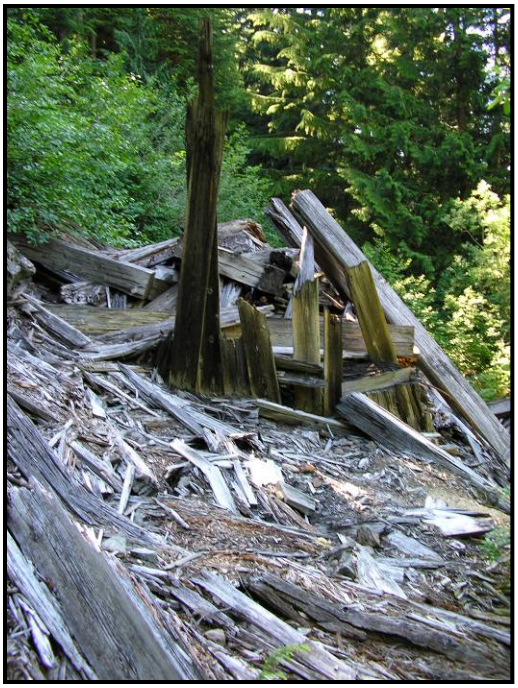

ENGINEERING EVALUATION / COST ANALYSIS
Monte Cristo Mining Area
Mt. Baker-Snoqualmie National Forest
Snohomish County, Washington

April 2010

A valmont COMPANY
Conserving Resources. Improving Life.

Cascade Earth Sciences
12720 E. Nora Avenue, Suite A
Spokane, WA 99216
(509) 921-0290
www.cascade-earth.com

CES A valmont COMPANY
Conserving Resources. Improving Life.

Engineering Evaluation / Cost Analysis
Monte Cristo Mining Area
Mt. Baker-Snoqualmie National Forest
Snohomish County, Washington

Prepared For:	USDA Forest Service Mt. Baker-Snoqualmie National Forest
Prepared By:	Cascade Earth Sciences 12720 E. Nora Avenue, Suite A Spokane, Washington 99216 (509) 921-0290
Authors/Reviewers:	Phillip R. Moyle, LG, Mining Geologist Dustin G. Wasley, PE, Principal Engineer
Report Date:	April 2010
Project Number:	2723029
Submitted By:	Dustin G. Wasley, PE, Principal Engineer

Cover Photographs: Upper Left = United Companies Concentrator; Upper Right = Ore Collector Crusher Base; Lower Left = Mystery Mine Adit Water.

Disclaimer: The contents of this document are confidential to the intended recipient at the location to which it has been addressed. The contents may not be changed, edited, and/or deleted. The information contained in this document is only valid on the date indicated on the original project file report retained by CES. By accepting this document, you understand that neither CES nor its parent company, Valmont Industries, Inc. (Valmont) accepts any responsibility for liability resulting from unauthorized changes, edits, and/or deletions to the information in this document.

CONTENTS

EXECUTIVE SUMMARY VII

1.0 INTRODUCTION 1

2.0 SITE CHARACTERIZATION 2
- 2.1 Site Description and Background 2
- 2.2 Data Gap Investigation 9
- 2.3 Description of Mines and Processing-Related Features in the MCMA 11
- 2.4 Sources, Nature, and Extent of Contamination 19

3.0 STREAMLINED RISK EVALUATION AND ASSESSMENT 31
- 3.1 Streamlined Human Health Risk Assessment 31
- 3.2 Streamlined Ecological Risk Assessment 38
- 3.3 Overview of the Human and Ecological Risk Assessment 42
- 3.4 Physical Hazards Associated with Mines and Processing Facilities 43

4.0 SITE CLEANUP CRITERIA 45
- 4.1 Potential Applicable or Relevant and Appropriate Requirements 45
- 4.2 Risk-Based Preliminary Remediation Goals 47
- 4.3 Recommended Cleanup Goals 48

5.0 IDENTIFICATION OF REMOVAL ACTION OBJECTIVES 48
- 5.1 Removal Action Justification 49
- 5.2 Scope of the Removal Action 49
- 5.3 Removal Action Schedule 50

6.0 IDENTIFICATION AND ANALYSIS OF REMOVAL ACTION ALTERNATIVES 50
- 6.1 Identification and Screening of Removal Action Options and Alternatives 50
- 6.2 Analysis of Selected Removal Action Alternatives 62
- 6.3 Identification of Data Gaps 63

7.0 COMPARATIVE ANALYSIS OF REMOVAL ACTION ALTERNATIVES 65
- 7.1 Glacier Basin Mines in the HMJ Wilderness Area - Pride of the Mountains, New Discovery, and Pride of the Woods Mines 66
- 7.2 Seventysix Gulch Mines in the HMJ Wilderness Area - Sheridan and Sidney Mines 69
- 7.3 Mystery Basin Mines near the HMJ Wilderness Area - Mystery, Justice, and Golden Cord Mines 72
- 7.4 Processing-Related Facilities in and near the Townsite - Ore Collector, Haulage Ways, Concentrator, and Assay Shack 75
- 7.5 Other Mines in the MCMA - Rainy and Boston-American Mines 77

8.0 RECOMMENDED REMOVAL ACTION 80
- 8.1 Recommended Removal Actions Common to All Mines and Facilities and the MCMA 80
- 8.2 Recommended Removal Action - Locality-Specific 82
- 8.3 Recommended Removal Action - MCMA Repository 88
- 8.4 Recommended Removal Action - Conclusion and Cost 90

REFERENCES 90

CONTENTS (continued)

TABLES

Table 1. Selected Information on Mines and Processing-Related Facilities Included in the Monte Cristo Mining Area EECA
Table 2. Surface Water Analytical Results
Table 3. Adit Drainage and Waste Rock Dump Seep Water Analytical Results
Table 4. Pore Water Analytical Results
Table 5. Sediment Analytical Results
Table 6. Waste Rock and Soil Analytical Results
Table 7. Background Soil Analytical Results
Table 8. Toxicity Characteristic Leaching Procedure and Synthetic Precipitation Leaching Procedure Results for Tailings and Waste Rock Samples
Table 9. Quality Assurance and Quality Control Analytical Results
Table 10. Removal Action Technology Screening Summary
Table 11. Surface Water ARARs and Proposal Cleanup Goals
Table 12. Mine Water ARARs and Proposal Cleanup Goals
Table 13. Sediment ARARs and Proposal Cleanup Goals
Table 14. Waste Rock, Soil, and Tailings ARARs and Proposal Cleanup Goals
Table 15. Comparative Analysis of Removal Action Alternatives – Pride of the Mountains Mine
Table 16. Comparative Analysis of Removal Action Alternatives – New Discovery Mine
Table 17. Comparative Analysis of Removal Action Alternatives – Pride of the Woods Mine
Table 18. Comparative Analysis of Removal Action Alternatives – Mystery Mine
Table 19. Comparative Analysis of Removal Action Alternatives – Golden Cord Mine
Table 20. Comparative Analysis of Removal Action Alternatives – Justice Mine
Table 21. Comparative Analysis of Removal Action Alternatives – Rainy Mine
Table 22. Comparative Analysis of Removal Action Alternatives – Ore Collector
Table 23. Comparative Analysis of Removal Action Alternatives – Haulage Ways
Table 24. Comparative Analysis of Removal Action Alternatives – Concentrator
Table 25. Comparative Analysis of Removal Action Alternatives – Assay Shack
Table 26. Comparative Analysis of Removal Action Alternatives – Boston-American Mine
Table 27. Comparative Analysis of Removal Action Alternatives – Sheridan Mine
Table 28. Comparative Analysis of Removal Action Alternatives – Sidney Mine
Table 29. Cost Summaries for Mine Waste and Adit/Seep Water Alternatives
Table 30. Cost Summary of Recommended Removal Action

PLATES

Plate 1. Site Layout Map of Monte Cristo Mining Area
Plate 2. Arsenic Concentrations in Aquatic and Mine Drainage Stations in the Monte Cristo Mining Area and South Fork Sauk River
Plate 3. Map of the Monte Cristo Mining Area Showing Selected Features of the Removal Action Plan

CONTENTS (continued)

FIGURES

Figure 1. Pride of the Mountains Mine
Figure 2. New Discovery Mine
Figure 3. Pride of the Woods Mine
Figure 4. Mystery Mine
Figure 5. Golden Cord Mine
Figure 6. Justice Mine
Figure 7. Rainy Mine
Figure 8. Ore Collector, Concentrator and Tailings, Assay Shack, and Haulage Ways
Figure 9. Ore Collector
Figure 10. United Companies Concentrator and Tailings
Figure 11. Assay Shack
Figure 12. Boston-American Mine
Figure 13. Sheridan Mine
Figure 14. Sidney Mine
Figure 15. Removal Action Conceptual Details

APPENDICES

Appendix A. Investigation Photographs
Appendix B. Benthic Macroinvertebrate Assessment
Appendix C. Streamlined Human and Ecological Risk Assessments
Appendix D. Potential Applicable and Relevant and Appropriate Requirements

LIST OF ACRONYMS AND ABBREVIATIONS

amsl	Above mean sea level
ARAR	Applicable or Relevant and Appropriate Requirement
BLM	Bureau of Land Management
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CES	Cascade Earth Sciences
CFR	Code of Federal regulations
DGI	Data Gap Investigation
Ecology	Washington State Department of Ecology
EECA	Engineering Evaluation/Cost Analysis
EECA-DGI	Data Gap Investigation for Engineering Evaluation/Cost Analysis
Forest Service	U.S.D.A. Forest Service
Haulage Ways	Ground and elevated rail haulage ways
HMJ Wilderness Area	Henry M. Jackson Wilderness
MCL	Monte Cristo Lake
MCMA	Monte Cristo Mining Area
MCPA	Monte Cristo Preservation Association
MTCA	Model Toxic Control Act
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
RARE II	U.S.D.A. Forest Service Second Roadless Area Review and Evaluation
SFSR	South Fork Sauk River
SI	Site Investigation
Site	Monte Cristo Mining Area (EECA investigation area)
SPLP	Synthetic Precipitation Leaching Procedure
TCLP	Toxicity Characteristic Leaching Procedure
TEE	Terrestrial Ecological Evaluation
90UCL	90_{th} percentile upper confidence limit on the arithmetic mean
USBM	U.S. Bureau of Mines
USEPA	U.S. Environmental Protection Agency
WRCC	Western Regional Climate Center

UNITS OF MEASURE

bcy	bank cubic yard
gpm	gallons per minute
t $CaCO_3$/Kt	tons of calcium carbonate needed to neutralize a kiloton of waste
<	less than
µg/L	micrograms per liter
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
mS/cm	microSiemans per centimeter
s.u.	standard units

EXECUTIVE SUMMARY

Cascade Earth Sciences (CES) prepared this Engineering Evaluation/Cost Analysis (EECA) for a proposed Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Removal Action in the Monte Cristo Mining Area (MCMA; also referred to as the Site) in Snohomish County, western Washington. The MCMA is located on the Mt. Baker-Snoqualmie National Forest, approximately 28 air-miles east-southeast of Granite Falls, Washington. The Site is in the South Fork Sauk River (SFSR) watershed, which is a perennial tributary to the Sauk River. The Removal Action Objectives are:

1. Reduce the human and ecological exposure to hazardous substances in the mining-related waste rock at mine and ore storage facilities, in tailings, and in contaminated soils associated with the Site.
2. Minimize or eliminate potential for hazardous substance mobilization and transport from contaminated waste rock, tailings, and soils on the Site by stabilizing and/or isolating sources.
3. Improve surface water quality by decreasing hazardous substance loading to Glacier Basin and Glacier Creek, Seventysix Creek (hereafter in this report, Seventysix Gulch refers to the valley and Seventysix Creek refers to the stream that flows through Seventysix Gulch), and the SFSR from mining- and processing-related sources.
4. Achieve potential applicable or relevant and appropriate requirements (ARAR) to the extent practicable, while considering the exigencies of the situation and the scope of the Removal Action.

An additional objective is to reduce human exposure to physical hazards associated with mining- and processing-related features (e.g. open mine workings, ruins of buildings, etc.) on the Site.

Based on the Site Inspection (CES, 2008), and other studies referenced in the SI, the MCMA considered in this EECA consists of the following ten mines and four facilities formerly used for ore storage, processing, and haulage (facilities), as well as the associated areal extent of contamination:

- Pride of the Mountains Mine
- New Discovery Mine
- Pride of the Woods Mine
- Mystery Mine
- Justice Mine
- Golden Cord Mine
- Rainy Mine
- Sheridan Mine
- Sidney Mine
- Boston-American Mine
- United Companies Concentrator (Concentrator)
- Ore Collector (Collector)
- Assay Shack
- Haulage Ways

This EECA, the SI (CES, 2008a), and the earlier associated studies indicate that concentrations of several hazardous substances, particularly arsenic, are above screening levels in one or more media at many locations in the MCMA. Furthermore, based on information provided in the Streamlined Risk Evaluation and Assessment of this report, contaminants of potential concern at the Site include: antimony, arsenic, copper, lead, manganese, mercury, selenium, and silver – with arsenic being the primary contaminant of concern (COC). Soil and waste rock in the vicinity of the Collector and the Concentrator, both in close proximity to the Monte Cristo Townsite (Townsite), contain the highest concentrations of arsenic in the MCMA; total arsenic ranges from 2,160 to 88,700 milligrams per kilogram (mg/kg) at the Collector and 137 to 92,000 mg/kg at the Concentrator. Most mines also contain moderate to very high total arsenic concentrations; from 72.6 to 226 mg/kg total arsenic at the Boston-American Mine on the southwest edge of the Townsite, to as high as 73,400 mg/kg total arsenic at the Rainy Mine adjacent to Glacier Creek. These compare to an U.S. Environmental Protection Agency (USEPA) Region 9 Industrial Preliminary Remediation Goal of 1.6 mg/kg for human receptors (USEPA, 2009a) and a background mean soil concentration in the MCMA of 137.5 mg/kg.

The highest concentrations of arsenic in water occur in mine drainage and dump seeps, particularly at the Pride of the Mountains (162 to 6,350 micrograms per liter [µg/L]), Pride of the Woods (4,060 µg/L), and Mystery (240 to 3,300 µg/L) Mines but several others exhibit elevated arsenic as well. Surface water samples at aquatic sites reveal that higher concentrations of arsenic occur in the reaches of Glacier and Seventysix Creeks, particularly below the mines and processing facilities sites. Total recoverable arsenic in Glacier Creek ranges from less than 3.0 µg/L in the headwaters up to 12.2 µg/L below the Concentrator, and total recoverable arsenic in Seventysix Creek ranges from less than 3 µg/L in the headwaters up to 9.64 µg/L near the Sidney Mine. This is compared to the USEPA recommended ambient water quality criteria of 0.018 µg/L total arsenic for protection of human consumption of water and fish (USEPA, 2009b) and a background mean surface water concentration in the MCMA of 1.63 µg/L total recoverable arsenic. Arsenic concentrations generally increase down the SFSR, particularly in Monte Cristo Lake (MCL), which is 6.8 miles downstream from the closest MCMA facility. Total recoverable arsenic in SFSR ranges up to 20.0 µg/L below MCL, and one surface water sample collected from MCL contained 68.5 µg/L total recoverable arsenic. Arsenic concentrations in pore water and sediments at aquatic sites generally follow the same pattern, although arsenic in pore water at MCL (2,820 µg/L dissolved arsenic) is particularly high. This may represent fine tailings transport downstream. The following table provides a summary of the arsenic concentrations in various media at the Site, along with applicable human and ecological regulatory standards.

Summary of Arsenic Human Health & Ecological Standards and Documented Arsenic Contamination

MCMA Area / Drainage System	Range Arsenic, Total	Average Arsenic, Total	Human & Ecological Standards[1] for Arsenic (maximum by media & receptor)	
Waste Rock, Tailings, and Soil				
Soil Background	**23.3** to **700** mg/kg	**137** mg/kg	WA - Method A Industrial Soil Cleanup Levels - Human Receptors	20 mg/kg
Upper Glacier Creek (Glacier Basin)	**42.6** to **41,400** mg/kg	**11,520** mg/kg		
Mystery Ridge/Basin Area near Glacier Creek	**732** to **39,400** mg/kg	**13,458** mg/kg	EPA Industrial PRGs - Human Receptors	1.6 mg/kg
Lower Glacier Creek and Monte Cristo Townsite Area	**63** to **92,100** mg/kg	**22,969** mg/kg	EPA - Ecological Receptors (m = mammal, b=bird, i = invertebrate, p = plant)	37 mg/kg (p)
Seventysix Creek Area	**1,720** to **38,400** mg/kg	**17,585** mg/kg	ORNL - Ecological Receptors	9.9 mg/kg
Adit/Seep Water				
Upper Glacier Creek (Glacier Basin) (Pride of the Mountains, Pride of the Woods, New Discovery Mines)	**2.8** to **6,350** µg/L	**1677** µg/L	Washington - Aquatic Life (Chronic)	190 µg/L
Mystery Ridge/Basin Area near Glacier Creek (Mystery & Justice Mines)	**196** to **3,300** µg/L	**702** µg/L	Washington - Human Health	0.018 µg/L
Lower Glacier Creek and Monte Cristo Townsite Area (Rainy & Boston American Mines)	**1.8** to **14.0** µg/L	**7.7** µg/L	Washington Drinking Water Criteria	10 µg/L
			EPA - Aquatic Life (CCC)	150 µg/L
Seventysix Creek Area (Sidney Mine)	**19** to **28.8** µg/L	**23.9** µg/L	EPA - Human Health (Water+Organism)	0.018 µg/L
Surface Water				
Background (Glacier + Seventysix Creeks)	< 0.37 to **4.52** µg/L	**1.63** µg/L	Washington - Aquatic Life (Chronic)	190 µg/L
Glacier Creek	**1.6** to **12.2** µg/L	**5.25** µg/L	Washington - Human Health	0.018 µg/L
Seventysix Creek	< 0.37 to **9.64** µg/L	**6.76** µg/L	Washington Drinking Water Criteria	10 µg/L
South Fork Sauk River & Monte Cristo Lake	**5.2 to 68.4** µg/L	**14.5** µg/L	EPA - Aquatic Life (CCC)	150 µg/L
			EPA - Human Health (Water+Organism)	0.018 µg/L

Summary of Arsenic Human Health & Ecological Standards and Documented Arsenic Contamination (continued)

MCMA Area / Drainage System	Range Arsenic, Total	Average Arsenic, Total	Human & Ecological Standards[1] for Arsenic (maximum by media & receptor)	
Stream Sediments				
Background (Glacier + Seventysix Creeks)	**16.8** to **227** mg/kg	**80** mg/kg	WA - Freshwater (under development)	51 mg/kg
Glacier Creek	**112** to **469** mg/kg	**255** mg/kg	WA - Marine	57 mg/kg
Seventysix Creek	**276** to **311** mg/kg	**294** mg/kg	NOAA - Freshwater TEL	5.9 mg/kg
South Fork Sauk River	**194** to **1,090** mg/kg	**407** mg/kg	NOAA - Freshwater PEL	17 mg/kg
Monte Cristo Lake	**0.281** to **656** mg/kg	**394** mg/kg	ORNL - Freshwater	42 mg/kg

Notes:

Abbreviations: µg/L = micrograms per liter, mg/kg = milligrams per kilogram.
Bold concentrations exceed one or more human health and ecological standards.
1. See Tables 2 though 7 for sources of human health and ecological standards.

The streamlined risk evaluation in this EECA indicates potential human health and ecological risk at the Site from exposure to such high concentrations of hazardous substances, particularly arsenic, in the mine waste, tailings, soil, sediment, water discharging from mine sites, and surface water. Risk-based cleanup levels for the reasonable maximum exposure (RME) scenario (conservative or worst-case estimate of potential exposure) were developed in the risk evaluation for the seasonal resident/visitor at the Near Sites and the recreational user at the Remote Sites based on the regulatory standard of 1E-06 excess cancer risk. Near locations are defined as those close to the Townsite and having fairly easy human access. Remote locations are typified by difficult terrain, lack of amenities, infrequent use, and difficult access. The potential for significant activity is considered to be moderate to high at the Near locations and very low at the Remote locations.

Based on ARARs and site-specific risk-based cleanup concentrations, proposed cleanup goals were developed for the Site. As arsenic was the primary COC, the following table shows the proposed arsenic cleanup goals for the Site; cleanup goals for other COC are provided in the EECA.

Preliminary Risk-Based Human Health Cleanup Goals

Medium	Arsenic Cleanup Goal	Location	Basis
Soil / Waste Rock	236 mg/kg	Near Features	Protection of RME Seasonal Resident - ingestion and dermal contact
	659 mg/kg	Remote Features	
Sediment	0.01 mg/kg	Near Features	Protection of RME Seasonal Resident - ingestion of fish
Surface Water	0.0008 µg/L	Near Features	Protection of RME Seasonal Resident - ingestion of fish

To address the identified human and ecological risks, a total of eight Removal Action alternatives were evaluated; five for the mine waste materials, and three for adit/seep water. These alternatives are outlined below.

Mine Waste Materials Alternatives

1. No Action
2. Institutional Controls
3. Mine Waste Cover
4. Removal and Disposal in MCMA Repository
5. Removal and Off-Site Disposal

Adit/Seep Water Alternatives

1. No Action
2. Diversion and Infiltration
3. Diversion, Passive Treatment and Infiltration

Based on the information outlined in this EECA, a CERCLA Removal Action is recommended to focus on the mines or process-related facilities with high recreational use, and/or in close proximity to surface water bodies with evidence of active erosion. Cleanup actions are recommended for the following mines and process-related facilities:

- Pride of the Woods Mine
- Rainy Mine
- Concentrator
- Ore Collector
- Assay Shack
- Boston-American Mine
- Haulage Ways
- Sidney Mine

The remaining mines are considered remote, with limited exposure, and may be addressed as part of additional investigation and potential Removal or Remedial Actions at the Site. Therefore, Removal Action alternatives are not recommended for the following mines (with the exception of physical hazard mitigation measures) at this time:

- Pride of the Mountains Mine
- New Discovery Mine
- Mystery Mine
- Justice Mine
- Golden Cord Mine
- Sheridan Mine

Based on the comparative analysis, Mine Waste Alternative 4 (Removal and Disposal in MCMA Repository) was selected as the recommended alternative for the eight sites listed above for the CERCLA Removal Action. In addition, Adit/Seep Water Alternative 3 (Diversion, Passive Treatment, and Infiltration) was selected as the recommended alternative for the Pride of the Woods and Sidney Mines. The recommended alternative would isolate a total of 15,725 bank cubic yards of mine waste from the eight mines/facilities in the on-Site MCMA repository. Additional actions would include mitigation of physical hazards by installation of bat-friendly closures at 15 open workings on 9 mines in the MCMA and selective removal of dangerous debris from facilities in the Townsite area. To support the recommended Removal Actions, long-term operations and maintenance as well as potential future Removal or Remedial Actions, a Forest Service Maintenance Level 2 road must be constructed from the Mountain Loop Road to the Monte Cristo Townsite.

The total estimated cost for the recommended CERCLA Removal Action alternatives, including design and oversight, 30-year of operations and maintenance, and contingency, is approximately $5.50 million.

