP9)			**Source: A810135-59**			**Analyzed: 10/20/08 08:57**						
D2216												
% Solids	**75.7**	---	1.00	% by Weight	1	---	76.0	---	---	0.4	20%	
Duplicate (8100246-DUPA)			**Source: A810135-75**			**Analyzed: 10/20/08 08:57**						
D2216												
% Solids	**76.0**	---	1.00	% by Weight	1	---	77.5	---	---	2	20%	

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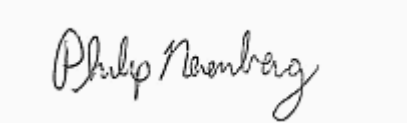

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

SAMPLE PREPARATION INFORMATION

Total Metals by EPA 6020 (ICPMS)

Prep: EPA 3015

Lab Number	Matrix	Method	Sampled	Prepared	Sample Initial/Final	Default Initial/Final	RL Prep Factor
Batch: 8100253							
A810135-43	Water	EPA 6020	10/07/08 12:55	10/17/08 13:35	45mL/50mL	45mL/50mL	1.00
A810135-44	Water	EPA 6020	10/07/08 12:45	10/17/08 13:35	45mL/50mL	45mL/50mL	1.00
A810135-45	Water	EPA 6020	10/07/08 15:15	10/17/08 13:35	45mL/50mL	45mL/50mL	1.00
A810135-46	Water	EPA 6020	10/07/08 15:20	10/17/08 13:35	45mL/50mL	45mL/50mL	1.00
A810135-49	Water	EPA 6020	10/08/08 11:40	10/17/08 13:35	45mL/50mL	45mL/50mL	1.00
A810135-52	Water	EPA 6020	10/08/08 12:25	10/17/08 13:35	45mL/50mL	45mL/50mL	1.00
A810135-55	Water	EPA 6020	10/08/08 12:55	10/17/08 13:35	45mL/50mL	45mL/50mL	1.00
A810135-58	Water	EPA 6020	10/08/08 13:50	10/17/08 13:35	45mL/50mL	45mL/50mL	1.00
A810135-60	Water	EPA 6020	10/08/08 13:35	10/17/08 13:35	45mL/50mL	45mL/50mL	1.00
A810135-63	Water	EPA 6020	10/08/08 16:45	10/17/08 13:35	45mL/50mL	45mL/50mL	1.00
A810135-66	Water	EPA 6020	10/08/08 17:15	10/17/08 13:35	45mL/50mL	45mL/50mL	1.00
A810135-69	Water	EPA 6020	10/09/08 09:30	10/17/08 13:35	45mL/50mL	45mL/50mL	1.00
A810135-71	Water	EPA 6020	10/09/08 10:15	10/17/08 13:35	45mL/50mL	45mL/50mL	1.00
A810135-74	Water	EPA 6020	10/09/08 11:00	10/17/08 13:35	45mL/50mL	45mL/50mL	1.00

Prep: EPA 3015 (Hg Only)

Lab Number	Matrix	Method	Sampled	Prepared	Sample Initial/Final	Default Initial/Final	RL Prep Factor
Batch: 8100260							
A810135-44	Water	EPA 6020	10/07/08 12:45	10/17/08 15:41	40mL/50mL	40mL/50mL	1.00
Batch: 8100330							
A810135-43	Water	EPA 6020	10/07/08 12:55	10/23/08 10:38	40mL/50mL	40mL/50mL	1.00
A810135-45	Water	EPA 6020	10/07/08 15:15	10/23/08 10:38	40mL/50mL	40mL/50mL	1.00
A810135-46	Water	EPA 6020	10/07/08 15:20	10/23/08 10:38	40mL/50mL	40mL/50mL	1.00
A810135-49	Water	EPA 6020	10/08/08 11:40	10/23/08 10:38	40mL/50mL	40mL/50mL	1.00
A810135-52	Water	EPA 6020	10/08/08 12:25	10/23/08 10:38	40mL/50mL	40mL/50mL	1.00
A810135-55	Water	EPA 6020	10/08/08 12:55	10/23/08 10:38	40mL/50mL	40mL/50mL	1.00
A810135-58	Water	EPA 6020	10/08/08 13:50	10/23/08 10:38	40mL/50mL	40mL/50mL	1.00
A810135-60	Water	EPA 6020	10/08/08 13:35	10/23/08 10:38	40mL/50mL	40mL/50mL	1.00
A810135-63	Water	EPA 6020	10/08/08 16:45	10/23/08 10:38	40mL/50mL	40mL/50mL	1.00
A810135-66	Water	EPA 6020	10/08/08 17:15	10/23/08 10:38	40mL/50mL	40mL/50mL	1.00
A810135-69	Water	EPA 6020	10/09/08 09:30	10/23/08 10:38	40mL/50mL	40mL/50mL	1.00
A810135-71	Water	EPA 6020	10/09/08 10:15	10/23/08 10:38	40mL/50mL	40mL/50mL	1.00
A810135-74	Water	EPA 6020	10/09/08 11:00	10/23/08 10:38	40mL/50mL	40mL/50mL	1.00

Prep: EPA 3051

Lab Number	Matrix	Method	Sampled	Prepared	Sample Initial/Final	Default Initial/Final	RL Prep Factor
Batch: 8100267							

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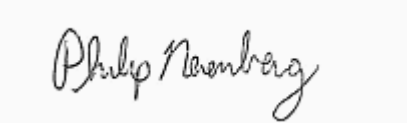

Philip Nerenberg, Lab Director

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503-718-0333 Fax

GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

SAMPLE PREPARATION INFORMATION

Total Metals by EPA 6020 (ICPMS)

Prep: EPA 3051

Lab Number	Matrix	Method	Sampled	Prepared	Sample Initial/Final	Default Initial/Final	RL Prep Factor
A810135-01	Soil	EPA 6020	10/06/08 11:40	10/20/08 07:53	0.491g/50mL	0.5g/50mL	1.02
A810135-02	Soil	EPA 6020	10/06/08 12:05	10/20/08 07:53	0.491g/50mL	0.5g/50mL	1.02
A810135-03	Soil	EPA 6020	10/06/08 12:30	10/20/08 07:53	0.483g/50mL	0.5g/50mL	1.04
A810135-04	Soil	EPA 6020	10/06/08 13:20	10/20/08 07:53	0.499g/50mL	0.5g/50mL	1.00
A810135-05	Soil	EPA 6020	10/06/08 14:25	10/20/08 07:53	0.495g/50mL	0.5g/50mL	1.01
A810135-06	Soil	EPA 6020	10/06/08 14:45	10/20/08 07:53	0.506g/50mL	0.5g/50mL	0.99
A810135-07	Soil	EPA 6020	10/06/08 15:30	10/20/08 07:53	0.492g/50mL	0.5g/50mL	1.02
A810135-08	Soil	EPA 6020	10/06/08 15:45	10/20/08 07:53	0.497g/50mL	0.5g/50mL	1.01
A810135-09	Soil	EPA 6020	10/06/08 16:05	10/20/08 07:53	0.505g/50mL	0.5g/50mL	0.99
A810135-10	Soil	EPA 6020	10/06/08 17:20	10/20/08 07:53	0.501g/50mL	0.5g/50mL	1.00
A810135-11	Soil	EPA 6020	10/07/08 09:10	10/20/08 07:53	0.504g/50mL	0.5g/50mL	0.99
A810135-12	Soil	EPA 6020	10/07/08 09:20	10/20/08 07:53	0.497g/50mL	0.5g/50mL	1.01
A810135-13	Soil	EPA 6020	10/07/08 09:30	10/20/08 07:53	0.503g/50mL	0.5g/50mL	0.99
A810135-14	Soil	EPA 6020	10/07/08 09:45	10/20/08 07:53	0.496g/50mL	0.5g/50mL	1.01
A810135-15	Soil	EPA 6020	10/07/08 10:05	10/20/08 07:53	0.501g/50mL	0.5g/50mL	1.00
A810135-16	Soil	EPA 6020	10/07/08 10:10	10/20/08 07:53	0.477g/50mL	0.5g/50mL	1.05
A810135-17	Soil	EPA 6020	10/07/08 10:25	10/20/08 07:53	0.497g/50mL	0.5g/50mL	1.01
A810135-18	Soil	EPA 6020	10/07/08 10:40	10/20/08 07:53	0.503g/50mL	0.5g/50mL	0.99
A810135-19	Soil	EPA 6020	10/07/08 10:50	10/20/08 07:53	0.479g/50mL	0.5g/50mL	1.04
Batch: 8100285							
A810135-20	Soil	EPA 6020	10/07/08 11:00	10/21/08 06:47	0.485g/50mL	0.5g/50mL	1.03
A810135-21	Soil	EPA 6020	10/07/08 11:05	10/21/08 06:47	0.508g/50mL	0.5g/50mL	0.98
A810135-22	Soil	EPA 6020	10/07/08 14:00	10/21/08 06:47	0.496g/50mL	0.5g/50mL	1.01
A810135-23	Soil	EPA 6020	10/07/08 14:05	10/21/08 06:47	0.488g/50mL	0.5g/50mL	1.02
A810135-24	Soil	EPA 6020	10/07/08 14:10	10/21/08 06:47	0.491g/50mL	0.5g/50mL	1.02
A810135-25	Soil	EPA 6020	10/07/08 14:15	10/21/08 06:47	0.48g/50mL	0.5g/50mL	1.04
A810135-26	Soil	EPA 6020	10/07/08 14:20	10/21/08 06:47	0.508g/50mL	0.5g/50mL	0.98
A810135-27	Soil	EPA 6020	10/07/08 14:30	10/21/08 06:47	0.484g/50mL	0.5g/50mL	1.03
A810135-28	Soil	EPA 6020	10/07/08 14:35	10/21/08 06:47	0.479g/50mL	0.5g/50mL	1.04
A810135-29	Soil	EPA 6020	10/07/08 14:40	10/21/08 06:47	0.478g/50mL	0.5g/50mL	1.05
A810135-30	Soil	EPA 6020	10/07/08 14:45	10/21/08 06:47	0.504g/50mL	0.5g/50mL	0.99
A810135-31	Soil	EPA 6020	10/07/08 14:50	10/21/08 06:47	0.489g/50mL	0.5g/50mL	1.02
A810135-32	Soil	EPA 6020	10/07/08 14:55	10/21/08 06:47	0.485g/50mL	0.5g/50mL	1.03
A810135-33	Soil	EPA 6020	10/07/08 16:00	10/21/08 06:47	0.502g/50mL	0.5g/50mL	1.00
A810135-34	Soil	EPA 6020	10/07/08 16:05	10/21/08 06:47	0.495g/50mL	0.5g/50mL	1.01
A810135-35	Soil	EPA 6020	10/07/08 16:10	10/21/08 06:47	0.48g/50mL	0.5g/50mL	1.04
A810135-36	Soil	EPA 6020	10/07/08 16:15	10/21/08 06:47	0.486g/50mL	0.5g/50mL	1.03
A810135-37	Soil	EPA 6020	10/07/08 16:20	10/21/08 06:47	0.483g/50mL	0.5g/50mL	1.04

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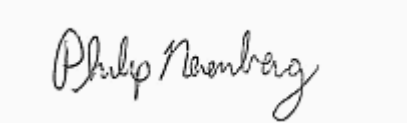

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

SAMPLE PREPARATION INFORMATION

Total Metals by EPA 6020 (ICPMS)

Prep: EPA 3051

Lab Number	Matrix	Method	Sampled	Prepared	Sample Initial/Final	Default Initial/Final	RL Prep Factor
A810135-38	Soil	EPA 6020	10/07/08 16:25	10/21/08 06:47	0.468g/50mL	0.5g/50mL	1.07
Batch: 8100321							
A810135-39	Soil	EPA 6020	10/07/08 16:30	10/23/08 07:47	0.495g/50mL	0.5g/50mL	1.01
A810135-40	Soil	EPA 6020	10/07/08 16:35	10/23/08 07:47	0.503g/50mL	0.5g/50mL	0.99
A810135-41	Soil	EPA 6020	10/07/08 16:35	10/23/08 07:47	0.5g/50mL	0.5g/50mL	1.00
A810135-42	Soil	EPA 6020	10/07/08 16:40	10/23/08 07:47	0.497g/50mL	0.5g/50mL	1.01
A810135-47	Soil	EPA 6020	10/08/08 14:05	10/23/08 07:47	0.501g/50mL	0.5g/50mL	1.00
A810135-48	Soil	EPA 6020	10/08/08 14:10	10/23/08 07:47	0.49g/50mL	0.5g/50mL	1.02
A810135-50	Soil	EPA 6020	10/08/08 11:40	10/23/08 07:47	0.48g/50mL	0.5g/50mL	1.04
A810135-53	Soil	EPA 6020	10/08/08 12:25	10/23/08 07:47	0.5g/50mL	0.5g/50mL	1.00
A810135-56	Soil	EPA 6020	10/08/08 12:55	10/23/08 07:47	0.485g/50mL	0.5g/50mL	1.03
A810135-59	Soil	EPA 6020	10/08/08 13:50	10/23/08 07:47	0.505g/50mL	0.5g/50mL	0.99
A810135-61	Soil	EPA 6020	10/08/08 13:35	10/23/08 07:47	0.492g/50mL	0.5g/50mL	1.02
A810135-64	Soil	EPA 6020	10/08/08 16:45	10/23/08 07:47	0.483g/50mL	0.5g/50mL	1.04
A810135-67	Soil	EPA 6020	10/08/08 17:15	10/23/08 07:47	0.478g/50mL	0.5g/50mL	1.05
A810135-70	Soil	EPA 6020	10/09/08 09:30	10/23/08 07:47	0.494g/50mL	0.5g/50mL	1.01
A810135-72	Soil	EPA 6020	10/09/08 10:15	10/23/08 07:47	0.489g/50mL	0.5g/50mL	1.02
A810135-75	Soil	EPA 6020	10/09/08 11:00	10/23/08 07:47	0.488g/50mL	0.5g/50mL	1.02

Dissolved Metals by EPA 6020 (ICPMS)

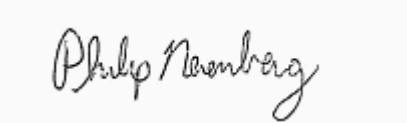
Prep: EPA 3015 - Dissolved

Lab Number	Matrix	Method	Sampled	Prepared	Sample Initial/Final	Default Initial/Final	RL Prep Factor
Batch: 8100315							
A810135-51	Water	EPA 6020 (Diss)	10/08/08 11:40	10/22/08 12:56	45mL/50mL	45mL/50mL	1.00
A810135-54	Water	EPA 6020 (Diss)	10/08/08 12:25	10/22/08 12:56	45mL/50mL	45mL/50mL	1.00
A810135-57	Water	EPA 6020 (Diss)	10/08/08 12:55	10/22/08 12:56	45mL/50mL	45mL/50mL	1.00
A810135-62	Water	EPA 6020 (Diss)	10/08/08 13:35	10/22/08 12:56	45mL/50mL	45mL/50mL	1.00
A810135-65	Water	EPA 6020 (Diss)	10/08/08 16:45	10/22/08 12:56	45mL/50mL	45mL/50mL	1.00
A810135-68	Water	EPA 6020 (Diss)	10/08/08 17:15	10/22/08 12:56	45mL/50mL	45mL/50mL	1.00
A810135-73	Water	EPA 6020 (Diss)	10/09/08 10:15	10/22/08 12:56	45mL/50mL	45mL/50mL	1.00
A810135-76	Water	EPA 6020 (Diss)	10/09/08 11:00	10/22/08 12:56	45mL/50mL	45mL/50mL	1.00

Prep: EPA 3015 (Hg Only)

Lab Number	Matrix	Method	Sampled	Prepared	Sample Initial/Final	Default Initial/Final	RL Prep Factor
Batch: 8100348							
A810135-51	Water	EPA 6020 (Diss)	10/08/08 11:40	10/24/08 12:15	40mL/50mL	40mL/50mL	1.00

Apex Laboratories



Philip Nerenberg, Lab Director

The results in this report apply to the samples analyzed in accordance with the chain of custody document. This analytical report must be reproduced in its entirety.

Apex Labs

12232 S.W. Garden Place
Tigard, OR 97223
503-718-2323 Phone
503-718-0333 Fax

GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

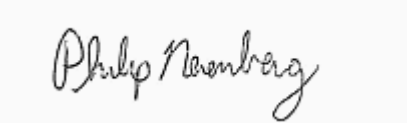
SAMPLE PREPARATION INFORMATION

Dissolved Metals by EPA 6020 (ICPMS)

Prep: EPA 3015 (Hg Only)

Lab Number	Matrix	Method	Sampled	Prepared	Sample Initial/Final	Default Initial/Final	RL Prep Factor
A810135-54	Water	EPA 6020 (Diss)	10/08/08 12:25	10/24/08 12:15	40mL/50mL	40mL/50mL	1.00
A810135-57	Water	EPA 6020 (Diss)	10/08/08 12:55	10/24/08 12:15	40mL/50mL	40mL/50mL	1.00
A810135-62	Water	EPA 6020 (Diss)	10/08/08 13:35	10/24/08 12:15	40mL/50mL	40mL/50mL	1.00
A810135-65	Water	EPA 6020 (Diss)	10/08/08 16:45	10/24/08 12:15	40mL/50mL	40mL/50mL	1.00
A810135-68	Water	EPA 6020 (Diss)	10/08/08 17:15	10/24/08 12:15	40mL/50mL	40mL/50mL	1.00
A810135-73	Water	EPA 6020 (Diss)	10/09/08 10:15	10/24/08 12:15	40mL/50mL	40mL/50mL	1.00
A810135-76	Water	EPA 6020 (Diss)	10/09/08 11:00	10/24/08 12:15	40mL/50mL	40mL/50mL	1.00

Apex Laboratories



Philip Nerenberg, Lab Director

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Apex Labs

12232 S.W. Garden Place
Tigard, OR 97223
503-718-2323 Phone
503-718-0333 Fax

GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	10/31/08 16:48

Notes and Definitions

Qualifiers:

B-02	Analyte detected in the extraction blank at a level below the MRL, but greater than one-half the MRL.
Q-01	The percent recovery and/or RPD was outside acceptance limits for this spiked sample. The batch was accepted based on LCS recovery.
Q-03	The Percent Recovery and/or RPD for this QC Spike Sample is out of control due to the high concentration of analyte present in the sample.
Q-04	The RPD and/or Percent Recovery for this QC sample is outside control limits due to a non-homogeneous sample matrix.
Q-05	Analyses are not controlled on RPD values from sample or duplicate concentrations near or below the reporting level.
Q-08	Recovery of Lab Control Spike or Lab Control Spike Duplicate was above established control limits for this analyte. Analyte was not detected in reported client samples. Data quality is not affected.
Q-11	The spike recovery for this matrix spike cannot be accurately quantified due to sample dilution required from high analyte concentration and/or matrix interference.
Q-29	Recovery for Lab Control Spike (LCS) is above the upper control limit. Data may be biased high.

Notes and Conventions:

DET	Analyte DETECTED
ND	Analyte NOT DETECTED at or above the reporting limit
NR	Not Reported
dry	Sample results reported on a dry weight basis
RPD	Relative Percent Difference
MDL	If MDL is not listed, data has been evaluated to the Method Reporting Limit only.
WMSC	Water Miscible Solvent Correction has been applied to Results and MRLs for volatiles soil samples per EPA 8000C.
Batch QC	Unless specifically stated, all analyses include full Batch QC, including Sample Duplicates, Matrix Spikes and/or Matrix Spike Duplicates, in order to meet or exceed method and regulatory requirements. This report contains only results for Batch QC derived from samples included in this report. Complete Batch QC results are available upon request. In cases where there is insufficient sample provided for Sample Duplicates and/or Matrix Spikes, a Lab Control Sample Duplicate (LCS Dup) is analyzed to demonstrate accuracy and precision of the extraction and analysis.