1.0 INTRODUCTION

On behalf of the United States Department of Agriculture, Forest Service (Forest Service), Cascade Earth Sciences (CES) has prepared the following Engineering Evaluation / Cost Analysis (EECA) for completing a Non-Time Critical Removal Action of the Monte Cristo Mining Area (MCMA; also referred to as the Site) located in the Mt. Baker-Snoqualmie National Forest of Washington, near the Henry M. Jackson Wilderness Area.

The EECA is being performed under the Comprehensive Environmental Response and Liability Act (CERCLA) cleanup authorities [42 USC 9604(a) and 7 Code of Federal Regulations [CFR] 2.60(a)(39)] and Federal Executive Order 12580, with a general purpose to select an alternative to minimize or eliminate any release or threat of release of a hazardous substance into the environment or impact on public health and welfare as outlined in 40 CFR 300.415(b)(2)(i-vii). However, this EECA is specifically focused on the MCMA contamination sources, which are the mines and features listed below; further investigations and response may be needed following the completion of this EECA.

The EECA is being prepared in accordance with the provisions of National Oil and Hazardous Substances Pollution Contingency Plan (NCP), 40 CFR 300.415(b)(4)(i); and utilizing the U.S. Environmental Protection Agency (USEPA) "Guidance on Conducting Non-Time-Critical Removal Actions under CERCLA" (USEPA, 1993).

The purpose of a Removal Action is to "abate, prevent, minimize, stabilize, mitigate, or eliminate the release or the threat of a release" (40 CFR 300.415), and is intended to:

- Satisfy environmental review requirements for Removal Actions;
- Satisfy administrative requirements for documenting of Removal Action selection; and
- Provide a framework for evaluating and selecting alternative technologies.

The features included in this EECA consist of ten mines (mines) and several facilities associated with storage, processing, and ore haulage (facilities). These features are listed below:

- Pride of the Mountains Mine
- New Discovery Mine
- Pride of the Woods Mine
- Mystery Mine
- Justice Mine
- Golden Cord Mine
- Rainy Mine
- Sheridan Mine
- Sidney Mine
- Boston-American Mine
- United Companies Concentrator (Concentrator)
- Ore Collector (Collector)
- Assay Shack
- Haulage Ways

Locations of the mines, facilities, downstream reaches of the South Fork Sauk River (SFSR), and other selected features included in this EECA are shown on Plate 1. Maps of the individual mines and facilities are in Figures 1 through 14. Relevant information about each of the mines and facilities is presented in Table 1. Laboratory analyses and supporting information for surface water, mine drainage water, pore water, stream sediment, and waste rock and soil samples from all investigations of the MCMA are provided in Tables 2 through 6, respectively. Background soil sample analyses are provided in Table 7; Synthetic Precipitation Leaching Procedure (SPLP) and Toxicity Characteristic Leaching Procedure (TCLP) on selected waste rock and soils are provided in Table 8; Quality Assurance and Quality Control (QA/QC) results are provided in Table 9. Table 10 summarizes the Removal Action technology screening. Table 11 – 14 outline the proposed cleanup goals by media. Tables 15-28 outline the comparative analysis of the

Removal Action alternatives for each mine/facility. Table 29 provides a summary of the Removal Action alternative costs for each mine/facility, and Table 30 presents the cost summary of the recommended Removal Action. Photographs of sites discussed in the EECA are in Appendix A (Photographs 1-39). The benthic macroinvertebrate assessment and associated tables are presented in Appendix B, and the human and ecological risk assessment report and associated tables are in Appendix C. A table of the potential applicable or relevant and appropriate requirements (ARARs) is presented in Appendix D.

2.0 SITE CHARACTERIZATION

2.1 Site Description and Background

2.1.1 Site Location and Status

The MCMA is located in Snohomish County, Washington, near the west-center margin of the Henry M. Jackson Wilderness Area (HMJ Wilderness Area), and approximately 28 air-miles east-southeast of Granite Falls, Washington, which, in turn, is about 9.5 miles east of Marysville, Washington. Driving time one-way via the Mountain Loop Road from Darrington or Granite Falls to the Barlow Summit trailhead near the MCMA is estimated to be approximately 45 minutes depending on road conditions.

The Monte Cristo Townsite (Townsite) at the core of the MCMA (Plates 1, 2, and 3) is located in the SE¼ of Section (Sec) 21, Township (T) 29 North (N), Range (R) 11 East (E) of the Willamette Meridian (WM), latitude 47° 59' 09" N, longitude 121° 23' 36" west (W), at an elevation of 2,755 feet above mean sea level (amsl). The high-elevation portion of the MCMA is drained by two creeks separated by Wilmans Peaks: Glacier Creek flows west to northwest about two and one-half miles from Glacier Basin to the Townsite, and Seventysix Creek flows northwest about two miles to the confluence with Glacier Creek at the Townsite. The headwaters of both streams lie at elevations of well over 6,000 feet, and their confluence at the Townsite marks the beginning of the SFSR which flows 6.8 miles northwest to Monte Cristo Lake (MCL) and continues into the Sauk River, the Skagit River, and eventually Skagit Bay.

Location, access, and ownership information for the ten mines and associated mining- and processing-related facilities that are the focus of this EECA are described in Section 2.3 of this report, and in Table 1. Location data, including latitude and longitude, are taken from CES field observations modified by orthographically-corrected aerial photos using ESRI's ArcGIS (version 9.3); access information is modified from Johnson, et. al., (1983a) and Northwest Underground Explorations (1997).

Land ownership in the MCMA is extremely complex, consisting of a mix of public lands administered by the Forest Service and private property. The Forest Service has CERCLA authority for the release or threatened release of hazardous substances where the release is on or the sole source of the release is from National Forest System lands. On private land, the Washington Department of Ecology (Ecology) has similar cleanup authorities under Washington State's Model Toxic Control Act (MTCA). Since several Site features are located on both National Forest System land and private land, the Forest Service and Ecology need to make concurrent cleanup decisions and coordinate cleanup actions to efficiently conduct the MCMA cleanup.

Parcel sizes range from very small lots (less than 0.1 acres) in the Townsite, to patented millsite and placer claims and multiple blocks of patented lode claims (in excess of 60 acres). The Forest Service previously purchased some privately held property in the MCMA, particularly within the HMJ Wilderness Area. Approximate private property boundaries based on an examination of mineral survey plats and Snohomish County records are illustrated on Plate 1. Ownership classification in this EECA is taken from the Site Inspection (SI; CES, 2008a); however, the SI identified accurate ownership boundaries as a data gap.

2.1.2 Site History

A total of 54 mines and prospects, as well as ore transport, storage, and processing facilities, were identified in the Monte Cristo Mining District (District) during a U.S. Bureau of Mines RARE II (U.S. Forest Service Second Roadless Area Review and Evaluation) study (Johnson, et al., 1983a, 1983b). Prospecting in the District began in the spring of 1889, and active claim staking and mine development ensued soon after. A railroad was completed to the Townsite in 1893, and construction began on a 300-tons-per-day concentrator. Mineral production flourished for a few years until massive floods destroyed rail access in 1897. Production was intermittent for a period of time; however, the mines were permanently closed again in the fall of 1907. Additional unsuccessful attempts were made to revive the District through the winter of 1920 but due to a variety of reasons, not the least of which were severe weather and access problems, the District has been idle since.

Mineral production reported in the literature varies, primarily because District records are sketchy, but ore production is estimated to be at least 310,000 tons (Johnson, et al., 1983b, 1985). Most of the production came from the Mystery, New Discovery, Pride of the Mountains, Pride of the Woods, Golden Cord, Comet, Justice, and Rainy Mines. The most significant mineral deposit in the District is in the northeast-trending, northwest-dipping shear zone developed by the Justice, Golden Cord, Mystery, Pride of the Woods, New Discovery, and Pride of the Mountains Mines. The zone is exposed underground and on the surface over a strike length of 5,800 feet. In addition to reports by Johnson, et al., (1983b, 1985), other relevant geologic and mining-related references include Hodges (1897), Spurr (1901, 1908), Westby (1939), Broughton (1942), Huntting (1956), Woodhouse (1979), Church, et al., (1983), Derkey, et al., (1990), USGS (1991), Northwest Underground Explorations (1997), and Orr and Orr (2002).

All mines in the MCMA used standard underground mining practices for the period. The smallest possible heading was maintained to minimize ore dilution and hand cobbing. In general stopes were not backfilled except in a few scattered locations. Stopes were simple open stopes with stulls for support on a minimal basis. In a few areas, stopes broke through or are caved to the surface.

Run-of-mine ore from the Glacier Creek/Basin mines was sent to the Ore Collector for coarse crushing. Because of the differences in ore morphology between the Mystery Mine and other mines, separate ore bins were maintained at the Ore Collector to facilitate independent handling and modified processing. Ore was trammed by horse-driven rail from the Ore Collector to the United Companies Concentrator (Concentrator) where it was comminuted through a series of fine crushers and rolls before being passed through a system of jigs for concentrating. Tailings were discharged to land and Glacier Creek.

2.1.3 Previous Environmental Evaluations

Previous investigations of the MCMA include the following, which are discussed in more detail in the SI (CES, 2008a):

- Raforth, R.L., Norman, D.K., and Johnson, Art, 2002. *Second Screening Investigation of Water and Sediment Quality of Creeks in Ten Washington Mining Districts, with Emphasis on Metals*. Washington State Department of Ecology Publication No. 02-03-024, June 2002.
- Forest Service, 2002. *Abbreviated Preliminary Assessment - Monte Cristo Concentrator, Mt. Baker-Snoqualmie National Forest, Snohomish County, Washington.* October 2002.
- Forest Service, 2003. *Abbreviated Preliminary Assessment - Mystery Mine, Mt. Baker-Snoqualmie National Forest, Snohomish County, Washington.* February 2003.
- Wolff, F.E., D.T. McKay, Jr., and D.K. Norman, 2003. *Inactive And Abandoned Mine Lands – Mystery and Justice Mines, Monte Cristo Mining District, Snohomish County, Washington*. Washington Department of Natural Resources, Division of Geology and Earth Resources, Open file Report 2003-7, p. 22. April 2003.

- Crofoot, G.W., and M.L. O'Brien, 2004. *Monte Cristo Mine Area Site Hazard Assessment.* Snohomish Health District and Washington Department of Ecology. January 2004.
- Forest Service, 2006a. *Abbreviated Preliminary Assessment – Sidney Mine in the Monte Cristo Mining District, Mt. Baker-Snoqualmie National Forest, Snohomish County, Washington.* September 2006.
- Forest Service, 2006b. *Abbreviated Preliminary Assessment - Pride of Woods, New Discovery, and Pride of Mountains Mines in the Monte Cristo Mining District, Mt. Baker-Snoqualmie National Forest, Snohomish County, Washington.* September 2006.
- CES, 2008b. *Final Site Inspection Report Monte Cristo Mining Area, Mt. Baker-Snoqualmie National Forest, Snohomish County, Washington*. Cascade Earth Sciences.

2.1.4 Site Physiology

The MCMA is in the Middle Sub-Province of the Cascade Mountain Physiographic Province in the Mt. Baker-Snoqualmie National Forest of Washington, in and near the HMJ Wilderness Area, at elevations ranging from 2,756 feet amsl to over 6,000 feet amsl. On the downstream reach of the SFSR included in the extended study, MCL is at an elevation of 1,978 feet amsl. The MCMA is characterized by steep mountainous terrain consisting of deep, U-shaped glacial valleys and rugged, high-elevation ridges. It is drained by the SFSR watershed including Glacier and Seventysix Creeks that flow predominantly north-northwest from the Cascade Mountains crest. Glacier Basin in the upper MCMA is characterized by steep talus slopes, cliffs, alpine glaciers, and glacial lakes.

The major plant communities identified at and surrounding the MCMA include a western hemlock forest community, a riparian community, and a disturbed mine community. The forest community canopy layer is dominated by western hemlock, western red cedar, and silver fir with a shrub layer of snowberry, salmonberry, devil's club, and vine maple, and herbaceous species including deer fern, bracken fern, bleeding heart, and sedges. The riparian community has a sparse canopy layer, primarily consisting of western hemlock and red alder, a dense shrub layer dominated by vine maple and salmonberry, and a dense ground cover. The natural forest and riparian vegetation has been disturbed on mine- and processing-related sites in the MCMA.

2.1.5 Climate and Meteorology

The climate in Snohomish County, characterized by warm, semi-dry summers and cool, moist winters, varies depending on elevation and distance from the Cascade Mountains summit. Precipitation increases and temperatures decrease as elevation rises to the summit of the Cascade Mountain Range. Within the MCMA, the lowest elevation is 2,755 feet amsl at the Townsite, and the site at the highest elevation is the Pride of the Mountains Mine at 4,860 feet amsl. Climate data were compiled from the Western Regional Climate Center (WRCC) web site (http://www.wrcc.dri.edu/) at the Desert Research Institute.

The WRCC lists Monte Cristo as a climate data station (ID # 455539; now closed) for two periods of time: 1895 to 1902 and 1964 to 1976. Data for the older period were poorly documented, and the recent data were not available. The next nearest active climate monitoring station is at Darrington, Washington (ID # 451992). Average annual precipitation is about 80 inches; however, the station is at an elevation of only 550 feet amsl where temperatures and snowfall would not reflect those at Monte Cristo. Data from two Washington monitoring stations that are in terrain and at elevations similar to Monte Cristo, located 22 to 26 miles to the southeast were examined. The stations include the Scenic (ID # 457379; WRCCa, 2006) at an elevation of 2,221 feet amsl (monitoring data 1948 to 1970) and Stevens Pass (ID # 458089; WRCCb, 2006) at an elevation of 4,070 feet amsl (monitoring data 1950 to 1994). Data from the two monitoring stations and relevant climatic information are summarized as follows:

- Total average precipitation ranges from approximately 81.5 to 90 inches per year.
- Total average snowfall at the two stations range from 296 to 494 inches per year.
- The maximum average monthly snow depths occurs in March; 47 inches at Scenic and 103 inches at Stevens Pass.
- On the average, 0 inches of snow depth at both stations are reported only for the months of July, August, and September; however, 6.5 inches of precipitation, primarily as rain, are received at the stations during the same three months.
- The average minimum monthly temperatures from December through February range from 19° to 22°Fahrenheit (F).
- The average maximum daily temperature of approximately 66°F occurs in July.

Because the Townsite and the Pride of the Mountains Mine are about 500 feet and 800 feet above the Scenic and Stevens Pass monitoring stations, the respective sites in the MCMA may have higher average snowfall totals and lower average temperatures than those associated with the monitoring stations.

2.1.6 Regional and Local Geology

Regional geologic information was obtained primarily from Orr and Orr (2002), and site-specific geology was compiled from Johnson, et al., (1983a and 1983b), Wolff (2003), and Northwest Underground Explorations (1997). In addition, site-specific reconnaissance and observations were performed by CES Washington Licensed Geologists and Professional Engineers.

The MCMA is located in the Eastern Mélange Belt within the North Cascades Physiographic Province which is comprised of folded, faulted, and metamorphicly altered rocks ranging in age from Precambrian through Lower Cretaceous. The province is subdivided into numerous terrains which were accreted onto the North American plate during the Cretaceous. The Eastern Mélange Belt is a diverse assemblage of rocks including mafic metavolcanic rocks, chert, argillite, and greywacke along with migmatitic gneiss, metadiabase and ultramafic rocks. No carbonate sequences are present. The rocks have been considerably deformed and slightly metamorphosed. Many rocks have been recrystallized by thermal metamorphism near Tertiary plutons.

The MCMA lies across a contact between Eocene Barlow Pass volcanics and interbedded sediments and a large intruding body of granodiorite and tonalite namely the Miocene-Oligocene aged Grotto batholith. Mineral deposits in the District are within near vertical shear zones in schist, tonalite, and andesite, with lenses of sulfide ore from 100 feet to 300 feet in height, 1 foot to 15 feet thick, and 70 feet to 400 feet in length. Mineralization also occurs in other minor fractures. The deposits are essentially en echelon shear zones, 1foot to 3 feet wide, striking north 50-60° east, and dipping 50-80° northwest. The fracturing is augmented by two or more sets of joint planes striking about north-south and east-west. These structures cross and are eroded by Glacier and Seventysix Creeks.

Superimposed on the bedrock of the District are the pronounced effects of Pleistocene glaciation. The snow fields and small Alpine glaciers visible on the flanks of some peaks in Glacier Basin and the upper reaches of Seventysix Gulch are the remnants of a long period of glaciation during which large glaciers carved the pre-existing drainage system into deep, U-shaped valleys that now characterize the area. Due to glaciation, the peaks and steep flanks of the mountains and upper valleys have only a thin to essentially non-existent regolith, and exposures of bedrock and talus dominate the upper elevations. Discovery of the Monte Cristo deposits occurred because the metallic sulfides in the mineralized rock and the surrounding, iron-oxide altered rock were easily visible from a long distance. The lower reaches of Glacier Creek and Seventysix Gulch, and particularly the broader, U-shaped valleys characteristic of SFSR, have alluvial deposits in the valley bottoms and a thin regolith on the lower flanks of the valleys.

The Justice, Golden Cord, Mystery, Pride of the Woods, New Discovery, and Pride of the Mountains Mines, which develop a northeast-trending, northwest-dipping shear zone, comprise the most productive deposits in the District. The zone is exposed either underground or on the surface over a strike length of 5,800 feet, varies in width from less than 1 foot to over 20 feet, and contains quartz veins and lenses which pinch and swell sporadically along both strike and dip. Varying amounts of the following minerals were observed in one or more veins and lenses at mine sites in the MCMA: pyrite, pyrrhotite, arsenopyrite, sphalerite, galena, chalcopyrite, stibnite, bornite, and lesser amounts of azurite, boulangerite, chalcocite, hematite, malachite, marcasite, realgar, orpiment, and numerous unknown sulfosalts. Granodiorite, andesite, and tonalite country rock bordering the quartz veins is sheared, bleached, limonite-stained and contains disseminated sulfide minerals. Metal concentrations are much lower in the country rock than in the veins. Most of the other deposits in the district resemble this deposit and are different only in scale, being smaller.

It is noteworthy that Glacier Creek crosses the northeast-trending mineralized zone that is roughly defined by the locations of the Pride of the Mountains, New Discovery, and Pride of the Woods Mines in Glacier Basin. Glaciation that carved deeply into this valley undoubtedly removed and transported downstream significant portions of the mineralized rocks in the deposits long before their discovery, and Glacier Creek continues to cut across and slowly erode the mineralized zone. The above mines are also interconnected by a drift that is beneath Glacier Creek.

2.1.7 Hydrology

The MCMA is located within the SFSR watershed and includes the Glacier Creek and Seventysix Creek sub-watersheds. Surface waters in the MCMA generally flow to the north and ultimately into the Sauk River which flows north about 40 miles to join the Skagit River and eventually Skagit Bay in the Puget Sound. The South Fork Sauk River begins at the confluence of Glacier Creek with Seventysix Creek immediately below the Townsite. The SFSR flows north 6.3 miles from the Townsite to MCL and joins the North Fork Sauk River approximately 12 miles downstream from the MCMA. Approximately two miles below the Townsite, the SFSR periodically disappears and flows underground for about ¼ mile before resurfacing. This usually occurs only during the summer months of August and September at low flow.

Streams in the MCMA are characteristically high energy, particularly during spring snow melt, and periodic flooding has caused significant damage to roads and bridges that accessed the area since the late-1800s. Consequently, stream substrates are generally coarse with finer sediments scarce, particularly in Glacier and Seventysix Creeks. It is noteworthy that some hikers and campers and several seasonal residents in the Townsite reportedly take their drinking water from local surface streams.

2.1.8 Hydrogeology

The MCMA is located within the SFSR watershed and includes the Glacier Creek and Seventysix Creek sub-watersheds. A review of the Washington Water Resources Department well log database indicates that there are no wells located within a 4-mile radius of the MCMA (CES, 2008a). The hydrogeology within the granodiorite, tonalite, and related rocks that host the deposits is unknown; however, it is probable that groundwater flows preferentially along the permeable bedrock-overburden contact and lesser flow probably occurs in the bedrock fracture system. Groundwater levels are highly variable and dependent on precipitation and snow melt events. Snow melt, as well as water from mine portals higher on mountainsides, appear to infiltrate into talus and other thin, coarse regolith and flow along bedrock into the alluvial deposits of the valley bottoms. Mine sites that exhibited evidence of water flowing from the adit or seeping from the dump during the field investigation include the Boston-American, Justice, Mystery, New Discovery, Pride of the Mountains, Pride of the Woods, Rainy, and Sidney Mines. Only effluent from the Sidney Mine Adit portal appears to flow directly to surface water. A seep from the toe of the Pride of the Woods waste rock dump appears, at times, to flow into Glacier Creek.

2.1.9 Local Land Uses

The Monte Cristo Preservation Association (MCPA) maintains a public trust under Snohomish Country sponsorship for the historic Townsite. Each summer, many visitors pass through the nearby towns of Granite Falls or Darrington, Washington, drive along the Mountain Loop National Scenic Byway to Barlow Pass, and then hike the four plus miles along the meandering SFSR to reach the Townsite. Surrounded by majestic peaks, high-elevation snow fields, rugged terrain, and mountain streams in the adjacent HMJ Wilderness Area, the Townsite and associated historic sites, including mines and the remains of processing facilities, attract many seasonal tourists for a range of activities. According to the Forest Service and members of the MCPA, visitor activities include hiking, bicycling, horseback riding, picnicking, mountain climbing, rock hounding (rock/mineral collecting), fishing and hunting, and even historians who study the remains of the Townsite, local mines, and other historic sites. The extent of fishing is not known, but the SFSR and lower reaches of Glacier and Seventysix Creeks reportedly contain threatened and endangered populations of Bull Trout/Dolly Varden, steelhead, salmon (pink, coho, and/or Chinook) (Forest Service, 2006a). A few winter visitors reportedly travel to the Townsite on snowmobiles. The Forest Service maintains a small campground just downstream from the Townsite, and many informal campsites lie upstream along Glacier Creek and in Glacier Basin. CES staff noted at least one campsite at the Pride of the Woods Mine, which lies along the Glacier Basin Trail (Forest service Trail #719). The Townsite and some of the adjacent mining area lie within a "cherry stem" or exclusion area from the HMJ Wilderness Area; however, upper Glacier Creek, Glacier Basin, and most of Seventysix Gulch are inside the HMJ Wilderness Area. A modern cabin has been constructed on a patented claim along Seventysix Creek.

The Townsite is located within federally owned land managed by the Mt. Baker-Snoqualmie National Forest, but there are some inholdings of private land in the Townsite (Plate 1) due to patented mining claims and the original Townsite which was platted in 1892. A total of 33 claims were staked in the area between 1889 and 1906, 16 of which were patented. In 1994, nine of the patented claims comprising all but three of the original Mystery Mine complex were transferred from private ownership to the Forest Service.