Apex Laboratories

Philip Nerenberg, Lab Director

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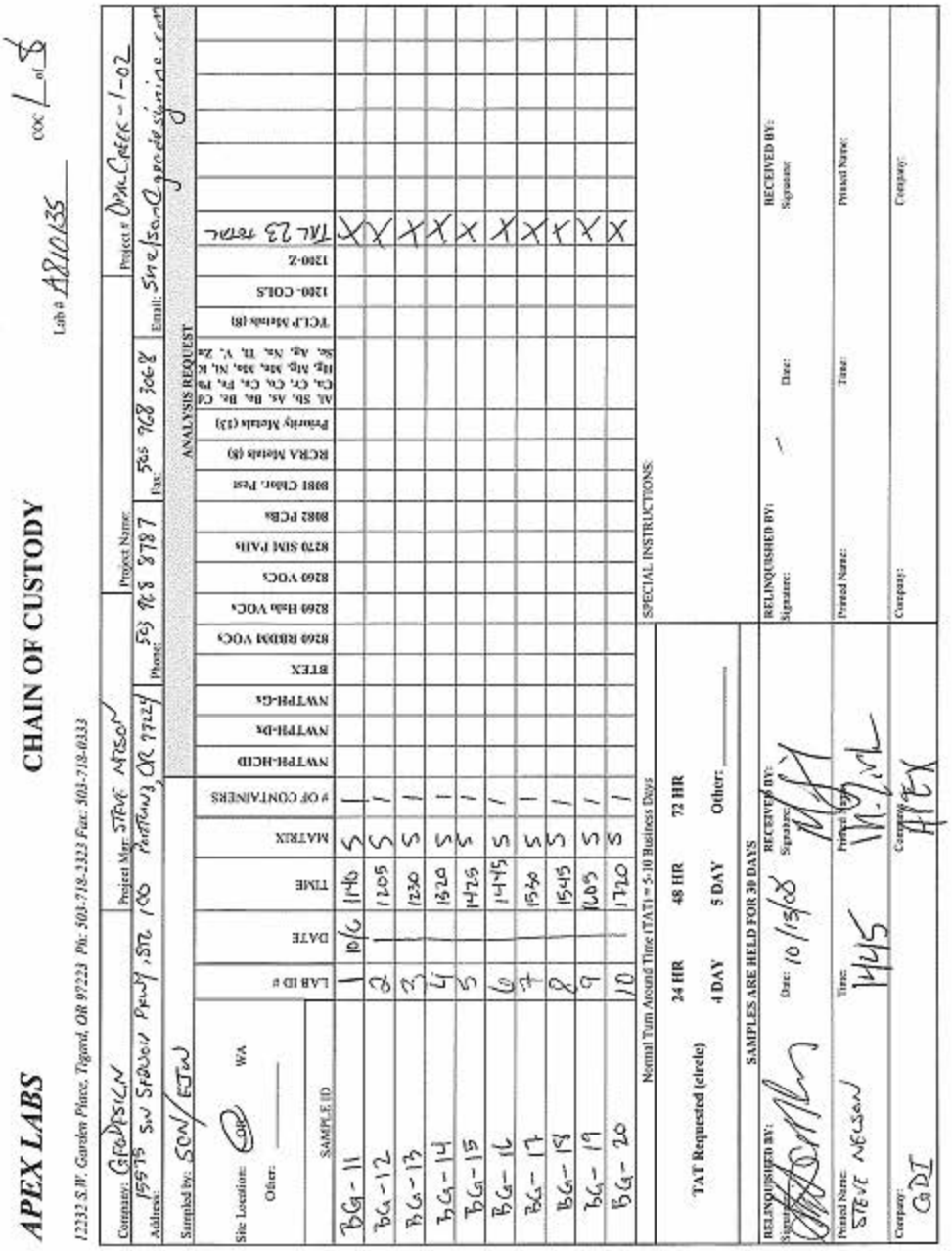
Apex Labs

12232 S.W. Garden Place
Tigard, OR 97223
503-718-2323 Phone
503-718-0333 Fax

GeoDesign, Inc. 15575 SW Sequoia Pkwy, Ste 100 Portland, OR 97224	Project: **Opal Creek** Project Number: [none] Project Manager: Steve Nelson	**Reported:** 10/31/08 16:48



APEX LABS — **CHAIN OF CUSTODY**

12232 S.W. Garden Place, Tigard, OR 97223 Ph: 503-718-2323 Fax: 503-718-0333

Lab # AP10135 COC 1 of 8

Company: GeoDesign — Project Mgr: Steve Nelson — Project Name: — Project # OpalCreek-1-02

Address: 15575 SW Sequoia Pkwy, Ste 100 Portland, OR 97224 — Phone: 503 968 8787 — Fax: 503 968 3068 — Email: snelson@geodesignine.com

Sampled by: SON/EJW — ANALYSIS REQUEST

Site Location: Coos — WA — Other: ____

SAMPLE ID	LAB ID #	DATE	TIME	MATRIX	# OF CONTAINERS	NWTPH-HCID	NWTPH-Dx	NWTPH-Gx	BTEX	8260 RBDM VOCs	8260 Halo VOCs	8260 VOCs	8270 SIM PAHs	8082 PCBs	8081 Chlor. Pest	RCRA Metals (8)	Priority Metals (13)	Al, Sb, As, Ba, Be, Cd, Ca, Cr, Co, Cu, Fe, Pb, Mg, Mn, Mo, Ni, K, Se, Ag, Na, Tl, V, Zn	TCLP Metals (8)	1200-COLS	1200-Z	TAL 23 metal				
BG-11	1	10/6	1140	S	1																	X				
BG-12	2		1205	S	1																	X				
BG-13	3		1230	S	1																	X				
BG-14	4		1320	S	1																	X				
BG-15	5		1425	S	1																	X				
BG-16	6		1445	S	1																	X				
BG-17	7		1530	S	1																	X				
BG-18	8		1545	S	1																	X				
BG-19	9		1605	S	1																	X				
BG-20	10		1720	S	1																	X				

Normal Turn Around Time (TAT) = 5-10 Business Days

TAT Requested (circle): 24 HR — 48 HR — 72 HR — 4 DAY — 5 DAY — Other: ____

SAMPLES ARE HELD FOR 30 DAYS

SPECIAL INSTRUCTIONS:

RELINQUISHED BY:	RECEIVED BY:
Signature: Date: 10/13/08	Signature:
Printed Name: STEVE NELSON	Printed Name:
Company: GDI	Company: APEX
Time: 1445	

RELINQUISHED BY:	RECEIVED BY:
Signature: Date:	Signature:
Printed Name:	Printed Name:
Company:	Company:
Time:	

Apex Laboratories

Philip Nerenberg

Philip Nerenberg, Lab Director

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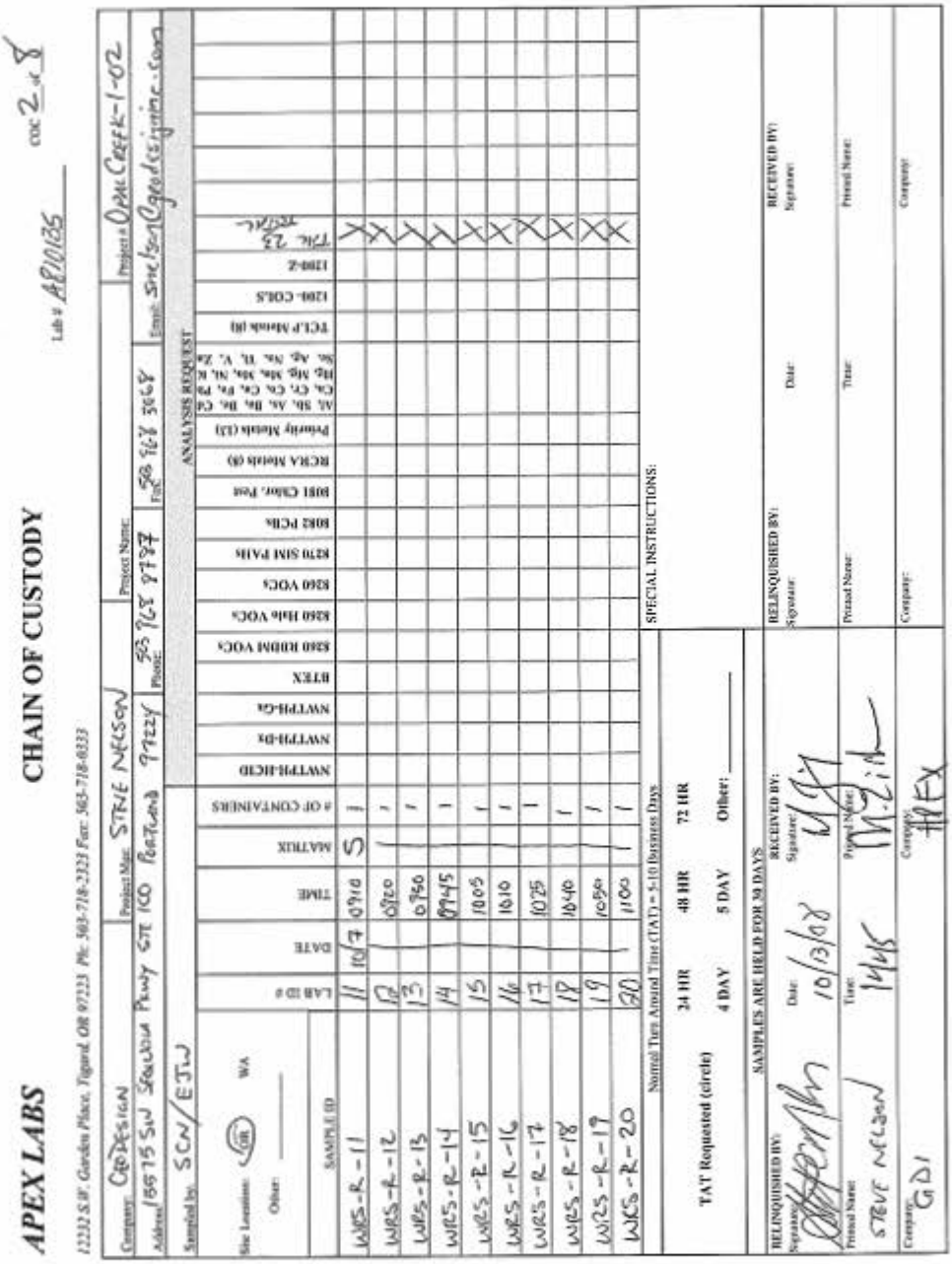
Apex Labs

12232 S.W. Garden Place
Tigard, OR 97223
503-718-2323 Phone
503-718-0333 Fax

GeoDesign, Inc.
15575 SW Sequoia Pkwy, Ste 100
Portland, OR 97224

Project: **Opal Creek**
Project Number: [none]
Project Manager: Steve Nelson

Reported:
10/31/08 16:48



APEX LABS — **CHAIN OF CUSTODY**

12232 S.W. Garden Place, Tigard, OR 97223 Ph: 503-718-2323 Fax: 503-718-0333

Lab # AE10135 — COC 2 of 8

Company: GeoDesign — Project Mgr: STEVE NELSON — Project Name: — Project #: OPAL CREEK-1-02

Address: 15575 SW Sequoia Pkwy STE 100 Portland 97224 — Phone: 503 968 9787 — Fax: 503 968 3068 — Email: snelson@geodesigninc.com

Sampled by: SCN/EJW

Site Location: OR WA — Other: _____

ANALYSIS REQUEST

SAMPLE ID	LAB ID #	DATE	TIME	ASATTUX	# OF CONTAINERS	NWTPH-HCID	NWTPH-Dx	NWTPH-Gx	BTEX	8260 HOBM VOCs	8260 Halo VOCs	8260 VOCs	8270 SIM PAHs	8082 PCBs	8081 Chlor. Pest	RCRA Metals (8)	Priority Metals (13)	As, Sb, As, Ba, Be, Cd, Ca, Cr, Co, Cu, Fe, Pb, Hg, Mg, Mn, Mo, Ni, K, Se, Ag, Na, Tl, V, Zn	TCLP Metals (8)	1200-COLS	1200-Z	THE 23 [illegible]
WRS-R-11	11	10/7	0910	S	1																	X
WRS-R-12	12		0920		1																	X
WRS-R-13	13		0930		1																	X
WRS-R-14	14		0945		1																	X
WRS-R-15	15		1005		1																	X
WRS-R-16	16		1010		1																	X
WRS-R-17	17		1025		1																	X
WRS-R-18	18		1040		1																	X
WRS-R-19	19		1050		1																	X
WRS-R-20	20		1100		1																	X

Normal Turn Around Time (TAT) = 5-10 Business Days

TAT Requested (circle): 24 HR 48 HR 72 HR 4 DAY 5 DAY Other: _____

SPECIAL INSTRUCTIONS:

SAMPLES ARE HELD FOR 30 DAYS

RELINQUISHED BY:	RECEIVED BY:	RELINQUISHED BY:	RECEIVED BY:
Signature: [signature]	Signature: [signature]	Signature:	Signature:
Date: 10/13/08		Date:	
Time: [illegible]		Time:	
Printed Name: STEVE NELSON	Printed Name: [illegible]	Printed Name:	Printed Name:
Company: GDI	Company: APEX	Company:	Company:

Apex Laboratories

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Philip Nerenberg, Lab Director

Apex Labs

12232 S.W. Garden Place
Tigard, OR 97223
503-718-2323 Phone
503-718-0333 Fax

GeoDesign, Inc.
15575 SW Sequoia Pkwy, Ste 100
Portland, OR 97224

Project: **Opal Creek**
Project Number: [none]
Project Manager: Steve Nelson

Reported:
10/31/08 16:48

APEX LABS — **CHAIN OF CUSTODY**

12232 S.W. Garden Place, Tigard, OR 97223 Ph: 503-718-2323 Fax: 503-718-0333

Lab # A810135 COC 3 of 8

Company: GeoDesign — Project Mgr: STEVE NELSON — Project Name: — Project #: OPAL CREEK-1-02
Address: 15575 SW SEQUOIA PKWY, STE 100 PORTLAND 97224 — Phone: 503 968 3068 — Fax: 503 968 3068 — Email: SNelson@geodesignnw.com

Site Location: OR WA Other: ____

Sampled by: SCN / ETW

ANALYSES REQUEST

SAMPLE ID	LAB ID #	DATE	TIME	MATRIX	# OF CONTAINERS	NWTPH-HCID	NWTPH-Dx	NWTPH-Gx	BTEX	8260 RBDM VOCs	8260 Halo VOCs	8260 VOCs	8270 SIM PAHs	8082 PCBs	8081 Chlor. Pest	RCRA Metals (8)	Priority Metals (13)	Al, Sb, As, Ba, Be, Cd, Ca, Cr, Co, Cu, Fe, Pb, Mg, Mg, Mn, Mo, Ni, K, Se, Ag, Na, Tl, V, Zn	TCLP Metals (8)	1200-COLS	1200-Z	TM, 23 PCBs
WRS-R-21	21	10/7	1105	S	1																	X
WRS-MS-1	22		1400		1																	X
WRS-MS-2	23		1405		1																	X
WRS-MS-3	24		1410		1																	X
WRS-MS-4	25		1415		1																	X
WRS-MS-5	26		1420		1																	X
WRS-MS-6	27		1430		1																	X
WRS-MS-7	28		1440		1																	X
WRS-MS-8	29		1440		1																	X
WRS-MS-9	30		1445		1																	X

Normal Turn Around Time (TAT) = 5-10 Business Days

TAT Requested (circle): 24 HR 48 HR 72 HR 4 DAY 5 DAY Other: ____

SPECIAL INSTRUCTIONS:

SAMPLES ARE HELD FOR 30 DAYS

RELINQUISHED BY:	RECEIVED BY:	RELINQUISHED BY:	RECEIVED BY:
Signature:	Signature:	Signature:	Signature:
Date: 10/13/08		Date:	
Time: 1445		Time:	
Printed Name: STEVE NELSON	Printed Name:	Printed Name:	Printed Name:
Company: GDI	Company: APEX	Company:	Company:

Apex Labs

12232 S.W. Garden Place
Tigard, OR 97223
503-718-2323 Phone
503-718-0333 Fax

GeoDesign, Inc.
15575 SW Sequoia Pkwy, Ste 100
Portland, OR 97224

Project: **Opal Creek**
Project Number: [none]
Project Manager: Steve Nelson

Reported:
10/31/08 16:48

APEX LABS — **CHAIN OF CUSTODY**

12232 S.W. Garden Place, Tigard, OR 97223 Ph: 503-718-2323 Fax: 503-718-0333

Lab # A810135 COC 4 of 8

Company: GeoDesign — Project Mgr: STEVE NELSON — Project Name: — Project: Opal Creek-1-02
Address: 15575 SW SEQUOIA PKWY, STE 100 PORTLAND 97224 — Phone: 503 768 2787 — Fax: 503 768 2608 — Email: snelson@geodesigninc.com
Sampled by: SCN/EJW

Site Location: OR WA Other: ____

ANALYSIS REQUEST

SAMPLE ID	LAB ID #	DATE	TIME	MATRIX	# OF CONTAINERS	NWTPH-HCID	NWTPH-Dx	NWTPH-Gx	BTEX	8260 BRDM VOCs	8260 Halo VOCs	8260 VOCs	8270 SIM PAHs	8082 PCBs	8081 Chlor. Pest	RCRA Metals (8)	Priority Metals (13)	AL Sb, As, Ba, Be, Cd, Ca, Cr, Co, Cu, Fe, Pb, Mg, Mn, Mo, Ni, K, Se, Ag, Na, Tl, V, Zn	TCLP Metals (8)	1200-COLIS	1200-Z	TKL 23 TBD/VOC
WRS-MS-10	31	10/7	1450	S	1																	X
WRS-MS-11	32		1455		1																	X
WRS-R-22	33		1600																			X
WRS-R-23	34		1605																			X
WRS-R-24	35		1610																			X
WRS-R-25	36		1615																			X
WRS-R-26	37		1620																			X
WRS-R-27	38		1625																			X
WRS-R-28	39		1630																			X
WRS-R-29	40		1635																			X

Normal Turn Around Time (TAT) = 5-10 Business Days

TAT Requested (circle): 24 HR 48 HR 72 HR; 4 DAY 5 DAY Other: ____

SPECIAL INSTRUCTIONS:

SAMPLES ARE HELD FOR 30 DAYS

RELINQUISHED BY: Signature: Date: 10/13/08 — RECEIVED BY: Signature:
Printed Name: STEVE NELSON — Time: 1445 — Printed Name:
Company: GDI — Company: APEX

RELINQUISHED BY: Signature: — RECEIVED BY: Signature:
Printed Name: — Date: — Time: — Printed Name:
Company: — Company:

Apex Laboratories

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Philip Nerenberg

Philip Nerenberg, Lab Director

Apex Labs

12232 S.W. Garden Place
Tigard, OR 97223
503-718-2323 Phone
503-718-0333 Fax

GeoDesign, Inc.
15575 SW Sequoia Pkwy, Ste 100
Portland, OR 97224

Project: **Opal Creek**
Project Number: [none]
Project Manager: Steve Nelson

Reported:
10/31/08 16:48

APEX LABS — **CHAIN OF CUSTODY**

12232 S.W. Garden Place, Tigard, OR 97223 Ph: 503-718-2323 Fax: 503-718-0333

Lab # 810135 COC 58

Company: GeoDesign — Project Mgr: Steve Nelson — Project Name: — Project # Opal Creek-1-02
Address: 15575 SW Sequoia Pkwy Ste 100 Portland 97224 — Phone: 968 8787 — Fax: 968 3068 — Email: snelson@geodesignine.com
Sampled by: SEN/EJW

Site Location: OR WA Other: ____

ANALYSIS REQUEST

SAMPLE ID	LAB ID #	DATE	TIME	MATRIX	# OF CONTAINERS	NWTPH-HCID	NWTPH-Dx	NWTPH-Gx	BTEX	8260 HMDM VOCs	8260 Halo VOCs	8260 VOCs	8270 SIM PAHs	8082 PCBs	8081 Chlor. Pest	RCRA Metals (8)	Priority Metals (13)	Al, Sb, As, Ba, Be, Cd Ca, Cr, Co, Cu, Fe, Pb Hg, Mg, Mn, Mo, Ni, K Se, Ag, Na, Tl, V, Zn	TCLP Metals (8)	1310-COLS	1310-2	TAL 25 total						
WLS-R-DUP	41	10/7	1635	S	1																	X						
WLS-R-30	42		1640	S	1																	X						
AW-MS-1	43		1255	W	1																	X						
SW-MS-11	44		1245	W	1																	X						
SW-MS-12	45		1515	W	1																	X						
SW-MS-13	46		1520	W	1																	X						
SED-MS-12	47	10/9	1465	S	1																	X						
SED-MS-13	48	10/8	1410	S	1																	X						
SW-MS-14	49	10/9	1140	W	1																	X						
SED-MS-14	50	10/8	1140	S	1																	X						

Normal Turn Around Time (TAT) = 5-10 Business Days

TAT Requested (circle): 24 HR 48 HR 72 HR; 4 DAY 5 DAY Other: ____

SPECIAL INSTRUCTIONS:

SAMPLES ARE HELD FOR 30 DAYS

RELINQUISHED BY:	RECEIVED BY:	RELINQUISHED BY:	RECEIVED BY:
Signature:	Signature:	Signature:	Signature:
Date: 10/10/08		Date:	
Time:		Time:	
Printed Name: STEVE NELSON	Printed Name:	Printed Name:	Printed Name:
Company: GDI	Company: APEX	Company:	Company:

Apex Labs

12232 S.W. Garden Place
Tigard, OR 97223
503-718-2323 Phone
503-718-0333 Fax

GeoDesign, Inc.
15575 SW Sequoia Pkwy, Ste 100
Portland, OR 97224

Project: **Opal Creek**
Project Number: [none]
Project Manager: Steve Nelson

Reported:
10/31/08 16:48

APEX LABS — **CHAIN OF CUSTODY**

12232 S.W. Garden Place, Tigard, OR 97223 Ph: 503-718-2323 Fax: 503-718-0333

Lab # A8J0135 COC 6 of 8

Company: GeoDesign — Project Mgr: STEVE NELSON — Project Name: — Project #: Opal Creek-1-02
Address: 15575 SW Sequoia Pkwy Ste 100 Portland, OR 97224 — Phone: 503 968 8787 — Fax: 503 968 3089 — Email: steve.nelson@geodesigninc.com
Sampled by: SCN/ESW

Site Location: OR WA Other: ____

ANALYSIS REQUEST

SAMPLE ID	LAB ID #	DATE	TIME	MATRIX	# OF CONTAINERS	NWTPH-HCID	NWTPH-Dx	NWTPH-Gx	BTEX	8260 HDPM VOCs	8260 Halo VOCs	8260 VOCs	8270 SIM PAHs	8082 PCBs	8081 Chlor. Pest	RCRA Metals (8)	Priority Metals (13)	Al, Sb, As, Ba, Be, Cd, Ca, Cr, Co, Cu, Fe, Pb, Mg, Mn, Mo, Ni, K, Se, Ag, Na, Tl, V, Zn	TCLP Metals (8)	1200-COLS	1200-Z	TAL 23 Total	TAL 23 Dissolved *
PW-MS-14	51	10/8	1146	W	1																		X
SW-MS-15	52		1225	W	1																	X	
SED-MS-15	53		1225	S	1																	X	
PW-MS-15	54		1225	W	1																		X
SW-MS-16	55		1255	W	1																	X	
SED-MS-16	56		1255	S	1																	X	
PW-MS-16	57		1255	W	1																		X
SW-MS-17	58		1350	W	1																	X	
SED-MS-17	59		1350	S	1																	X	
SW-MS-18	60		1355	W	1																	X	

Normal Turn Around Time (TAT) = 5-10 Business Days

TAT Requested (circle): 24 HR 48 HR 72 HR; 4 DAY 5 DAY Other: ____

SAMPLES ARE HELD FOR 30 DAYS

SPECIAL INSTRUCTIONS:
* ALL SAMPLES FOR DISSOLVED METALS HAVE BEEN FIELD FILTERED

RELINQUISHED BY:	RECEIVED BY:	RELINQUISHED BY:	RECEIVED BY:
Signature:	Signature:	Signature:	Signature:
Date: 10/13/08		Date:	
Time: 1445		Time:	
Printed Name: STEVE NELSON	Printed Name:	Printed Name:	Printed Name:
Company: GDI	Company: APEX	Company:	Company:

Apex Laboratories

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Philip Nerenberg, Lab Director

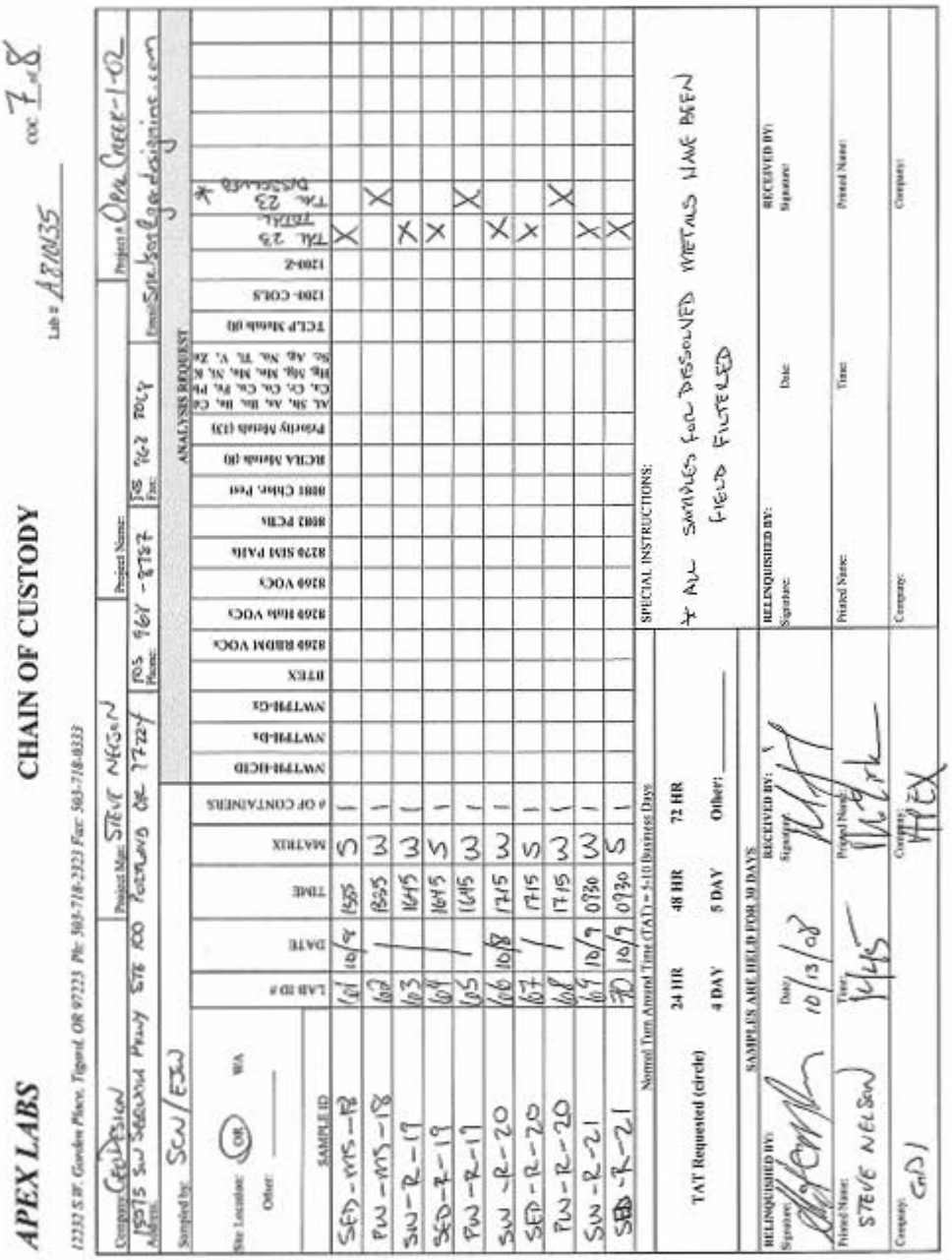
Apex Labs

12232 S.W. Garden Place
Tigard, OR 97223
503-718-2323 Phone
503-718-0333 Fax

GeoDesign, Inc.
15575 SW Sequoia Pkwy, Ste 100
Portland, OR 97224

Project: **Opal Creek**
Project Number: [none]
Project Manager: Steve Nelson

Reported:
10/31/08 16:48



APEX LABS

12232 S.W. Garden Place, Tigard, OR 97223 Ph: 503-718-2323 Fax: 503-718-0333

CHAIN OF CUSTODY

Lab # A810435 cc 7 of 8

Company: GeoDesign Project Mgr: Steve Nelson Project Name: Project #: Opal Creek-1-02

Address: 15575 SW Sequoia Pkwy Ste 100 Portland OR 97224 Phone: 503 968-8787 Fax: 503 968-8796 Email: steve.nelson@geodesigninc.com

Sampled by: SCW/ETW

Site Location: OR WA Other: ____

SAMPLE ID	LAB ID #	DATE	TIME	MATRIX	# OF CONTAINERS	NWTPH-HCID	NWTPH-Dx	NWTPH-Gx	BTEX	8260 RBDM VOCs	8260 HCs VOCs	8260 VOCs	8270 SIM PAHs	8082 PCBs	8081 Chlor. Pest	RCRA Metals (8)	Priority Metals (13)	Al, Sb, As, Ba, Be, Cd, Ca, Cr, Co, Cu, Fe, Pb, Mg, Mn, Mo, Ni, K, Se, Ag, Na, Tl, V, Zn	TCLP Metals (8)	1200-COLS	1200-2	TAL 23 Total	TAL 23 Dissolved *
SED-MW5-18	101	10/9	1505	S	1																	X	
PW-MW5-18	102		1525	W	1																		X
SW-R-19	103		1645	W	1																	X	
SED-R-19	104		1645	S	1																	X	
PW-R-19	105		1645	W	1																		X
SW-R-20	106	10/8	1715	W	1																	X	
SED-R-20	107		1715	S	1																	X	
PW-R-20	108		1715	W	1																		X
SW-R-21	109	10/9	0930	W	1																	X	
SED-R-21	110	10/9	0930	S	1																	X	

Normal Turn Around Time (TAT) = 5-10 Business Days

TAT Requested (circle): 24 HR 48 HR 72 HR; 4 DAY 5 DAY Other: ____

SAMPLES ARE HELD FOR 30 DAYS

SPECIAL INSTRUCTIONS:
* ALL SAMPLES FOR DISSOLVED METALS HAVE BEEN FIELD FILTERED

RELINQUISHED BY: Signature: Date: 10/13/08 Printed Name: STEVE NELSON Company: GDI

RECEIVED BY: Signature: Date: 10/13/08 Time: Printed Name: Company: APEX

RELINQUISHED BY: Signature: Date: Time: Printed Name: Company:

RECEIVED BY: Signature: Date: Time: Printed Name: Company:

Apex Laboratories

The results in this report apply to the samples analyzed in accordance with the chain of custody document. This analytical report must be reproduced in its entirety.

Philip Nerenberg, Lab Director

Apex Labs

GeoDesign, Inc.
15575 SW Sequoia Pkwy, Ste 100
Portland, OR 97224

Project: **Opal Creek**
Project Number: [none]
Project Manager: Steve Nelson

12232 S.W. Garden Place
Tigard, OR 97223
503-718-2323 Phone
503-718-0333 Fax

Reported:
10/31/08 16:48

APEX LABS — CHAIN OF CUSTODY

COC 8 of 8

Lab # A810135

12232 S.W. Garden Place, Tigard, OR 97223 Ph: 503-718-2323 Fax: 503-718-0333

Company: GEODESIGN | Project Mgr: STEVE NELSON | Project Name: | Project #: OPAL CREEK-1-02

Address: 15575 SW SEQUOIA PKWY STE 100 PORTLAND 97224 | Phone: 968 8787 | Fax: 968 8068 | Email: snelson@geodesigninc.com

Sampled by:

Site Location: (OR) WA
Other: _____

ANALYSIS REQUEST

SAMPLE ID	LAB ID #	DATE	TIME	MATRIX	# OF CONTAINERS	NWTPH-HCID	NWTPH-Dx	NWTPH-Gx	BTEX	8260 RBDM VOCs	8260 Halo VOCs	8260 VOCs	8270 SIM PAHs	8082 PCBs	8081 Chlor. Pest	RCRA Metals (8)	Priority Metals (13)	Al, Sb, As, Ba, Be, Cd, Ca, Cr, Co, Cu, Fe, Pb, Hg, Mg, Mn, Mo, Ni, K, Se, Ag, Na, Tl, V, Zn	TCLP Metals (8)	1200-COLS	1200-Z	TAL 23 TOTAL	TAL 23 DISSOLVED *					
SW-R-22	71	10/9	10/15 10/15	W	1																	X							
SED-R-22	72		10/15	S	1																	X							
PW-R-22	73		1015	W	1																		X						
SW-R-23	74		1100	W	1																	X							
SED-R-23	75		1100	S	1																	X							
PW-R-23	76		1100	W	1																		X						

Normal Turn Around Time (TAT) = 5-10 Business Days

TAT Requested (circle): 24 HR | 48 HR | 72 HR | 4 DAY | 5 DAY | Other: _____

SAMPLES ARE HELD FOR 30 DAYS

SPECIAL INSTRUCTIONS:
* FIELD FILTERED SAMPLES FOR DISSOLVED METALS

RELINQUISHED BY:	RECEIVED BY:	RELINQUISHED BY:	RECEIVED BY:
Signature:	Signature:	Signature:	Signature:
Date: 10/13/08		Date:	
Printed Name: STEVE NELSON	Printed Name:	Printed Name:	Printed Name:
Time: 12:45		Time:	
Company: GDI	Company: APEX	Company:	Company:

Apex Laboratories

The results in this report apply to the samples analyzed in accordance with the chain of custody document. This analytical report must be reproduced in its entirety.

Philip Nerenberg, Lab Director

GeoDesign Opal Creek Benthos 2008
Sort Report

EcoA Sample ID	Site	Sorter	Sort Date	Matrix	Pre-Rinse Volume (L)	Post-Rinse Volume (L)	Sorted Grids	Total Grids	Sort 1 Count	QC Sorter	QC Date	QC 1 Count	%Efficacy 1	%Efficacy 2
5242.1-1	BI-MS-14	Jen Bobier	11/13/08	coarse organic	0.26	0.03	6.00	6.00	143	Lori Robinson	11/13/08	4	89.94	N/A
5242.1-2	BI-MS-15	Rebecca Fritz	11/17/08	coarse organic	0.20	0.17	4.00	4.00	88	Jennifer Rideout	11/17/08	1	95.65	N/A
5242.1-3	BI-MS-16	Julie Blasinski	11/14/08	coarse organic	0.23	0.18	6.00	6.00	175	Jennifer Rideout	11/17/08	3	92.40	N/A
5242.1-4	BI-MS-18	Julie Blasinski	11/14/08	coarse organic	0.14	0.04	4.00	4.00	197	Jennifer Rideout	11/17/08	2	95.35	N/A
5242.1-5	BI-R-19	Julie Blasinski	11/15/08	coarse organic	0.10	0.10	5.75	6.00	535	Jennifer Rideout	11/17/08	2	98.24	N/A
5242.1-6	BI-R-20	Julie Blasinski	11/17/08	coarse organic	0.08	0.08	4.00	4.00	498	Jennifer Rideout	11/17/08	0	100.00	N/A
5242.1-7	BI-R-22	Desiree Hill	11/17/08	fine organic	0.30	0.15	6.00	6.00	285	Jennifer Rideout	11/17/08	0	100.00	N/A
5242.1-8	BI-R-23	Donna Mills	11/17/08	coarse organic	0.20	0.10	6.00	6.00	216	Jennifer Rideout	11/17/08	2	96.43	N/A

GeoDesign Opal Creek Benthos 2008
Data are NOT adjusted for subsampling

	Stream	**Battle Ax**	**Battle Ax**	**Battle Ax**	**Battle Ax**	**Battle Ax**	**Battle Ax**	**Battle Ax**	**Battle Ax**
	Site	**BI-MS-14**	**BI-MS-15**	**BI-MS-16**	**BI-MS-18**	**BI-R-19**	**BI-R-20**	**BI-R-22**	**BI-R-23**
	Date	**10-08-2008**	**10-08-2008**	**10-08-2008**	**10-08-2008**	**10-08-2008**	**10-08-2008**	**10-09-2008**	**10-09-2008**
	Device	**kick net**	**kick net**	**kick net**	**kick net**	**kick net**	**kick net**	**kick net**	**kick net**
	Habitat	**pool**	**riffle**	**pool**	**riffle**	**pool**	**riffle**	**pool**	**riffle**
	Percent Subsampled	**100.00**	**100.00**	**100.00**	**100.00**	**96.15**	**100.00**	**100.00**	**100.00**
	EcoAnalysts Sample ID	**5242.1-1**	**5242.1-2**	**5242.1-3**	**5242.1-4**	**5242.1-5**	**5242.1-6**	**5242.1-7**	**5242.1-8**
Ephemeroptera	Ameletus sp.	7	11	8	13	29	7	27	10
	Baetis sp.	0	6	0	0	0	0	0	0
	Baetis tricaudatus	27	0	20	18	50	178	36	35
	Caudatella hystrix	0	0	1	0	0	0	0	0
	Cinygmula sp.	7	1	2	0	10	4	5	6
	Diphetor hageni	0	0	0	0	1	0	0	0
	Drunella doddsi	5	2	5	18	21	84	9	17
	Drunella spinifera	3	0	2	2	7	4	2	2
	Epeorus grandis	0	0	0	2	0	5	3	0
	Epeorus sp.	0	0	1	0	0	0	0	0
	Ephemerella sp.	0	1	0	0	2	0	0	0
	Ironodes sp.	0	0	0	1	0	0	0	0
	Leptophlebiidae	2	1	1	0	8	4	3	3
	Rhithrogena sp.	16	0	1	39	4	25	8	19
Plecoptera	Calineuria californica	8	3	8	12	13	34	20	16
	Chloroperlidae	1	0	0	0	0	0	0	0
	Kathroperla sp.	0	0	0	2	0	1	0	1
	Kogotus/Rickera sp.	2	0	2	1	2	5	1	2
	Leuctridae	3	0	1	0	0	2	0	0
	Megarcys sp.	1	1	1	5	0	3	0	2
	Moselia infuscata	1	0	0	0	0	1	0	0
	Paraleuctra sp.	0	0	0	0	2	0	2	0
	Pteronarcys sp.	0	0	0	1	0	0	0	0
	Skwala sp.	2	0	3	5	5	9	8	2
	Sweltsa sp.	7	22	21	7	11	21	12	9
	Visoka cataractae	1	0	0	1	1	3	3	0
	Yoraperla sp.	9	0	2	6	6	6	7	4
	Zapada cinctipes	5	0	4	1	13	2	7	5
	Zapada columbiana	0	0	0	2	0	0	1	0
	Zapada frigida	0	0	0	0	0	0	1	1

Coleoptera	Heterlimnius sp.	4	0	2	1	8	0	6	3
	Narpus sp.	0	0	0	0	0	0	2	0
	Optioservus sp.	0	0	0	2	1	0	0	1
Megaloptera	Orohermes crepusculus	0	0	1	1	1	4	4	1
Diptera-Chironomidae	Boreochlus sp.	0	1	0	0	0	0	0	0
	Brillia sp.	0	4	2	2	1	0	1	1
	Chaetocladius sp.	0	0	0	1	0	0	0	0
	Corynoneura sp.	0	0	0	0	1	0	0	0
	Cricotopus (Nostoc.) nostocicola	0	0	0	0	0	1	0	0
	Diamesa sp.	1	0	0	0	0	0	0	0
	Dicrotendipes sp.	0	1	0	0	0	0	0	0
	Eukiefferiella sp.	0	1	0	0	1	1	0	0
	Limnophyes sp.	0	2	1	0	0	0	0	0
	Micropsectra sp.	0	0	23	1	15	5	13	2
	Orthocladius (Symp.) lignicola	0	1	0	0	0	0	0	0
	Orthocladius Complex	0	0	0	0	0	0	0	1
	Parametriocnemus sp.	0	2	0	0	1	2	0	0
	Parorthocladius sp.	1	0	1	0	5	1	0	1
	Polypedilum sp.	0	0	0	1	0	0	0	0
	Reomyia sp.	0	0	0	1	1	0	0	0
	Rheocricotopus sp.	0	0	0	0	1	0	0	2
	Smittia sp.	0	0	0	1	0	0	0	0
	Tanytarsus sp.	3	0	1	0	0	0	0	0
	Thienemanniella sp.	0	0	0	1	1	0	0	0
	Thienemannimyia gr. sp.	0	0	1	0	2	1	2	0
	Tvetenia bavarica gr.	2	0	1	0	4	5	1	2
Diptera	Bezzia/Palpomyia sp.	3	1	2	0	2	2	4	3
	Dicranota sp.	4	5	4	4	21	9	2	7
	Hesperoconopa sp.	1	0	0	0	0	0	0	0
	Hexatoma sp.	1	1	0	0	4	3	0	2
	Oreogeton sp.	2	0	0	0	2	0	2	1
	Pericoma/Telmatoscopus sp.	0	0	0	0	1	0	0	0
	Simulium sp.	0	0	0	1	1	0	0	5
	Tipula sp.	1	1	2	0	0	0	0	0
Trichoptera	Anagapetus sp.	0	1	0	5	0	6	1	3
	Arctopsyche grandis	0	0	0	0	0	0	0	1
	Ecclisomyia sp.	0	1	4	0	7	0	0	0
	Glossosoma sp.	1	0	0	1	0	2	3	0
	Hydatophylax sp.	0	1	0	0	1	0	0	0
	Lepidostoma sp.	0	0	26	1	235	17	24	11
	Limnephilidae	0	0	4	0	0	0	0	0
	Micrasema sp.	1	1	2	1	0	7	2	3

	Neophylax occidentis	0	0	0	3	0	5	4	11
	Parapsyche elsis	0	0	0	2	0	1	1	0
	Polycentropodidae	0	0	0	0	0	0	3	0
	Polycentropus sp.	2	1	1	0	2	2	0	1
	Rhyacophila arnaudi	0	0	0	0	0	0	0	1
	Rhyacophila betteni gr.	0	2	0	4	2	4	0	0
	Rhyacophila brunnea gr.	0	0	0	1	1	1	1	1
	Rhyacophila hyalinata gr.	1	0	0	1	1	4	0	0
	Rhyacophila narvae	9	1	2	0	4	5	6	5
Gastropoda	Menetus opercularis	0	0	0	0	0	0	2	1
	Pristinicola hemphilli	10	0	0	1	0	0	1	1
Annelida	Oligochaeta	4	0	0	6	8	2	57	1
Acari	Oribatei	0	0	0	0	0	0	1	0
	Protzia sp.	0	0	0	0	0	0	1	0
Other Organisms	Polycelis sp.	1	2	0	6	3	6	13	7
	TOTAL	**159**	**78**	**163**	**185**	**523**	**494**	**312**	**213**

GeoDesign Opal Creek Benthos 2008
Data are adjusted for subsampling

Stream	Battle Ax	Battle Ax	Battle Ax	Battle Ax	Battle Ax	Battle Ax	Battle Ax	Battle Ax
Site	BI-MS-14	BI-MS-15	BI-MS-16	BI-MS-18	BI-R-19	BI-R-20	BI-R-22	BI-R-23
Date	10-08-2008	10-08-2008	10-08-2008	10-08-2008	10-08-2008	10-08-2008	10-09-2008	10-09-2008
Device	kick net	kick net	kick net	kick net	kick net	kick net	kick net	kick net
Habitat	pool	riffle	pool	riffle	pool	riffle	pool	riffle
Percent Subsampled	100.00	100.00	100.00	100.00	96.15	100.00	100.00	100.00
EcoAnalysts Sample ID	5242.1-1	5242.1-2	5242.1-3	5242.1-4	5242.1-5	5242.1-6	5242.1-7	5242.1-8
Abundance Measures								
Corrected Abundance	159.00	78.00	163.00	185.00	543.92	494.00	312.00	213.00
EPT Abundance	121.00	56.00	122.00	155.00	455.52	452.00	200.00	171.00
Dominance Measures								
Dominant Taxon	Baetis tricaudatus	Sweltsa sp.	Lepidostoma sp.	Rhithrogena sp.	Lepidostoma sp.	Baetis tricaudatus	Oligochaeta	Baetis tricaudatus
Dominant Abundance	27.00	22.00	26.00	39.00	244.40	178.00	57.00	35.00
2nd Dominant Taxon	Rhithrogena sp.	Ameletus sp.	Micropsectra sp.	Drunella doddsi	Baetis tricaudatus	Drunella doddsi	Baetis tricaudatus	Rhithrogena sp.
2nd Dominant Abundance	16.00	11.00	23.00	18.00	52.00	84.00	36.00	19.00
3rd Dominant Taxon	Pristinicola hemphilli	Baetis sp.	Sweltsa sp.	Baetis tricaudatus	Ameletus sp.	Calineuria californica	Ameletus sp.	Drunella doddsi
3rd Dominant Abundance	10.00	6.00	21.00	18.00	30.16	34.00	27.00	17.00
% Dominant Taxon	16.98	28.21	15.95	21.08	44.93	36.03	18.27	16.43
% 2 Dominant Taxa	27.04	42.31	30.06	30.81	54.49	53.04	29.81	25.35
% 3 Dominant Taxa	33.33	50.00	42.94	40.54	60.04	59.92	38.46	33.33
Richness Measures								
Species Richness	37.00	28.00	35.00	42.00	47.00	43.00	43.00	43.00
EPT Richness	23.00	16.00	23.00	27.00	25.00	30.00	27.00	25.00
Ephemeroptera Richness	7.00	6.00	9.00	7.00	9.00	8.00	8.00	7.00
Plecoptera Richness	11.00	3.00	8.00	11.00	8.00	11.00	10.00	9.00
Trichoptera Richness	5.00	7.00	6.00	9.00	8.00	11.00	9.00	9.00
Chironomidae Richness	4.00	7.00	7.00	7.00	11.00	7.00	4.00	6.00
Oligochaeta Richness	1.00	0.00	0.00	1.00	1.00	1.00	1.00	1.00
Non-Chiro. Non-Olig. Richness	32.00	21.00	28.00	34.00	35.00	35.00	38.00	36.00
Rhyacophila Richness	2.00	2.00	1.00	3.00	4.00	4.00	2.00	3.00
Community Composition								
% Ephemeroptera	42.14	28.21	25.15	50.27	25.24	62.96	29.81	43.19
% Plecoptera	25.16	33.33	25.77	23.24	10.13	17.61	19.87	19.72
% Trichoptera	8.81	10.26	23.93	10.27	48.37	10.93	14.42	17.37
% EPT	76.10	71.79	74.85	83.78	83.75	91.50	64.10	80.28
% Coleoptera	2.52	0.00	1.23	1.62	1.72	0.00	2.56	1.88
% Diptera	11.95	25.64	23.31	7.03	12.24	6.07	8.01	12.68
% Oligochaeta	2.52	0.00	0.00	3.24	1.53	0.40	18.27	0.47
% Baetidae	16.98	7.69	12.27	9.73	9.75	36.03	11.54	16.43
% Brachycentridae	0.63	1.28	1.23	0.54	0.00	1.42	0.64	1.41
% Chironomidae	4.40	15.38	18.40	4.32	6.31	3.24	5.45	4.23

% Ephemerellidae	5.03	3.85	4.91	10.81	5.74	17.81	3.53	8.92
% Hydropsychidae	0.00	0.00	0.00	1.08	0.00	0.20	0.32	0.47
% Odonata	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
% Perlidae	5.03	3.85	4.91	6.49	2.49	6.88	6.41	7.51
% Pteronarcyidae	0.00	0.00	0.00	0.54	0.00	0.00	0.00	0.00
% Simuliidae	0.00	0.00	0.00	0.54	0.19	0.00	0.00	2.35
Functional Group Composition								
% Filterers	1.89	0.00	0.61	0.54	0.19	0.00	0.96	2.82
% Gatherers	30.82	35.90	38.04	23.78	27.34	41.70	46.47	28.64
% Predators	27.67	50.00	27.61	26.49	14.53	22.27	23.72	27.70
% Scrapers	20.13	5.13	6.75	39.46	8.22	27.33	11.86	28.17
% Shredders	13.21	8.97	26.38	8.65	49.52	7.89	15.38	11.74
% Piercer-Herbivores	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
% Unclassified	6.29	0.00	0.61	1.08	0.19	0.81	1.60	0.94
Filterer Richness	1.00	0.00	1.00	1.00	1.00	0.00	1.00	2.00
Gatherer Richness	9.00	11.00	10.00	9.00	17.00	10.00	8.00	11.00
Predator Richness	14.00	10.00	10.00	12.00	16.00	16.00	14.00	14.00
Scraper Richness	5.00	3.00	5.00	9.00	5.00	8.00	9.00	8.00
Shredder Richness	7.00	4.00	8.00	9.00	7.00	8.00	9.00	6.00
Piercer-Herbivore Richness	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unclassified	1.00	0.00	1.00	2.00	1.00	1.00	2.00	2.00
Diversity/Evenness Measures								
Shannon-Weaver H' (log 10)	1.36	1.17	1.25	1.32	1.06	1.10	1.33	1.38
Shannon-Weaver H' (log 2)	4.52	3.90	4.15	4.38	3.51	3.67	4.42	4.59
Shannon-Weaver H' (log e)	3.13	2.70	2.88	3.04	2.43	2.54	3.07	3.18
Margalef's Richness	7.10	6.20	6.67	7.85	7.30	6.77	7.31	7.83
Pielou's J'	0.87	0.81	0.81	0.81	0.63	0.68	0.82	0.85
Simpson's Heterogeneity	0.94	0.89	0.92	0.92	0.78	0.83	0.93	0.94
Biotic Indices								
% Indiv. w/ HBI Value	91.82	98.72	98.16	98.38	99.24	98.79	96.47	97.65
Hilsenhoff Biotic Index	2.13	2.03	2.58	1.69	1.92	2.30	3.33	2.21
% Indiv. w/ MTI Value	74.21	57.69	78.53	83.78	90.82	87.65	62.82	77.46
Metals Tolerance Index	2.49	2.40	2.02	2.03	1.69	2.82	2.20	2.50
% Indiv. w/ FSBI Value	75.47	75.64	58.28	82.70	42.83	86.23	56.41	78.87
Fine Sediment Biotic Index	103.00	71.00	104.00	132.00	120.00	124.00	117.00	116.00
FSBI - average	2.78	2.54	2.97	3.14	2.55	2.88	2.72	2.70
FSBI - weighted average	4.88	4.17	4.76	5.42	4.75	5.39	4.85	5.02
% Indiv. w/ TPM Value	80.50	69.23	74.23	85.95	84.32	91.50	65.71	84.04
Temp. Pref. Metric - average	4.65	3.64	4.09	4.64	4.11	4.79	4.51	4.19
TPM - weighted average	6.35	6.74	5.73	6.48	5.49	5.94	5.80	6.06
Karr BIBI Metrics								
Long-Lived Taxa Richness	11.00	5.00	8.00	11.00	8.00	10.00	10.00	8.00
Clinger Richness	23.00	14.00	22.00	28.00	25.00	26.00	26.00	25.00
% Clingers	77.99	69.23	70.55	83.78	41.49	86.03	60.90	77.46
Intolerant Taxa Richness	22.00	14.00	19.00	24.00	22.00	27.00	23.00	22.00

% Tolerant Individuals	2.74	0.00	0.00	3.30	1.48	0.41	18.94	0.48
% Tolerant Taxa	2.70	7.14	2.86	2.38	2.13	2.33	2.33	2.33
Coleoptera Richness	1.00	0.00	1.00	2.00	2.00	0.00	2.00	2.00

Apex Labs

12232 S.W. Garden Place
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503-718-2323 Phone
503-718-0333 Fax

Friday, August 14, 2009

Steve Nelson
GeoDesign, Inc.
15575 SW Sequoia Pkwy, Ste 100
Portland, OR 97224

RE: Opal Creek / [none]

Enclosed are the results of analyses for work order A907201, which was received by the laboratory on 7/27/2009 at 10:30:00AM.