The MCPA and the Forest Service cooperatively manage a summer visitor Host Program based at the Forest Service cabins just above the confluence of Glacier and Seventysix Creeks. No systematic or scientifically-based study has been conducted to determine the number of visitors to the MCMA during the summer season which generally begins in late May and runs into September or later which covers about 20 to 25 weekends, depending on weather. Based upon visitor host observations at the Townsite and periodic car counts at the Barlow Pass trailhead, the MCPA and Forest Service estimate there are about 3,500 visitors to MCMA annually. Although the number of visitors to the Townsite has probably diminished since severe damage occurred to the old road and bridges along SFSR during the 2006 floods, visitation rates are still high (Carol Gladsjo, Forest Service Recreation Manager, 11/4/2008). There are no documented year-round residents; several private land owners maintain cabins which are intermittently occupied over the summer season. Occasional winter use by private land owners is also likely. The MCPA estimated 8 to 10 such cabins with part time residents. It is noteworthy that Northwest Underground Explorations (1997), an informal group interested in finding and exploring historic mines, published a book describing the location, condition, and history of many of the mines in the MCMA, potentially attracting more visitors. Due to the high visitor interest, institutional controls in the form of temporary fencing and signage were installed in July 2006 to restrict public access to the Concentrator, Ore Collector, and the Assay Shack.

2.1.10 Sensitive Environments

Pursuant to section 2.4 of USEPA (1993), CES identified sensitive environments and ecosystems within and near the MCMA in the SI (CES, 2008a). Following is an overview of the sensitive environments and ecosystems discussed in the SI.

Wilderness Areas

The HMJ Wilderness was created by the 1984 Washington Wilderness Act. The MCMA is surrounded on three sides by the HMJ Wilderness; with the upper elevations of the MCMA (Glacier Basin and Seventysix Gulch) extend into the HMJ Wilderness. The HMJ Wilderness is managed by the Mt. Baker-Snoqualmie National Forest. As part of the National Wilderness Preservation System, the HMJ Wilderness is subject to numerous laws, including the 1964 Wilderness Act as amended, in order to protect its largely pristine character. Generally, motorized equipment and equipment used for mechanical transport (e.g., vehicles, helicopters, etc.) are prohibited on all federal lands designated as wilderness. The use of motorized equipment or mechanical transport are described in the special regulations in effect for a specific wilderness area; therefore, careful coordination with the Forest Service, and special waivers will be required to undertake significant Removal Actions within the HMJ Wilderness Area.

Wetlands and Wild & Scenic Rivers

The National Wetlands Inventory (NWI), a division of the U.S. Fish and Wildlife Service, prepares and utilizes maps as a preliminary tool for determining the location of potential wetlands; although, the map alone is not sufficient for ascertaining the presence of jurisdictional wetlands. Wetlands were identified based on vegetation, visible hydrology, and geography in accordance with Classification of Wetlands and Deepwater Habitats of the United States. The following areas are "listed" on the NWI map (USFWS, 1995) that could be affected by the MCMA.

- The SFSR below the MCMA is designated as Riverine, Upper Perennial, Open Water/Unknown Bottom, Intermittently Exposed/Permanent (R3OWZ).
- The SFSR, approximately 1.5 miles downstream of the MCMA, is classified as R3OWZ and R3FLY, Riverine, Upper Perennial, Semi-permanently Flooded.

The NWI map does not clearly outline the boundaries of riverine wetland systems. Therefore, the lateral boundaries adjacent to the stream cannot be determined without a jurisdictional wetland delineation conducted in accordance with the U.S. Army Corps of Engineers (USACE) Technical Report/Y-87-1.

According to 40 CFR 230.3 and USACE Technical Report/Y-87-1, "wetlands are those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions." A jurisdictional wetland delineation in accordance with USACE standards was not conducted during this investigation. As such, the exact boundaries and areas of potential wetlands were not defined. Based on this definition, other wetlands are probably present near the adit drainages (below Mystery Mine) and other areas of the MCMA (i.e., along the Glacier and Seventysix Creeks).

There are no designated wild and scenic rivers near the Site. The nearest is the Skagit River to the west.

Aquatic Ecology

Aquatic surveys were conducted, as part of the SI (CES, 2008a, Appendix B), at eight locations within Glacier Creek, Seventysix Creek, and the SFSR to assess the potential impacts of the MCMA on the in-stream habitat, benthic macroinvertebrate community, and presence of fish. Riparian habitat, in-stream habitat conditions, and presence of fish were observed at two other locations, one on Glacier Creek and one on the SFSR.

- Some alpine riparian habitat was present on Glacier Creek in the vicinity of aquatic stations GC-02 and GC-03. Riparian habitat was best developed along the middle portion of Seventysix Creek and the lower portions of the SFSR.
- Rainbow trout/steelhead, cutthroat trout, and bull trout are known to inhabit Glacier Creek and SFSR downstream from the falls (located between aquatic stations GC-04 and GC-05); however, no

anadromous fish reside and no fish were observed above the falls. The same fish species also likely inhabit the lower portions of Seventysix Creek.

Sensitive Species

Rare, threatened, or endangered (RTE) species and numerous other sensitive species known or expected to inhabit the MCMA and surrounding areas were also listed in the SI (CES, 2008a, Appendix B). Following is an overview of sensitive species described in the SI; however, please refer to Table B-2 in the SI (CES, 2008a) for a complete list of RTE and sensitive species expected to be found or possibly found in or near the MCMA.

- The marbled murrelet (federally threatened) was the only threatened or endangered bird species observed or expected near the Site. Olive-sided flycatchers (*Contopus borealis*; federal species of concern) were observed and three-toed woodpeckers (*Picoides tridactylus*; state monitor species) are expected at the Site.
- Deer tracks were noted in the vicinity of the Site, suggesting that black-tailed deer (*Odocoileus hemionus columbianus*; state priority; Forest Service Management Indicator Species) are present.
- Townsend's big-eared bats (*Plecotustownsendi;* state candidate species; federal species of concern; Forest Service Sensitive) may inhabit caves or mine shafts in the vicinity of the Site. The long-eared myotis (*Myotis evotis*: state monitor species; federal species of concern; Forest Service sensitive), and Keen's myotis (*Myotis keenii*; state candidate species) are also expected in the vicinity.
- The spotted frog (*Rana pretiosa*; state endangered species; federal candidate) possibly inhabits the area, tailed frog (*Ascaphus truei*) and western toad (*Bufo boreas*) are sensitive species expected to be on or near the Site.
- Bull trout, a federally threatened species, are also reported in the SFSR a lower reaches of Seventysix and Glacier Creeks.
- Numerous sensitive plant species possibly inhabit the Site; only the Boreal bedstraw (*Galium kamtschaticum*) is expected to be found on the Site.

2.2 Data Gap Investigation

As part of this EECA, CES conducted a Data Gap Investigation (DGI) of the MCMA from August 19-26, 2008, in order to gather additional data related to the potential threat to human health and the environment not acquired during the SI completed by CES (2008a). The core of the MCMA at the Townsite is nearly five miles from the nearest road passable by vehicles; therefore, helicopter transport was used to transport and establish a field camp at the Townsite during the August field exercise. CES field staff were accompanied by Rod Lentz, of the Forest Service, for four of six days of field operations. Two CES staff hiked into the Townsite on foot and conducted limited follow-up field work on the DGI from September 28-30, 2008. The overall field operations, sampling, and analysis plans are outlined in the DGI Field Operation Plan (CES, 2008b) and summarized in the following sections.

2.2.1 Overview of Field Activities

The mine team examined ten mines, collected waste rock samples, and constructed field maps of each mine. The aquatic team collected surface water and sediment samples from stations along Glacier Creek, Seventysix Creek, and the SFSR that were previously sampled during earlier investigations and from water draining from adits and seeping from waste rock dumps. Water and sediment sampling was performed at this time of the year in order to target low flow conditions; however, heavy rains over the first three days of the field investigation caused stream flows to increase significantly. The aquatic team spent approximately two additional days collecting surface water, pore water, sediment, and benthic macroinvertebrate samples from locations further downstream along the SFSR to and including MCL. The locations of all mines, sample localities, and other relevant features were determined using a global positioning system (GPS) unit. Due to

thick vegetative canopy at lower elevations and the limited aspect in the steep upland areas, the GPS data for some locations were modified in ArcGIS using a high-resolution orthophotograph of the area.

2.2.2 Mine Surveying, Data Collection, and Waste Rock Sampling

Ten mines were visited during the field investigation, and additional reconnaissance was conducted at previously examined processing facilities and other selected areas in the MCMA.

Mine Examinations

External areas around each of the mines were examined and sufficient reconnaissance conducted to prepare sketch maps showing the waste rock dump configuration and other important features (workings, surface water, etc.). Photographs were also taken, and the examination was documented in field notes. Waste rock dump volumes were calculated based on the field reconnaissance and sketch maps.

Waste Rock Sampling

Two or more representative samples of waste rock were collected from dumps at each mine as listed below. All samples were analyzed for ten total metals (antimony, arsenic, cadmium, chromium, copper, lead, mercury, selenium, silver, and zinc) and soil pH. In addition, SPLP and TCLP for the eight Resource Conservation Recovery Act (RCRA) metals (arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver), as well as SPLP for copper and zinc, and acid-base accounting (ABA) were conducted on selected waste rock samples. ABA is a static leaching test where the acid neutralizing potential (ANP) and acid generating potential (AGP) of waste samples are determined, and the difference, acid base potential (ABP), is calculated. The results are expressed in terms of tons of calcium carbonate needed to neutralize a kiloton of waste (t $CaCO_3$/Kt). Negative numbers indicate a likelihood of acid generation. Results of the laboratory analysis are presented in Tables 6 and 8.

Other Mine Data

Where possible, mine working openings (adit portals, shaft collars, etc.) were examined externally and dimensions collected to determine the suitability for potential bate gate installation. Mine openings that showed evidence of flowing water were also examined for optimum placement of a passive, *in situ* water treatment and/or infiltration system should one be needed.

Repository Reconnaissance

A brief reconnaissance was made of the lower MCMA to identify suitable candidate locations for placement of a centralized waste repository and for possible soil cover sources. Three candidate repository sites were examined (Plate 3: REP-1, REP-2, and REP-3), and limited reconnaissance and survey was conducted at two of the sites that are potentially suitable (REP-1 and REP-2, Photographs 34 and 35).

Mineral Survey Monument

At the request of the Forest Service, CES staff also conducted a limited reconnaissance of a 1,500-foot-long area along the top of Mystery Ridge in search of a U.S. Mineral Monument. The survey monument was not found.

2.2.3 Aquatic Sampling

Surface Water, Pore Water, and Sediment Sampling

Ten surface water and sediment samples were collected from the previously established aquatic sample stations (CES, 2008a) in Glacier Creek, Seventysix Creek, and the SFSR (Plates 1 and 2). Based on a change of scope for the EECA-DGI approved by the Forest Service, additional surface water, pore water, and sediment samples were collected at aquatic stations further down the SFSR to and including MCL and one

additional aquatic station 0.25 mile downstream from MCL (Plate 1). One surface water, one pore water, and six discrete sediment samples were collected from the middle of MCL, and one benthic macroinvertebrate sample was composited from the six sediment locations in the lake (see the following *Benthic Macroinvertebrate Sampling* section). Sampling and handling methodologies, laboratory analysis techniques, and other parameters are described in detail in the EECA Field Operations Plan (CES, 2008b).

All surface water, pore water, and sediment samples were analyzed for the metals antimony, arsenic, cadmium, chromium, copper, lead, mercury, selenium, silver, and zinc, and surface and pore water samples were also analyzed for calcium and magnesium. All water and sediment analytical results from the EECA-DGI, as well as those from the SI (CES, 2008a) and earlier preliminary investigations, are presented in Tables 2, 3, 4, and 5. Field parameters - specific conductivity, pH, temperature, dissolved oxygen, oxidation/reduction potential, stream flow (volume rate of flow) and other relevant data - measured at each surface and pore water station are presented in Tables 2, 3, and 4. Unfortunately, the field instrument (YSI Model 556) utilized by CES to collect most of these parameters was not fully functional and data at some localities was not collected (shown as IM [instrument malfunction] on Tables 2, 3, and 4). A second field instrument (Horiba U-22) rented by CES to complete the DGI also did not function correctly, and these parameters are also shown as IM on Tables 2, 3, and 4.

Benthic Macroinvertebrate Sampling

Six benthic macroinvertebrate samples (SFSR-04 to SFSR-09) were collected from the additional stations on the SFSR and one sample was composited from six pore water and sediment sample locations in MCL (MCL-1). Sampling and handling methodologies, analytical techniques, and other parameters are described in detail in the EECA Field Operations Plan (CES, 2008b), and the results of the benthic macroinvertebrate sample analyses - Benthic Invertebrate Index of Biological Integrity – for the six samples collected from SFSR are presented in Appendix B. Aquatic Biology Associates, Inc. of Corvallis, Oregon did not conduct an analysis of the sample composited from MCL because the enumeration methodology (Karr BIBI) is not an appropriate index for lake samples

Drainage Water Sampling

Eleven water samples were collected from adit drainage and waste rock dump seeps at eight of the ten mines in the MCMA (Plate 2). One sample each was collected from the Pride of the Mountains (PM-01), New Discovery (ND-01), and Pride of the Woods (PW-01) Mines in Glacier Basin, one each of adit drainage and waste rock dump seep were collected from the Mystery (MY-01 and MY-02) and Justice (JU-01 and JU-02) Mines in Mystery Basin, one drainage water sample was collected from the Rainy Mine (RY-01), an adit drainage water sample was collected from the Sidney Mine (SY-01) in Seventysix Gulch, and two samples – one adit drainage and one dump seep – were collected from the Boston-American Mine (BA-01 and BA-02). Sampling and handling methodologies, laboratory analysis techniques, and other parameters are described in detail in the EECA Field Operations Plan (CES, 2008b), and the analytical results are presented in Table 3.

2.3 Description of Mines and Processing-Related Features in the MCMA

The MCMA is divided into the following geographic areas: the Upper Glacier Creek (Glacier Basin) Area; the Mystery Ridge/Basin Area; the Lower Glacier Creek and Townsite Area; and the Seventysix Creek (Seventysix Gulch) Area (See Plate 1). Descriptions of each of the mines and four processing-related facilities in the in the MCMA are summarized in the following sections. Plate 1 shows the MCMA, including mines and processing facilities addressed in the EECA, the SFSR, MCL, and aquatic and background soil sample sites. Table 1 provides a summary of selected details about the mines and related features outlined below, and sketch maps of the sites are shown in Figures 1 through 14.

2.3.1 Upper Glacier Creek (Glacier Basin) Area

Pride of the Mountains Mine

The Pride of the Mountains Mine is located in SW¼ Sec 23, T 29 N, R 11 E, WM (longitude 121° 21' 31" W, latitude 47° 58' 49" N) at an elevation of about 4,860 feet amsl on Forest Service administered land in the HMJ Wilderness Area (Plate 1). It is accessed via the Forest Service Glacier Basin Trail east 2.25 miles up Glacier Creek from the Townsite, and then 1,000 feet east up a talus slope to the mine.

Only the Main Adit and waste rock dump at this site was examined during the EECA-DGI. Information on the remainder of the area is taken from Johnson, et al., (1983a) and Wolff, et al., (2003). Surface workings include several open cuts, five adit portals, three caved and two partially caved, and a largely-caved inclined shaft (Figure 1; Photographs 1-5); open cuts are not shown on the surface map. Over 2,314 feet of underground workings on three main levels are connected by a maze of stopes at the mine. The remains of a tram station and bunkhouse are located just west of the Main Adit (lowest, southwestern-most) portal which is partially caved. Water is impounded several inches deep behind sloughed material inside the Main Adit portal which is only about a foot high and two feet wide due to slough. Water apparently drains through the slough pile and down the east side of a large waste rock dump which is located below the main, southwestern-most adit portal. The mine water flows at a rate of 1.8 gallons per minute (gpm; Table 3; 8/23/2008) about 200 feet down slope on the waste rock surface before infiltrating into the dump and underlying talus. The slope distance from the waste rock infiltration point to Glacier Creek is approximately 900 feet. The portal of a second adit, named Adit 2, is partially caved leaving an opening only about 14 inches high. In 2002, the Washington Department of Natural Resources (DNR) noted that the air temperature at the Main Adit portal was 60° F, air was not exhausting from the adit, and there was no evidence of bats (Wolff, et al., 2003). The opening of the partially caved portal of Adit 2, possibly known as the "Mukelteo" Adit, is about six feet wide by one foot high.

The main waste rock dump, associated with the southwestern-most adit, extends approximately 410 feet in a N 40° E direction down a steep (-43° at the top) slope, averaging about 65 feet wide and 5 feet thick (Figure 1). Based on this geometry, it is estimated that the dump contains approximately 5,000 bank cubic yards (bcy) of waste rock. The main dump is relatively barren of vegetation. Two additional waste rock dumps associated with the eastern-most workings are small, each with 100 to 200 bcy, but these dumps were not examined in detail nor were measurements made.

New Discovery Mine

The New Discovery Mine is located in the SW¼ Sec 23, T 29 N, R 11 E, WM (longitude 121° 21' 44" W, latitude 47° 58' 52" N) at an elevation of 4,590 feet amsl on Forest Service administered land in the HMJ Wilderness Area (Plate 1). It is accessed via the Forest Service Glacier Basin Trail east 1.5 miles along Glacier Creek from the Townsite, then about 1,000 feet east to the portals.

Three open adit portals and associated waste rock dumps are present on the New Discovery Mine (Figure 2; Photographs 6-8). The waste rock dumps are relatively barren of vegetation. The portals of the two primary adits, named the Northwest and Southeast Adits (Forest Service, 2006b), are about 95 feet apart, and the adits are driven northeast into a vertical rock face from a narrow ledge (Photographs 6-8) that connects these two adits. The Northwest Adit is over 10 feet wide and about 5 feet high at the portal which is slumping, but it narrows to about 5 feet wide at less than 10 feet into the working and is about 6 feet high. The Southeast Adit is 5 feet wide and 7 feet high at the portal. The third adit, named the Barren Adit (Forest Service, 2006b), lies about 200 feet to the southeast of the Southeast Adit, is also driven northeast, and is 4-feet wide and 6.5-feet high at the portal. The Barren Adit, as its name implies, appears to develop unmineralized rock, and the small waste rock dump shows no sulfide minerals, alteration, or iron-oxide staining. Water drains from the Southeast Adit at a flow rate of <4.5 gpm (Table 3; 4/2003,WADNR) (flow rate was too low to measure during the EECA-DGI) and infiltrates into the dump about 20 feet from the portal; slope distance from the

waste rock infiltration point to Glacier Creek is approximately 365 feet. The Northwest and Barren Adits are dry. In 2002, DNR noted that the air temperature at the portals was 60°F, no air was exhausting from the adits, and there was no evidence of bats (Wolff, et al., 2003).

Underground maps from Johnson, et al. (1983a) show that the Northwest Adit was driven about 920 feet and the Southeast Adit was driven approximately 510 feet. Based on the dimensions of the two adits and assuming a 40 percent swell factor, the Northwest Adit dump is estimated to contain 1,430 bcy of waste rock, and the Southeast Adit dump is estimated to contain 925 bcy of waste rock. The underground map of Johnson, et al., (1983a) shows that both adits drifted on sulfide-bearing veins, suggesting that the dump volumes might be smaller since ore would have been shipped by tram or underground via the Mystery Mine with which it is connected; however, stoping above and below the adit levels may also have generated additional waste rock. Based on the dimensions of the dumps, which have slopes that range from -35° to -38°, the Northwest Adit dump is estimated to contain over 1,300 bcy and the Southeast Adit dump contains about 1,000 bcy. Since the waste rock volumes based on adit dimensions are nearly identical to the volumes calculated from dump dimensions, it is concluded that the Northwest and Southeast dumps contain a maximum combined waste rock volume of about 2,400 bcy. A volume estimate was not made for the Barren Adit dump.

Pride of the Woods Mine

The Pride of the Woods Mine is located in the SW¼ Sec 23, T 29 N, R 11 E, WM (longitude 121° 21' 53" W, latitude 47° 58' 53" N) at an elevation of 4,350 feet amsl on Forest Service administered land in the HMJ Wilderness Area (Plate 1). It is accessed via the Forest Service Glacier Basin Trail southeast 1.75 miles from the Townsite along Glacier Creek.

A partially to completely collapsed (Forest Service, 2006b) adit portal and a waste rock dump were observed at the mine (Figure 3; Photographs 9-11). The actual condition of the adit portal is unknown because it was partially covered with boulders and snow at the time of examination; however, DNR noted in 2002 that the air temperature at the collapsed portal was 56°F, air was faintly exhausting from the adit, and there was no evidence of bats (Wolff, et al., 2003).

The Pride of the Woods Adit was originally driven 587 feet along the strike of the vein, and a raise at the end of the adit is reported to connect with the Mystery Mine. The vein above and below the Pride of the Woods Adit has been stoped (Johnson, et al., 1983a). The toe of the waste rock dump is about 20 feet from the left bank of Glacier Creek (Photograph 11). Although dump seepage was not reported in an earlier Forest Service (2006b) study, water was observed to seep at a flow rate of 0.045 gpm (Table 3; 8/23/2008) from the dump toe into Glacier Creek during EECA-DGI site visit. The source of the water may be from snow melt, or possibly from water draining from the collapsed adit, infiltrating into and through the waste rock dump.

Based on an adit length of 587 feet and an average cross section of 6 feet high by about 5 feet wide, it is estimated that about 650 bcy of waste rock were excavated from the adit. Assuming a 40 % swell factor and that all waste rock from the original adit is located in the dump, the dump is calculated to contain about 900 bcy of waste rock. A first-order calculation of waste rock volume based on the dump geometry resulted in about 850 bcy; therefore, it is concluded that the dump contains approximately 900 bcy of waste rock.

2.3.2 Mystery Ridge/Basin Area Near Glacier Creek

The Mystery Mine

The Mystery Mine is located in SE¼ Sec 22, T 29 N, R 11 E, WM (longitude 121° 22' 13" W, latitude 47° 58' 51" N) at an elevation of 4,015 to 4,290 feet amsl on Forest Service administered land (Plate 1). It is accessed via the Forest Service Glacier Basin Trail southeast 0.8 mile along Glacier Creek from the Townsite, and then south-southeast 1,800 feet cross country up a steep talus slope to Adit #3. Adit #3

(discharging lower adit) and nearby Adit #1 and #2 are apparently located on the west end of the Mystery Lode claim and, therefore, on land administered by the Forest Service. Adit #3 appears to be very close to the west boundary, however, and ownership cannot be verified until additional survey work is completed. Immediately west and down slope from Adit #3, is the patented (private) Baltic Lode Claim, which is adjacent to the Mystery Lode Claim. Based on the map delineation in Plate 1, it appears that much of the Mystery Adit #3 waste rock may be on private land. As noted, additional surveying is necessary.