Thank you for using Apex Labs. We appreciate your business and strive to provide the highest quality services to the environmental industry.

If you have any questions concerning this report or the services we offer, please feel free to contact me by email at: pnerenberg@apex-labs.com, or by phone at 503-718-2323.

Apex Laboratories

Philip Nerenberg, Lab Director

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	08/14/09 16:46

ANALYTICAL REPORT FOR SAMPLES

SAMPLE INFORMATION

Sample ID	Laboratory ID	Matrix	Date Sampled	Date Received
AW-MS-2	A907201-01	Water	07/24/09 10:30	07/27/09 10:30
AW-MS-2-DISS	A907201-02	Water	07/24/09 10:35	07/27/09 10:30
SW-MS-17-2	A907201-03	Water	07/24/09 11:00	07/27/09 10:30
SW-MS-17-2-DISS	A907201-04	Water	07/24/09 11:05	07/27/09 10:30
AW-R-4-2	A907201-05	Water	07/24/09 11:55	07/27/09 10:30
AW-R-4-2-DISS	A907201-06	Water	07/24/09 12:00	07/27/09 10:30
AW-R-5-2	A907201-07	Water	07/24/09 12:40	07/27/09 10:30
AW-R-5-2-DISS	A907201-08	Water	07/24/09 12:45	07/27/09 10:30
SW-R-24	A907201-09	Water	07/24/09 13:30	07/27/09 10:30
SW-R-24-DISS	A907201-10	Water	07/24/09 13:35	07/27/09 10:30

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	08/14/09 16:46

ANALYTICAL CASE NARRATIVE

Work Order: A907201

In all cases where a dissolved metal result is greater than a total metal result, precision criteria is acceptable in that results are either less than five times the MRL or the total/ dissolved relative percent difference (RPD) is less than 20%.

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	08/14/09 16:46

ANALYTICAL SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
AW-MS-2 (A907201-01)			**Matrix: Water**					
Arsenic	**5.17**	---	1.00	ug/L	1	08/06/09 16:04	EPA 6020	
Barium	ND	---	1.00	"	"	"	"	
Cadmium	ND	---	1.00	"	"	"	"	
Calcium	**12500**	---	500	"	5	08/07/09 11:14	"	
Copper	ND	---	4.00	"	1	08/06/09 16:04	"	
Lead	**2.11**	---	1.00	"	"	"	"	
Magnesium	**254**	---	100	"	"	"	"	
Zinc	**38.4**	---	4.00	"	"	"	"	
Hardness (Calc by 6020)	**32.2**	---	1.66	mg CaCO3/L	5	08/07/09 11:14	Calc	
SW-MS-17-2 (A907201-03)			**Matrix: Water**					
Arsenic	ND	---	1.00	ug/L	1	08/06/09 16:14	EPA 6020	
Barium	**1.20**	---	1.00	"	"	"	"	
Cadmium	ND	---	1.00	"	"	"	"	
Calcium	**5230**	---	100	"	"	"	"	
Copper	ND	---	4.00	"	"	"	"	
Lead	ND	---	1.00	"	"	"	"	
Magnesium	**528**	---	100	"	"	"	"	
Zinc	**11.9**	---	4.00	"	"	"	"	
Hardness (Calc by 6020)	**15.2**	---	0.662	mg CaCO3/L	"	"	Calc	
AW-R-4-2 (A907201-05)			**Matrix: Water**					
Arsenic	ND	---	1.00	ug/L	1	08/06/09 16:17	EPA 6020	
Barium	**10.6**	---	1.00	"	"	"	"	
Cadmium	**35.0**	---	1.00	"	"	"	"	
Calcium	**69000**	---	2000	"	20	08/07/09 11:17	"	
Copper	**7.27**	---	4.00	"	1	08/06/09 16:17	"	
Lead	**27.1**	---	1.00	"	"	"	"	
Magnesium	**1350**	---	100	"	"	"	"	
Zinc	**6670**	---	80.0	"	20	08/07/09 11:17	"	
Hardness (Calc by 6020)	**178**	---	5.41	mg CaCO3/L	"	"	Calc	
AW-R-5-2 (A907201-07)			**Matrix: Water**					
Arsenic	ND	---	1.00	ug/L	1	08/06/09 16:20	EPA 6020	
Barium	**4.11**	---	1.00	"	"	"	"	
Cadmium	**4.99**	---	1.00	"	"	"	"	
Calcium	**42900**	---	500	"	5	08/07/09 11:20	"	
Copper	ND	---	4.00	"	1	08/06/09 16:20	"	

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	08/14/09 16:46

ANALYTICAL SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
AW-R-5-2 (A907201-07)			**Matrix: Water**					
Lead	ND	---	1.00	ug/L	1	"	EPA 6020	
Magnesium	**1020**	---	100	"	"	"	"	
Zinc	**1550**	---	20.0	"	5	08/07/09 11:20	"	
Hardness (Calc by 6020)	**111**	---	1.66	mg CaCO3/L	"	"	Calc	
SW-R-24 (A907201-09)			**Matrix: Water**					
Arsenic	ND	---	1.00	ug/L	1	08/06/09 16:23	EPA 6020	
Barium	**4.47**	---	1.00	"	"	"	"	
Cadmium	**5.00**	---	1.00	"	"	"	"	
Calcium	**43200**	---	500	"	5	08/07/09 11:23	"	
Copper	ND	---	4.00	"	1	08/06/09 16:23	"	
Lead	ND	---	1.00	"	"	"	"	
Magnesium	**1000**	---	100	"	"	"	"	
Zinc	**1520**	---	20.0	"	5	08/07/09 11:23	"	
Hardness (Calc by 6020)	**112**	---	1.66	mg CaCO3/L	"	"	Calc	

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	08/14/09 16:46

ANALYTICAL SAMPLE RESULTS

Dissolved Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
AW-MS-2-DISS (A907201-02)			**Matrix: Water**					
Arsenic	**5.61**	---	1.00	ug/L	1	07/31/09 17:13	EPA 6020 (Diss)	
Barium	ND	---	1.00	"	"	"	"	
Cadmium	ND	---	1.00	"	"	"	"	
Calcium	**12000**	---	500	"	5	07/31/09 17:38	"	
Copper	ND	---	4.00	"	1	07/31/09 17:13	"	
Lead	**1.74**	---	1.00	"	"	"	"	
Magnesium	**260**	---	100	"	"	"	"	
Zinc	**35.9**	---	4.00	"	"	"	"	
Hardness (Calc by 6020) - Dissolved	**31.0**	---	1.66	mg CaCO3/L	5	07/31/09 17:38	CALC	
SW-MS-17-2-DISS (A907201-04)			**Matrix: Water**					
Arsenic	**1.41**	---	1.00	ug/L	1	07/31/09 17:22	EPA 6020 (Diss)	
Barium	**1.47**	---	1.00	"	"	"	"	
Cadmium	ND	---	1.00	"	"	"	"	
Calcium	**5470**	---	100	"	"	"	"	
Copper	ND	---	4.00	"	"	"	"	
Lead	ND	---	1.00	"	"	"	"	
Magnesium	**540**	---	100	"	"	"	"	
Zinc	**13.5**	---	4.00	"	"	"	"	
Hardness (Calc by 6020) - Dissolved	**15.9**	---	0.662	mg CaCO3/L	"	"	CALC	
AW-R-4-2-DISS (A907201-06)			**Matrix: Water**					
Arsenic	ND	---	1.00	ug/L	1	07/31/09 17:25	EPA 6020 (Diss)	
Barium	**11.0**	---	1.00	"	"	"	"	
Cadmium	**36.3**	---	1.00	"	"	"	"	
Calcium	**67200**	---	2000	"	20	07/31/09 17:53	"	
Copper	**5.18**	---	4.00	"	1	07/31/09 17:25	"	
Lead	**22.3**	---	1.00	"	"	"	"	
Magnesium	**1360**	---	100	"	"	"	"	
Zinc	**6440**	---	80.0	"	20	07/31/09 17:53	"	
Hardness (Calc by 6020) - Dissolved	**173**	---	5.41	mg CaCO3/L	"	"	CALC	
AW-R-5-2-DISS (A907201-08)			**Matrix: Water**					
Arsenic	ND	---	1.00	ug/L	1	07/31/09 17:28	EPA 6020 (Diss)	
Barium	**4.50**	---	1.00	"	"	"	"	
Cadmium	**5.38**	---	1.00	"	"	"	"	

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	08/14/09 16:46

ANALYTICAL SAMPLE RESULTS

Dissolved Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dilution	Date Analyzed	Method	Notes
AW-R-5-2-DISS (A907201-08)			**Matrix: Water**					
Calcium	**41800**	---	500	ug/L	5	07/31/09 17:56	EPA 6020 (Diss)	
Copper	ND	---	4.00	"	1	07/31/09 17:28	"	
Lead	ND	---	1.00	"	"	"	"	
Magnesium	**1010**	---	100	"	"	"	"	
Zinc	**1510**	---	20.0	"	5	07/31/09 17:56	"	
Hardness (Calc by 6020) - Dissolved	**109**	---	1.66	mg CaCO3/L	"	"	CALC	
SW-R-24-DISS (A907201-10)			**Matrix: Water**					
Arsenic	ND	---	1.00	ug/L	1	07/31/09 17:31	EPA 6020 (Diss)	
Barium	**4.83**	---	1.00	"	"	"	"	
Cadmium	**5.20**	---	1.00	"	"	"	"	
Calcium	**41500**	---	500	"	5	07/31/09 17:59	"	
Copper	ND	---	4.00	"	1	07/31/09 17:31	"	
Lead	ND	---	1.00	"	"	"	"	
Magnesium	**1000**	---	100	"	"	"	"	
Zinc	**1430**	---	20.0	"	5	07/31/09 17:59	"	
Hardness (Calc by 6020) - Dissolved	**108**	---	1.66	mg CaCO3/L	"	"	CALC	

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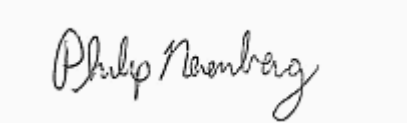
GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	08/14/09 16:46

QUALITY CONTROL (QC) SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 9080060 - EPA 3015							**Water**					
Blank (9080060-BLK1)					Prepared: 08/05/09 13:05		Analyzed: 08/06/09 15:58					
EPA 6020												
Arsenic	ND	---	1.00	ug/L	1	---	---	---	---	---	---	
Barium	ND	---	1.00	"	"	---	---	---	---	---	---	
Cadmium	ND	---	1.00	"	"	---	---	---	---	---	---	
Calcium	ND	---	100	"	"	---	---	---	---	---	---	
Copper	ND	---	4.00	"	"	---	---	---	---	---	---	
Lead	ND	---	1.00	"	"	---	---	---	---	---	---	
Magnesium	ND	---	100	"	"	---	---	---	---	---	---	
Zinc	ND	---	4.00	"	"	---	---	---	---	---	---	
LCS (9080060-BS1)					Prepared: 08/05/09 13:05		Analyzed: 08/06/09 16:01					
EPA 6020												
Arsenic	55.9	---	1.00	ug/L	1	55.6	---	101	80-120%	---	---	
Barium	55.5	---	1.00	"	"	"	---	100	"	---	---	
Cadmium	54.2	---	1.00	"	"	"	---	98	"	---	---	
Calcium	5370	---	100	"	"	5560	---	97	"	---	---	
Copper	54.2	---	4.00	"	"	55.6	---	98	"	---	---	
Lead	54.8	---	1.00	"	"	"	---	99	"	---	---	
Magnesium	5510	---	100	"	"	5560	---	99	"	---	---	
Zinc	54.7	---	4.00	"	"	55.6	---	98	"	---	---	
Matrix Spike (9080060-MS2)					Prepared: 08/05/09 13:05		Analyzed: 08/06/09 16:26					
QC Source Sample: SW-R-24 (A907201-09)												
EPA 6020												
Arsenic	55.6	---	1.00	ug/L	1	55.6	0.678	99	75-125%	---	---	
Barium	61.0	---	1.00	"	"	"	4.47	102	"	---	---	
Cadmium	59.6	---	1.00	"	"	"	5.00	98	"	---	---	
Copper	55.6	---	4.00	"	"	"	2.14	96	"	---	---	
Lead	56.0	---	1.00	"	"	"	0.633	100	"	---	---	
Magnesium	6410	---	100	"	"	5560	1000	97	"	---	---	
Matrix Spike (9080060-MS4)					Prepared: 08/05/09 13:05		Analyzed: 08/07/09 11:26					
QC Source Sample: SW-R-24 (A907201-09)												
EPA 6020												
Calcium	48700	---	500	ug/L	5	5560	43200	99	75-125%	---	---	Q-16

Apex Laboratories



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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	08/14/09 16:46

QUALITY CONTROL (QC) SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 9080060 - EPA 3015							**Water**					
Matrix Spike (9080060-MS4)						Prepared: 08/05/09 13:05	Analyzed: 08/07/09 11:26					
QC Source Sample: SW-R-24 (A907201-09)												
Zinc	1560	---	20.0	ug/L	"	55.6	1520	73	"	---	---	Q-03, Q-16

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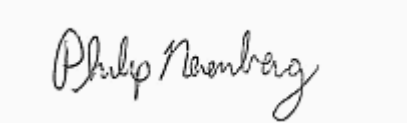

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	08/14/09 16:46

QUALITY CONTROL (QC) SAMPLE RESULTS

Dissolved Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 9070472 - EPA 3015 - Dissolved							**Water**					
Blank (9070472-BLK1)					Prepared: 07/31/09 12:06		Analyzed: 07/31/09 16:51					
EPA 6020 (Diss)												
Arsenic	ND	---	1.00	ug/L	1	---	---	---	---	---	---	B-02
Barium	ND	---	1.00	"	"	---	---	---	---	---	---	B-02
Cadmium	ND	---	1.00	"	"	---	---	---	---	---	---	
Calcium	ND	---	100	"	"	---	---	---	---	---	---	B-02
Copper	ND	---	4.00	"	"	---	---	---	---	---	---	
Lead	ND	---	1.00	"	"	---	---	---	---	---	---	
Magnesium	ND	---	100	"	"	---	---	---	---	---	---	
Zinc	ND	---	4.00	"	"	---	---	---	---	---	---	B-02
Blank (9070472-BLK2)					Prepared: 07/31/09 12:06		Analyzed: 07/31/09 16:58					
EPA 6020 (Diss)												
Arsenic	ND	---	1.00	ug/L	1	---	---	---	---	---	---	B-02
Barium	ND	---	1.00	"	"	---	---	---	---	---	---	
Cadmium	ND	---	1.00	"	"	---	---	---	---	---	---	
Calcium	ND	---	100	"	"	---	---	---	---	---	---	
Copper	ND	---	4.00	"	"	---	---	---	---	---	---	
Lead	ND	---	1.00	"	"	---	---	---	---	---	---	
Magnesium	ND	---	100	"	"	---	---	---	---	---	---	
Zinc	ND	---	4.00	"	"	---	---	---	---	---	---	
LCS (9070472-BS1)					Prepared: 07/31/09 12:06		Analyzed: 07/31/09 17:01					
EPA 6020 (Diss)												
Arsenic	55.5	---	1.00	ug/L	1	55.6	---	100	80-120%	---	---	
Barium	57.4	---	1.00	"	"	"	---	103	"	---	---	
Cadmium	56.0	---	1.00	"	"	"	---	101	"	---	---	
Calcium	5610	---	100	"	"	5560	---	101	"	---	---	
Copper	55.7	---	4.00	"	"	55.6	---	100	"	---	---	
Lead	56.9	---	1.00	"	"	"	---	102	"	---	---	
Magnesium	5550	---	100	"	"	5560	---	100	"	---	---	
Zinc	52.5	---	4.00	"	"	55.6	---	94	"	---	---	
Duplicate (9070472-DUP1)					Prepared: 07/31/09 12:06		Analyzed: 07/31/09 17:16					
QC Source Sample: AW-MS-2-DISS (A907201-02)												
EPA 6020 (Diss)												
Arsenic	**5.72**	---	1.00	ug/L	1	---	5.61	---	---	2	20%	

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	08/14/09 16:46

QUALITY CONTROL (QC) SAMPLE RESULTS

Dissolved Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 9070472 - EPA 3015 - Dissolved							**Water**					
Duplicate (9070472-DUP1)					Prepared: 07/31/09 12:06		Analyzed: 07/31/09 17:16					
QC Source Sample: AW-MS-2-DISS (A907201-02)												
Barium	ND	---	1.00	ug/L	"	---	ND	---	---	---	20%	
Cadmium	ND	---	1.00	"	"	---	ND	---	---	---	20%	
Copper	ND	---	4.00	"	"	---	ND	---	---	---	20%	Q-05
Lead	**1.78**	---	1.00	"	"	---	1.74	---	---	2	20%	
Magnesium	**262**	---	100	"	"	---	260	---	---	0.7	20%	
Zinc	**35.7**	---	4.00	"	"	---	35.9	---	---	0.6	20%	
Duplicate (9070472-DUP2)					Prepared: 07/31/09 12:06		Analyzed: 07/31/09 17:47					
QC Source Sample: AW-MS-2-DISS (A907201-02)												
EPA 6020 (Diss)												
Calcium	**11900**	---	500	ug/L	5	---	12000	---	---	1	20%	Q-16
Matrix Spike (9070472-MS1)					Prepared: 07/31/09 12:06		Analyzed: 07/31/09 17:19					
QC Source Sample: AW-MS-2-DISS (A907201-02)												
EPA 6020 (Diss)												
Arsenic	62.1	---	1.00	ug/L	1	55.6	5.61	102	75-125%	---	---	
Barium	59.7	---	1.00	"	"	"	0.467	107	"	---	---	
Cadmium	58.3	---	1.00	"	"	"	0.333	104	"	---	---	
Copper	56.5	---	4.00	"	"	"	0.311	101	"	---	---	
Lead	59.5	---	1.00	"	"	"	1.74	104	"	---	---	
Magnesium	5720	---	100	"	"	5560	260	98	"	---	---	
Zinc	87.4	---	4.00	"	"	55.6	35.9	93	"	---	---	
Matrix Spike (9070472-MS2)					Prepared: 07/31/09 12:06		Analyzed: 07/31/09 17:50					
QC Source Sample: AW-MS-2-DISS (A907201-02)												
EPA 6020 (Diss)												
Calcium	17000	---	500	ug/L	5	5560	12000	91	75-125%	---	---	Q-16

Apex Laboratories

Philip Nerenberg, Lab Director

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Tigard, OR 97223
503-718-2323 Phone
503-718-0333 Fax

GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	08/14/09 16:46

SAMPLE PREPARATION INFORMATION

Total Metals by EPA 6020 (ICPMS)

Prep: EPA 3015

Lab Number	Matrix	Method	Sampled	Prepared	Sample Initial/Final	Default Initial/Final	RL Prep Factor
Batch: 9080060							
A907201-01	Water	EPA 6020	07/24/09 10:30	08/05/09 13:05	45mL/50mL	45mL/50mL	1.00
A907201-03	Water	EPA 6020	07/24/09 11:00	08/05/09 13:05	45mL/50mL	45mL/50mL	1.00
A907201-05	Water	EPA 6020	07/24/09 11:55	08/05/09 13:05	45mL/50mL	45mL/50mL	1.00
A907201-07	Water	EPA 6020	07/24/09 12:40	08/05/09 13:05	45mL/50mL	45mL/50mL	1.00
A907201-09	Water	EPA 6020	07/24/09 13:30	08/05/09 13:05	45mL/50mL	45mL/50mL	1.00

Dissolved Metals by EPA 6020 (ICPMS)

Prep: EPA 3015 - Dissolved

Lab Number	Matrix	Method	Sampled	Prepared	Sample Initial/Final	Default Initial/Final	RL Prep Factor
Batch: 9070472							
A907201-02	Water	EPA 6020 (Diss)	07/24/09 10:35	07/31/09 12:06	45mL/50mL	45mL/50mL	1.00
A907201-04	Water	EPA 6020 (Diss)	07/24/09 11:05	07/31/09 12:06	45mL/50mL	45mL/50mL	1.00
A907201-06	Water	EPA 6020 (Diss)	07/24/09 12:00	07/31/09 12:06	45mL/50mL	45mL/50mL	1.00
A907201-08	Water	EPA 6020 (Diss)	07/24/09 12:45	07/31/09 12:06	45mL/50mL	45mL/50mL	1.00
A907201-10	Water	EPA 6020 (Diss)	07/24/09 13:35	07/31/09 12:06	45mL/50mL	45mL/50mL	1.00

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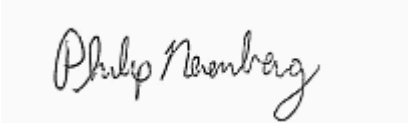

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GeoDesign, Inc.	Project: **Opal Creek**	
15575 SW Sequoia Pkwy, Ste 100	Project Number: [none]	**Reported:**
Portland, OR 97224	Project Manager: Steve Nelson	08/14/09 16:46

Notes and Definitions

Qualifiers:

B-02	Analyte detected in the extraction blank at a level below the MRL, but greater than one-half the MRL.
Q-03	The Percent Recovery and/or RPD for this QC Spike Sample is out of control due to the high concentration of analyte present in the sample.
Q-05	Analyses are not controlled on RPD values from sample or duplicate concentrations near or below the reporting level.
Q-16	Reanalysis of an original Batch QC sample.

Notes and Conventions:

DET	Analyte DETECTED
ND	Analyte NOT DETECTED at or above the reporting limit
NR	Not Reported
dry	Sample results reported on a dry weight basis. Results listed as 'wet' or without 'dry'designation are not dry weight corrected.
RPD	Relative Percent Difference
MDL	If MDL is not listed, data has been evaluated to the Method Reporting Limit only.
WMSC	Water Miscible Solvent Correction has been applied to Results and MRLs for volatiles soil samples per EPA 8000C.
Batch QC	Unless specifically requested, this report contains only results for Batch QC derived from client samples included in this report. All analyses were performed with the appropriate Batch QC (including Sample Duplicates, Matrix Spikes and/or Matrix Spike Duplicates) in order to meet or exceed method and regulatory requirements. Any exceptions to this will be qualified in this report. Complete Batch QC results are available upon request. In cases where there is insufficient sample provided for Sample Duplicates and/or Matrix Spikes, a Lab Control Sample Duplicate (LCS Dup) is analyzed to demonstrate accuracy and precision of the extraction and analysis.

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GeoDesign, Inc.
15575 SW Sequoia Pkwy, Ste 100
Portland, OR 97224

Project: **Opal Creek**
Project Number: [none]
Project Manager: Steve Nelson

Reported:
08/14/09 16:46

APEX LABS — CHAIN OF CUSTODY

12232 S.W. Garden Place, Tigard, OR 97223 Ph: 503-718-2323 Fax: 503-718-0333

Lab # A 907201 COC 1 of 1

Company: GEODESIGN | Project Mgr: STEVE NELSON | Project Name: | Project #:
Address: | Phone: 503 968 8787 | Fax: 503 968 3068 | Email: snelson@geodesigninc.com
Sampled by: SCN

Site Location: (OR) WA
Other: _____

ANALYSIS REQUEST

SAMPLE ID	LAB ID #	DATE	TIME	MATRIX	# OF CONTAINERS	NWTPH-HCID	NWTPH-Dx	NWTPH-Gx	BTEX	8260 RBDM VOCs	8260 Halo VOCs	8260 VOCs	8270 SIM PAHs	8082 PCBs	8081 Chlor. Pest	RCRA Metals (8)	Priority Metals (13)	TCLP Metals (8)	1200- COLS	1200-Z
AW-MS-2	1	7/24	1030	W	1															
AW-MS-2-DISS	2		1035	W	1															
SW-MS-17-2	3		1100	W	1															
SW-MS-17-2-DISS	4		1105	W	1															
AW-R-4-2	5		1155	W	1															
AW-R-4-2-DISS	6		1200	W	1															
AW-R-5-2	7		1240	W	1															
AW-R-5-2-DISS	8		1245	W	1															
SW-R-24	9		1330	W	1															
SW-R-24-DISS	10		1335	W	1															

Normal Turn Around Time (TAT) = 5-10 Business Days

TAT Requested (circle): 24 HR | 48 HR | 72 HR | 4 DAY | 5 DAY | Other: _____

SAMPLES ARE HELD FOR 30 DAYS

SPECIAL INSTRUCTIONS:
- HARDNESS
- TOTALS
- DISSOLVED

RELINQUISHED BY:	RECEIVED BY:	RELINQUISHED BY:	RECEIVED BY:
Signature:	Signature:	Signature:	Signature:
Date: 7/27		Date:	
Printed Name: STEVE NELSON	Printed Name: Kendra Hinckley	Printed Name:	Printed Name:
Time: 1030		Time:	
Company: GEODESIGN	Company: Apex	Company:	Company:

Apex Laboratories

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Philip Nerenberg, Lab Director

APPENDIX G

GEODESIGN INC

November 17, 2009

Opal Creek Ancient Forest Center
c/o Perkins Coie, LLP
1120 NW Couch Street, Tenth Floor
Portland, OR 97209-4128

Attention: Mr. Christopher Rich

Report of Slope Stability Evaluation
Ruth Mine - Opal Creek Scenic and Recreation Area
Willamette National Forest
Marion County, Oregon
GeoDesign Project: OpalCreek-1-03

INTRODUCTION

GeoDesign, Inc. is pleased to present this report summarizing our slope stability evaluation of the Ruth Mine. The Ruth Mine site is located on the south side of Battle Ax Creek along Ruth Creek in the western half of Section 27 of Township 8 South, Range 5 East in Marion County, Oregon. The site lies within the Opal Creek Scenic and Recreation Area of the Willamette National Forest that is administered by the U.S. Forest Service. The Ruth Mine is approximately 1 mile east of Jawbone Flats, a historical mining camp. The elevations of the Ruth Mine workings range from approximately 2,450 to 2,650 feet above mean sea level (MSL). The Ruth Mine site is shown relative to the surrounding vicinity on Figure 1.

Our evaluation of the Ruth Mine was limited to the 4th and 5th levels, as shown on Figure 2. The map shown on this figure shows the development in the Ruth Mine area in 1935, near the height of mining activity (George and Weber, 1985). Today, only closed mine openings and adits, access roads, scattered remnants of wooden structures and mining equipment including narrow gauge mine car tracks, and waste rock piles can be found on the site. Forest Road 2209 (labeled Road to Mehama) is located between the two mine levels as shown on Figure 2.

This report summarizes our findings regarding the potential for mass wasting of the mine waste material in the area of the 4th and 5th levels. This report also presents potential options for mitigating mass wasting.

MASS WASTING EVALUATION

Mass wasting is a general term that encompasses all forms of down-slope movement of soil and rock material. It includes mechanisms such as landsliding, soil creep, debris flows, surficial erosion, and rock fall, all of which influence the stability of sloping ground. Mass wasting of the waste rock material at the 4th level of the Ruth Mine site could result in a release of some of this material into Ruth Creek, and stream flow or continued mass wasting may carry this material to Battle Ax Creek. Mass wasting of the waste rock material at the 5th level of the Ruth Mine site could result in a release of some of this material directly into Battle Ax Creek. We have identified the most likely mass wasting mechanisms that could impact the waste rock material and cause rapid down-drainage movement of this material. These critical mass wasting mechanisms are:

- incorporation of the waste rock pile within a debris flow,
- surficial soil erosion (rain-splatter transport and rill erosion), and
- internal slumping or landsliding of the waste rock pile.

In addition, we consider the potential impacts of bank erosion along Ruth and Battle Ax Creeks on the waste rock piles in the 4th and 5th level areas as a mass wasting process to be evaluated for this report.

We have reviewed stereo-pair aerial photographs taken in June 1994 and August 2000 to evaluate possible impacts of the extreme flooding events that occurred during the winter of 1995/96. We conducted a geologic reconnaissance of the site on June 22, 2009 as part of our evaluation of the potential for mass wasting impacts on the waste rock material. The following discussion summarizes the results of our observations and analyses.

RUTH MINE 4TH LEVEL

The existing conditions that we observed during our June 22, 2009 field reconnaissance are shown on Figure 3. None of the structures shown on Figure 2 are standing, and only the plank floor and support posts of the ore bin located west of the 4th level entry remain in their original location. A pile of waste rock forms a flat bench next to the mine entrance and adit, and a slope that drops to Ruth Creek. A narrow gauge mine car track is situated on the waste rock bench, and the eastern end is cantilevered over Ruth Creek. Figure 4a is a photograph of the 4th level taken during our field reconnaissance showing the mine entrance, waste rock pile, and tracks. Figure 4b is an historical photograph looking southeast towards the 4th level entrance showing the ore bin and shed. The mined ore was conveyed from the shed to the ore bin along a covered track shown on Figure 2 and visible on Figure 4b.

We observed a pile of rock debris occupying the active creek channel immediately downstream from the suspended tracks. Ruth Creek flows along the ground surface upstream and downstream of this rock debris pile but disappears beneath the pile at its upstream end. We interpret this pile as the debris left from the failure of the short embankment that supported the rail tracks that are now cantilevered above Ruth Creek. This section of track would have been used to turn rail cars leaving the mine so that they could reverse direction and convey the ore to the ore bin. Also, equipment and material could be brought to the mine along the road from the miner's cabins and conveyed across the creek on the tracks.

Steep rock slopes bound the northern and southern sides of the narrow valley containing Ruth Creek in the area of the 4th level. We observed a recent slump on the slope south of the road to the miner's cabins within a notch in the steep rock slope. This slump mobilized into a small debris flow that deposited soil and rock on the slope above and below the road, as shown on Figure 3. We also observed a depression in the middle portion of the waste rock pile that we interpret as a small slope failure, as indicated on Figure 3. Directly upstream of the waste rock pile, we observed a recently incised cut bank on the north side of Ruth Creek.

Slumping and Landsliding

The location of the waste rock pile adjacent to the mine opening is shown on Figure 3. The slope on the western side of the pile is covered by a layer of waste rock material that thins down slope. A small patch of bedrock is exposed in the veneer of waste rock as located on Figure 3 and shown on Figure 5a. A stump at the base of the slope has a small amount of waste rock buttressed against it, as shown on Figure 5a. The wedge of waste rock on the slope south of the mine entrance is thicker and is supported by a buttress of medium to large boulders (1 foot to 4 feet in diameter) that defined the edge of the active creek channel. The location of the rock buttress is shown on Figure 3, and a photograph of the waste rock pile and buttress is shown on Figure 5b. The waste pile slopes at a constant grade of approximately 1.5 horizontal to 1 vertical (1.5H:1V, or 70 percent) from its crest to the top edge of the rock buttress.

A portion of the central part of the waste rock pile does not have a rock buttress at its base, and the slope has slumped. The approximate extent of this slope failure is indicated on Figure 3, and the slump can be seen on Figure 5b to have undermined a small section of the mine car track. The slope grade within the slump failure is approximately 1H:1V (100 percent). We interpret that this slope failure resulted from undercutting of the un-buttressed toe of the slope during high flows in Ruth Creek. The existing 1H:1V slope represents the repose angle of the waste rock material.

The extent of a recent slump on the slope south of the road to the miner's cabins is shown on Figure 3. This slump occurred at the top of a steep slope within a notch in the rock slopes that bound the valley containing Ruth Creek. This slump mobilized into a small debris flow that deposited soil and rock on the slope above and below the road. A similar slump was observed where Forest Road 2209 crosses an unnamed creek approximately ¼ mile west of Ruth Creek. This slump occurred at the top of a steep slope in cross-bedded sand and gravel. Our interpretation is that both of these failures occurred in small, secondary drainages that collected and carried water from the sidewalls of the Ruth Creek drainage.

Debris Flow Potential

The drainage basin for Ruth Creek is approximately 200 acres, with approximately 170 acres above the elevation of the 4th level. This is a moderately sized drainage basin, so that flow down Ruth Creek is likely to continue a low volume through the summer. During our field reconnaissance, we estimated that the flow was a few (1 to 3) cubic feet per second (cfs). Rapid melting of snow or a large rain storm would result in significantly higher flow and would have the potential to carry debris down stream.

During our field reconnaissance, we traversed upstream from the 4th level to observe channel conditions that would be unaffected by mining activity, such as the construction of the creek crossing embankment. Debris stranded on bushes and trees indicated that the maximum flow height along portions of the creek were 3 to 4 feet above the channel base during the previous winter. The active channel area upstream of the 4th level is narrow, so that the flow cross section is less than the cross section along the creek in the vicinity of the 4th level. From our observations we estimate that along the stretch of Ruth Creek at the 4th level, the highest water flow during the previous winter would have crested approximately 2 to 3 feet above the channel base.

During our reconnaissance upstream of the 4th level, we observed natural rock and wood debris bars in the active channel. Cultural items were incorporated in these debris bars, including heavily corroded steel drums and iron pipe, and a lack ABS plastic pipe. Figure 2 indicates a water line tapped into Ruth Creek upstream of the 4th level, and we speculate that the iron pipe that we observed may be part of this water line system.

In our previous report for the nearby Morning Star Mine we documented the annual peak flows recorded at the stream gauging station at the North Fork Road bridge crossing of the Little North Santiam River (GeoDesign, 2009). Table 1 presents the peak annual stream flow data obtained from the gauging station up to 2008 (USGS, 2009). The peak annual flows shown in this table represent all annual peak events with a discharge greater than 50 percent of the largest flow, recorded in 1964, at the Little North Santiam River station.

The December 22, 1964 flood event resulted in the undermining and collapse of the ore bin at the Ruth Mine (George and Weber, 1985) and also a washout of the bridge at Jawbone Flats (Mr. Tom Atiyeh, personal communication, 2009). This flood event's peak discharge is over 1.5 times the peak discharge of the second largest flow that occurred on November 20, 1962.

Table 1. Peak Annual Stream Flow, Little North Santiam River

Date	Peak Flow (cfs)	Gage Height (feet)
12/22/64	36,000	16.73
11/20/62	22,100	13.81
01/21/72	21,800	13.42
12/25/80	20,800	13.04
11/25/77	20,600	12.99
11/24/60	19,500	13.16
11/22/53	19,300	13.1
12/20/74	18,600	12.51
01/07/48	18,100	13

Our interpretation is that the debris bars upstream of the 4th level containing metal and plastic debris were modified from existing bars that are a typical feature of stream channels in steep,

mountainous terrain. These in-channel bars have formed from rock material introduced into the active channel from the adjacent slope and mobilized by extreme flows, such as those that occurred during the 1964 and 1996 flood events. These in-channel bars are relatively unaffected by more typical stream flows such as those that occurred this past winter.

There were two man-made embankments that crossed Ruth Creek at the time of the 1964 flood. The upstream embankment supported the rail car spur just above the mine entrance, and downstream embankment was adjacent to the ore bin and can be seen in the photograph shown on Figure 5b. The mid-channel rock debris shown on Figure 3 represents the material left after collapse of this embankment during the 1964 flood event. Exposed culverts and similar rock debris observed downstream from the remains of the ore bin are likely associated with the failure of the embankment shown on Figure 5b. In our opinion, the cascading failure of these two embankments would have resulted in a pulse of high water that caused the destruction of the ore bin structure. The mid-channel rock debris shown on Figure 3 does not appear to have been significantly altered by the 1996 flood event, which was very similar in terms of the peak flow measured at the North Santiam River gauging station.

Bank Erosion

We observed that the northern bank of Ruth Creek directly upstream of the waste rock pile is being eroded by the formation of a meander bend. This bank erosion is shown on Figures 6a and 6b. This erosion is relatively recent and appears to be ongoing based on the scant vegetation growth observed on the cut bank.

Surficial Soil Erosion

The waste rock material observed at the 4th level of the Ruth Mine would be classified as well-graded, sandy gravel with silt based on the Unified Soil Classification System or as very gravelly loamy sand based on the U.S. Department of Agriculture textural classification. Because of the coarse-grained texture of the waste rock material, it has a low susceptibility to rain-splatter mobilization and consequently a low rate of down-slope particle transport. We did not observe the formation of any rills on the surface of the waste rock pile, even though this material is devoid of vegetative support. The lack of rill erosion is again due to the very coarse texture of this material. The surface exposures of the soil were notably less silty than the material exposed in shallow, shovel-dug holes. It does appear that the fines (silt and clay-sized particles) of the waste rock have been mobilized by surface water run-off and eroded from the pile. We have not attempted to quantify the rate of water-driven erosion of the waste rock material, because the coarse-grained texture and lack of erosional features indicate that the rate of erosion of this material is very low.

Conclusions

Two mass wasting processes have the potential to impact the stability of the waste rock pile at the 4th level of the Ruth Mine. There is apparently no rock buttress support for the central part of this pile, which has resulted in local slumping of the waste rock material. The adjacent portions of the waste rock pile that are supported behind a rock buttress appear stable, as indicated by a shallower grade, planar rather than concave slopes, and a lack of impact from the 1996 flood. Recent bank erosion shown on Figures 3, 6a, and 6b has not impacted the stability of the waste

rock pile. However, this process is currently ongoing and has the potential of migrating downstream and compromising the rock buttress and consequent stability of the waste rock supported behind this structure.

Extreme flood events have the potential for modifying in-stream debris bars, and based on our field observations, the 1964 and 1996 flood events resulted in minor modification of in-stream bars above the 4th level workings. However, we did not observe evidence that the 1996 flood resulted in significant modification of the mid-channel rock debris adjacent to the waste rock pile. We also did not observe that this flood event caused any significant undermining of the rock buttress that supports the waste rock pile slopes. It appears possible that the 1996 flood event may have initiated the bank erosion upstream of the waste rock pile.

The coarse texture of the waste rock pile material inhibits rain-splatter and rill erosion except for the silt and clay-sized fraction exposed at the ground surface. In our opinion, based on the observations of lack of erosional features, and the coarse-grained texture of the material, the rate of water-born erosion of the waste rock pile is likely very low, although we did not attempt to quantify this rate.

Recommendations

Because of the potential for ongoing bank erosion to impact the long-term stability of the waste rock pile, we recommend that some form of mitigation action be considered to prevent future mass-wasting. We summarize three possible options that would mitigate mass-wasting impacts on the waste rock pile.

1. Stabilize the potential for bank erosion upstream of the waste rock pile along the cut bank shown on Figure 3 by armoring the bank with a combination of large, woody debris and boulders. Also, the rock buttress at the base of the waste rock pile should be reconstructed where it has been undermined, particularly in the area below the 100 percent slope shown on Figure 3. Implementation of this option would minimize the risk of stream erosion and destabilization of the waste rock pile.
2. Bank stabilization as described in option 1 should be performed. In addition, the waste rock pile should be re-graded to a 2H:1V to 3H:1V (50 to 33 percent) slope. The re-graded waste rock should be covered with open matting (e.g., jute matting) and seeded with a fast-growing vegetation (e.g., grass) to prevent soil erosion. The re-graded slope should be sufficiently shallow to allow for retention and infiltration of precipitation adequate to support vegetative growth. Implementation of this option would minimize the risk of stream erosion and destabilization of the waste rock pile, possible landslide transport of waste rock to Ruth Creek, and erosion of the fine component of the waste rock material.
3. After completing option 1 and the re-grading discussed in option 2, the waste rock should be covered with topsoil having a high organic content that would allow establishment of native grasses and bushes. The short-term erosion mitigation options discussed in option 2 should be implemented. However, it may not be necessary to seed the area if the imported topsoil is obtained from nearby stripping and contains seeds and roots that would sprout native vegetation. Implementation of this option would

minimize the risk of stream erosion and destabilization of the waste rock pile, possible landslide transport of waste rock to Ruth Creek, and erosion of the fine component of the waste rock material.

RUTH MINE 5TH LEVEL

The 5th level of the Ruth Mine is located on the high terrace adjacent to the southern bank of Battle Ax Creek as shown on Figure 2. The bank of this creek is a nearly vertical slope that drops 20 to 30 feet from the terrace to the active stream channel. During our June 22, 2009 field reconnaissance, we observed that the waste rock is distributed in three separate areas. The waste rock forms a low (approximately 3 to 4 feet high) pile that supports rail car tracks. It also is present in a thin, discontinuous layer of waste rock that covers the level ground along what was the power plant and tramway shown on Figure 2 (current road bed). Finally, a low (0.5 foot to 2 feet high) berm of waste rock is located on the northern edge of the terrace. This berm is partially side-cast on the crest of the slope dropping to Battle Ax Creek. We observed a number of notches in the berm where the waste rock has failed, dropping into the active channel of Battle Ax Creek, as shown on Figures 7a and 7b. The slope failure shown on Figure 7a is a shallow, translational landslide within the side-cast material. As shown on Figure 7b the failure is the result of erosion from surface water that pooled on the terrace and overflowed onto the slope. We observed eight failures of the side-cast material on the slope above Battle Ax Creek during our field reconnaissance. Approximately half of these failures were translational landslides or slumps, and the remaining failures were erosional channels formed by surface water that flowed from pools that formed seasonally in low areas on the terrace. The steep slopes south of the terrace appear to be relatively stable, and we did not observe any evidence of recent landslides in this area.

Field Mapping and Volumetric Estimate of the Side-Cast Berm

We performed a tape and level survey of the Ruth Mine 5th level on July 30, 2009 to map the side-cast waste rock currently residing on the slope above the creek. We also collected data during this field survey to support an estimate of the volume of waste rock involved in past slope failures. We developed cross-terrace sections using a tape and level and mapped contacts of side-cast waste rock and native rock or colluvium on these sections. We developed a section approximately every 20 feet from the end of the terrace east of the mine entrance to approximately 120 feet west of the intersection of the spur road with the terrace.

We used these sections to calculate the volume of side-cast material that has previously failed by visually reconstructing the slope within the areas of failure to their original configuration and determining the volume of failed material based on this reconstruction. We estimate that approximately 20 cubic yards of waste rock along the side-cast berm have failed since the berm was constructed.

Conclusions

The steep bank on the south side of Battle Ax Creek is underlain by rock, and large-scale landsliding of this slope is unlikely. Also, because the slope is underlain by rock, rapid erosion of this bank by Battle Ax Creek is unlikely. The height of the terrace would prevent any debris flows or flooding along Battle Ax Creek from impacting the stability of the waste rock at the 5th level.

The only mass wasting of waste rock observed at the 5th level is the failure of the side-cast berm at the crest of the south bank slope. These slope failures are limited in their lateral extent and do not appear to be very frequent as this berm has been in its present location for a number of decades. We estimate that approximately 20 cubic yards of side-cast waste rock has failed since the berm was originally constructed. We did not observe conditions that indicate that the rate of mass wasting of these side-cast slopes and the consequent delivery of material to Battle Ax Creek should increase in the future

MITIGATION OPTIONS

We used the field mapping sections to estimate the volume of side-cast waste rock that could be pulled back as a potential method of mitigating future translational failures. We assumed that the excavator used to pull back the side-cast waste rock would have a maximum vertical reach of 10 feet below the elevation of the terrace. The side-cast waste rock would be pulled back to a 2H:1V slope to provide a more stable condition than the existing side-cast slope, which ranges from 1.5H:1V to 1H:1V. We have also assumed that the lowest 2 feet of the toe of the side-cast waste rock would be left in place.