The Mystery Mine consists of three primary adits (Figure 4; Photographs 12-17). The primary haulage adit is Adit #3 (Photographs 13-15), which also served as the haulage adit for the Pride of the Woods Mine. The remains of the aerial tramway that transported ore from Adit #3 to the Ore Collector are visible approximately 100 feet north of the portal. Approximately 170,000 tons of ore were extracted from the Mystery Mine (Johnson, 1983a, 1983b) from the three primary adits and sublevels, exclusive of Pride of the Woods Mine production. The total length of workings is 6,020 feet, excluding stopes. Adit #3 is open at the portal and is 3,800 feet long. Wolff, et al., (2003) reported Adit #3 was open but partly caved, timbers at the portal were rotten and slabs of tonalite had closed off most of the entrance; the portal was 6 feet wide by 7 feet high; air temperature at portal was 38°F; air was exhausting from the adit; and there was no evidence of bats. Adit #2, which is 134 feet above Adit #3 and 910 feet long, is caved. Adit #1, which is 262 feet above Adit #3 and 830 feet long, is also caved. Ore from Adits #1 and #2 were moved down through a system of ore chutes and rail to the Adit #3 tramway for transport to the Ore Collector. The waste rock dumps from Adits #1 and #2 merge into a single dump with partial and more recent talus/rock fall cover. Based on underground maps available from Johnson (1983a), we speculate that most to the waste rock from the upper two adits was derived from an exploratory crosscut in Adit #1 that is not in veins. This is reflected in slightly lower metal contents relative to the Adit #3 waste rock dump. The vein above Adit #1 has been stoped to and is open to the surface. The resulting opening is approximately 120 feet along strike, is about 6 feet wide, and at least 100 feet deep. This constitutes a major safety hazard. Acid mine drainage exits from the Adit #3 portal at a rate of 4.5 gpm (Table 3; 8/20/2008) and flows for the full length of the waste rock dump before infiltrating into the underlying talus; water was also observed draining from the toe of the waste rock dump at a rate of 0.045 gpm (Table 3; 8/20/2008). Secondary iron minerals precipitate for the full length of the flow path. The slope distance from the infiltration point at the toe of the Adit # 3 waste rock dump to Glacier Creek is approximately 2,000 feet.

There are two distinct waste rock dumps at the Mystery Mine, upper and lower (neither was surveyed). Material exposed on the surface of the upper waste rock dump (Adits #1 and #2) is dominantly iron-stained metasediment and igneous rock. Waste rock from Adits #1 and #2 coalesce and are partially covered by recent talus. Sulfide mineral content of this waste is significantly lower compared to the Adit #3 (lower) waste rock and the quality of the rock is slightly better, as indicated by analyses on Table 6. The material exposed at the surface of the Adit #3 dump is significantly more sulfidic as is indicated by analyses in Table 6. A swath of ferricrete-cemented waste rock approximately 30 feet wide by 1 foot thick occurs at the surface and extends from the tramway ruins to the toe. This is probably derived from spills related to ore tramming.

The upper dump is approximately 80 feet long and 40 feet wide. The average depth is assumed to be 16 feet. This yields a volume of 1,900 bcy. Based on volume estimates from underground maps and using heading dimension of 6 feet high by 5 feet wide, a swell factor of 40%, and recovery of 40% ore, the volume of the upper dump is approximately 1,600 bcy. This assumes a combined working length of 1,650 feet and does not include raises, stopes, or chutes. The upper dump is assumed to be the larger of the two values at 1,900 bcy. The volume of the lower dump at Adit #3 was determined by constructing an iso-thickness contour map followed by polar planimeter area determinations between contours corrected for an average slope of 34°. Average thickness of each area was assumed to be the midpoint between contours. Average dimensions are 240 feet long by 140 feet wide by 20 feet deep. Using this method, the total volume of the lower dumps is approximately 30,000 bcy. Total combined volume of the dumps is approximately 32,000 bcy.

Golden Cord Mine

The Golden Cord Mine is located in the SE¼ Sec 22, T 29 N, R 11 E, WM (longitude 121° 22' 26" W, latitude 47° 58' 50" N) at an elevation of 4,110 to 4,210 feet amsl on Forest Service administered land (Plate 1). It is accessed via the Forest Service Glacier Basin Trail southeast 0.9 mile along Glacier Creek from the Townsite to the Justice Mine portal, then 0.1 mile steeply southeast above the Justice Mine through dense brush and cliffs.

The three main underground levels of the Golden Cord total 1,442 feet. Sublevel 4008 is 496 feet long and sublevel 3857 is 348 feet long. Stopes and a three-compartment raise connect the Justice Mine and sublevels 3857 and 4008 at the Golden Cord. A 4,800-foot aerial tramway once connected the mine with the Collector, an ore collection terminal for the United Concentration Company's mill. Most of the ore was transported to the Justice Mine tramway through an underground rail- and ore-passage system.

The surface expression of the Golden Cord Mine consists of two waste rock dumps (Figure 5; Photographs 18-19). The upper of the two dumps is derived from the portal of Adit #2. Most material is iron-stained metasediment and igneous rock. Sulfide content is estimated to be approximately 1%. Vein material may have been hand cobbed for direct shipment to a smelter or concentrator. There are no structural or equipment remains and little room for such on the dump. A small cutout east of the caved portal may have provided storage area. The lower of the two dumps is Adit #1, the primary production and haulage adit and is caved. Waste was trammed by rail along the top of the dump and discharged at the end into a steep canyon where part of the waste was apparently dispersed downslope. There are two platform excavations approximately halfway down the dump. These may have provided level space for an aerial tramway terminal, and remains also indicate the probable presence of a boiler and compressor. There is also adequate room for a shelter. No seeps occur at either portal.

A third level, Adit #3, is identified on mine maps (Johnson, 1983a, 1983b) but was not found during the EECA-DGI by foot or aerial reconnaissance. The projected location is in a ravine where waste would have been dispersed without creating a dump, and no iron staining was observed. This adit is approximately 345 feet long and connected to the lower adits via raises. Most production may have been ore and transported through the raises, leaving little waste to dispose through the portal.

There are two distinct waste rock dumps at the Golden Cord Mine. Neither site was surveyed. The volumes of both dumps were determined by constructing an iso-thickness contour map followed by polar planimeter area determinations between contours corrected for an average slope of 31° at the upper dump and 38° at the lower dump. The average thickness of each area was assumed to be the midpoint between contours. The upper dump contains 710 bcy of waste rock with an average estimated horizontal length of 75 feet and an average width of 32 feet. This yields an average approximate true thickness of 9.3 feet. The lower dump contains 2,800 bcy of waste rock with an average estimated horizontal length of 163 feet and an average width of 42 feet. This yields an average approximate true thickness of 14 feet. Total combined volume of the two dumps is approximately 3,510 bcy.

Justice Mine

The Justice Mine is located in the SE¼ Sec 22, T 29 N, R 11 E, WM (longitude 121° 22' 33" W, latitude 47° 58' 52" N) at an elevation of 3,800 feet amsl on Forest Service administered land (Plate 1). It is accessed via the Forest Service Glacier Basin Trail southeast 0.9 mile up Glacier Creek from the Townsite then about 300 feet southeast to the toe of the dump.

The Justice Mine site consists of two adits – the Main Adit portal (Justice Adit 3) and a second, caved adit portal 150 feet to the west – the ruins of the old cookhouse, bunkhouse, headhouse, a tram station, and a large waste rock dump below the Main Adit portal (Figure 6; Photos A-20 to A-22). The Main Adit portal is 6 feet wide and 7 feet high in solid rock. It is driven south 10° east into a vertical rock face on the south side of an

80-foot-long by 10- to 20-foot-wide ledge blasted out by the original operators (Northwest Underground Explorations, 1997). Mine water flows out of the Main Adit portal at a flow rate of 90 gpm (Table 3; 8/20/2008), across the ledge (Photograph 20) and is confined to a channel approximately 490 feet down the face of the waste rock dump before infiltrating into the dump and underlying talus. Water seeps from waste rock and talus wetland-like area at the toe of the dump, about 230 feet below, at a flow rate of 1.35 gpm (Table 3; 8/20/2008) and again infiltrates into talus. The slope distance from this point to Glacier Creek is approximately 540 feet. In 2002, DNR noted that the air temperature at the Main Adit was 56°F, air was exhausting from the adit, and there was no evidence of bats (Wolff, et al., 2003).

A waste rock volume estimate based on dump geometry is considered the most accurate method at this site. The waste rock dump is 720 feet long on a steep slope ranging from -32° from -38°. The dump ranges from 65 to 110 feet wide and from 5 to 10 feet thick. Waste rock on the west side of the dump commingles with talus; therefore, care was taken to delineate the outer boundaries of the dump. Based on the exposed surface area and the thickness exposures in the drainage water channel, the volume is estimated for three parts: upper dump (237 feet long by 90 feet wide by 8 feet thick); the middle dump (130 feet long by 70 feet wide by 8 feet thick); and the lower dump (354 feet long by 75 feet wide by 5 feet thick). The dump is estimated to contain at least 14,000 bcy of waste rock.

2.3.3 Lower Glacier Creek and Townsite Area

Rainy Mine

The Rainy Mine is located in SW¼ Sec 22, T 29 N, R 22 E, WM (longitude 121° 22' 59" W, latitude 47° 59' 02" N) at an elevation of 2,960 feet amsl on private land (Plate 1). It is accessed via the Forest Service Glacier Basin Trail east 2,500 feet up the Glacier Creek trail from the Townsite to the Ore Collector and then 250 feet north across creek.

Surface features observed include a partly-caved adit with a flooded open cut and a two-level waste rock dump that is thickly vegetated (Figure 7; Photographs 23-24). The property was developed by an 855-foot-long adit, that trends north 32° east at the portal, and a 210-foot-deep shaft which accessed four levels according to an unidentified 1915 mine map (Johnson, et al., 1983a). A raise was driven from the working level to the surface 80 feet into the adit from the portal (Northwest Underground Explorations, 1997). However, no evidence of the shaft collar was found in the heavily vegetated area where it is projected to be during the site examination by CES. The adit portal is unstable and partially-collapsed with a pile of caved rock 6 feet high by 6 foot wide behind which water is impounded. Beyond the partial portal collapse, the adit appears to be about 6 feet high by 5 feet wide; further underground examination was considered to be too dangerous. Drainage water apparently flows through the collapsed rock pile at the portal and into a sink hole in the open cut (flow rate of 0.045 gpm on 8/21/2008; Table 3); the only evidence of a shaft collar shown on a surface map as being directly in front of the adit portal (Johnson, et al., 1983a). Glacier Creek is approximately 40 feet down slope from the ponded water. Northwest Underground Explorations (1997) also reported that the shaft collar was boarded over and covered with dirt, which would constitute a safety hazard. The two-level waste rock dump present at the site (Photograph 23) is puzzling because the adit portal and apparent (collapsed or covered) shaft collar appear to be on the lower dump level at the base of the upper dump level. A search of the heavily vegetated upper dump level and surrounding area found no evidence of additional workings. It is noteworthy that the south face of the dump, facing Glacier Creek, appears to have experienced significant erosion by high flow conditions in the creek (Photograph 24).

The waste rock dump volume was calculated by two methods: volume of underground workings, and the geometry of the dump. The estimates were very close; therefore, it is concluded that the dumps contain a minimum of 3,300 bcy of waste rock minus erosion by Glacier Creek, which may have been as much as 200 bcy. The analytical results of one drainage water sample (MCEE-DW-RY-01) and two waste rock samples (MCEE-WR-RY-01, MCEE-WR-RY-01-02) collected by CES during the EECA-DGI (Figure 7) are shown in Tables 3 and 6.

Ore Collector

The Ore Collector is located in the SW¼ Sec 22, T 29 N, R 11 E, WM (longitude 121° 23' 02" W, latitude 47° 59' 01" N) at an elevation of 3,005 feet amsl (Plate 1). The site lies between Glacier Creek and the old Forest Service road and can be reached via the Forest Service Glacier Basin Trail. The Ore Collector consists of the collapsed remains a tramway terminal ore storage facility (Figures 8 and 9; Photographs 25-27) on which stockpiled ore remains and around which ore was spilled. The site was mapped and sampled during the SI (CES, 2008a), and it was calculated that 1,800 bcy of coarse ore and 700 bcy of finely-crushed ore remain on the site. Based on the location of these remains relative to the Concentrator, it appears that the Ore Collector is located on private ground; however, additional surveying is necessary to confirm property boundaries. The analytical results of 14 soil samples collected by CES (2008a) during the SI and one sample collected by the Forest Service in 2005 are shown in Table 6.

Haulage Ways

The Haulage Ways include an approximately 2,500-foot-long surface network of primitive roadways (1,800 feet) and railroad (700 feet) utilized to transport ore from the Ore Collector to the Concentrator and tailings area and that also includes the roadway to the Assay Shack (Figure 8; Photograph 30). Spillage of coarse- to fine-grained rock along these routes has left a sporadic thin veneer of materials with high concentrations of hazardous substances. The SI reported a cumulative volume of 200 bcy along the total length of the haulage routes (CES, 2008a). The analytical results of five samples (HW-01 to HW-05) collected by CES during the SI are shown in Table 6.

Concentrator and Tailings

The Concentrator and Tailings are located in SE¼ Sec 21, T 29 N, R 11 E, WM (longitude 121° 23' 20" W, latitude 47° 59' 04" N) at an elevation of approximately 2,880 feet amsl (Plate 1). The site lies between Glacier Creek and the Forest Service Glacier Basin Trail and can be easily reached via the trail about ¼ mile upstream from the Townsite. Most of the mill foundation is on land administered by the Forest Service; however, the area between the foundation ruins and Glacier Creek, including soils/materials (tailings) containing hazardous substances, appears to be privately owned (CES, 2008a). Additional surveying is necessary to confirm property boundaries.

The five-story, 300-tons-per-day United Concentration Gravity Mill (Figures 8 and 10; Photographs 28-30), also referred to as the United Companies Concentrator (Concentrator), was completed and began operating in 1894, ceased processing ore in 1912, and was dismantled in 1917. The mill used a series of crushers and rolls to liberate ore minerals from host rock and water-washed jigs to develop a concentrate that was sent to the Everett, Washington smelter. This type of gravity processing is inefficient and tends to yield metal-rich tailings. The primary ore minerals shipped to the Concentrator were chalcopyrite, galena, sphalerite, jamesonite, and realgar; gangue minerals included arsenopyrite, pyrite, quartz, calcite, epidote, and amphibole. The Concentrator is positioned about 100 feet above the south bank of Glacier Creek, and tailings are irregularly distributed along the stream bank west of the Concentrator and between Forest Service Glacier Basin Trail (# 719) and the creek. It appears that the tailings were either discharged directly into the stream (Wolff, et al., 2003), into a small bunker (Written Communication, Johanson, 2009) or onto a tailings spill area along the south bank of the stream. An 8,100 bcy mixture of tailings, contaminated soil, and waste rock up to about 5 feet to 7 feet thick was delineated in that area, and an additional 100 bcy of Dangerous Waste was identified around the Concentrator during the SI (CES, 2008a). The analytical results of 24 soil samples collected by CES (2008a) during the SI, three samples collected by Ecology (Crofoot and O'Brien, 2004), and two samples collected by the Forest Service in 2005 are shown in Table 6.

Assay Shack

The Assay Shack is located in SE¼ Sec 21, T 29 N, R 11 E, WM (longitude 121° 23' 26" W, latitude 47° 59' 00" N) at an elevation of approximately 2,910 feet amsl on Forest Service administered land (Plate 1). The

site, located adjacent to a trail in the south part of the Townsite approximately 1,100 feet southeast of the Forest Service cabins, consists of a raised, rectangular, platform-like area approximately 50 feet square by about 2 to 3 feet thick (Figure 11; Photograph 31). Based on these dimensions, the site is estimated to contain 200 bcy of material consisting of variably-colored soils and small rocks as well as broken glass and bricks. The analytical results of three samples (AS-02, AS-03, and AS-04) collected by CES (2008a) for the SI in 2006 and one sample (Assay Shack) collected by the Forest Service in 2005 are shown on Table 6.

Boston-American Mine

The Boston-American Mine is located in NW¼ SE¼ Sec 21, T 29 N, R 11 E, WM (longitude 121° 23' 44" W, latitude 47° 59' 05" N) at an elevation of approximately 2,985 feet amsl, and it assumed to be located on mixed private and Forest Service administered land (Plate 1). The site, which is heavily vegetated, is accessed by a rough trail 600 feet southwest from the Townsite.

An adit portal, a small shed, and a two-level waste rock dump were found on the site (Figure 12). The adit, closed by a locked steel door at the portal, consists primarily of one long crosscut that develops 3,842 feet of underground workings on one level. A tram terminal may have been located on the top of the lower dump (elevation 2,900 feet amsl) that also appears to be connected by road that provided access to the mill. Water drains from the adit at a flow rate of 1.35 gpm (Table 3; 8/20/2008) and ponds in the open cut near the portal. Water also seeps at a flow rate of 0.135 gpm (Table 3; 8/20/2008) from the hillside near the south perimeter of the dump below the adit. The slope distance from the seep to Seventysix Creek is estimated to be 700 feet.

Based on an adit length of 3,842 feet and an average cross section of 6 feet high by about 5 feet wide, it is estimated that about 4,300 bcy of rock were excavated from the adit. Assuming a 40 % swell factor and considering that 18 car loads of ore are reported to have been shipped from the mine, the dump is estimated to contain approximately 6,000 bcy of waste rock. The analytical results of two drainage water samples (MCEE-DW-BA-01 and MCEE-DW-BA -02) and two waste rock samples (MCEE-WR-BA-01 and MCEE-WR-BA -02) collected by CES during the EECA-DGI are shown in Tables 3 and 6.

The Boston-American Mine was included in the EECA-DGI at the request of the Forest Service. Due to the potential mixed ownership status and evidence of active exploration or mining activities observed on-Site, the Forest Service and State may need to coordinate any potential Removal Action.

2.3.4 Seventysix Creek Area

Sheridan Mine

The Sheridan Mine is located in the NW¼ Sec 27, T 29 N, R 11 E, WM (longitude 121° 23' 08" W, latitude 47° 58' 33" N) at an elevation of 3,395 feet amsl on Forest Service administered land (Plate 1). It is accessed by a crude trail 3/4 mile southeast from the Townsite along Seventysix Creek, then west about 200 feet cross-country to the portal.

A 410-foot adit is driven about 75° west at the portal (Johnson, et al., 1983a). The adit, accessed by way of a 20-foot open cut, is approximately 9 feet wide and 5 feet high at the irregular-shaped portal, but the working appears to continue with a 6-foot-high by 5-foot-wide section. The top of the waste rock dump, now heavily overgrown with vegetation, is about 35 feet long in a north 65° east direction and ranges from about 5 feet to 16 feet wide (Figure 13).

Based on an adit length of 410 feet and an average cross section of 6 feet high by about 5 feet wide, it is estimated that 456 bcy of rock were excavated from the adit. Assuming a 40 % swell factor, the dump contains approximately 650 bcy of waste rock.

Sidney Mine

The Sidney Mine (also known as the Peabody-Knowlton Mine) is located in the NW¼ Sec 27, T 29 N, R 11 E, WM (longitude 121° 23' 09" W, latitude 47° 58' 38" N) at an elevation of 3,290 feet amsl on Forest Service administered land (Plate 1). It is accessed by a crude trail 2/3 miles southeast from Townsite along Seventysix Creek then east through steep terrain across the creek.

The Sidney Mine was developed by 750 feet of underground workings; however, only about 200 feet of workings were open at the time of the U.S. Bureau of Mines field examination (Johnson, et al., 1983a). Debris and snow from a major avalanche during the 2007-2008 winter and high water due to heavy rain blocked access to most of the area by CES field personnel during the EECA-DGI field examination. Waste rock was apparently hauled out of the mine on rails and side cast on steep side slopes immediately adjacent to Seventysix Creek. Only a 90-foot-long waste rock dump, partially eroded by Seventysix Creek, was mapped and sampled during the first visit. The majority of the waste rock is comprised of ferricrete, and the dump is fairly well vegetated with shrubs and small trees. During a follow-up site visit a month later, the adit portal (6-foot high by 5-foot wide) and the remains of a stream-side cribbed impoundment of waste rock for rail transport to the waste rock dump were found on the northeast side of the creek approximately 150 feet upstream from the dump (Figure 14; Photographs 32 and 33). Water flows at a rate of 1.35 gpm (Table 3; 9/30/2008) from the adit portal which is at the stream level. The drainage water is clear, and there is no discoloration of the substrate. Square set timbers at the portal were collapsing due to damage by large debris (broken trees) in the avalanche. The Forest Service notes (2006a) that a significant amount of mine rail and other mining-related equipment has accumulated in Seventysix Creek just downstream from the mine.

Descriptions from Johnson (1983a) indicate that the adit was driven initially 75 feet in andesite but intersected at least 70 feet of consolidated alluvial gravels in a paleochannel before once again encountering bedrock. The adit was caved at this point, so the thickness of the alluvial section is unknown.

Waste rock volume was estimated by two methods - observed waste rock volume, and volume based on dimensions of underground workings. Calculation of expected waste rock volume based on the dimensions of underground workings development suggests that a total of approximately 1,200 bcy of waste rock would have been produced, considerably more than appears to be present. Most of the streamside impoundment used for waste rock rail haulage to the main dump was not visible due to avalanche debris; however, it is conservatively estimated that it contained about 50 bcy. Based on the observed dimensions of the dump and streamside impoundment, the site is estimated to contain about 375 bcy of waste rock. The large difference in volume estimates may be due to the operators dumping waste rock directly into Seventysix Creek, as well as subsequent erosion of the dump.

2.4 Sources, Nature, and Extent of Contamination

Analytical results of samples collected during the EECA-DGI, the SI (CES, 2008a) , and earlier studies (see section 2.1.3) indicate that concentrations of several hazardous substances, particularly arsenic, are above screening levels in one or more media at multiple sites in the MCMA. Furthermore, based on information provided in the Streamlined Risk Evaluation and Assessment (Section 3.0) of this report, chemicals of concern (COCs) at the Site include in particular - antimony, arsenic, copper, lead, manganese, mercury, selenium, and silver – with arsenic being the primary COC. Soil and waste rock in the vicinity of the Collector and Concentrator contain the highest concentrations of arsenic in the MCMA, and most mine sites contain very high arsenic concentrations as well. The highest concentrations of arsenic in water occur in mine drainage and dump seeps, particularly at the Pride of the Mountains, Pride of the Woods, and Mystery Mines but several others exhibit elevated arsenic as well. Surface water samples at aquatic sites reveal that higher concentrations of arsenic occur in the downstream reaches of Glacier and Seventysix Creeks, particularly below the mines and processing facilities sites, and arsenic concentrations generally increase down the SFSR, particularly in MCL. Arsenic concentrations in pore water and sediments at aquatic sites generally follow the same pattern, although arsenic in pore water at MCL is particularly high. This may

represent fine tailings transport downstream. A summary of selected characteristics, estimated volumes of contaminated waste rock and soil, and flow rates of water from the mines addressed in this EECA are provided in Table 1, the results of analyses of samples collected from various media during this and earlier investigations are presented in Tables 2-8. Plate 2 shows the locations of mines and processing facilities and includes arsenic concentrations in surface water, pore water, and stream sediments at aquatic sample stations in Glacier Creek, Seventysix Creek, SFSR, and MCL. The inset graphs illustrate a subtle downstream increase in arsenic concentrations.

The source, nature, and extent of contamination in the MCMA are described in the following sections by media type and geographic area. Mine materials – waste rock, tailings, and soil – will be discussed first followed by groundwater (mainly mine water). The surface water pathway will be addressed next, and the air pathway will be discussed last.

2.4.1 Soil Pathway, including Waste Rock and Tailings

Elevated concentrations of one or more hazardous substances are present in some soils in impacted areas, particularly on Haulage Ways and near the Concentrator, in one or more waste rock dumps at the 10 mines included in the EECA and at the Ore Collector, and in tailings near the Concentrator (Plate 2). These areas vary in size, relative position and access, and the concentrations of hazardous substances (Tables 6 and 8). In addition, a total of 26 waste rock, tailings, and soil samples, 15 for the SI (2008a) and an additional 11 for the EECA, were submitted for SPLP and TCLP analyses for the 10 metals (arsenic, barium, cadmium, chromium, copper, lead, mercury, selenium, silver, and zinc). Following is a description of background soil sampling and descriptions of the nature and extent of contamination associated with the soil, waste rock, and tailings at these 14 sites.