We calculated the volume of the side-cast waste rock pullback on each of our measured sections and then linearly interpolated between our measured sections to compute the total pullback volume of the side-cast waste rock. We calculated that the total volume would be approximately 260 cubic yards of material.

Pulling back of the side-cast berm to create a more stable slope appears to be an option for long-term stabilization of this material. But this option carries risk of material loss downslope to Battle Ax Creek. In pulling back the side-cast material, the toe of the fill slope will be outside of the range of sight of the excavator operator. Also, the side-cast material is not a homogenous soil, but contains large timbers and boulders. These conditions will cause some proportion of the side-cast material to fall down slope during removal. Because a near-vertical rock cliff lies directly below the side-cast fill slope, there is no practical approach to catching the waste rock that escapes during removal. We estimate that on the order of 5 to 10 percent of the waste rock could be lost during the re-grading and that the bulk of this material would fall down the steep slope into Battle Ax Creek. The volume of the uncontrolled loss of waste rock could range from 13 to 26 cubic yards and would approximately equal the volume of side-cast material that has previously failed in the several decades since the berm was constructed. As the berm re-grading would be completed in approximately five working days, the rate of release of side-cast waste rock into Battle Ax Creek would be significant in comparison to the average rate of release of past berm failure.

Consequently, the short-term release of waste rock resulting from side-cast waste rock pullback should be balanced against the larger site investigation results to determine if significant future risk reduction would be achieved or is warranted.

◆ ◆ ◆

We appreciate the opportunity to serve you on this project. Please call if you have questions regarding this report.

Sincerely,

GeoDesign, Inc.

Stephen P. Palmer, Ph.D., C.E.G.
Senior Associate Engineering Geologist

Jeffery D. Tucker, P.E., G.E.
Principal Engineer

CERTIFIED
OREGON
STEPHEN P. PALMER
E2155
ENGINEERING GEOLOGIST

cc: Mr. Pete Jones, U.S. Department of Agriculture, Forest Service (via email only)
Mr. Tom Atiyeh, Opal Creek Ancient Forest Center (via email only)
Mr. James Alexander, U.S. Department of Agriculture (via email only)
Ms. Christy Darden, U.S. Department of Agriculture, Forest Service (via email only)

SPP:SCN:CWW:JDT:kt
Attachments
One copy submitted (via email only)
Document ID: OpalCreek-1-03-111709-geolr.doc
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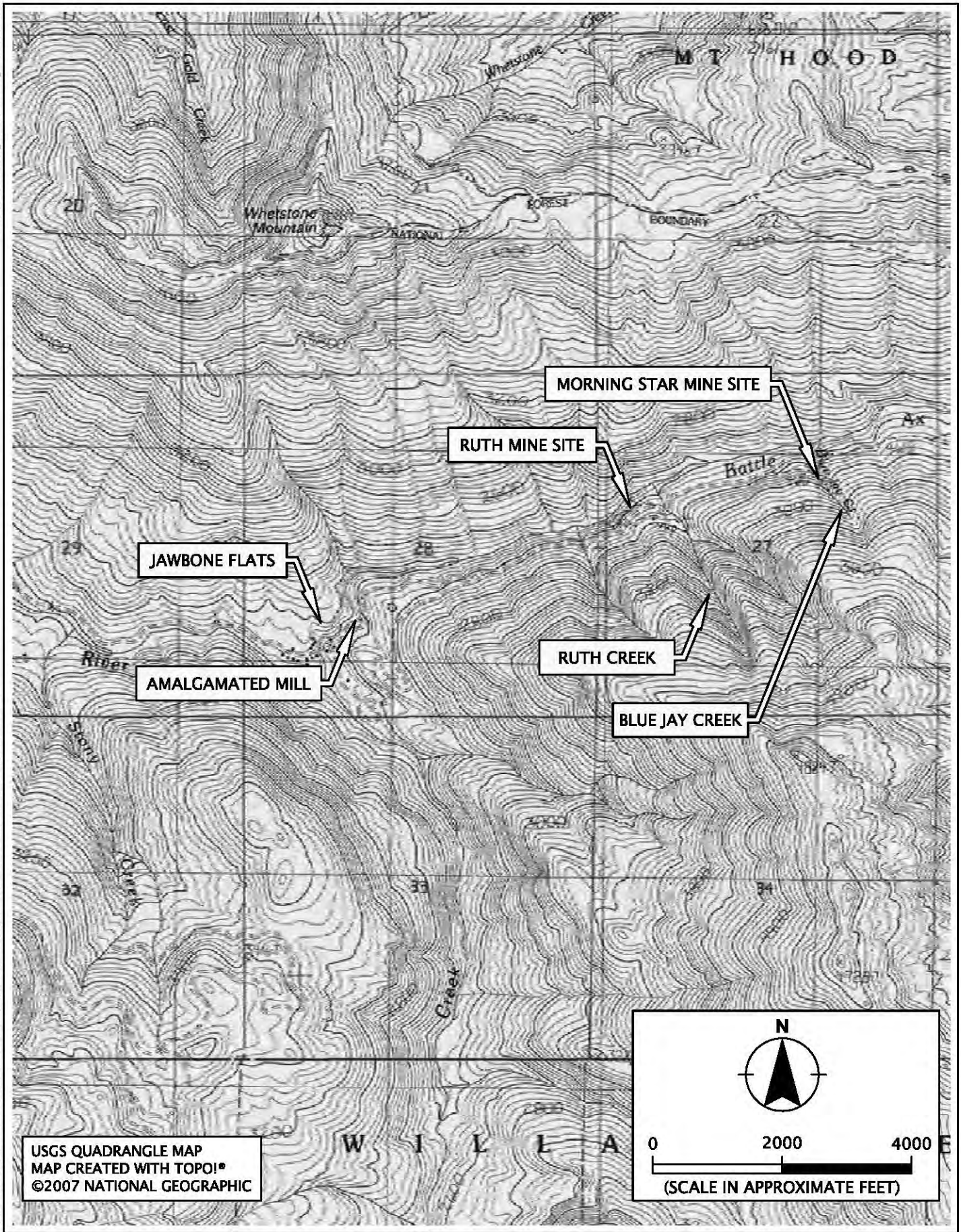
GeoDesign, Inc. (2009), *Report of Slope Stability Evaluation, Morning Star Mine - Opal Creek Scenic and Restoration Area, Willamette National Forest, Marion County, Oregon,* dated May 6, 2009. GeoDesign Project: OpalCreek-1-03

George, A. J.; Weber, J. E. (1985), The Santiam Mining District of the Oregon Cascades – A Cultural Property Inventory and Historical Survey: The Solo Press, Salem, Oregon.

USGS (2009), USGS Surface-Water Data for the USA, accessed at http://nwis.waterdata.usgs.gov/nwis/sw on April 28, 2009, U.S. Geological Survey

FIGURES



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OPALCREEK-1-03	VICINITY MAP	
NOVEMBER 2009	MINE SITES AT OPAL CREEK MARION COUNTY, OR	FIGURE 1

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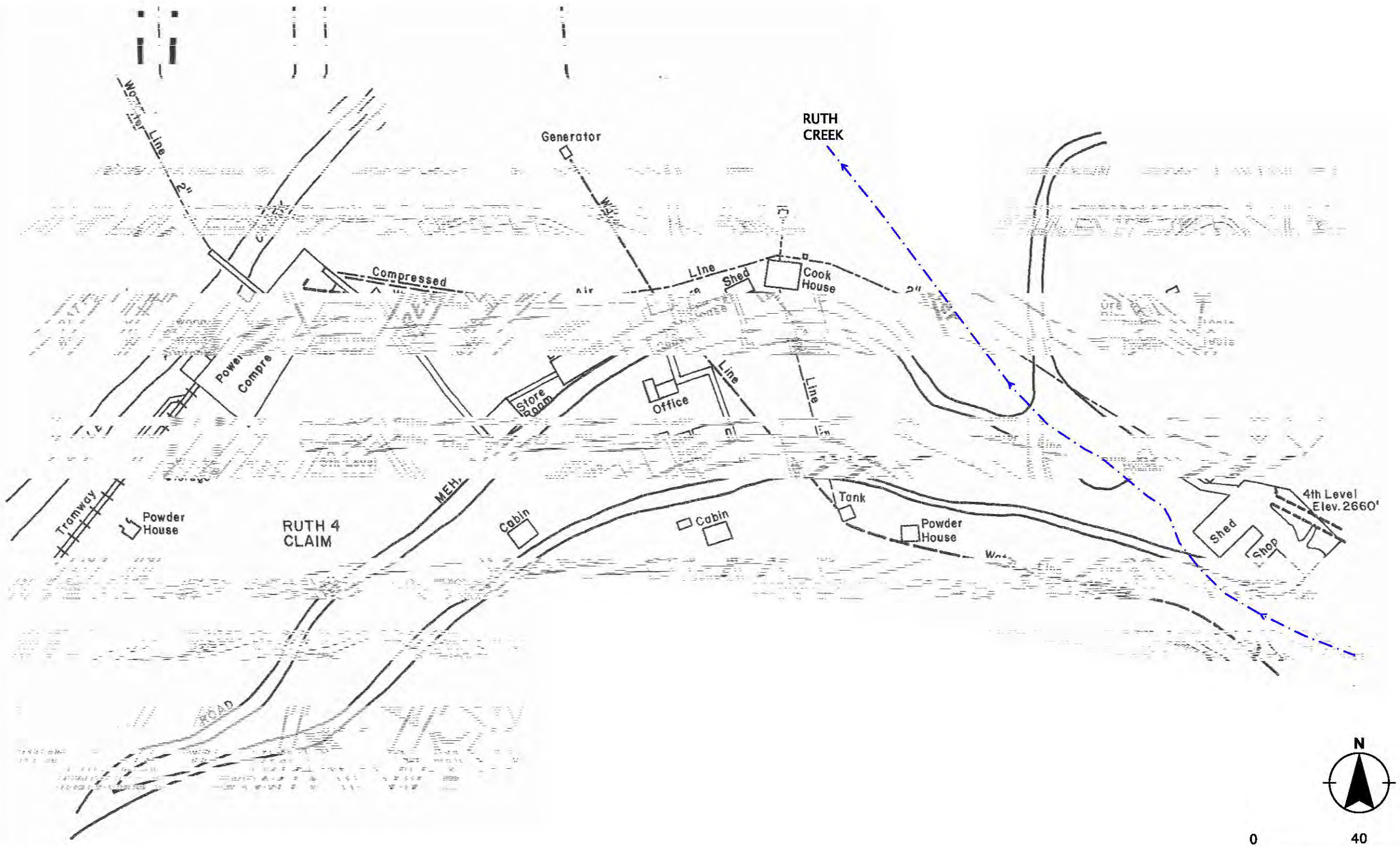

SITE PLAN BASED ON DRAWING MODIFIED FROM GEORGE AND WEBER (1985)

MAP OF 4TH AND 5TH LEVELS RUTH MINE

MINE SITES AT OPAL CREEK
MARION COUNTY, OR

FIGURE 2

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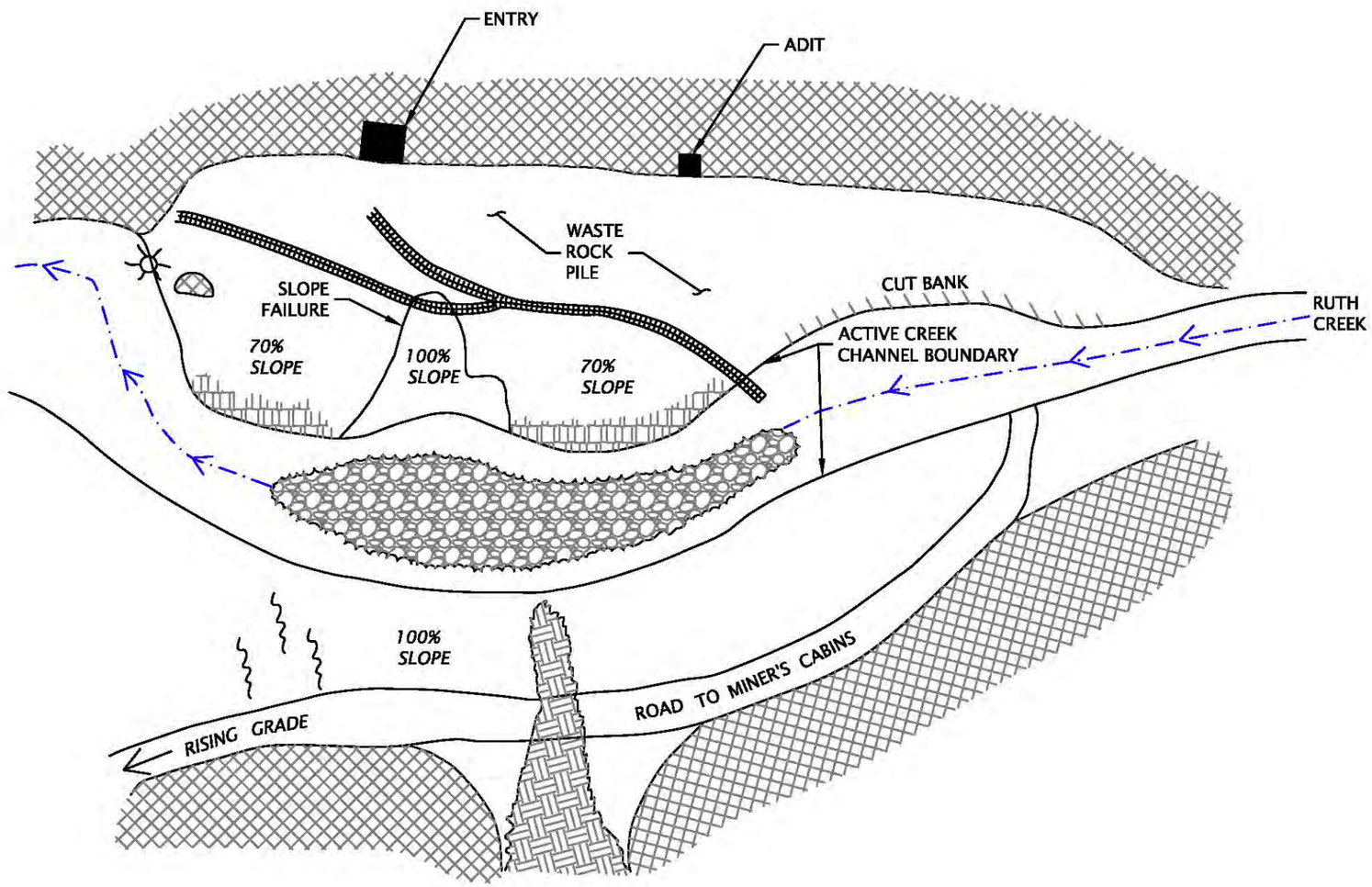

LEGEND:

- SURFACE FLOWING STREAM
- FLOW DIRECTION
- AREA OF ROCK OUTCROP
- ROCK BUTTRESS
- NARROW GAUGE TRACK
- ROCK DEBRIS
- SOIL DEBRIS
- GULLIES
- STUMP

N

0 15 30

(SCALE IN APPROXIMATE FEET)

SITE PLAN BASED ON OBSERVATIONS AND FIELD MEASUREMENTS BY GEODESIGN STAFF

FIGURE 3

PLAN MAP OF 4TH LEVEL, RUTH MINE

MINE SITES AT OPAL CREEK
MARION COUNTY, OR

OPALCREEK-1-03

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File Name: J:\M-R\OpalCreek\OpalCreek-1\OpalCreek-1-03\Figures\CAD\OpalCreek-1-03-SP02.dwg | Layout: FIGURE 3

FIGURE 4A. PHOTOGRAPH OF THE 4TH LEVEL OF THE RUTH MINE SHOWING THE MINE ENTRANCE, WASTE ROCK PILE, AND TRACKS SUSPENDED OVER RUTH CREEK.

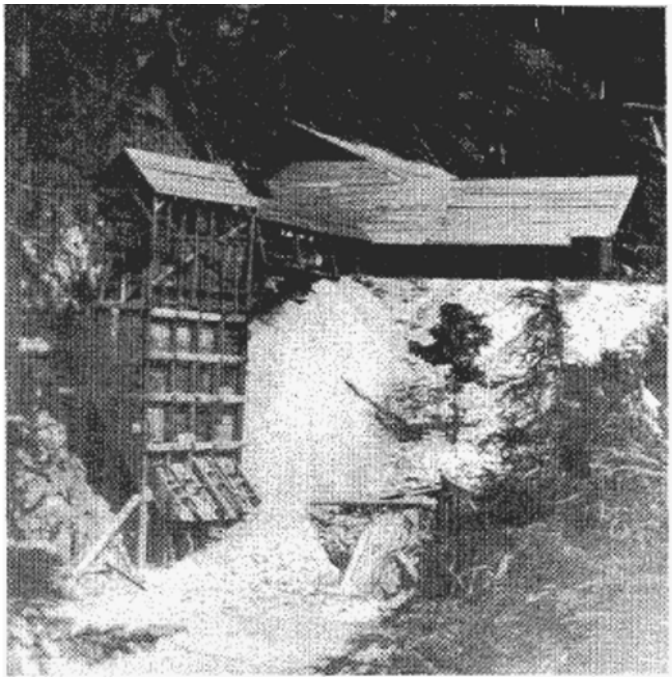

FIGURE 4B. HISTORICAL PHOTOGRAPH OF THE 4TH LEVEL LOOKING SOUTHEAST FROM DOWNSTREAM OF THE MINE ENTRANCE.

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OPALCREEK-1-03	**PROJECT SITE PHOTOGRAPHS**	
NOVEMBER 2009	MINE SITES AT OPAL CREEK MARION COUNTY, OR	**FIGURE 4**

FIGURE 5A. VIEW OF BEDROCK OUTCROP AND STUMP ON WESTERN SLOPE OF WASTE ROCK PILE.

FIGURE 5B. VIEW OF THE WASTE ROCK PILE AND ROCK BUTTRESS SOUTH OF THE RUTH MINE ENTRANCE.

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OPALCREEK-1-03	**PROJECT SITE PHOTOGRAPHS**	
NOVEMBER 2009	MINE SITES AT OPAL CREEK MARION COUNTY, OR	**FIGURE 5**

FIGURE 6A. BANK EROSION DIRECTLY UPSTREAM FROM 4TH LEVEL WASTE ROCK PILE.

FIGURE 6B. UPSTREAM CONTINUATION OF BANK EROSION SHOWN ON FIGURE 6A.

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OPALCREEK-1-03	**PROJECT SITE PHOTOGRAPHS**	
NOVEMBER 2009	MINE SITES AT OPAL CREEK MARION COUNTY, OR	**FIGURE 6**

FIGURE 7A. SHALLOW FAILURE OF THE WASTE ROCK BERM AT THE 5TH LEVEL OF THE RUTH MINE.

FIGURE 7B. SHALLOW FAILURE OF THE WASTE ROCK BERM AT THE 5TH LEVEL OF THE RUTH MINE.

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OPALCREEK-1-03	**PROJECT SITE PHOTOGRAPHS**	
NOVEMBER 2009	MINE SITES AT OPAL CREEK MARION COUNTY, OR	**FIGURE 7**

APPENDIX H

GEODESIGN INC

May 1, 2009

Opal Creek Ancient Forest Center
c/o Perkins Coie, LLP
1120 NW Couch Street, Tenth Floor
Portland, OR 97209-4128

Attention: Mr. Christopher Rich

Report of Slope Stability Evaluation
Morning Star Mine - Opal Creek Scenic and Recreation Area
Willamette National Forest
Marion County, Oregon
GeoDesign Project: OpalCreek-1-03

INTRODUCTION

GeoDesign, Inc. is pleased to present this report summarizing our slope stability evaluation of the Morning Star Mine. The Morning Star Mine site is located on the south side of Battle Ax Creek in a rugged and remote area of Section 27 of Township 8 South, Range 5 East of the Willamette Meridian in Marion County, Oregon. The site lies within the Opal Creek Scenic and Recreation Area of the Willamette National Forest that is administered by U.S. Forest Service. The Morning Star Mine is approximately 1.5 aerial miles east-northeast of Jawbone Flats, a historical mining camp. The elevation of the Morning Star Mine is approximately 2,800 feet above mean sea level (MSL). The Morning Star Mine site is shown relative to the surrounding vicinity on Figure 1.

The Morning Star Mine area includes the adit area, a small access road that spurs southeast off of Forest Road 2209 leading to the adit, and a waste rock pile below the adit. Blue Jay Creek runs in a south to north direction and is located approximately 15 feet to the east of the adit. Blue Jay Creek is a seasonal stream and is a tributary to Battle Ax Creek. A map of the site is shown on Figure 2.

This report summarizes our findings regarding the potential for mass wasting of the mine waste material, including the primary waste rock pile, down-slope material, and road bed material.

SLOPE STABILITY EVALUATION

Mass wasting is a general term that encompasses all forms of down-slope movement of soil and rock material. It includes mechanisms such as landsliding, soil creep, debris flows, surficial erosion, and rock fall, all of which influence the stability of sloping ground. Mass wasting of the waste rock material at the Morning Star Mine site could result in uncontrolled release of this material into Blue Jay Creek, and stream flow or continued mass wasting may carry this material to Battle Ax Creek. We have identified the most likely mass wasting mechanisms that could impact the waste rock material and cause rapid down-drainage movement of this material. These critical mass wasting mechanisms are:

- incorporation of the waste rock pile within a debris flow,
- surficial soil erosion (rain-splatter transport and rill erosion), and
- internal slumping or landsliding of the waste rock pile.

We have reviewed site photographs taken in October 2008 and conducted a geologic reconnaissance of the site on April 27, 2009 as part of our evaluation of the potential for mass wasting impacts on the waste rock material. The following discussion summarizes the results of our observations and analyses.

POTENTIAL DEBRIS FLOW IMPACTS

The drainage basin for Blue Jay Creek is approximately 50 acres, with approximately 44 acres above the elevation of the Morning Star Mine adit. This is a relatively small drainage basin, and the flow down Blue Jay Creek is typically small and seasonal. During our field reconnaissance, the flow was likely less than 1 cubic foot per second (cfs). Rapid melting of snow during a heavy rain storm could result in significantly higher flow and would have the potential to carry debris down stream.

Blue Jay Creek runs steeply down to Battle Ax Creek from an elevation of approximately 3,100 feet above MSL to approximately 2,400 feet above MSL in a distance of approximately 1,500 feet. This corresponds to an average stream gradient of approximately 25 degrees. We measured the stream gradient along stretches of Blue Jay Creek both below and above the Morning Star Mine adit, and they ranged from 20 degrees to 45 degrees as shown on Figure 2. These gradients are sufficiently steep to allow incorporation of additional material necessary to allow "bulking" during passage of a debris flow.

During our field reconnaissance, we observed that the surface flow along Blue Jay Creek disappeared at approximately the elevation of the mine adit and did not reappear at the surface until approximately 200 feet downstream. This stretch of the channel was filled with fresh, angular cobbles and boulders of andesitic rock and wood debris mainly composed of hewn timbers associated with the mine development. Figure 3A is a photograph of this rock-armored channel directly below the upstream end of the waste rock pile. Downstream of the waste rock pile we observed rock and timber debris packed against the upstream end of large conifers that are growing in the central part of the creek channel. The locations of these debris-packed trees are shown on Figure 2, and a photograph of one of these trees is shown on Figure 3B. This rock-armored channel continues down stream towards the confluence with Battle Ax Creek. The

approximate extent of the rock-armored channel is shown on Figure 2. The creek flow disappears into and reappears from this rock-armored channel a number of times before reaching Battle Ax Creek.

Based on these observations, it is clear that a large debris flow has passed down Blue Jay Creek since cessation of the active underground mining, which we understand to have closely followed the end of the Second World War (Mr. Tom Atiyeh, personal communication, 2009). To evaluate the extent of this debris flow event, we traversed the stream course above the Morning Star Mine adit to observe the existing conditions of the natural creek channel unaffected by mining activities. Figure 4A is a photograph taken during our traverse looking upstream from above the area of mining. The vantage point of this photograph is shown on Figure 2. Figure 4B is a photograph from the same location as Figure 4A looking downstream towards the mine area. In this portion of the stream course, we found no evidence of a rock-armored channel or log jams indicative of rapid, downstream debris movement. Figure 5A is a photograph of Blue Jay Creek looking upstream from the mine adit. This part of the creek also shows no evidence of a rock-filled channel or debris flow. Our conclusion is that the debris flow must have initiated in the vicinity of the mine adit and that no debris flow occurred upstream of the mine.

Debris Source

We observed that the channel debris immediately downstream of the mine adit was composed of angular, cobble- to boulder-size andesite typical of the host rock for the Morning Star ore deposit. Many of the andesite clasts observed in this section of the channel debris had a reddish fracture coating caused by cinnabar mineralization. This reddish fracture coating is ubiquitous to the andesite host rock in the vicinity of the mine adit. We also found clasts of the ore rock, including vein quartz containing bornite and chalcopyrite minerals, and bleached and pyritized andesite host rock in contact with a mineralized quartz vein. The debris contained a large amount of hewn timbers associated with the mine and a variety of iron or steel material including barrels, rods, and pipes. The source of the debris is clearly restricted to the vicinity of the mining operation.

The amount and proportion of wood timbers and cinnabar-stained andesite in the debris decreases downstream towards Battle Ax Creek. This is consistent with the "bulking" of the debris flow as it incorporates material during its downstream flow. We observed large wooden timbers and metal debris below Forest Road 2209 shown on Figure 2, which is approximately 100 feet vertically above Battle Ax Creek. We observed that the culvert passing beneath this road was completely plugged with sand and gravel debris.

Mine Embankment

The size and nature of the debris deposited in the creek channel below the mine adit indicates a very high velocity flow of water. The upstream end of the rock-armored channel is directly downstream of the mine adit, and the rock, wood, and metal debris is all derived from the vicinity of the adit. Figure 5B is a photograph of the existing mine adit and it shows a very limited working space in front of the opening. Figure 6A shows that there is a deposit of waste rock on the creek bank across from the adit. This waste rock is visually identical to the material within the waste rock pile shown on Figure 2. We observed a large hewn timber at the top of this deposit and poured concrete on the bedrock at the edge of the waste rock.

Based on our observations, it is clear that there was some sort of creek crossing built to support the mining activities, presumably to increase the working space in front of the mine. During mining operations the waste rock was end-dumped from the ore carts onto a natural dipping rock "chute" on the bedrock promontory, where it fell onto the waste rock pile shown on Figure 2. The geometry of the rock "chute" and the fan of waste rock are clearly visible on Figure 6A. However, to convey waste rock in a string of ore carts, there must have been a "Y" in the rail tracks to allow sequential dumping of these carts. The work area in front of the adit is inadequate to store a string of carts, so the miners must have extended the tracks over the creek.

This extension could have been made by either constructing a bridge or an embankment over the creek. The bridge would have to span approximately 40 feet, which would have required construction of a trestle support. It is likely that an embankment was constructed using the waste rock derived from the opening of the adit to allow for the development of the rail track. The approximate location of this embankment is shown on Figure 2. After the embankment and rail track were in place, then waste rock could be end dumped onto the waste rock pile.

We estimate that the embankment would have been approximately 40 feet in length (to span the creek), 10 feet in width (to provide an adequate working and storage area), and approximately 20 feet in height (the height of the adit above the creek). Slopes on the upstream and downstream face would have been between 1.5 horizontal to 1 vertical (H:V) to 2H:1V in order to remain stable. Based on this geometry, the total volume of waste rock used to construct the embankment would have been between 1,200 and 1,500 cubic yards. The miners would have placed a pile of large boulders covered by timber to allow passage of the creek beneath the embankment. This "natural" culvert would have been adequate for the typical flow of Blue Jay Creek.

Failure of the Embankment and Resulting Debris Flow

In our opinion, collapse of the mine embankment during severe flooding is the only reasonable explanation for a large debris flow in Blue Jay Creek. The rock-filled channel associated with the debris flow is only observed downstream of the mine adit, and there is no evidence of a large debris-carrying event upstream of the mining operation. The debris is composed of andesitic cobbles and boulders that have characteristics (cinnabar staining, pyritization, and bleaching) related to the ore mineralization and contains hewn timbers and metal objects related to the mining operation. The rock-filled channel extends downstream nearly to the confluence of Battle Ax Creek, a distance of more than 500 feet, and timbers and metal debris can be observed along its entire extent.

Based on historical photographs of the Morning Star Mine, we know that this embankment collapse and related debris flow must have occurred before 1983[1]. Based on the history of the mining operation, we know that this event must post-date 1946. Table 1 presents the peak annual stream flow data obtained from the stream gauging station at the Little North Santiam

[1] George, Anthony J. P.E. and Weber, Joseph E., 1985: The Santiam Mining District of the Oregon Cascades, A Cultural Property Inventory and Historical Survey; The Solo Press, Salem, Oregon.

River[2]. The peak annual flows shown represent all annual peak events with a discharge greater than 50 percent of the largest flow, recorded in 1964, at the Little North Santiam River station.

The December 22, 1964 flood event resulted in the undermining and collapse of the draw works building at the nearby Ruth Mine (George and Weber, 1985) and also a washout of the bridge at Jawbone Flats (Mr. Atiyeh, personal communication, 2009). This flood events peak discharge is over 1.5 times the peak discharge of the second largest flow that occurred on November 20, 1962.

Table 1. Peak Annual Stream Flow, Little North Santiam River

Date	Peak Flow (cfs)	Gage Height (feet)
12/22/64	36,000	16.73
11/20/62	22,100	13.81
01/21/72	21,800	13.42
12/25/80	20,800	13.04
11/25/77	20,600	12.99
11/24/60	19,500	13.16
11/22/53	19,300	13.1
12/20/74	18,600	12.51
01/07/48	18,100	13

Our conclusion is that the flow down Blue Jay Creek during the December 22, 1964 flood event overwhelmed the drain system beneath the mine embankment. Flood water backed up behind the embankment, which then failed catastrophically. The rapid release of the impounded water generated a debris flow and deposited the rock-filled channel, timbers, and metal objects downstream.

SURFICIAL SOIL EROSION

The waste rock material observed at the Morning Star Mine would be classified as well-graded sandy gravel with silt based on the Unified Soil Classification System or as very gravelly loamy sand based on the U.S. Department of Agriculture textural classification. Because of the coarse texture of the waste rock material, it has a low susceptibility to rain-splatter mobilization and consequently a low rate of down-slope particle transport. We did not observe the formation of any rills on the surface of the waste rock pile, even though this material is devoid of vegetative support. The lack of rill erosion is again due to the very coarse texture of this material. We have not attempted to quantify the rate of water-driven erosion of the waste rock material, but our observations indicate that the rate of erosion of this material is very low.

[2] U.S. Geological Survey, 2009, USGS Surface-Water Data for the USA, accessed at http://nwis.waterdata.usgs.gov/nwis/sw on April 28, 2009

SLUMPING AND LANDSLIDING

The location of the waste rock pile is shown on Figure 2. The slope below the pile is covered by a layer of waste rock material that thins down slope. Slumping or landsliding of the waste rock pile could result in uncontrolled release of this material into Blue Jay Creek. During our field reconnaissance, we did not observe any evidence of past slumping or landsliding within the waste rock pile or within the area down slope of the pile. We did not observe any seepage from the face of the waste rock pile slope. The slope of the waste rock pile is relatively steep, having a grade of approximately 80 percent (38 degrees), and is likely near its angle of repose. The height of this slope varies from 6 to 8 feet along the southern part of the pile and from20 to 30 feet along the northern part of the pile.

We observed that the original cribbing used to contain the waste rock pile is exposed along the southern portion of the pile, as shown on the bottom of Figure 6B. The location of this exposed cribbing is shown on Figure 2. This cribbing appears to be tilted downward towards the rock-filled channel of Blue Jay Creek. We interpret that this tilting is due to undercutting of the toe of the waste rock pile during the 1964 debris flow and lurching of the pile and cribbing towards the undercut toe. However, the waste rock pile did not fail as a landslide into the debris channel, providing evidence of the relative stability of the waste rock pile to extreme undercutting of its toe.

Figure 7A shows that the northern part of the waste rock pile slope is littered with timbers that have remained in their original position for many years. The location of this timber covered slope is shown on Figure 2. There is no indication of any slope movement or failure disrupting this veneer of timber debris, even though this slope is approximately 20 feet in height.

We observed that the slope face of the waste rock pile is very steep (near the angle of repose), but did not observe any groundwater seepage along the slope face, which indicates that the surface water that infiltrates into the pile must freely drain into the underlying native soil and rock mass. We did observe evidence that the taller portion of the slope face has remained stable for many years. We also observed that erosion of the toe of the waste rock pile slope during the 1964 debris flow event did not result in slumping or landsliding of the pile.

The surface base of the access road may be partially composed of waste rock material. We observed a small amount of soil material has been side cast directly down slope of the road, as evidenced by the wedge of material trapped on the up-slope side of trees shown on Figure 7B. This photograph shows a notable color change between the gray, fresh mine waste rock and the brown soil material that composes the road base. We did not observe any evidence of slumping of the road or significant down-slope movement of the side cast material.

CONCLUSIONS

Based on our field reconnaissance, we reach the following conclusions regarding the stability of the waste rock material associated with the Morning Star Mine.

1. A large debris flow occurred after cessation of active mining in 1946, likely the result of collapse of an embankment constructed as part of mining activities. This debris flow occurred prior to 1983 and most likely occurred during the 1964 flooding event recorded at the Little North Santiam River gauging station. This debris flow released between 1,200 and 1,500 cubic yards of mine waste material into Blue Jay Creek.

2. Our observations along Blue Jay Creek upstream of the mine, coupled with the total area of the creek's drainage basin, indicates that a large volume, natural debris flow would represent an extremely rare event. It would require a climatic event that delivers combined rainfall and snow melt runoff to the Blue Jay Creek watershed at a much greater rate than occurred during the 1964 storm event. The 1964 flooding event delivered the largest peak flow recorded at the Little North Santiam River gauging station since it began its operations in 1931.

3. The coarse texture of the waste rock pile material inhibits rain-splatter and rill erosion. In our opinion, the rate of water-born erosion of the waste rock pile is likely very low, although we did not attempt to quantify this rate.

4. We did not observe evidence of slumping or landsliding of the waste rock pile or access road, although the slopes below these features are extremely steep and near the angle of repose. In fact, we observed evidence that the steep slope face of the waste rock pile has been stable for many years, likely decades. Also, we observed evidence that rapid erosion of the toe of the waste rock pile during the 1964 debris flow event did not result in slumping or landsliding. In our opinion, there is very little potential that slumping or landsliding would result in the down-slope movement of a significant volume of the waste rock pile or access road. Because of the north-facing aspect of the slope beneath the road, it is unlikely that slumping or landsliding of the access road would carry material directly into the creek.

5. It is our general conclusion that the waste rock pile and access road are relatively stable with respect to the mass wasting mechanisms that we believe are relevant for the assessment of environmental risk assessment. The likelihood of a mass wasting event that could lead to down-slope movement of a large volume of the waste rock material is, in our opinion, extremely low.

♦ ♦ ♦

We appreciate the opportunity to serve you on this project. Please call if you have questions regarding this report.

Sincerely,

GeoDesign, Inc.

Stephen P. Palmer, Ph.D., C.E.G.
Senior Associate Engineering Geologist

Jeffery D. Tucker, P.E., G.E.
Principal Engineer

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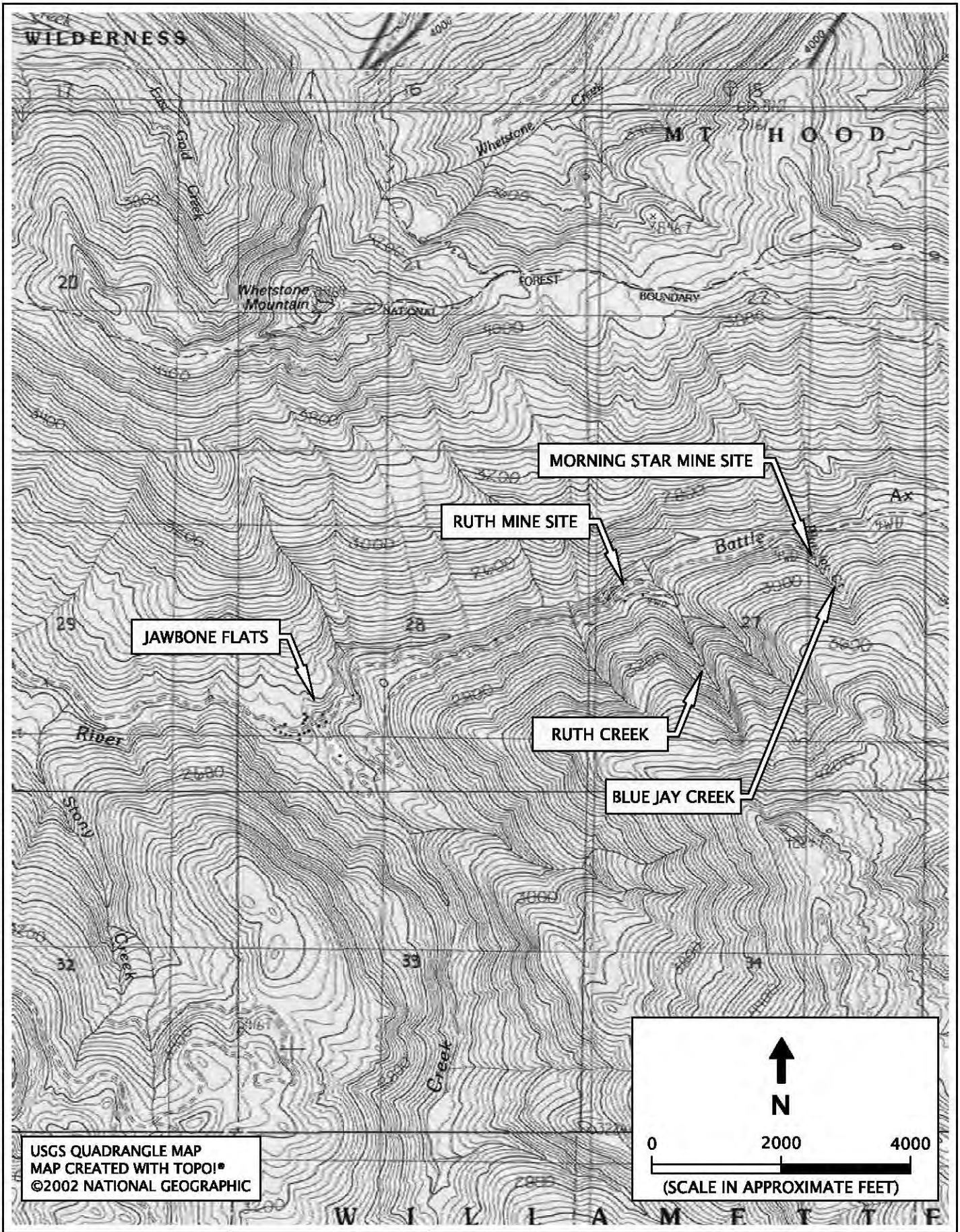
FIGURES



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OPALCREEK-1-03	**VICINITY MAP**	
MAY 2009	RUTH AND MORNING STAR MINE SITES, OPAL CREEK MARION COUNTY, OR	**FIGURE 1**

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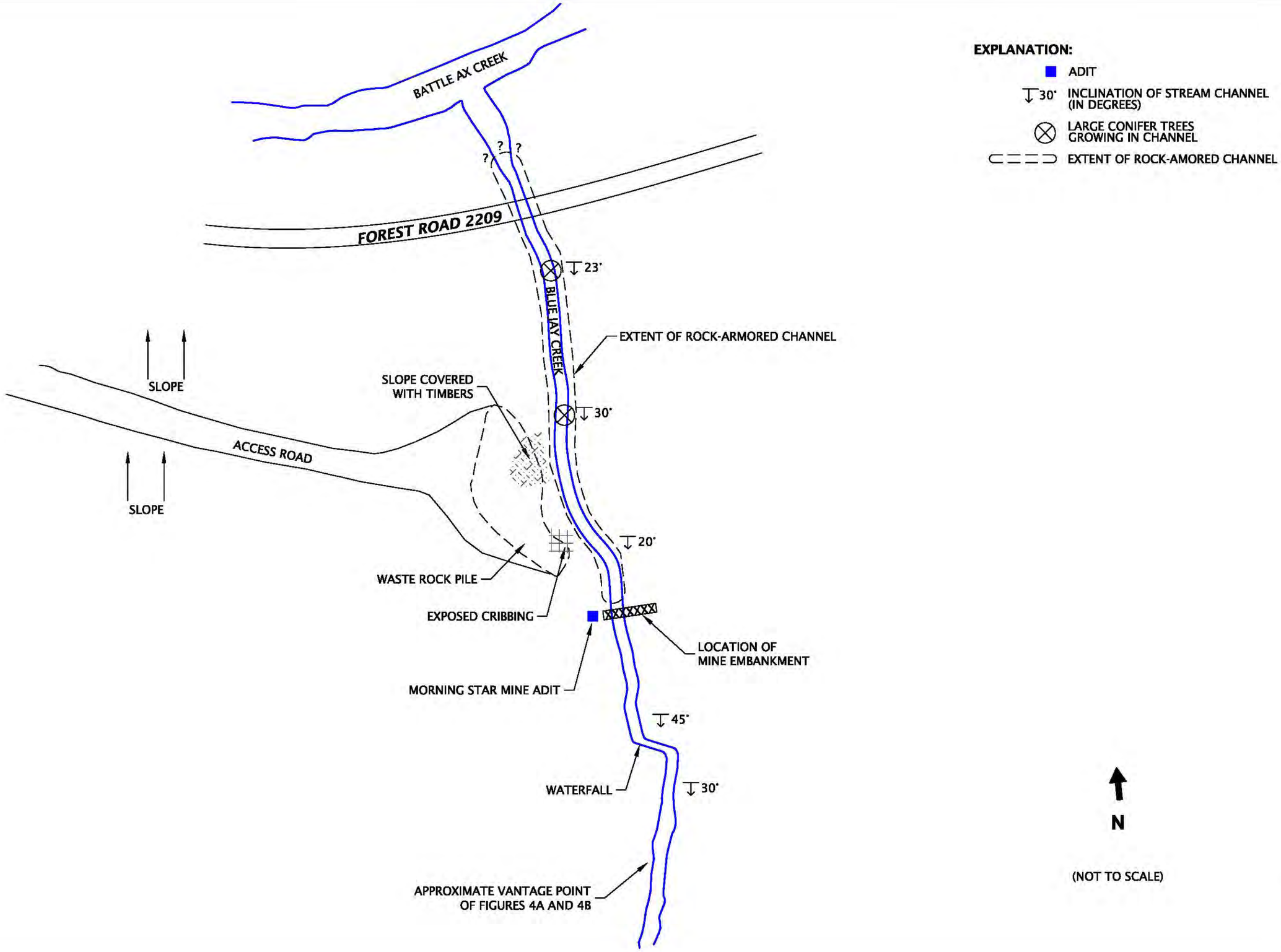

SITE MAP

FIGURE 2

RUTH AND MORNING STAR MINE SITES, OPAL CREEK
MARION COUNTY, OR

OPALCREEK-1-03

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File Name: \\chromite\Files\Jobs\M-R\OpalCreek\OpalCreek-1\OpalCreek-1-03\Figures\CAD\OpalCreek-1-03-SP01.dwg | Layout: FIGURE 2

FIGURE 3A. CHANNEL FILL DIRECTLY BELOW THE UPSTREAM END OF THE WASTE ROCK PILE.

FIGURE 3B. DEBRIS PACKED AGAINST THE UPSTREAM SIDE OF A LARGE CONIFER GROWING WITHIN THE CHANNEL OF BLUE JAY CREEK.

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OPALCREEK-1-03	**PROJECT SITE PHOTOGRAPHS**	
MAY 2009	RUTH AND MORNING STAR MINE SITES, OPAL CREEK MARION COUNTY, OR	**FIGURE 3**

FIGURE 4A. VIEW LOOKING UP BLUE JAY CREEK (SOUTH) FROM A VANTAGE POINT FAR UPSTREAM OF THE MORNING STAR MINE WORKINGS.

FIGURE 4B. VIEW LOOKING DOWN BLUE JAY CREEK (NORTH) FROM THE LOCATION OF FIGURE 4A; NOTE THE LARGE LOG BRIDGING THE CREEK IN THE DISTANCE.

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FIGURE 5A. VIEW LOOKING UP BLUE JAY CREEK (SOUTH) FROM IMMEDIATELY UPSTREAM OF THE MORNING STAR MINE WORKINGS; NOTE THE LOG BRIDGING THE CREEK THAT CAN ALSO BE SEEN ON FIGURE 4B.

FIGURE 5B. MORNING STAR MINE ADIT; NOTE THE SMALL WORKING AREA IN FRONT OF THE OPENING AND STEEP ROCK "CHUTE" USED TO DISPOSE OF MINE WASTE ROCK.

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FIGURE 6A. VIEW LOOKING SOUTHWEST FROM THE WASTE ROCK PILE TOWARDS THE MINE ADIT BEHIND THE BEDROCK PROMONTORY ON THE RIGHT SIDE OF THE PHOTO; NOTE THE FAN OF WASTE ROCK BENEATH THE ROCK "CHUTE" AND THE SLOPE OF WASTE ROCK MATERIAL ON THE LEFT SIDE OF THE PHOTO (ACROSS THE CREEK FROM THE MINE ADIT).

FIGURE 6B. CRIBBING USED TO SUPPORT THE WASTE ROCK PILE IS TILTED TOWARDS THE ROCK-FILLED CHANNEL OF BLUE JAY CREEK.

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OPALCREEK-1-03	**PROJECT SITE PHOTOGRAPHS**	
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FIGURE 7A. TIMBER COVERED SLOPE OF THE WASTE ROCK PILE VIEWED FROM ABOVE.

FIGURE 7B. VIEW LOOKING WEST DOWN THE ACCESS ROAD; NOTE THE SIDE CASE DEBRIS CAUGHT ON THE UPSLOPE SIDE OF THE TREES BELOW THE ROAD.