Background Soil

In order to established a threshold concentration to identify potential hazardous substances, 10 background soil samples were collected in 2005 by CES (2008a) from a variety of locations in the Glacier Creek and Seventysix Creek watersheds and from the divide between the watersheds (Plate 2; Table 7). The mean and 90UCL (90th percentile upper confidence limit on the arithmetic mean), an upper-bound (i.e., conservative) estimate of mean chemical concentration, were calculated for each analyte. Both the background mean and the 90UCL concentration for antimony, total arsenic, chromium, mercury, selenium, vanadium, and zinc exceed one or more ecological screening criteria (Table 7). Furthermore, the mean and 90UCL concentration for total arsenic also exceed human health criteria by an order of magnitude. It is noteworthy that sample BKG-07, collected above the Justice Mine, exhibited a much higher concentration of total arsenic (700 milligrams per kilogram [mg/kg]) than other background samples. This may result from erosion of underlying mineralized structures and is indicative of locally high background concentrations present in the MCMA. Background soil pH ranged from 3.72 to 5.43 standard units (s.u.), indicating predominantly acidic soils.

Upper Glacier Creek (Glacier Basin) Area

- **Pride of the Mountains Mine**

Several workings are present at this site; however, only one large waste rock dump with significant contamination, located at the Main Adit (Figure 1; Photographs 1-3), was investigated. It is situated well above the valley bottom. Five samples, three by CES and one each by Ecology and WADNR, were collected (Table 6) from the dump, which is estimated to contain 5,000 bcy of waste rock. One or more waste rock samples exceeded background 90UCLs as well as one or more ecological and/or human health criteria for antimony, arsenic, cadmium, chromium, copper, iron, lead, mercury, silver, and zinc. Arsenic in particular exceeds the more conservative human health criteria by several orders of magnitude with total concentrations ranging from 332 to 17,300 mg/kg. In three of five samples, pH ranged from 3.4 to 4.1 s.u. indicating predominantly acidic soils. Sulfur analysis of sample (MCEE-WR-PM-02) collected by CES from the

middle of the dump showed the following: 1.34% total sulfur; 0.76% pyritic sulfur; 0.5% non-extractable sulfur; and 0.08% sulfate. The ABP of this sample is -24 t $CaCO_3$/Kt, which is indicative of probable acid generation. The one sample analyzed for TCLP and SPLP did not exceed any RCRA criteria.

- **New Discovery Mine**

Three adits were developed at this site. The Northwest and Southeast Adits share a composite waste rock dump estimated at 2,400 bcy with elevated hazardous substances (Figure 2; Photographs 6-8). Waste rock samples exceeded background 90UCLs as well as one or more ecological and/or human health criteria for antimony, arsenic, cadmium, copper, lead, mercury, silver, and zinc. Arsenic in particular exceeds the more conservative human health criteria by several orders of magnitude with total concentrations ranging from 7,170 to 22,100 mg/kg. One waste rock sample from the third working, referred to as the Barren Adit, contained very low concentrations of most hazardous substances. In two waste rock samples collected from the composite dump (Table 6), one from each side, soil pH was 3.7 and 4.1 s.u. indicating acidic soil. Sample MCEE-WR-ND-01 from the Northwest Adit showed the following: 2.89% total sulfur; 1.64% pyritic sulfur; 0.81% non-extractable sulfur; and 0.44% sulfate. The ABP of this sample was -77 t $CaCO_3$/Kt which is indicative of probable acid generation. One sample analyzed for TCLP and SPLP did not exceed any RCRA criteria.

- **Pride of the Woods Mine**

One adit, now blocked and possibly caved at the portal, was developed at this site (Figure 3; Photographs 9-11). The waste rock dump is estimated to contain about 900 bcy of waste rock with elevated concentrations of hazardous substances. In a total of four samples collected, two by CES and one each by Ecology and the Forest Service, waste rock in one or more samples exceeded background 90UCLs as well as one or more ecological and/or human health criteria for antimony, arsenic, cadmium, copper, iron, lead, mercury, selenium, silver, thallium, and zinc. Arsenic in particular exceeds the more conservative human health criteria by several orders of magnitude with total concentrations ranging from 3,980 to 41,400 mg/kg. In two of four waste rock samples collected soil pH was 2.9 and 4.1 s.u. indicating strongly acidic soil. Sample MCEE-WR-PW-02 showed the following: 0.85% total sulfur; 0.30% pyritic sulfur; 0.28% non-extractable sulfur; and 0.27% sulfate. The ABP of this sample was -27 t $CaCO_3$/Kt, which is indicative of probable acid generation. One sample analyzed for TCLP and SPLP did not exceed any RCRA criteria.

Mystery Ridge/Basin Area Near Glacier Creek

- **Mystery Mine**

The Mystery Mine was primarily developed by three main adits, only Adit #3 remains open, and three dumps with a total of 32,000 bcy of waste rock are present (Figure 4; Photographs 12-14). A total of 10 samples, 9 by CES (plus 1 duplicate sample) and 1 by WADNR, have been collected from the waste rock dumps (Table 6). One or more of the waste rock samples exceeded background 90UCLs as well as one or more ecological and/or human health criteria for antimony, arsenic, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, selenium, silver, thallium, and zinc. Arsenic and zinc in particular exceed the more conservative human health criteria by several orders of magnitude, with total arsenic concentrations ranging from 2,480 to 24,300 mg/kg and total zinc ranging from 159 to 3,540 mg/kg. Although concentrations of hazardous substances varied widely, there did not appear to be an appreciable difference between concentrations in the Adit #1 and Adit #3 dumps. Soil pH ranged from 1.7 to 6.18 s.u. and averaged 3.8 s.u. indicating predominantly strongly acidic soil. Sulfur analysis of four samples showed the following: total sulfur ranged from 0.11 to 5.2%; pyritic sulfur ranged from 0.01 to 2.8%; non-extractable sulfur ranged from 0.03 to 0.51%; and sulfate sulfur ranged from 0.07 to 1.99%. The ABP of these samples ranged from -3 to -87.5 t $CaCO_3$/Kt which is indicative of undetermined to probable acid generation. Sample MM-03-0.5', collected from the top of the Adit #3 dump, had by far the highest percent sulfur (total sulfur, 5.2 %) as well as the highest ABP, -87.5 t $CaCO_3$/Kt, indicating that waste rock in this area has a significant acid generation potential. One sample analyzed for TCLP and SPLP did not exceed any RCRA criteria.

- **Golden Cord Mine**

The Golden Cord Mine was developed by three adits, all caved and only two of which were found. Three dumps totaling 3,500 bcy of waste rock with elevated concentrations of contaminates are on the site (Figure 5; Photographs 18 and 19). Two waste rock samples were collected by CES in 2008 (Table 6). One or both waste rock samples exceeded background 90UCLs as well as one or more ecological and/or human health criteria for antimony, arsenic, cadmium, copper, lead, mercury, silver, and zinc. Arsenic in particular exceeds the more conservative human health criteria by several orders of magnitude with concentrations of 14,300 and 33,600 mg/kg. Soil pH was 4.2 and 5.4 s.u. indicating moderately acidic soil. Sulfur analysis from one sample showed: 0.09% total sulfur; 0.01% pyritic sulfur; 0.05% non-extractable sulfur; and 0.03% sulfate sulfur. The ABP of this sample is +3 t $CaCO_3$/Kt which is uncertain with regards to generation of acid. One sample analyzed for TCLP and SPLP did not exceed any RCRA criteria.

- **Justice Mine**

The Justice Mine was primarily developed by two interconnected adits, one of which is caved, and one dump with a total of 14,000 bcy of waste rock (Figure 6; Photographs 20-22). A total of seven samples, six by CES and one by WADNR, have been collected from the waste rock dump (Table 6). One or more waste rock samples exceeded background 90UCLs as well as one or more ecological and/or human health criteria for antimony, arsenic, cadmium, copper, lead, mercury, selenium, silver, and zinc. Arsenic in particular exceeds the more conservative human health criteria by several orders of magnitude with concentrations ranging from 732 to 39,400 mg/kg. The highest concentrations of hazardous substances were in sample MCEE-WR-JU-03 which was collected from the ruins of the aerial tram suggesting that the sample may represent spilled ore rather than typical waste rock. Soil pH ranged from 4.3 to 5.3 s.u. indicating moderately acidic soil. Sulfur analysis of two samples showed the following: total sulfur, 0.34 and 0.91%; pyritic sulfur 0.10 and 0.43%; non-extractable sulfur, 0.18 and 0.37%; and sulfate sulfur, ranged 0.06 and 0.11%. The ABP of these samples was -6 and -24 t $CaCO_3$/Kt which is indicative of uncertain to probable acid generation. One sample analyzed for TCLP and SPLP did not exceed any RCRA criteria.

Lower Glacier Creek and Townsite Area

- **Rainy Mine**

The Rainy Mine was developed by one adit, now partially caved, and one or two shafts, neither found. The two-level dump contains an estimated 3,300 bcy of waste rock (Figure 7; Photographs 23-24). Two waste rock samples were collected by CES in 2008, one each from the lower and upper dumps (Table 6). One or both waste rock samples exceeded background 90UCLs as well as one or more ecological and/or human health criteria for antimony, arsenic, cadmium, chromium, copper, iron, lead, mercury, silver, and zinc. Arsenic in particular exceeds the more conservative human health criteria by several orders of magnitude with concentrations of 7,510 and 73,400 mg/kg. Soil pH was 3.5 s.u. in both dump samples indicating acidic soil. Sulfur analysis from the lower dump showed the following: 2.02% total sulfur; 0.92% pyritic sulfur; 0.69% non-extractable sulfur; and 0.41% sulfate sulfur. The ABP of this sample was -63 t $CaCO_3$/Kt which is indicative of probable generation of acid. One sample analyzed for TCLP and SPLP did not exceed any RCRA criteria.

- **Ore Collector**

According to the SI (CES, 2008a), 2,500 bcy of stockpiled ore remaining at the collapsed Ore Collector (Figures 8 and 9; Photographs 25-27) exceeds most human health and ecological criteria as well as the background 90UCLs for antimony, arsenic, cadmium, copper, lead, mercury, selenium, silver, thallium, and zinc. Antimony and arsenic in particular and sporadically zinc, exceed the more conservative human health criteria by several orders of magnitude. Arsenic was detected at up to 88,700 mg/kg in this area. In addition, most soil pH tests were acidic, ranging from 3.25 to 5.65 s.u. The material is also net acid producing, with ABP ranging from -18.8 to -40 t $CaCO_3$/Kt; however, the two samples analyzed for the TCLP and SPLP did

not exceed any RCRA criteria. Overall, analyses and accessibility indicate that this material is a potential health and ecological hazard. A temporary fence was erected around this area during Phase III of the SI to limit access; however, during the EECA-DGI the fencing was largely collapsed, apparently due to snow loads.

- **Haulage Ways**

According to the SI (CES, 2008a), 200 bcy of ore that was spilled along the approximately 2,500 foot length of haulage routes (Figure 8; Photograph 30) exceeds most human health and ecological criteria as well as the background 90UCLs for antimony, arsenic, chromium, copper, lead, mercury, selenium, silver, thallium, and zinc. Antimony and arsenic in particular, and sporadically zinc, exceed the more conservative human health criteria by several orders of magnitude. Arsenic was detected up to 22,600 mg/kg in this area. Soil pH values ranged from 3.98 to 5.90 s.u. One samples had an ABP of -31.6 t $CaCO_3$/Kt. The two samples analyzed for TCLP and SPLP did not exceed any RCRA criteria. Overall, analyses and accessibility indicate that this material is a potential health and ecological hazard.

- **Concentrator and Tailings**

According to the SI (CES, 2008a), 8,100 bcy of partially processed ore residue, spilled ore, and spilled tailings remaining at the Concentrator ruins (Figures 8 and 10; Photographs 28-29) exceed most human health and ecological criteria as well as the background 90UCLs for antimony, arsenic, cadmium, chromium, copper, lead, mercury, selenium, silver, thallium, and zinc. Antimony and arsenic in particular, and sporadically zinc, exceed the more conservative human health criteria by several orders of magnitude. Arsenic was detected up to 92,100 mg/kg in this area. Various criteria and background 90UCLs were occasionally exceeded for barium, iron, and nickel; and all other hazardous substances were elevated. In addition, most soil pH tests were acidic, ranging from 3.00 to 5.02 s.u. The material is also net acid producing, with ABP ranging from -32.8 to -229 t $CaCO_3$/Kt. One of the seven samples analyzed for TCLP and SPLP exceeded the RCRA criteria for arsenic and lead by both leaching procedures. The arsenic TCLP limit (5.0 milligrams per liter [mg/L]) and the lead TCLP limit (5.0 mg/L) were both exceeded in one sample (CON-09-0.5': arsenic = 6.58 mg/L; and lead = 49.7 mg/L). By virtue of exceeding TCLP criteria, this material is classified as Dangerous Waste in accordance with MTCA regulations. This sample appears to represent a volume of up to approximately 100 bcy of apparent spilled concentrate. Overall, analyses and accessibility indicate that this material is a potential health and ecological hazard. A temporary fence was erected around this area during Phase III of the SI to limit access; however, during the EECA-DGI the fencing was largely collapsed, apparently due to snow loads.

- **Assay Shack**

According to the SI (CES, 2008a), 200 bcy of soil and mixed wastes remaining at the Assay Shack (Figures 8 and 11; Photograph 31) exceed most human health and ecological criteria as well as the background 90UCLs for antimony, arsenic, cadmium, copper, lead, mercury, selenium, silver, thallium, and zinc at ratios similar to the Ore Collector and Concentrator. Arsenic was detected up to 85,800 mg/kg in this area and all other hazardous substances analyzed were elevated. The soil pH test was acidic (2.98 to 4.69 s.u.), and the one sample analyzed had an ABP of -21.3 t $CaCO_3$/Kt. One sample was also analyzed for TCLP and SPLP but did not exceed any RCRA criteria. Overall, analyses and accessibility indicate that this area is a potential health and ecological hazard. A temporary fence was erected around this area during Phase III of the SI to limit access; however, during the EECA-DGI the fencing was largely collapsed, apparently due to snow loads.

- **Boston-American Mine**

The Boston-American Mine was developed by one adit. A two-level dump contains an estimated 6,000 bcy of waste rock with elevated concentrations of contaminates (Figure 12). Two waste rock samples were collected by CES in 2008, one each from the lower and upper dumps (Table 6). Soil pH was 4.1 and 7.2 s.u.

indicating moderately acidic to neutral soil. One or both waste rock samples exceeded background 90UCLs or exceeded one or more ecological and/or human health criteria for arsenic, copper, mercury, selenium, and zinc. Although some hazardous substances at this site exceed one or more human health or ecological standards, overall hazardous substance concentrations are considerably lower than most other sites. Sulfur analysis of the lower dump showed the following: 0.38% total sulfur; 0.19% pyritic sulfur; 0.18% non-extractable sulfur; and 0.01% sulfate sulfur. The ABP of this sample is +11 t $CaCO_3$/Kt which is indicative of a low probability for generation of acid but still uncertain. One sample analyzed for TCLP and SPLP did not exceed any RCRA criteria.

Seventysix Creek Area

- **Sheridan Mine**

The Sheridan Mine was also developed by one adit with one waste rock dump and contains an estimated 650 bcy (Figure 13). The waste rock dump lies well away from and above Seventysix Creek. Two waste rock samples were collected by CES in 2008 (Table 6). One or both waste rock samples exceeded background 90UCLs as well as one or more ecological and/or human health criteria for arsenic, cadmium, copper, lead, mercury, selenium, silver, and zinc. Arsenic in particular exceeds the more conservative human health criteria by two orders of magnitude with concentrations of 1,720 and 2,120 mg/kg. Soil pH was 5.8 and 3.6 s.u. indicating slightly acidic to acidic soil. Sulfur analysis showed the following: 2.29% total sulfur; 0.52% pyritic sulfur; 1.23% non-extractable sulfur; and 0.54% sulfate sulfur. The ABP of this sample was -72 t $CaCO_3$/Kt which is indicative of a high probability for generation of acid; however, the results of TCLP and SPLP analysis of this sample did not exceed any RCRA criteria.

- **Sidney Mine**

The Sidney Mine was developed by one adit, which is at stream level. The dump, which is severely eroded by Seventysix Creek, contains an estimated 425 bcy of waste rock (Figure 14; Photographs 32 and 33). It appears that a considerable volume of waste rock has been eroded and transported downstream. Two waste rock samples were collected by CES in 2008, one from the center of the dump and one from the northwest end of the dump (Table 6). One or both waste rock samples exceeded background 90UCLs as well as one or more ecological and/or human health criteria for antimony, arsenic, cadmium, chromium, copper, lead, mercury, selenium, silver, and zinc. Arsenic in particular exceeds the more conservative human health criteria by several orders of magnitude with concentrations of 28,100 and 38,400 mg/kg. The soil pH of both samples was 4.0 s.u. indicating moderately acidic soil. Sulfur analysis showed the following: 8.54% total sulfur; 3.79% pyritic sulfur; 4.17% non-extractable sulfur; and 0.58% sulfate sulfur. The ABP of this sample was -254 t $CaCO_3$/Kt which is indicative of a high probability for generation of acid. The Sidney Mine had the lowest ABP (highest potential to generate acid) among all areas tested in the MCMA; however, the sample analyzed for TCLP and SPLP did not exceed any RCRA criteria.

Summary of Soil Pathway

Based on the information presented above, the soil pathway is complete and further action is recommended. It is noteworthy that an unknown, but substantial, volume of waste rock and concentrator tailings have been introduced into the surface water system and transported downstream an unknown distance. Two waste rock dumps at mines included in the EECA-DGI show direct evidence of erosion and transport by local streams. Contaminated materials eroded from the Rainy Mine waste rock dump (est. 200 bcy) by Glacier Creek and the Sidney Mine waste rock dump (est. 800 bcy) by Seventysix Creek were probably transported well downstream as little to no evidence of local re-deposition was observed. As noted above, waste rock at both mines contains high concentrations of a range of hazardous substances. The larger portion of tailings from the Concentrator were more than likely deposited in Glacier Creek and transported downstream during flood events. Much of this (volume unknown) may still be mixed within active stream gravel and can be observed visually and identified by sampling. The consequences of the introduction of waste rock and tailings into active streams will be discussed in the surface water pathway (Section 2.4.3).

2.4.2 Groundwater Pathway including Mine Drainage and Dump Seeps

The target distance for the groundwater pathway has been defined as 4-miles, and example targets are drinking water wells, wellhead protection areas, etc. No wellhead protection areas or water supply wells were identified within a 4-mile radius of the MCMA (CES, 2008a). Groundwater is not known to be used for drinking water within 4-miles of the MCMA, and no wells were available for sampling. This removal will address ground water only indirectly in consideration of contaminated surface seeps, adit flows, or mine wastes present at several features.

The hydrogeology within the granodiorite, tonalite, and related rocks that underlie the MCMA is unknown; however, it is probable that groundwater flows preferentially along the permeable bedrock-overburden contact and lesser flow probably occurs in bedrock fracture systems. The most significant of these is the northeast-trending, northwest-dipping shear zone, exposed underground and on the surface over a strike length of 5,800 feet, which is developed by the Justice, Golden Cord, Mystery, Pride of the Woods, New Discovery, and Pride of the Mountains Mines, most of which are interconnected by underground workings. Flowing adit drainage and/or dump seeps associated with these and other mineralized veins were observed and sampled at eight of the ten mine sites (Tables 1 and 3) visited during the field investigation. Mines that exhibited evidence of flowing water during the field investigation include the Boston-American, Justice, Mystery, New Discovery, Pride of the Mountains, Pride of the Woods, Rainy, and Sidney Mines. The source of the groundwater is probably the water from spring and summer melting of the heavy snow packs, characteristic of the high Cascade Mountains, infiltrating into the bedrock, particularly major fracture zones. Snow melt, as well as the flowing water from mine portals higher on mountainsides, appear to infiltrate into talus and other thin, coarse regolith. Whether or not mine drainage water impacts nearby surface water or groundwater in alluvial deposits of the valley bottoms is unknown for most sites. However, mine drainage flowing from the Southeast Adit of the New Discovery Mine (Figure 2) in Glacier Basin appears, based on a seep sample, to reach Glacier Creek, and water draining from the Sidney Mine (Figure 14) flows directly into Seventysix Creek.

Drainage water samples listed in Table 3 represent several generations of sample collection and analysis by different groups (Forest Service, WADNR, Ecology, and CES) conducted from 2003 through 2008. Sample analyses are generally of total recoverable metals and measured field parameters, and analytical results have been standardized to common units of measure. For the contaminants of potential concern (COPCs) discussed here, background concentrations for surface water samples collected in upper Glacier and Seventysix Creeks (Table 2) will be used for comparison (results in micrograms per liter [µg/L].

Upper Glacier Creek (Glacier Basin) Area

Water with notable to significant concentrations of one or more COPCs flows from three mine sites in Glacier Basin (Plate 2) – Pride of the Mountains, New Discovery, and Pride of the Woods Mines. Information about the sites and flow characteristics are described in the following sections.

- **Pride of the Mountains Mine**

Water drains from the Main Adit (Figure 1; Photograph 3) at a rate of 1.8 gpm (Table 3; 8/23/2008) and flows about 200 feet down the dump where it infiltrates into the waste rock approximately 900 feet upslope from Glacier Creek. There are no indications, such as staining, along this reach of Glacier Creek that suggest drainage water reaches the stream. Of three samples of mine water collected at various times (Table 3), concentrations ranged from 12.3 to 30 µg/L for antimony, 162 to 6,350 µg/L for arsenic, 90 to 2,640 µg/L for copper, 15.8 to 562 µg/L for lead, and 830 to 5,170 µg/L for zinc. These concentrations are significantly above the background for surface water and exceed one or more water quality standards. Conductivity ranged from 201 to 316 microsiemens per centimeter (µS/cm) and pH was 6.6 and 7.7 s.u. in two of three samples measured.

- **New Discovery Mine**

Water drains from the Southeast Adit (Figure 2, Photograph 8) at a rate of <4.5 gpm (Table 3; 4/2003, WADNR) and flows about 20 feet across the dump where it infiltrates into the waste rock approximately 365 feet upslope from Glacier Creek. Of three samples of water collected at various times (Table 3), notable concentrations include: arsenic ranged from 2.8 to 31.6 µg/L and zinc ranged from 7.9 to 850 µg/L. These concentrations are moderately to significantly above the background for surface water, and most exceed one or more water quality standards. Conductivity ranged from 49 to 267 µS/cm and pH was 6.7 and 6.81 s.u. in two of three samples measured.

- **Pride of the Woods Mine**

Water seeps from the toe of the waste rock dump (Figure 3; Photograph 11) at a rate of 0.045 gpm (Table 3; 8/23/2008) and flows a about 20 feet across alluvium into Glacier Creek. In one sample of seepage water collected at the dump toe (Table 3) notable concentrations include: 25 µg/L antimony, 4,060 µg/L arsenic, 410 µg/L copper, 125 µg/L lead, 522 µg/L manganese, 0.820 µg/L mercury, 3.82 µg/L silver, and 1220 µg/L zinc. These concentrations are moderately to significantly above the background for surface water and exceed one or more water quality standards. Conductivity was 130 µS/cm and pH was 3.8 s.u.