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OPALCREEK-1-03	**PROJECT SITE PHOTOGRAPHS**	
MAY 2009	RUTH AND MORNING STAR MINE SITES, OPAL CREEK MARION COUNTY, OR	**FIGURE 7**

APPENDIX I

United States Department of Agriculture

Forest Service

Willamette National Forest

Detroit Ranger District
HC 73, Box 320
Mill City , Oregon 97360
(503)-854-3366
(503)-854-4239 FAX

File Code: 2520 Watershed Protection Management **Date:** January 20, 2012

Route To: 2840 Reclamation

Subject: Morning Star Waste Rock Stability Evaluation

To: Pete Jones

Introduction:

On 5/23/2011 Grady McMahan (Detroit Ranger District Ranger), Stacey Forson (Willamette Recreation Land and Minerals Staff Officer), Judith McHugh (Willamette Public Affairs Officer), Dani Pavoni (Detroit Ranger District Recreation Staff officer), Darrin Neff (Detroit Ranger District Fish Biologist), Brad Peterson (Detroit Ranger District Wilderness, Trails Program Manager), Doug Shank (Willamette Geologist), Pete Jones (R6 Oregon CERCLA Coordinator),and Dave Halemeier (Detroit Ranger District Hydrologist) met on site to inspect the Morning Star and Ruth Mine sites. Dani, Doug and Dave have worked within the area for a combined time exceeding 60 years between the three of them and so their insights were shared. Other members that had additional information and discussed this with the group.

The purpose of the visit was twofold. First, to share information with attendees as to the history and proposed scope of future actions relating to the sites; and second, to review GeoDesign waste rock pile stability evaluations and compare to District specialist's observations and opinions.

Under item #1, Pete Jones informed the group of the recent studies of the mines, and the alternatives proposed for future action. Under item #2, Doug Shank discussed the potential risk for slope stability failures in the upslope stream banks and disclosed that, due to the type of geology and the soil types found within the area, that a low risk of failure exists. This concurs with GeoDesign's findings.
Dave Halemeier discussed the historic impacts of the 1996 flood event and shared his findings from reconnoitering the channel (Blue Jay Creek) above the Morning Star adit.

Although the potential for slope stability failures is low, there is the potential for localized channel bank failures associated with high water events. This could result in mine waste rock being eroded and re-deposited downstream in Battle Axe Creek. This report discusses in further detail findings under #2 and proposes remediation needed to reduce the risk associated with the site.

Slope Stability Evaluation:

The bedrock geology of the Little North Fork is comprised primarily of andesites and basalts. Consequently, the soils for the most part are relatively stable. Extensive reconnaissance by Doug Shank in past years in this and surrounding areas of Battle Ax Creek have shown a remarkably stable landscape. Unlike other areas on the Detroit Ranger District, the Little North Fork in general and Battle Ax Creek in particular do not develop debris chute type failures on the hill sides or in disturbed areas. As was mentioned in the Introduction, the findings of GeoDesign, Inc (Report of Slope Stability Evaluation - Morning Star Mine – Opal Creek Scenic and Recreational Area, Willamette National Forest, dated May 6, 2009) echo this observation. I support their conclusion that the waste rock pile and the access road are relatively stable with respect to a mass wasting potential. The evident concern is related to excessive erosion if Blue Jay Creek were to leave its current channel.

Channel Bank and Waste Rock Pile Stability Evaluation:

Morning Star Mine:
Channel conditions of Blue Jay Creek from the confluence to Battle Ax Creek upstream to 3500' elevation, (approximately 1500' upstream from the adit) consist of very angular unconsolidated steps. These steps are the result of historic flow events eroding bank material and depositing this material behind tree bowls and root wads, large boulders (> 1.5 feet), or bedrock pinch points within the streams valley bottom. Evidence of historic exploratory mining is apparent along the upper banks of the channel with the waste material deposited within the channel. Channel banks are greater than 65% slope and contain typical inner gorge characteristics (bedrock outcrops, wood accumulation, and moss covered middle to high banks). Small eroded sections of low to middle banks exist from annual flows eroding the toe slope of the channel and destabilizing the lower to middle banks in localized areas. Evidence exists of higher flows (1996) altering the valley bottom and lower through upper banks through erosional processes. Due to the unconsolidated nature of the substrate and bedrock bottom parent material, these high flows move abundant material when they occur.

Channel substrate material is very coarse, angular well drained material. Fines consist of less than 20 percent of volume of substrate. Figure 1 shows the channel at approximately 200 feet downstream of the adit. Note the eroded middle banks (Line 1) and the abrupt change from the middle to upper banks depicting the unstable nature of the middle banks. Line 2 shows the extent of the lower bank (bank full flow height).

Figure 2 shows the channel above the adit. The steep nature of the channel and its sideslopes create a very high energy system that is confined by its channel banks and is efficient in moving material. The wood found within the channel reduces this energy and creates the steps described above where deposition occurs when flows recede.

Evidence of mine waste material moving downstream is still apparent at the lower road crossing. A delta of mine waste material is evident on the road where this material is intermittently being transported downstream from the existing waste pile.

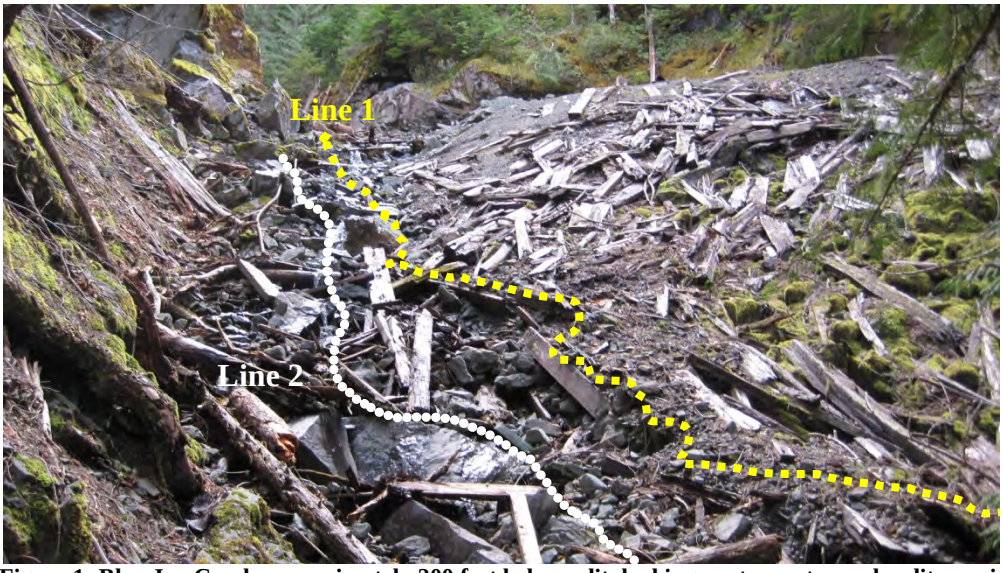

Figure 1: Blue Jay Creek approximately 200 feet below adit, looking upstream towards adit opening.

Figure 2: Blue Jay Creek looking upstream from the adit; Note old waste rock material incorporated into middle and upper banks on the left hand side of the picture (gray colored angular rock and fines). This waste rock is susceptible to mobilization due to the wood incorporated into the bank rotting and allowing the material to move down slope into channel.

During flow events greater than 1.5 year return intervals it is typical for these channels to occupy their middle banks. Having fines scoured from these areas destabilizes the toe of the upper bank and channel bank failures occur. While upslope stability is good for the area, the channel banks are susceptible to failures due to the confined nature of the channel. Putting additional debris, waste rock, and associated wood debris on the upper banks (Figure 1 above Line 1, Figure 2 left side of picture), created a risk of future failures during high flow events. Figure 3 shows an overview of the channel in relation to the adit and the amount of material perched on the upper bank available to fail (native material is brown colored, waste material is grey colored, dotted line surrounds waste rock pile).

Localized areas of concern stems from perched material located on the upper banks at the waste area to the adit, as shown in Figure 3.

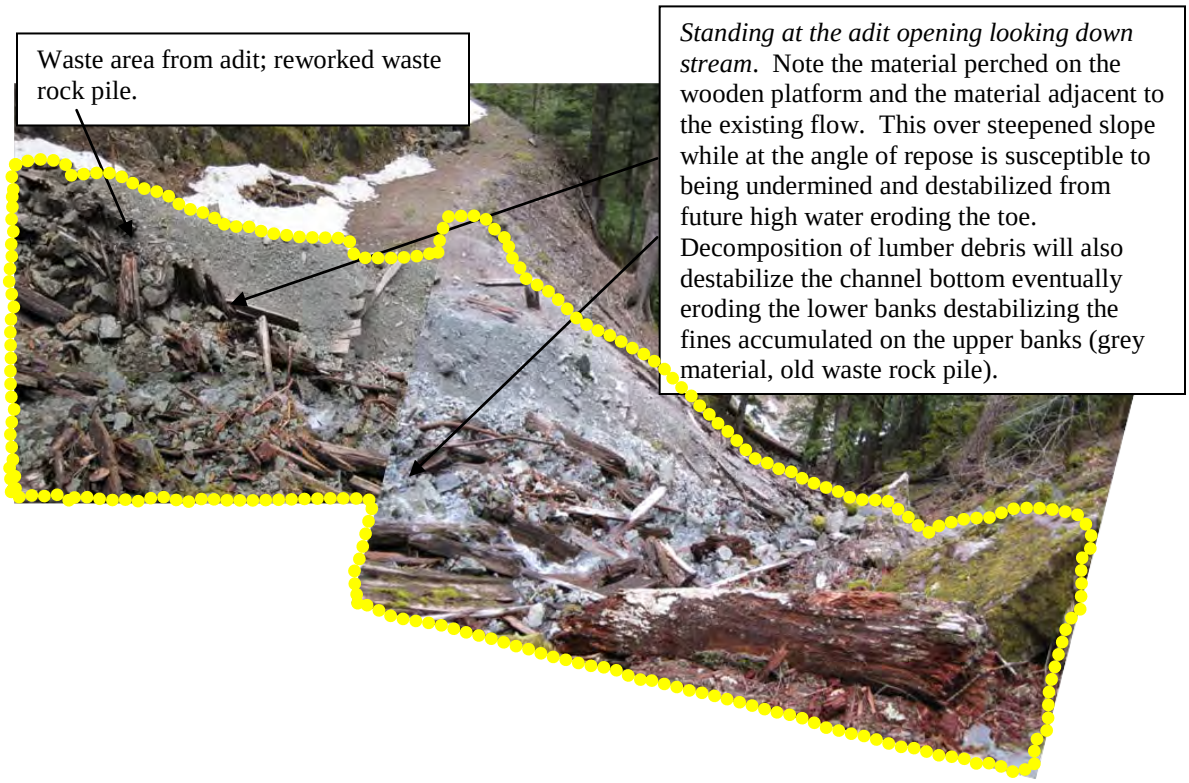

Figure 3: Localized area of concern directly downstream of adit.

Evidence from the deposits found within Blue Jay creek upstream and downstream of the adit show that annual flows erode the lower banks and cause minor sloughing of middle and upper bank material to enter the channel. As flow increases to the 1.5-35 year flow return interval, this middle-to-upper bank disturbance increases. In 1996 a 35 year storm occurred in this area and channel banks were destabilized due to the increased flows. Material shown in Figure 1 above line 1 was stock piled at the edge of the road before 1996 and the material migrated downslope as a result of the loss of lower and middle bank material supporting the pile. Since 1996 this material has continued to move closer to the flowing water as a result of gravity and eroding lower banks from annual flows. While not as spectacular as the 100 year flow in 1964 in which the entire channel was gutted and facilities lost adjacent to the adit, these smaller flows slowly remove material and transport it downstream. The sheer amount of old lumber and wood found within the banks creates further risk of failure into the stream as the wood decays and allows material supported by the wood to move downslope.

Figure 4: Typical Channel Cross-section and associated banks

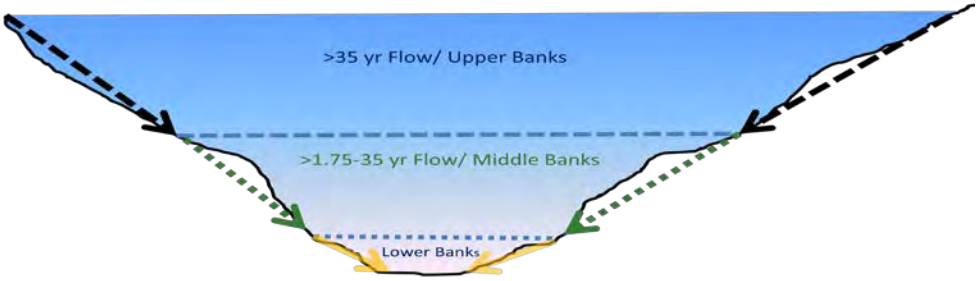

Figure 4 shows a typical valley cross-section or channel cross-section and its associated banks.

Remediation Proposal:

Proposed remediation would be to utilize an excavator to pull fine material back from the channel and stockpile against the hillside, as shown in Figure 5. Collect all lumber and wood debris along the channel bottom and lower through upper banks and use to cover waste rock material stockpile removed from channel and banks for erosion protection. After waste rock and debris material is removed a channel should be created through the site utilizing onsite rock to stabilize the toe along the edge of the lower banks (annual flow channel) on both margins. Bankfull width for this site is approximately 10-12 feet. Rock greater than 16 inches in diameter that is excavated from the site should be stockpiled and utilized as riprap along the channel margins to reduce lower bank erosion rates.

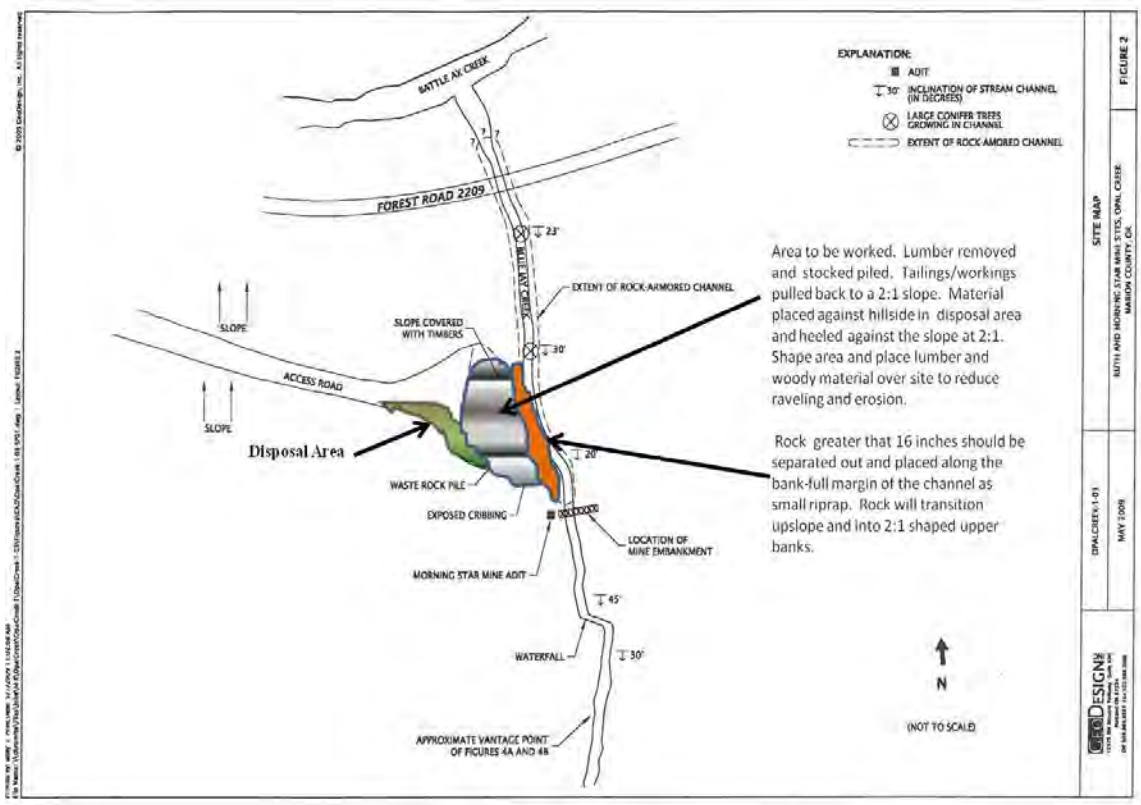

Figure 5: Taken from Figure 2 of GeoDesign Stability Evaluation, with remediation notes added.

Steps will need to be created due to the channel gradient. These steps can be constructed utilizing onsite rock, and placed every 10-20 lineal feet. This will reduce energy through the site and allow water and sediments to pass through site without destabilizing middle or upper banks. All work activities need to occur within the approved ODFW in-stream work window.

It is important to note that these recommendations are general and a hydrologist should be on site to work with the operator to guide the remediation work. Seasonal flow prior to remediation work could alter the site enough to warrant new direction.

Dave Halemeier[1]

Hydrologist, Detroit Ranger District

Doug Shank[2]

Geologist, Willamette National Forest

1: Dave Halemeier has been a Forest Service hydrologist for 33 years, with 23 of those years serving on the Detroit Ranger District. He has been making observations and investigating hydrology and water quality of the mines located in the area over a 20 year period. He has received his Bachelor of Science in Resource Planning and Interpretation, from Humboldt State University in 1978, and his Master of Science in Natural Resources/Watershed Management from Humboldt State University in 1983.

2: Doug Shank has been a Forest Service geologist for more than 35 years working on the Detroit Ranger District. He specializes in slope stability and geotechnical evaluations for both timber management and road construction. He has extensively investigated the soils and geology concerns for this and other projects within the area having completed extensive soil mapping for the Detroit Ranger District. He has received his Bachelor of Science in Geology, from Youngstown State University in 1971 and his Master of Science in Geology from Arizona State University in 1973.

APPENDIX J

TABLE J-1
Cost Estimate Alternative 2
Institutional Controls

Capital Cost	Rate	Unit	Quantity	Subtotal
Signage (custom sign and post)	$102	SIGN/POST	6	$612
Installation	$1,400	LS	1	$1,400
Administration (signage)	$2,000	LS	1	$2,000
Administration (removal restriction)	$3,500	LS	1	$3,500
			SUBTOTAL	$7,512
Contingency			30%	$2,254
TOTAL (rounded)			TOTAL	**$9,800**

TABLE J-2
Cost Estimate Alternative 3
Ruth Mine Adit 4 Waste Rock Stabilization, Re-Grade, Stream Buttressing,
Morning Star Mine Waste Rock Pull Back, Slope Stabilization, and Consolidation

Capital Cost	**Rate**	**Unit**	**Quantity**	**Subtotal**
Design, Implementation Coordination	$24,000	LS	1	$24,000
Helicopter Access (estimate)	$150,000	LS	1	$150,000
Spider Hoe Limited-Access Work				
Spider Hoe Grading	$225	HOUR	240	$54,000
Support Vehicle, Laborer	$150	HOUR	320	$48,000
Rock Buttressing	$225	HOUR	40	$9,000
Site Preparation	$15,000	LS	1	$15,000
Post-Grading Erosion Control	$15,000	LS	1	$15,000
Adit Drainage Construction	$225	HOUR	40	$9,000
Bridge/Road Repair (high estimate)	$170,000	LS	1	$170,000
Construction Observation				
Field Oversight	$129	HOUR	140	$18,060
Expenses	$2,500	LS	1	$2,500
Documentation	$12,000	LS	1	$12,000
		Subtotal Helicopter		$356,560
		Subtotal Bridge/Road Repair		$376,560
Contingency Helicopter			30%	$106,968.0
Contingency Bridge/Road Repair (high)			30%	$112,968.0
CAPITAL COST		TOTAL Helicopter		$463,528
		TOTAL Bridge/Road Repair		$489,528
MONITORING, OPERATIONS, AND MAINTENANCE (MOM)				
Assumes Visual Inspection, Photographs				
Two Water Samples in Battle Ax Creek (dissolved metals)				
Memorandum Reporting				
	Rate	**Unit**	**Quantity**	**Subtotal**
Scheduling, Correspondence	$129	HOUR	5	$645
Field Inspection, Sampling	$129	HOUR	12	$1,548
Equipment	$100	LS	1	$100
Travel, Mileage	$0.55	MILE	180	$99.00
Laboratory Analysis	$230	SAMPLE	2	$460
Memorandum				
Project Management	$129	HOUR	8	$1,032
Principal Review	$169	HOUR	2	$338
Project Assistant	$70	HOUR	2	$140
Support	$55	HOUR	2	$110
			SUBTOTAL	$4,472
Contingency			15%	$670.80
			TOTAL	$5,143
MOM Net Present Value (events at year 1, , and 5)			NPV	$9,299
TOTAL Helicopter (rounded) (Capital and MOM)				**$473,000**
TOTAL Bridge/Road Repair (rounded) (Capital and MOM)				**$499,000**

TABLE J-3
Cost Estimate Alternative 4
Disposal at Ruth Adit 4 and Morning Star Mine

Assume 1,800 yards x 1.5 tons/yard is 2,700 tons
Assume 5-yard dumps to gate then 20-yard trucks to landfill
360 trips from mine to gate, assume 3 trucks at 4 trips/day is 30 days
90 20-yard trips in 30 days is 3 trips a day
90 trips to landfill, assume 3 hours each trip

Capital Cost	Rate	Unit	Quantity	Subtotal
Design, Implementation	$20,000	LS	1	$20,000
Removal with Spider Hoe	$225	HOUR	100	$22,500
Transfer Once Removed	$200	HOUR	240	$48,000
Support Vehicle, Laborer	$150	HOUR	340	$51,000
Transport (5-yard dump)	$20	TON	2700	$54,000
Transfer	$200	HOUR	240	$48,000
Transport (20-yard dump)	$30	TON	2700	$81,000
Site Preparation	$10,000	LS	1	$10,000
Post-Grading Erosion Control	$10,800	LS	1	$10,800
Disposal	$40	TON	2700	$108,000
Bridge/Road Repair	$170,000	LS	1	$170,000
Construction Observation				
Field Oversight	$129	HOUR	300	$38,700
Expenses	$6,000	LS	1	$6,000
Documentation	$12,000	LS	1	$12,000
			SUBTOTAL	$680,000
Contingency			30%	$204,000
CAPITAL COST			TOTAL	$884,000

MONITORING, OPERATIONS, AND MAINTENANCE (MOM)
Assumes Visual Inspection, Photographs
Two Water Samples in Battle Ax Creek (dissolved metals)
Memorandum Reporting

	Rate	Unit	Quantity	Subtotal
Scheduling, Correspondence	$129	HOUR	5	$645
Field Inspection, Sampling	$129	HOUR	12	$1,548
Equipment	$100	LS	1	$100
Travel, Mileage	$0.55	MILE	180	$99.00
Laboratory Analysis	$230	SAMPLE	2	$460
Memorandum				
Project Management	$129	HOUR	8	$1,032
Principal Review	$169	HOUR	2	$338
Project Assistant	$70	HOUR	2	$140
Support	$55	HOUR	2	$110
			SUBTOTAL	$4,472
Contingency			15%	$670.80
			TOTAL	$5,143
MOM Net Present Value (events at year 1, 3, and 5)			NPV	$9,299
TOTAL (rounded) (Capital and MOM)				**$893,000**