Mystery Ridge/Basin Area Near Glacier Creek

Mystery Mine and Justice Mine are two of three mines in the Mystery Ridge/Basin Area (Plate 2) with notable to significant concentrations of one or more COPCs flowing from their associated adits. Information about the sites and flow characteristics are described in the following sections.

- **Mystery Mine**

Water drains from Adit #3 (Figure 4; Photographs 13-14) at rates measured from 4.5 to 40 gpm (Table 3) and flows for the full length of the waste rock dump, about 120 feet, before infiltrating into the underlying talus. Water also seeps from the dump toe at measured rates of 0.045 and 4.5 gpm and flows a few feet before it infiltrates into talus approximately 2,000 feet upslope from Glacier Creek. Of the three samples of adit drainage and two samples of dump seep water collected at various times (Table 3), notable concentrations include: 7.5 to 31.2 µg/L antimony, 240 to 3,300 µg/L arsenic, 360 to 710 µg/L copper, 1,370 to 4,230 µg/L manganese, 0.0019 to 0.0034 µg/L mercury, and 2,340 to 6,590 µg/L zinc. These concentrations are moderately to significantly above the background for surface water, and most exceed one or more water quality standards. Conductivity ranged from 141 to 578 µS/cm and pH ranged from 3.81 to 4.4 s.u. in three samples measured.

- **Justice Mine**

Water flows from the Main Adit (Figure 6; Photographs 20-22) at flow rates ranging from <4.5 (Table 3; 4/2003) to 90 gpm (Table 3; 8/20/2008) and flows across a narrow rock platform and then about 490 feet down the center of the waste rock dump before infiltrating into waste rock and underlying talus. Water also seeps from the dump toe at a measured rate of 1.35 gpm (Table 3; 8/20/2008) into a bog area where it appears to infiltrate into talus approximately 540 feet upslope from Glacier Creek. Of four samples of adit drainage and two samples of dump seep water collected at various times (Table 3), notable concentrations include: 9.1 to 11.6 µg/L antimony, 186 to 264 µg/L arsenic, 2.83 to 10 µg/L copper, 0.5 to 1.26 µg/L lead, 11 to 12.4 µg/L manganese, and 19 to 56.8 µg/L zinc. These concentrations are moderately above the background for surface water, and most exceed one or more water quality standards. Conductivity was 33 and 149 µS/cm in two samples measured, and pH ranged from 3.5 to 8.1 s.u. in three samples measured.

Lower Glacier Creek and Townsite Area

In the Lower Glacier Creek Area (Plate 2) water with notable to significant concentrations of one or more COPCs is impounded (Rainy Mine) or infiltrates into waste rock (Boston-American Mine). Information about the sites and flow characteristics are described below.

- **Rainy Mine**

Water is impounded in the open cut leading to the adit over an area suspected to overlie a covered shaft (Figure 7; Photograph 23); the water appears to flow from the partially-caved adit through the sloughed material at a flow rate of 0.045 gpm (Table 3; 8/21/2008) . There is no evidence of water flow beyond the impoundment; however, the water is only about 40 feet from Glacier Creek. In one sample of water collected at the site (Table 3), notable concentrations include: 14.0 µg/L arsenic, 0.9 µg/L lead, 17 µg/L manganese, 0.006 µg/L mercury, and 3.82 µg/L silver. These concentrations are moderately above the background for surface water and exceed one or more water quality standards. Conductivity was 198 µS/cm; however, pH was not measured due to instrument malfunction.

- **Boston-American Mine**

Water drains from the adit portal (Figure 12) at a rate of 1.35 gpm (Table 3; 8/20/2008), flows a few feet across the dump, and infiltrates into the waste rock. Water also seeps from the southeast side of the dump, over 100 feet below the infiltration point, at a rate of 0.135 gpm (Table 3; 8/20/2008) and flows a few feet before it infiltrates into talus approximately 700 feet upslope from Seventysix Creek. Of one sample each of adit drainage and dump seep water collected in August 2008 (Table 3), notable concentrations include: 1.8 and 7.3 µg/L arsenic, 10 µg/L copper in the adit, 0.8 µg/L lead in the seep, 13 µg/L manganese in the seep, and 0.0039 and 0.0210 µg/L mercury. These concentrations are slightly above the background for surface water and exceed one or more water quality standards. Conductivity ranged from 261 to 414 µS/cm and pH ranged from 8.1 to 7.1 s.u., respectively.

Seventysix Creek

Water with notable to significant concentrations of one or more COPCs flows from the adit portal at one mine site in the Seventysix Creek Area (Plate 2) – the Sidney Mine. Information about the site and flow character is described below.

- **Sidney Mine**

During low-flow conditions in September 2008, water flows from the Sidney Adit directly into Seventysix Creek (Figure 14; Photograph 33) at a rate of 1.35 gpm (Table 3; 9/30/2008). It appears that Seventysix Creek backs up into the adit during high- to moderate-flow conditions, which are expected to occur during spring and early summer snow melt. In two water samples collected at this mine (Table 3), notable concentrations included 19 and 28.8 µg/L total recoverable arsenic. These concentrations are above the background for surface water and exceed one or more water quality standard, but are much lower than many other sites. Conductivity was 54 and 25 mS/cm, and pH was 6.42 and 5.5 s.u. The source of water draining from the adit is undetermined; however, consolidated alluvial gravels, probably a paleochannel of Seventysix Creek, encountered 70 ft into the adit (Johnson, et al., 1983a) suggest that local snowmelt may infiltrate through the alluvium and into the adit. Such a local and short migration path could explain the relatively low arsenic concentration, low conductively, and near-neutral pH of the water.

2.4.3 Surface Water Pathway

Surface water bodies at or near the MCMA that could be affected by the mines and processing-related facilities are identified in Section 2.1.8. During the SI (2008a), CES established five aquatic stations (GC-01 to GC-05) in Glacier Creek, two aquatic stations (76G-01 and 76G-02) in Seventysix Creek, and two aquatic stations (SFSR-01 and SFSR-02) in the SFSR below the Townsite. For the EECA-DGI in 2008, additional

aquatic sampling stations were established further downstream in the SFSR (SFSR-03 to SFSR-09) and in MCL (MCL-01 to MCL-06). One or more surface water, pore water, and stream sediment samples were collected from these sites during different flow conditions to assess the impact of the various mines and processing-related facilities in the MCMA. Sampling to establish background concentrations of hazardous substances in surface water, pore water, and stream sediment were also collected from upper Glacier Creek and upper Seventysix Creek. Sample station locations are depicted on Plate 2 and results are tabulated in Tables 2, 4, and 5. Plate 2 also shows concentrations of arsenic in surface water (total recoverable arsenic), pore water (dissolved arsenic), and stream sediment (total arsenic) for each station in samples collected by CES during the 2008 EECA-DGI. In addition, three graphs presented on Plate 2 show the distribution of arsenic in surface water, pore water, and stream sediments beginning in Glacier Basin, down Glacier Creek and SFSR, and through MCL to the northern-most station, SFSR-09. In general, the graphs depict a significant increase in arsenic from the headwaters down Glacier Creek, SFSR, and particularly to the peak concentration in MCL which appears to be a settlement or sink area. Both man-made and natural sources may contribute to the observed increase. Benthic macroinvertebrate sampling was also conducted for the SFSR sample stations, and the results are presented in Appendix B.

Glacier Creek

- **Surface Water**

A total of 21 surface water samples have been collected from Glacier Creek (Plate 2; Table 2) with 8 considered background samples. Most notable are the arsenic concentrations which are variable but overall increase downstream. In 18 samples in which arsenic was detected, concentrations ranged from a low of 0.28 µg/L (background) to 12.2 µg/L (below the Concentrator) compared to the mean background arsenic concentration of 1.63 µg/L. In one sample for which speciation was analyzed (GC-SW3), total recoverable arsenic was 4.5 µg/L, arsenic III was 0.125 µg/L, and arsenic V was calculated to be 4.375 µg/L. The proximity of local mines and facilities appears to affect arsenic concentration. For instance, Forest Service samples MC-GC-5 and MC-GC-3, collected respectively above and below the New Discovery Mine, show a nearly four-fold increase in arsenic from 1.6 to 6.0 µg/L. Arsenic concentrations also show significant increases from above to below the Ore Collector-Rainy Mine area, and from above to below the Concentrator area. Each of these areas may represent a source that contributes to an increase in hazardous substances; and relative decreases in concentrations below some sources may be due to dilution. Surface water quality of Glacier Creek is probably affected by continuing natural weathering and erosion of mineralized bedrock as well as the mine and mining-related features; to what degree by each is not known.

- **Pore Water**

Four pore water samples were collected from Glacier Creek by CES in 2005 (Plate 2; Table 4). Two of these are background samples. Arsenic was not detected in the two background pore water samples. However, downstream arsenic concentrations were 3.8 µg/L in sample GC-PW3 collected just below the New Discovery and Pride of the Woods Mines, and 7.6 µg/L in sample GC-PW4 collected below the Ore Collector-Rainy Mine area. As with the surface water samples, arsenic V is the dominant species. Barium is slightly elevated in all samples, and zinc is slightly elevated in one background sample. The proximity of local mines and facilities appears to effect arsenic concentration in pore water.

- **Stream Sediments**

A total of 11 stream sediment samples have been collected from the five aquatic stations on Glacier Creek (Plate 2; Table 5), of which five are background samples. Sample analyses show elevated concentrations of several hazardous substances with ranges as follows: antimony, 0.43 mg/kg (background) to 16.3 mg/kg; arsenic, 42.1 mg/kg (background) to 367 mg/kg; cadmium, 0.44 mg/kg (background) to 1.91 mg/kg; chromium, 12 to 53.5 mg/kg; cobalt, 8.62 mg/kg (background) to 12.5 mg/kg; copper, 13 mg/kg (background) to 117 mg/kg; lead, 7.88 mg/kg (background) to 84.8 mg/kg; mercury, 0.16 to 4.6 mg/kg; and zinc, 66 mg/kg (background) to 185 mg/kg. Aluminum, barium, beryllium, iron, manganese, nickel,

potassium, thallium, and vanadium also showed slight but irregular increases in some samples. As in other aquatic media, arsenic concentrations in several samples were significantly above, three- to four-fold, the mean background concentration of 80.33 mg/kg, and arsenic V was the dominant species in samples analyzed.

In order to investigate possible impacts of the Ore Collector-Rainy Mine and Concentrator areas, CES collected ten additional stream sediment samples (Table 5) from Glacier Creek, five from each area, in 2005. Concentrations of hazardous substances in the samples collected from these reaches of Glacier Creek were significantly elevated compared to those collected from the aquatic stations (discussed above).

In general, stream sediment data from the aquatic stations indicate arsenic concentrations increase downstream, strongly suggesting influences from several sources – both mines and related facilities and possibly natural sources such as the vein system crossed and eroded by Glacier and Seventysix Creeks.

This removal will address stream sediment only by controlling or eliminating contaminated source areas at key MCMA features.

Seventysix Creek

- **Surface Water**

A total of ten surface water samples have been collected from Seventysix Creek (Table 2), of which five of these are background samples. As in Glacier Creek, the most notable hazardous substance is arsenic, which is variable but overall increases downstream. In five samples in which arsenic was detected, concentrations ranged from a low of 0.45 µg/L (background) to 9.64 µg/L (near the Sidney Mine) compared to the mean background arsenic concentration of 1.63 µg/L. Sample MCEE-SW-76G-02, collected in the Townsite near the confluence with Glacier Creek and the SFSR, exhibited arsenic at 7.7 µg/L. The distribution of arsenic suggests that waste rock at the Sidney Mine contributes to an increase in arsenic concentration in the downstream reach of Seventysix Creek. Surface water quality of Seventysix Creek is probably affected by continuing natural weathering and erosion of mineralized bedrock as well as the mine features; to what degree by each is not known.

- **Pore Water**

Total arsenic was detected at 10.6 µg/L in one sample (76G-PW2) which was collected downstream from the Sidney Mine in Seventysix Creek; the dominant species was arsenic V. Arsenic was not detected in the background sample above the method detection limit. The Sidney Mine may also affect arsenic concentration in pore water.

- **Stream Sediments**

Four stream sediment samples were collected on Seventysix Creek, two from each aquatic station (Plate 2; Table 5), of which two are background samples. Sample analyses show elevated concentrations of several hazardous substances, particularly in the samples collected downstream of the Sidney Mine, with ranges as follows: antimony, < 2.0 mg/kg (background) to 12.1 mg/kg; arsenic, 16.8 mg/kg (background) to 276 mg/kg; cadmium, 0.33 mg/kg (background) to 2.91 mg/kg; chromium, 19 to 42.6 mg/kg; copper, 12 mg/kg (background) to 34.2 mg/kg; lead, 9.8 mg/kg (background) to 172 mg/kg; and zinc, 77.4 mg/kg (background) to 295 mg/kg. As in other aquatic media, arsenic concentrations in the downstream samples were significantly above, three- to four-fold, the mean background concentration of 80.33 mg/kg; and arsenic V was the dominant species in one sample analyzed. Sediments in Seventysix Creek are probably affected by continuing natural weathering and erosion of mineralized bedrock as well as the mine features; to what degree of each is not known.

South Fork Sauk River and Monte Cristo Lake

- **Surface Water**

A total of 18 surface water samples have been collected from the SFSR, 17 from the 6.8-mile reach between the Townsite and MCL and 1 below MCL, and 1 sample was collected from MCL (Plate 2; Table 2). The most notable hazardous substance is arsenic which is variable but occurs in much higher concentrations than in Glacier and Seventysix Creeks. In 15 samples in which arsenic was detected, concentrations ranged from a low of 5.2 µg/L (MCEE-SW-SFSR-04) to 27.4 µg/L (near MCL) and averaged 10.8 µg/L compared to the mean background arsenic concentration of 1.63 µg/L. In two samples for which speciation was analyzed (SFSR-SW1 and SFSR-SW1), total arsenic was 9.4 and 12.4 µg/L, arsenic III was 0.147 and 0.243 µg/L, and arsenic V was calculated to be 9.253 and 12.157 µg/L, respectively. Sample MCEE-SW-MCL-01, collected in MCL, contained 68.5 µg/L arsenic. Overall, the distribution of arsenic increases downstream and peaks significantly in MCL.

- **Pore Water**

CES collected nine pore water samples from SFSR and one from MCL (Plate 2; Table 4). The most notable hazardous substance is arsenic, which was detected in all samples. Total arsenic concentrations in SFSR ranged from 7.9 to 15.8 µg/L, and the arsenic concentration in the MCL sample was 2,829 µg/L, two orders of magnitude higher. As in the surface water samples, arsenic V was the dominant species in two samples analyzed. The lower reaches of SFSR also show slight increases in calcium and magnesium concentrations. There are no known significant sources of contamination along this reach of the SFSR. The source of arsenic in pore water, either by direct (from water) or indirect means (sediment transport/leaching) is probably the MCMA; although, tributaries that flow into SFSR may also contribute hazardous substances from historic mining areas.

- **Sediments**

Thirteen stream sediment samples have been collected from South Fork Sauk River, and six samples were collected from MCL (Plate 2; Table 5). Sample analyses show elevated concentrations of several hazardous substances in both SFSR and MCL; however, the distribution does not present a distinct geographic pattern. Hazardous substance concentration ranges are as follows: antimony, 0.0085 to 47 mg/kg; arsenic, 0.281 to 1,090 mg/kg (avg. 403 mg/kg); cadmium, 0.77 to 3.90 mg/kg; chromium, 23 to 65 mg/kg; copper, 56 to 207 mg/kg; lead, 60 to 278 mg/kg; and zinc, 147 to 806 mg/kg. It may be noteworthy that the only non-CES sample, SHA-3374088 collected by Ecology, reported significantly higher concentrations for arsenic (1,090 mg/kg) and zinc (806 mg/kg), both about twice the nearest reported concentration. As in other aquatic media, arsenic concentrations in the downstream samples were significantly above, three- to four-fold, the mean background concentration of 80.33 mg/kg; and arsenic V was the dominant species (speciation was determined from a single sample analysis).

2.4.4 Air Pathway

The most probable air pathway is due to inhalation of particulate matter, predominantly dust related to historic mining activities in the MCMA. Arsenic and other hazardous substances were likely released to the air during mining and processing (i.e., crushing, screening, haulage, etc.) that characterized the area during the mining era; however, these activities have not occurred on the Site since the early 1900's. The target distance for the air pathway has been defined as one and four miles from the MCMA. There are no year-round homes within four miles of the Site; however, public usage of the area is moderate to high during the summer, and cabins on local private lands are occupied intermittently during the summer season. The nearest year-round residences are in Silverton, approximately 12 miles west of the MCMA. The annual prevailing wind direction is to the east-southeast; however, the wind direction shifts to the north-northwest in the summer. Currently, there is little sign of dust migration. Soils at the Concentrator, near the Assay Shack, and along the Haulage Ways are well vegetated or covered with duff, and ore/waste rock at the Ore Collector and

mine sites are generally indurate, so fine-grained particulates are not easily wind-eroded. Air samples were not collected as part of the SI or EECA field activities.

The air pathway is considered complete because metal contaminated soil and waste material is concentrated at the surface where human and ecological receptors could be exposed to particulate matter. Because the air pathway is linked to the soil exposure pathway, addressing and/or eliminating the soil exposure pathway will address the air exposure pathway for hazardous substances. Further assessment of the air pathway is not recommended; however, proper precautions should be observed to protect workers and the public during any removal activities that would cause hazardous substances to become airborne.

3.0 STREAMLINED RISK EVALUATION AND ASSESSMENT

3.1 Streamlined Human Health Risk Assessment

The Human Health Risk Assessment (HHRA) evaluated the potential for adverse health effects that could result from current or future human exposures to hazardous substances present at the Site. The COPCs were selected by screening chemicals of interest (COIs) using approved human health risk-based screening procedures; exposure doses were then calculated for each COPC and receptor. The exposure doses were then compared to acceptable doses of the COPCs using approved screening numbers to determine the potential risk or hazard associated with the COPCs. The following are the primary elements of the HHRA.

- Hazard Identification and Selection of COPCs
- Exposure Assessment
- Toxicity Assessment
- Risk Characterization
- Summary of Human Health Risks

The following sections briefly summarize the estimated human health risks and hazards. A more detailed discussion of the HHRA is provided in Appendix C.

3.1.1 Potential Receptors and Exposure Pathway

There are no documented year-round residents; several private land owners maintain cabins which are intermittently occupied over the summer season. In addition, recreational receptors (e.g., hikers, hunters, and campers) have the potential to access the Site and were selected as the most likely current and future receptor. Complete exposure pathways were evaluated for seasonal resident and the recreational receptor, and included.

- Inhalation of soil and dust particulates;
- Incidental ingestion of surface water and sediment;
- Ingestion of surface water as a drinking water source;
- Dermal contact with soil, surface water and sediment; and
- Ingestion of fish.

The use of groundwater as potential drinking water was eliminated as a pathway of concern because there are no reported drinking water wells within several miles of the Site.
For purposes of the risk assessment, the mines and facilities were divided into Near and Remote features as shown below.

Near Features	Remote Features
Glacier Creek, downstream Ore Collector	Pride of the Mountains Mine
Haulage Ways	New Discovery Mine
Concentrator	Pride of the Woods Mine
Collector	Mystery Mine
Assay Shack	Golden Cord Mine
Boston-American Mine	Justice Mine
Rainy Mine	Sheridan Mine
	Sidney Mine

Near features were defined as those close to the Townsite, and having fairly easy human access. The potentially exposed population for the Near features was determined to be seasonal visitors consisting of children and adults. Remote features are typified by difficult terrain, lack of amenities, infrequent use, and difficult access. The potentially exposed population for the Remote locations was determined to be recreational/occasional visitors. Due to limited accessibility and difficulty of terrain, only adult exposures were considered for these locations. The potential for significant activity is considered to be moderate to high at the Near locations and low at the Remote locations.

3.1.2 Hazard Identification and Selection of Chemicals of Potential Concern

The media of interest for human health included surface soil, surface water, and sediment. Maximum concentrations of the COIs in these media were compared to the USEPA Risk Based Concentration Table. Industrial values were selected as the most appropriate screening criteria for soil and sediment because of the remote location of the Site, and that the area only has seasonal residents, none of which are located on or adjacent to the source areas. Tap water risk-based concentrations represented a very conservative screen for surface water. The following table lists the results of the COPC screening.

Contaminants of Potential Concern for the Human Health Exposure Media

COPCs	Surface Soil / Waste Rock	Surface Water	Sediment
Antimony	X		
Arsenic	X	X	X
Lead	X	X[1]	

NOTES:
X = COPC for the Site.
[1] There is no PRG for lead in surface water; it was, therefore, selected as a COPC.

3.1.3 Risk and Hazard Estimates

This section summarizes the results of the quantitative risk assessment. Calculations, assumptions, exposure point concentrations, and exposure inputs are available in Appendix C. Risks and hazards were calculated for both the central tendency exposure and reasonable maximum exposure. In general, the reasonable maximum exposure (RME) scenario is a conservative or worst-case estimate of potential exposure, while the central tendency exposure (CTE) scenario is typically more realistic and uses exposure factors that are more indicative of the average recreational user. For this risk assessment, the RME was assumed to represent the seasonal resident and the CTE was assumed to be the occasional visitor. Because of easier access to the Near locations and nearby amenities, both child and adult exposures were considered. Typical USEPA default exposure for a child is six (6) years. Therefore, the CTE exposure assumed six (6) years as a child and nine (9) years as an adult; the RME exposure scenario assumed six (6) years as a child and twenty four (24) years as an adult. Because of the limited access and the difficult terrain, receptors at the Remote locations were

assumed to be adults and no childhood exposures were considered. The exposure factors used in this risk assessment are presented in Appendix B2.

The Hazard Quotient (HQ) is defined as a comparison of the estimated intake dose of a hazardous substance with the reference dose or concentration, expressed as a ratio. Hazard Quotients greater than 1.0 indicate the potential for adverse health effects because the intake exceeds the reference dose. The sum of all individual chemical-specific HQs is termed the Hazard Index (HI); and is calculated under each exposure pathway. Thus, an HI less than 1.0 is not anticipated to produce unacceptable human health effects. The excess cancer risk (ECR) is defined as the incidence of cancer over and above known background (one case for every three people). The standard of one in one million (1E-06) sets the allowable "excess" cancer cases at one more case in a population of one million people. The following sections provide a brief summary of the non-carcinogenic and carcinogenic risks.

Non-Carcinogenic Risk Results

Arsenic and antimony were identified as the non-carcinogenic COPCs. Arsenic was identified as a COPC in surface soil, sediment, and surface water; antimony was identified as a COPC only in soil.

Datasets from the Near and Remote features are quantitatively addressed, and summarized in the following tables and in Appendix C. Ingestion of arsenic in soil/waste rock under RME condition (which represents the seasonal user) is the primary driver for unacceptable non-carcinogenic risk at the Near features because the HQ was greater than 1.0 (HQ = 3.0). None of the other pathways of exposure exceed the regulatory standard of 1.0. No unacceptable non-carcinogenic human health impacts are expected under the CTE conditions, which represent the occasional recreational visitor to the Site. The Remote features represent mines which are located distant from Townsite; wherein, access is limited and very difficult. No unacceptable non-carcinogenic risks under either CTE or RME exposure conditions are anticipated at the Remote features.

Summary of Non-Carcinogenic Risks – Near Features

Exposure Route	COPC	Hazard Quotient	
		CTE	RME
Soil and Waste Rock			
Ingestion	Antimony Arsenic	6.6E-04 5.1E-02	4.3E-02 **2.8E+00**
Inhalation of Particulates	Arsenic	1.2E-04	3.2E-03
Dermal Contact	Arsenic	2.1E-13	1.1E-09
Surface Water			
Ingestion	Arsenic	4.4E-04	3.5E-02
Dermal Contact	Arsenic	4.5E-13	8.8E-10
Sediment			
Ingestion	Arsenic	3.4E-03	1.5E-01
Dermal Contact	Arsenic	3.0E-08	1.5E-07
	Hazard Index	0.1	**3.0**

NOTE: **Bold** values exceed the regulatory standard of 1.0.

The Remote features represent mines that are located distant from Townsite; wherein, access is limited and difficult. No unacceptable non-carcinogenic risks under the CTE exposure conditions are anticipated at the Remote features. As shown below, ingestion of arsenic in surface water under RME condition (which represents the recreational user) is the primary driver for unacceptable non-carcinogenic risk at the Remote features because the HQ was greater than 1.0 (HQ = 4.8). None of the other pathways of exposure at the Remote features exceed the regulatory standard of 1.0.

Summary of Non-Carcinogenic Risks – Remote Features

Exposure Route	COPC	Hazard Quotient	
		CTE	RME
Soil and Waste Rock			
Ingestion	Antimony Arsenic	4.4E-05 6.2E-03	3.6E-03 1.3E-01
Inhalation of Particulates	Arsenic	1.4E-05	1.5E-04
Dermal Contact	Arsenic	2.2E-06	7.4E-04
Surface Water			
Ingestion	Arsenic	7.2E-05	2.1E-03
Dermal Contact	Arsenic	8.3E-09	3.0E-06
Sediment			
Ingestion	Arsenic	2.0E-01	**4.6E+00**
Dermal Contact	Arsenic	6.8E-07	1.8E-05
	Hazard Index	0.2	**4.8**

NOTE: **Bold** values exceed the regulatory standard of 1.0.

Carcinogenic Risk Results

Arsenic was identified as the only carcinogenic COPC at the Site. Datasets from the Near and Remote features are quantitatively addressed, and summarized in the following tables and in Appendix C. Carcinogenic risks are expected from ingestion and dermal contact with soil/waste rock, and ingestion of sediment and surface water under the RME exposure conditions for Near features. In addition, carcinogenic risks are expected from ingestion of arsenic-impacted soil/waste rock under CTE exposure conditions.

Summary of Carcinogenic Risks – Near Features

Exposure Route	COPC	Excess Cancer Risk	
		CTE	RME
Soil and Waste Rock			
Ingestion	Arsenic	**7.8E-05**	**4.0E-03**
Dermal Contact	Arsenic	9.6E-17	2.6E-13
Inhalation of Particulates	Arsenic	6.8E-09	5.0E-07
Sediment			
Ingestion	Arsenic	2.5E-08	**5.4E-06**
Dermal Contact	Arsenic	6.6E-19	1.3E-15
Surface Water			
Ingestion	Arsenic	4.3E-07	**2.3E-05**
Dermal Contact	Arsenic	2.9E-12	3.4E-10
	Total Excess Cancer Risk	**7.8E-05**	**4.0E-03**

NOTE: **Bold** values exceed the regulatory standard of 1E-06.

Ingestion of arsenic in soil and surface water used as drinking water are the drivers for unacceptable excess cancer risks under the CTE and RME exposure conditions for the occasional visitor to the Remote features. In addition, dermal contact with soil and ingestion of sediment pose an unacceptable excess cancer risk under RME exposure conditions.

Summary of Carcinogenic Risks – Remote Features

Exposure Route	COPC	Excess Cancer Risk	
		CTE	RME
Soil and Waste Rock			
Ingestion	Arsenic	**1.6E-05**	**1.1E-04**
Dermal Contact	Arsenic	9.4E-09	**2.2E-06**
Inhalation of Particulates	Arsenic	2.2E-07	**1.4E-06**
Sediment			
Ingestion	Arsenic	4.6E-07	**1.7E-06**
Dermal Contact	Arsenic	2.2E-10	7.1E-08
Surface Water			
Ingestion	Arsenic	**1.2E-05**	**7.1E-04**
Dermal Contact	Arsenic	3.9E-11	2.8E-09
Total Excess Cancer Risk		**2.8E-05**	**8.3E-04**

NOTE: **Bold** values exceed the regulatory standard of 1E-06.

Fish Ingestion

Ingestion of fish from potentially impacted surface water bodies was determined to be a complete pathway of exposure for the Near features, but not for the Remote features. A risk-based arsenic fish tissue concentration was calculated using standard USEPA formulas. Setting the ECR to the regulatory standard of 1E-06, acceptable fish tissue concentrations were determined based on estimated fish consumption rates identified by the Forest Service. Once these risk-based concentrations were calculated, acceptable sediment and surface water concentrations were calculated using USEPA formulas and default input values for transfer factors, lipid concentration of fish, and sediment organic matter content. Surface water and sediment samples were taken from numerous locations throughout the Site; however, a site-specific exposure point concentration (EPC) was not calculated because it would likely not be an accurate representation of conditions at specific waterways. In lieu of calculating an EPC and characterizing overall risk for fish consumption, the individual sediment and surface water samples were screened against the risk-based sediment and surface water concentrations. While this does not provide a measure of potential human health impacts from fish consumption, the results of the screening do indicate that most of the samples collected in sediments and surface water exceed both the CTE and RME risk-based arsenic concentrations (RBCs). RBCs for surface water and sediment for the Near features are presented below and in Appendix C.

Arsenic RBCs for Surface Water and Sediment – Fish Ingestion Pathway (Near Features)

Medium	Units	RBC	
		CTE	RME
Near Features			
Surface Water	µg/L	0.04	0.0008
Sediment	mg/kg	0.5	0.01

Sediment screening results determined that with the exception of sample MCEE-SS-MCL-06 (0.281 mg/kg), all sediment samples exceeded the RBCs for the fish consumption pathway for both RBCs. All surface water concentrations exceeded both RBCs. This screening represents a worst case scenario as sampling localities were specifically selected to identify areas of high concentration and the dataset for each waterway was very small, often consisting of one worst case sample. A better characterization of the individual waterways focusing on: 1) representative sampling rather than worst case, 2) collection of more samples that would allow for statistical analysis rather than the use of the maximum concentration, 3) evaluation of the model and tissue sampling to determine if the conservative mathematical model and inputs accurately represent site

conditions, and 4) site-specific input on fish consumption, could all affect the risk characterization results for this pathway of exposure and provide a more site-specific estimate of human health impacts from ingestion of fish. Therefore, the arsenic RBCs for sediment and surface water only provide a snapshot of the potential worst case scenario for fish consumption and do not necessarily present a risk characterization of the Site.

Lead Risk for Soil and Waste Rock

The USEPA's lead models simulate soil lead exposures at a single location. Two models have been developed, the Integrated Exposure Uptake/Biokinetic Model and the Adult Lead Model, which correlate dose with blood lead levels. These models require a minimum of three months of continuous exposure of at least one day per week. Three months is considered to be the minimum exposure to produce a quasi-steady-state lead concentration. The reliability of the models for predicting lead concentrations for exposure durations shorter than 3 months has not been assessed. In order to address non-continuous exposures, the USEPA Office of Solid Waste and Emergency Response has developed a guidance document for evaluating intermittent exposures to lead for scenarios such as recreational users and trespassers.

Since the exposure frequency is less than three months, predicted intake values were compared with the provisional values. Only the ingestion pathway is quantified. No unacceptable human health impacts are anticipated from exposure to lead in soil/waste rock because the predicted intake values were less than the provisional intake values.

Summary of Human Health Risks Due to Lead in Soil, Waste Rock, and Sediment

EPC (mg/kg)		Intake (mg/kg/day)		Predicted Intake (mg/day)		Provisional Intake Value (mg/kg)		
CTE	RME	CTE	RME	CTE	RME	Child	Female	Male
Monte Cristo Mining Area – Combined								
5.4E+03	7.3E+03	4.6E-08	5.0E-07	2.5E-04	3.6E-03	6.0E-03	1.5E-02	7.5E-02
Near Features								
6.1E+03	7.9E+03	4.6E-08	5.0E-07	2.8E-04	3.9E-03	6.0E-03	1.5E-02	7.5E-02
Remote Features								
4.5E+03	9.3E+03	4.6E-08	5.0E-07	2.1E-04	4.6E-03	6.0E-03	1.5E-02	7.5E-02

Lead Risk for Surface Water

Lead was also identified as a COPC in surface water because no PRG was available for screening. Many of the non-carcinogenic effects associated with lead may not exhibit a threshold, especially in young children. USEPA considers lead to be a B2 carcinogen. The maximum concentration of lead found in surface water (not adit/seep water) at the MCMA was 0.0008 mg/L. Adit/seep water was not considered a viable drinking water source in the MCMA. For purposes of this risk assessment, ingestion and dermal contact with surface water under normal "household" use was considered a complete pathway of exposure. Concentrations of lead in surface water at Near and Remote locations are lower than the Federal Action Level for lead (0.015 mg/L). Therefore, no unacceptable human health impacts are anticipated for lead in surface water.

3.1.4 Calculation of Risk-Based Cleanup Goals

Site specific risk-based cleanup goals for soil, sediment and surface water protective of the RME (seasonal resident) at the Near features, and the RME (occasional visitor) at the Remote features were calculated based on the regulatory standard of 1 E-06 ECR. The site-specific cleanup goals are presented in the following table.

Preliminary Risk-Based Human Health Cleanup Goals

Medium	Arsenic Cleanup Goal	Location	Basis
Soil / Waste Rock	67 mg/kg 659 mg/kg	Near Features Remote Features	Protection of RME Seasonal Resident - ingestion and dermal contact
Sediment	0.01 mg/kg	Near Features	Protection of RME Seasonal Resident - ingestion of fish
Surface Water	0.0008 µg/L	Near Features	Protection of RME Seasonal Resident - ingestion of fish

3.1.5 Summary of Human Health Risks

Unacceptable carcinogenic and noncarcinogenic risks were identified at the Site. Of the 22 COIs identified at the Site, antimony, arsenic, and lead were identified as major COPCs. Based on current and future land use, potential receptors were identified as individuals who might come in contact with Site-related contaminants through occasional activities (i.e., hunting, hiking, and camping) or as seasonal residents.

Due to the remote nature of several of the mines, the Site was divided into Near and Remote features. Near features were defined as those close to the Townsite, and having fairly easy human access. Remote features are typified by difficult terrain, lack of amenities, infrequent use, and difficult access. The potential for significant activity is considered to be moderate to high at the Near features and very low at the Remote features.

The risk assessment determined that there are no unacceptable human health impacts from lead in surface water or in soil/waste rock. The maximum concentration of lead (0.0008 mg/L) found in surface water did not exceed the Federal Action Limit for lead in drinking water (0.015 mg/L). Predicted intakes of lead from ingestion of soil/waste rock did not exceed USEPA Provisional Intakes for any receptors.

The risk assessment determined that there were no unacceptable noncarcinogenic health effects expected from exposure to antimony in soil. Potentially unacceptable noncarcinogenic risks are likely from ingestion of arsenic in soil under RME exposure conditions for the seasonal resident at the Near locations and ingestion of surface water under RME exposure conditions for the occasional visitor to the Remote locations. Unacceptable excess cancer risks are likely from ingestion of arsenic in soil under both exposure conditions for the seasonal resident and occasional visitor. Ingestion of sediment and surface water under RME exposure conditions are likely to results in unacceptable excess cancer risks for both occasional visitors and seasonal residents. Dermal contact with soil is likely to result in unacceptable excess cancer risk to occasional visitors to Remote locations.

Because the Site is a popular recreational area, the indirect pathway of fish ingestion was also considered a complete pathway. The impact of contaminants in surface water and sediments on fish tissue concentrations was evaluated to determine potential human health impacts from this pathway of exposure using an RBC screening approach. Site specific RBCs for surface water and sediment were calculated for Near location conditions. Fish ingestion was only considered at the Near locations. Fishing in the Remote locations is highly unlikely as there is little traffic in those areas and fish barriers along the creeks make it highly unlikely that these areas would be used successfully for fishing. Sampling data were screened against these RBCs. Most of the samples collected exceeded the site-specific RBCs at both the Near and Remote locations. However, the RBCs for sediment and surface water only provide a snapshot of the potential worst case scenario for fish consumption and do not necessarily present a risk characterization of the Site.

3.2 Streamlined Ecological Risk Assessment

The goal of the ecological risk assessment (ERA) is to determine whether there is an unacceptable ecological risk associated with the Site. This report, which is presented in Appendix C, consists of:

- Problem Formulation
- Risk-Based Screening
- Risk Characterization
- Uncertainty Analysis
- Summary of Ecological Risk

An ecological survey was conducted as part of a previously completed SI (CES, 2008a). The SI report documented ecological features and conditions at and near the Site. A Terrestrial Ecological Evaluation (TEE) was completed based on the ecological survey, in accordance with Ecology requirements (Ecology, 2007), and is provided in Appendix C. Based on the results, a TEE exclusion is not acceptable and a site-specific terrestrial ERA is warranted. Ecology does not provide specific guidance for an ERA of water or freshwater sediment and specific methods are not prescribed for Site-specific ERA of soil. Therefore, risk-based screening methods appropriate for Ecology (2007) and the USEPA (1997, 1999) were implemented to assess the potential for risks posed by Site-related COIs in surface soil, waste rock, tailings, surface water, pore water, and sediment. This includes completing a problem formulation, risk-based screening, and risk characterization.

The problem formulation, risk assessment data, ecological risk-based screening, risk characterization, uncertainty analysis, conclusions, and recommendations are included in Appendix C. The problem formulation determines the scope of the ERA and culminates in a conceptual ecological exposure model and assessment endpoints. The assessment endpoints tie the risk assessment results to risk management decisions and present the focus of the ERA. The analytical data used for the ERA are briefly described, and a risk-based screening is conducted, comparing the Site data to ecological risk-based screening concentrations. The results of the risk-based screening are discussed along with the uncertainties inherent in the ERA process. Finally, conclusions and recommendations are provided regarding the potential for ecological risks posed by Site-related contaminants and whether further investigation or remediation is warranted for the protection of ecological receptors.

3.2.1 Ecological Risk-Based Screening

Ecological risk-based screening begins with the list of COIs shown in Appendix C. Exposure point concentrations are then determined for each COI in each potential exposure medium and compared to selected ecological risk-based screening concentrations (ERBSC), with consideration of bioaccumulation potential and exposures to multiple hazardous substances and multiple media. Risk ratios greater than one (1.0) indicate a potential risk; COIs for which potential ecological risks are indicated become the contaminants of potential ecological concern (COPECs). The results of the risk-based screening are provided in Appendix C. The COPECs identified for the Site are outlined in the following table.

Selected Contaminants of Potential Ecological Concern

COPECs	Surface Soil, Waste Rock, Tailings	Surface Water	Pore Water	Sediment
Aluminum	X[1]	X[1,2]		X[3]
Antimony	X[1,3,5]	X[3]	X[3]	X[1]
Arsenic III	X[1,2]	X[2]	X[2]	
Arsenic V	X[1,2,4]	X[1,2]	X[2]	X[1,4]
Arsenic, total	X[1,2,4]	X[1,2]	X[1,2,4]	X[1,4]
Barium	X[1]	X[1]		X[3]
Beryllium	X[3]			X[3]
Cadmium	X[2]	X[1,2,5]	X[5]	X[1,4]
Chromium VI			X[1,2,4]	
Cobalt	X[3]	X[3]		X[3]
Copper	X[1]	X[1,4,5]	X[5]	X[1,4]
Iron	X[1,2,4]	X[1,3]		
Lead	X[1,2]	X[1,2,4,5]	X[2,4,5]	X[1,4]
Manganese	X[1]	X[1]		
Mercury	X[1,2]	X[1,2,5]	X[2]	X[1,2,3]
Mercury, Methyl	X[1,3]			X[3]
Nickel				X[1]
Selenium	X[1,2,5]	X[2]		
Silver	X[1,3]	X[1,3,5]	X[3,5]	
Thallium	X[1,3,5]	X[3]		X[3]
Vanadium	X[1,3]			X[3]
Zinc	X[1]	X[1,4]		X[1,4]

NOTES:
1 – Selected as a COPEC due to exceedance of an ERBSC.
2 – Selected as a COPEC due to a potential for bioaccumulation.
3 – Selected as a COPEC because no ERBSC was available.
4 – Selected as a COPEC because of inordinate contribution to overall risk.
5 – Selected as a COPEC because of an elevated reporting limit.

3.2.2 Ecological Risk Characterization

Surface Soil, Waste Rock, and Tailings

The COPECs for surface soil, waste rock, and tailings are listed above and in Appendix C; Appendix C-A summarizes the calculation and determination of background concentrations used in the Risk Assessment. Aluminum was selected as a COPEC due to exceedances of the ERBSCs at one sample location, and no other samples had aluminum concentrations that exceeded background concentrations. Barium exceeded wildlife ERBSCs at eight locations, all from near the Concentrator. Beryllium concentrations exceeded the background concentration by more than a factor of two in two samples near the Concentrator. Cadmium was selected as a COPC because of its potential to bioaccumulate. Cobalt concentrations exceeded the background concentration by a factor of more than two at one sample location, at the Concentrator. Of the six samples in which manganese exceeded ERBCs, three were at the Concentrator, two were at the Collector, and one was at the Mystery Mine. Manganese risks were predicted for invertebrates at six locations, all but one (at Mystery Mine) were at the Concentrator or the Collector. Vanadium risks were predicted for invertebrates at the Concentrator, Haulage Ways, and Mystery Mine. Based on this ecological risk characterization, the risks predicted for aluminum, barium, beryllium, cobalt, cadmium, manganese, and

vanadium were a result of either a prediction of bioaccumulation or unacceptable concentrations at the Concentrator, Collector, Haulage Ways, and Mystery Mine.

Given the extent and number of exceedances of background concentrations and ERBSCs, plus the lack of ERBSCs for antimony, arsenic III, arsenic V, total arsenic, copper, iron, lead, mercury, methyl mercury, selenium, silver, and zinc in soil, it is likely that the concentrations in soil, waste rock, and tailings are high enough to result in ecological risks if significant exposure occurs. The pH at many of the waste rock areas is relatively low; suggesting some hazardous substances may be mobilized from the source areas and available for uptake. The most significant risk would be posed to plants and invertebrates growing within the relatively small contaminated areas (compared to surrounding uncontaminated areas). More mobile and wide-ranging wildlife species are unlikely to spend large amounts of time on or around the mine waste areas and, thus, are less likely to be impacted by the COPECs.

Surface Water

Unacceptable risks were predicted due to multiple COPECs, for aquatic life, but not for birds or mammals. Arsenic III and selenium were selected as COPECs due to the potential to bioaccumulate. No background/reference concentrations were available for these two COPECS, so comparisons were not possible; however, significant ecological risk is not expected due to the relatively low concentrations.

Antimony, cobalt, and thallium were all selected because of the lack of an ERBSC. Antimony exceeded background concentrations by a factor of more than two in about 25% of the samples. Most of these were at adit/seep water near mine-related locations (i.e., not in creek or river samples). The remaining three were collected from Glacier Creek, but were the result of elevated reporting limits for non detected results. Cobalt was only detected in one of nine collected samples. Thallium is similar to cobalt in that only one water sample collected at the Mystery Mine adit water had a detected concentration. Thus, any potential risks for these COPECs appear to be limited to adit water and waste rock seeps.

Aluminum, arsenic V, cadmium, manganese, total arsenic, iron, and zinc exceeded ERBSCs at 1 to 17 sample locations. All of these were at adit water or waste rock seeps. Barium exceeded ERBSCs at two Glacier Creek sample locations, but the barium concentrations at these locations were identical and both above background concentrations by a factor of 1.3. Copper appears to exceeded ERBSCs in 66% of the samples. However, most of these apparent exceedances for copper are due to elevated reporting limits for non detected concentrations. Examining the copper concentrations detected above the reporting limit, there is one exceedance of an ERBSC in the South Fork Sauk River at station MCEE-SW-SFSR-04, and 13 exceedances at adit water and waste rock seeps. Similarly, lead and silver appear to have multiple ERBSC exceedances in the surface water bodies; however, examination of the detected concentrations for lead indicates one exceedance in Seventysix Gulch and three at or below Monte Cristo Lake, with 14 exceedances, at adit/wasterock seeps. For silver, there were 4 exceedances, at adit/wasterock seeps.

The pH of surface water is within normal ranges suggesting that mine-related pH impacts are not occurring in Glacier Creek, Seventysix Gulch, and the South Fork Sauk River. However, the low pH in waste rock may allow mobilization of metals via overland or subsurface transport.

Pore Water

Antimony was chosen as a COPEC due to the lack of a bird ERBSC. No antimony background/reference concentration was available for comparison to site-related concentrations. Arsenic III, arsenic V, and mercury had no ERBSC exceedances but were chosen as COPECs due to their potential to bioaccumulate. No arsenic III or arsenic V background/reference concentration was available for comparison to site-related concentrations. One of the samples for mercury exceeded the respective mercury background concentrations, by a factor of 1.2.

Silver was selected as a COPEC due to elevated reporting limits in 6 of 13 samples and also did not have a background/reference concentration available. Cadmium and lead were selected due to elevated reporting limits in 2 and 6 of 13 samples, respectively, and due to the potential to bioaccumulate. No background/reference concentrations for cadmium and lead were available for comparison.

Total arsenic exceeded the aquatic life ERBSC at one station (Monte Cristo Lake). Chromium VI exceeded the aquatic life ERBSC in the only sample analyzed (collected from Glacier Creek) for this COPEC. However, this concentration was determined using a field measurement tool. Laboratory-measured total chromium was not detected in this or any other pore water sample, all with reporting limits less than the field measured chromium VI concentration. This suggests chromium VI is not a COPEC in pore water.

The pH of pore water is within the normal range. This suggests that mine-related pH impacts are not occurring in pore water.

Sediment

Aluminum, barium, beryllium, cobalt, methyl mercury, thallium, and vanadium were selected as COPECs due to a lack of ERBSCs. None of the detected concentrations of aluminum or barium exceeded the background concentrations measured for the Site. Beryllium, cobalt, iron, and thallium concentrations did not exceed background by more than a factor of two. Methyl mercury had no background concentration for comparison.

Similarly, zinc concentrations exceeded invertebrate and wildlife ERBSCs at multiple stations, but only exceeded background concentrations by a factor of more than two at one station. Mercury and nickel exceeded the invertebrate ERBSC and the background concentration at one station each. Antimony, arsenic V, total arsenic, cadmium, copper, and lead had multiple exceedances of the invertebrate and/or wildlife ERBSCs and background concentrations in adit/waste rock seeps, Glacier Creek, Seventysix Gulch, and/or the South Fork Sauk River.

3.2.3 Summary of Ecological Risks

Unacceptable concentrations of at least one of several COPECs are present in most of the soil, waste rock, and tailings samples collected from the Site, and it is likely that individual plants and invertebrates are impacted within these localized areas. Given the highest unacceptable risk ratios and the more widespread distribution, antimony, arsenic III, arsenic V, total arsenic, copper, lead, mercury, selenium, and silver have the most potential to be causing any terrestrial ecological risks. Given their proximity, the waste rock and tailings piles are likely past and current sources for chemicals to be transported primarily to Glacier Creek and Seventysix Gulch, both of which flow into the South Fork Sauk River.

While there are unacceptable concentrations of COPECs for aquatic life in adit/waste rock seeps, because the seeps are very small and not suitable for most aquatic life, aquatic life populations of concern are unlikely to be at risk due to direct exposure to COPEC in the seeps. However, barium, lead, mercury, and possibly silver were each present at unacceptable concentrations in Glacier Creek, Seventysix Gulch, and/or the South Fork Sauk River. Elevated concentrations of several COPEC were more consistently noted in the GC-03, GC-04, and GC-05 sample locations than in other locations.

In sediment, antimony, arsenic V, total arsenic, cadmium, copper, and lead had multiple unacceptable exceedances of the invertebrate and/or wildlife ERBSCs and background concentrations in adit/waste rock seeps, Glacier Creek, Seventysix Gulch, and/or the South Fork Sauk River. Antimony and total arsenic were particularly prevalent in sediment, with unacceptable concentrations extending as far downstream as MCL. The very few number of unacceptable concentrations of COPECs in pore water suggests that the COPECs may be bound fairly tightly to sediment.

3.3 Overview of the Human and Ecological Risk Assessment

The MCMA covers a diverse topographical area along several miles of Glacier Creek and Seventysix Creek. Mine and facilities were divided into Near and Remote features based on proximity to the Townsite and relative accessibility. Occasional visitors and seasonal residents were identified as likely human receptors for the Near features. Occasional visitors were identified as the likely human receptors for the Remote features.

Arsenic was identified as a human health COPC. Potential unacceptable health impacts from ingestion of and skin contact with arsenic contaminated soils, sediment, and surface water under some exposure conditions may be present at the Site. Total ECRs exceeded Ecology's regulatory standard of 1E-06. With the exception of one sediment sample (MCEE-SS-MCL-06 = 0.281 mg/kg), concentrations of arsenic in surface water and sediment exceeded the RBCs for the fish ingestion pathway for both RME and CTE exposure scenarios. However, these fish consumption RBCs provide only a snapshot of the potential worst case scenario and do not necessarily present a risk characterization of the Site. More detailed risk assessment is needed to accurately determine the risk associated with consumption of fish in the MCMA.

Arsenic concentrations, in general, are high in soil, waste rock, tailings, and sediment. The following table presents the recommended preliminary risk-based cleanup goals and the critical pathway of concern for protection of human health.

Preliminary Risk-Based Human Health Cleanup Goals

Medium	Arsenic Cleanup Goal	Location	Basis
Soil / Waste Rock	67 mg/kg	Near Features	Protection of RME Seasonal Resident - ingestion and dermal contact
	659 mg/kg	Remote Features	
Sediment	0.01 mg/kg	Near Features	Protection of RME Seasonal Resident - ingestion of fish
Surface Water	0.0008 µg/L	Near Features	Protection of RME Seasonal Resident - ingestion of fish

Based on the information presented in the ERA, significant ecological impacts are expected for individual plants and invertebrates exposed to Site-related COPECs in soil, waste rock, and tailings near the adits, mines, and mine-related areas. These risks assume 100 percent exposure of the ecological receptors to the contaminated areas, which is unlikely. A site-specific risk assessment would be required to better define actual risks posed to ecological receptors. A definite potential for risk was predicted for aquatic receptors exposed to COPECs in adit/wasterock seeps. There were COPECs that exceeded aquatic life ERBSCs in the creeks and rivers, which may bioaccumulate into the aquatic food chain. In addition, numerous high unacceptable risks were calculated for invertebrates and wildlife exposed to COPECs in sediment, particularly for antimony and total arsenic. These sediment risks appear to extend several miles downstream from the Site. More detailed assessment is recommended for aquatic ecological receptor exposure and risk due to COPECs in surface water and sediment.

The pattern of risk reinforces the transport and fate pathways shown in the Conceptual Ecological Exposure Model (Appendix C), with mine adits and waste rock and adit/waste rock seeps contributing a vast majority of the predicted risks. Because of this, ecological protective cleanup actions, particularly at the Concentrator, Collector, and Haulage Ways, would dramatically reduce the predicted risks and reduce the potential for further contribution of COPECs to the creeks and rivers.

3.4 Physical Hazards Associated with Mines and Processing Facilities

Thirteen accessible underground workings, ranging from open to partially-caved adits, a partially-caved shaft, and a large open stope, were found at eight of the ten mine sites included in the EECA; however, access to one of the open adits, the Boston American Mine is blocked by a steel door. Additional undiscovered open workings may be present on some sites, particularly at the Rainy Mine. Furthermore, discussions with former Bureau of Mines geologists and engineers that mapped the underground workings in the later-1970's (Johnson, et al., 1983a,b) indicate that some underground stopes are open to the near surface, but are covered by talus. These openings would probably not be visible on the surface but could constitute a serious hazard if the talus bridge fails. Waste rock dumps at some mine sites are very steep, ranging from less that 20° to over 40°, and a ferricrete crust developed on the surface of many of the steep dumps make them extremely dangerous to climb. Access routes to several mine sites traverse steep, irregular, and unstable talus slopes. The remnants and ruins of mine operations, storage buildings, housing, haulage ways, and processing facilities contain a range of physically hazardous materials including burned timbers and boards with nails, broken machinery and glass, rusty cables and parts, and other debris. The portals at any of the mine workings described in this report may be susceptible to rock falls at any time. Some workings are driven into vertical rock faces which present additional hazards for rock falls, particularly where bedrock is jointed. Water is impounded behind caved materials at some adit portals, which presents a hydraulic blowout hazard under certain conditions.

The physical hazards recognized for each site are presented in the following sections.

3.4.1 Upper Glacier Creek (Glacier Basin) Area

Pride of the Mountains

Open workings at this mine (Figure 1) include two partially caved adits and a largely-caved inclined shaft. Water is impounded behind a slough pile at the portal of the Main Adit, and water apparently drains through the slough and down the dump. The adit opening is only about 1 foot high by about 2 feet wide due to the slough. DNR noted in 2002 that there was no evidence of bats (Wolff, et al., 2003). The opening of the partially caved portal of Adit 2, possibly known as the “Mukelteo” Adit, is about 6 feet wide by 1 foot high. The three openings appear to be suitable for bat-friendly culvert closures because the openings are too small to accommodate a bate gate. The upper portion of the Pride of the Mountains waste rock dump is very steep, over 40°, and the surface is composed of ferricrete making it hazardous to stand or climb. The lower portion of the dump and the steep mountainside consists of commingled coarse, unstable mine waste rock and talus.

New Discovery Mine

Three adits are open at this mine (Figure 2). The Northwest Adit is over 10 feet wide and about 5 feet high at the portal which is slumping, but it narrows to about 5 feet wide at less than 10 feet into the working and is about 6 feet high. The Southeast Adit is 5 feet wide and 7 feet high at the portal. The third adit, named the Barren Adit (Forest Service, 2006b) is 4 feet wide and 6.5 feet high at the portal. The three adit portals appear to be suitable for bat gate closures. The waste rock dumps are also very steep, over 30°. The dump and the steep mountainside consist of commingled coarse, unstable mine waste rock and talus.

Pride of the Woods

The portal of an adit at this mine is largely sloughed and covered with boulders (Figure 3; Photograph 10). Other hazards observed consist of rusty broken metal debris and glass and the remnants of structures. Portions of the waste rock dump have a ferricrete surface making it difficult to climb.

3.4.2 Mystery Ridge/Basin Area Near Glacier Creek

Mystery Mine

This mine has one adit and one stope open to the surface (Figure 4). Adit #3 is open at the portal but partly caved, timbers at the portal are rotten and slabs of tonalite have closed off part of the portal, which is 6 feet wide by 7 feet high. Wolff, et. al., (2003) noted that there was no evidence of bats. Acid mine drainage flows from the Adit #3 portal. A portion of Adit #1, which is caved at the portal, has been stoped to the surface resulting a dangerous opening approximately 120 feet along strike, is about 6 feet wide, and is at least 100 feet deep. This constitutes a major safety hazard. The portal of Adit #3 appears to be suitable for a standard bat gate closure; however, further examination may be required to determine a suitable closure - a very large bat gate, a cupola gate, cable netting, or fencing – for the 120-foot-long by 6-foot-wide open stope. The dump and the steep mountainside consist of coarse, unstable mine waste rock and talus, commingled in some areas, making access by foot hazardous. The ruins of an aerial tramway station and buildings present additional hazards.

Golden Cord Mine

There are no open workings at this mine (Figure 5); however, the dumps and the steep mountainside consist of coarse, unstable mine waste rock and talus, commingled in some areas, making access by foot hazardous. The ruins of an aerial tramway station and buildings present additional minor hazards.

Justice Mine

One adit is open at this mine (Figure 6). The Main Adit portal is 6 feet wide and 7 feet high in solid rock. It is driven south 10° east into a vertical rock face on the south side of an 80-feet-long by 10-feet- to 20-feet-wide ledge blasted off the rock face. Mine water flows out of the mine portal and across the ledge (Photographs 20 and A-21). The mine and the extensive workings accessed by the Main Adit are described by Northwest Underground Explorations (1997) making the Justice Mine workings a popular feature to explore. DNR noted that there was no evidence of bats (Wolff, et al., 2003). The adit portal appears to be suitable for a bat gate closure. The dump and the steep mountainside consists of coarse, unstable mine waste rock and talus, commingled in some areas, making access by foot hazardous.

3.4.3 Lower Glacier Creek and Townsite Area

Rainy Mine

One partly-caved adit with a flooded open cut is at this mine (Figure 7). A pile of caved rock at the portal impounds water back into the working. Beyond the partial portal collapse, the adit appears to be about 6 feet high by 5 feet wide; further underground examination was considered to be too dangerous. A sink hole in the portal open cut into which adit water flows may be the only evidence of a boarded over shaft collar that was covered with dirt (Johnson, et al., 1983a; Northwest Underground Explorations, 1997). CES staff searched for a second shaft, reportedly developed as a raise about 80 feet northeast of the portal on the adit working level, but no evidence was found in the heavily vegetated area. Unstable rock at the adit portal and a possible covered flooded shaft in the open cut leading to the portal constitute serious hazards to the public. The partially-caved adit portal appears to be suitable for a bat culvert closure. Although the toe of the lower waste rock dump is at creek level, portions of it are near vertical and therefore unstable due to erosion and undercutting by periodic high-runoff events in Glacier Creek.

Ore Collector, Haulage Ways, and Concentrator & Tailings

These features (Figures 8, 9, and 10) are primarily facility ruins consisting of remnant brick, rock, and concrete foundations and piles of collapsed wooden structures with associated rusty nails and machinery, broken glass, and related debris. Physical hazards are mainly tripping on and falling into the debris.

Assay Shack

Physical hazards associated with this small feature (Figure 11) consist primarily of broken brick, concrete, glass, and other debris.

Boston-American Mine

This mine has one open adit, but casual access into the working is blocked at the portal by a locked steel door (Figure 12). The portal opening is about 6 feet high by 5 feet wide, and adit drainage water is impounded near the portal. The two-level waste rock dump at this mine is steep, ranging from 30° to nearly 40°, and portions of the dump are loose and unstable.

3.4.4 Seventysix Creek Area

Sheridan Mine

One adit is open at this mine (Figure 13). The adit is approximately 9 feet wide and 5 feet high at the irregular-shaped portal, but the working appears to continue with a 6-foot-high by 5-foot-wide section. The adit portal appears to be suitable for a bat gate closure. Portions of the waste rock dump are steep.

Sidney Mine

One adit is open at this mine (Figure 14). The adit portal is 6 feet high by 5 foot wide, and square set timbers at the portal were collapsing due to damage by a large debris avalanche. Water drains from the adit portal, which is about at the low stream flow level of Seventysix Creek. The adit portal appears to be suitable for a bat gate closure. Access to this mine is extremely difficult and hazardous, particularly now that a debris avalanche has covered the access route across Seventysix Creek. The waste rock dump, approximately 150 feet downstream, has evidently been eroded by high-runoff events, and some portions of it are near vertical and unstable.

4.0 SITE CLEANUP CRITERIA

4.1 Potential Applicable or Relevant and Appropriate Requirements

ARARs are "*applicable*" and/or "*relevant and appropriate*" federal and state environmental requirements. The *applicable* requirements include cleanup standards and other important requirements, criteria, or limitations promulgated from federal or state laws that apply to hazardous substances and Removal Actions, in this case the MCMA. *Relevant and appropriate* requirements are not necessarily applicable, but may be suitable for use because they address issues or problems sufficiently similar to those that exist at a site. In addition to ARARs, federal and state environmental and public health guidance and proposed standards that may not be legally binding but could prove useful are standards "*to be considered*" (TBC).

Federal, state, and local potential ARARs are used to:

1. Evaluate the extent of cleanup needed at the Site,
2. Scope and develop Removal Action alternatives, and
3. Guide the implementation and operation of the preferred alternative.

The NCP (40 CFR 300.415(j)) establishes that Removal Actions shall "to the extent practicable considering the exigencies of the situation, attain ARARs under federal environmental or state environmental or facility siting laws." To determine whether compliance with potential ARARs is practicable, two factors are specified in 40 CFR 300.415(j): (1) urgency and (2) scope of the Removal Action. The scope of the Removal Action is often directed at minimizing and mitigating potential hazard rather than eliminating the hazard. Therefore, even though a particular standard may be an ARAR for a particular medium, it may be outside of the scope of the immediate problem. For example, removal of a hazardous substance source may

improve groundwater or surface water quality without meeting water quality criteria, thus not meeting the potential ARAR, can be an acceptable Removal Action.

The potential ARARs are grouped as federal or State of Washington potential ARARs; no specific local potential ARARs were identified (Appendix D). Potential ARARs are identified by a statutory or regulatory citation, followed by a brief explanation of the potential ARAR, and whether the potential ARAR is (1) "potentially applicable", (2) "potentially relevant and appropriate", or (3) "to be considered".

In accordance with Section 121(e) of CERCLA, no permits are required for an on-site Removal Action. However, as discussed above, substantive requirements, which a permit might otherwise address, must be met to the extent practicable.

Potential ARARs are either: chemical-, location-, or action-specific.

- Chemical-specific requirements address chemical or physical characteristics of chemicals or hazardous substances. These values establish acceptable amounts or concentrations of chemicals that may be found in or discharged to the ambient environment.
- Location-specific requirements are restrictions placed on the concentrations of hazardous substances or the conduct of cleanup activities because they are in specific locations. Location-specific ARARs relate to the geographical or physical positions of a site rather than to the nature of hazardous substances at sites.
- Action-specific requirements are usually technology based or activity based requirements or limitations on actions taken with respect to chemicals or hazardous substances. A given cleanup activity could trigger an action-specific requirement. Such requirements do not themselves determine the cleanup alternative but define how to perform chosen cleanup methods.

The following sections outline the key potential ARARs for the MCMA EECA.

4.1.1 Key Chemical-Specific ARARs

Soil, Sediment and Water Quality Standards

As allowed by MTCA, risk-based cleanup concentrations were calculated for human exposure to soil/waste rock, surface water and sediment at the MCMA (see Section 4.2). Ecological risk-based cleanup concentrations were not calculated for ecological receptors in and around the MCMA. Additional site-specific ecological risk evaluation is needed before ecological risk-based cleanup concentrations can be calculated. Therefore, the following potential ARARs are considered key for the MCMA.

- Washington State Water Quality Standards (WAC Chapter 173-201A-240)
- National Recommended Water Quality Criteria (Section 304(a) of the CWA)
- Priority Contaminants of Ecological Concern for Sites that Qualify for the Simplified TEE Procedure (WAC 173-340-900, Table 749-2)
- Ecological Indicator Soil Concentrations for Protection of Terrestrial Plants and Animals (WAC 173-340-900, Table 749-3)
- Federal Freshwater Sediment Standards, Threshold Effects Level and Probably Effects Level, as outlined in the National Oceanic and Atmospheric Administration Screening Quick Reference Tables (NOAA, 2008)

Tables 11 -14 provide a summary of the key chemical-specific potential ARARs, along with a summary of the risk-based cleanup concentrations for human receptors, for the surface water, mine water, stream sediments, and soil/waste rock.

4.1.2 Key Action-Specific ARARs-

Solid/Dangerous Waste Disposal Requirements

The Solid and Dangerous Waste disposal ARARs establish the performance standards for proper handling and disposal of solid waste; outline responsibilities of various entities and stakeholders; and outline requirements for solid waste handling facility location, design, construction, operation, and closure. All substantive requirements for closure and post-closure of limited purpose landfills (WAC 173-350-400) are potential ARARs (WAC 173-340-710[7][c]). The waste rock/soils at the Site are landfills that contain solid waste and are releasing hazardous substances above both state and federal cleanup standards.

4.1.3 Key Location-Specific ARARs

Forest Plan Standards and Guidelines

Portions of the Land and Resource Management Plan (LRMP) for Mt. Baker Snoqualmie National Forest (Forest Service, 1990), as amended by Pacific Northwest Forest Plan (NWFP) in 1994 are potentially ARARs for assessing Site removal action alternatives. The LRMP and NWFP include standards and guidelines that are potentially relevant and appropriate to actions at the Site, including activities within, or that affect Riparian Management Areas along Glacier Creek, Seventysix Creek, and the SFSR. These standards and guidelines include RF-2 through RF-7, which control the design, construction, and use of temporary and permanent roads and other modifications within Riparian Reserves; and MM-3, which controls solid waste and mine waste facilities within Riparian Reserves. Particular aspects of MM-3 that are potentially relevant and appropriate to closure of the waste rock piles at the Site include requirements for: (a) analysis based on best conventional methods; (b) designing waste facilities using best conventional techniques so that mass stability and prevent the release of acid or toxic materials; and (c) reclamation and monitoring waste facilities so that chemical and physical stability, and to meet Aquatic Conservation Strategy objectives.

Historic and Cultural Requirements

In regards to historic and cultural requirements, there are several potential location-specific and some potential action-specific ARARs that will be considered during the design phase of the removal, after the removal decision identifies the selected alternative and removal activities. Key potential historic and cultural ARARs are outlined below:

- National Historic Preservation Act (16 USC § 470)
- Historic Site, Buildings, Objects, and Antiquities Act (16 USC § 461-467)
- Archeological and Historic Preservation Act (16 USC § 469)

4.2 Risk-Based Preliminary Remediation Goals

Using MTCA guidelines and formulas, and as outlined in the Risk Assessment and in Section 3.0, risk-based cleanup concentrations were calculated based on the RME exposure condition (worst case scenario) and site-specific exposure factors (i.e., daily intake, body weight, exposure duration and frequency, and other factors). These cleanup concentrations are summarized in the following table.

Preliminary Risk-Based Human Health Cleanup Goals

Medium	Arsenic Cleanup Goal	Location	Basis
Soil / Waste Rock	67 mg/kg	Near Features	Protection of RME Seasonal Resident - ingestion and dermal contact
	659 mg/kg	Remote Features	
Sediment	0.01 mg/kg	Near Features	Protection of RME Seasonal Resident - ingestion of fish
Surface Water	0.0008 µg/L	Near Features	Protection of RME Seasonal Resident - ingestion of fish

4.3 Recommended Cleanup Goals

Tables 11, 12, 13, and 14 summarize the background concentrations, mean concentrations, maximum detected concentrations, chemical-specific ARARs and the calculated human health risk-based cleanup goals for surface water, mine water, stream sediments, and soil/waste rock/tailings. These tables also provide a recommended cleanup goal, along with a justification for these goals. Note that because a human health risk assessment was performed at the Site, proposed cleanup goals are based on ecological receptors for all COPC other than arsenic, since arsenic was the only COPC that resulted in unacceptable human risks. In addition, as allowed by MTCA, background concentrations were recommended as the proposed cleanup goals if these values were higher than the ARARs or calculated human health risk-based goals. The following table summarizes the recommended cleanup goals for arsenic; cleanup goals for other hazardous substances are outlined in Tables 11-14.

Recommended Cleanup Goals – Arsenic

Medium	Arsenic Cleanup Goal	Location	Basis
Soil / Waste Rock	236 mg/kg	Near Features	Natural background soil (90UCL)
	659 mg/kg	Remote Features	Protection of RME Seasonal Resident - ingestion and dermal contact
Sediment	0.01 mg/kg	Near Features	Protection of RME Seasonal Resident - ingestion of fish
Surface Water	0.0008 µg/L	Near Features	Protection of RME Seasonal Resident - ingestion of fish

5.0 IDENTIFICATION OF REMOVAL ACTION OBJECTIVES

The goal of a Removal Action is to protect human health and the environment by preventing, controlling or minimizing the release or potential release of a hazardous substance, and reducing the potential for direct contact and transport of hazardous substances to the environment. Based on the information presented in this EECA, the following Removal Action Objectives (RAOs) were developed for the Site:

- Reduce the human and ecological exposure to hazardous substances in the mining-related waste rock, tailings, and the associated contaminated soils.
- Minimize or eliminate potential for hazardous substance mobilization and transport from contaminated waste rock, tailings, and soils on the Site by stabilizing and/or isolating sources.
- Improve surface water quality by decreasing hazardous substance loading to Glacier Basin and Glacier Creek, Seventysix Creek, and the SFSR from mining- and processing-related sources.

A secondary objective is to reduce human exposure to physical hazards associated with mining- and processing-related features (e.g., open mine workings, ruins of buildings, etc.) on the Site. The following sections discuss the Removal Action justification, scope, and the proposed schedule.

5.1 Removal Action Justification

The NCP states that an appropriate Removal Action may be conducted when a threat to human health or welfare or the environment is identified. The Removal Action is undertaken to abate, prevent, minimize, stabilize, mitigate, or eliminate the release or the threat of a release at a site. Section 300.415(b)(2) of the NCP outlines eight factors to be considered when determining the appropriateness of a Removal Action. The applicable factors are outlined in the Removal Action Justification Table below and provide justification for undertaking Removal Action. Since there are no hazardous substances stored in containers and there is no known threat of fire or explosion associated with the Site, these factors will not be addressed.

Removal Action Justification Table

Factor	Site Summary	Justification
(1) Actual or potential exposure to nearby human populations, animals, or the food chain from hazardous substances or pollutants or contaminants	Complete exposure pathways to human (recreational) and ecological receptors (aquatic and terrestrial) were documented during the SI from exposure to metal-impacted waste rock, soil, tailings, and stream sediment.	**Yes**
(2) Actual or potential contamination of drinking water supplies or sensitive ecosystems	Recreational visitors and seasonal residents may use local streams as a drinking water source. Surrounding surface waters and associated ecological receptors are being impacted by the erosion of waste rock, soil, tailings, and sediment located adjacent to the creeks.	**Yes**
(3) High levels of hazardous substances or pollutants or contaminants in soils largely at or near the surface, that may migrate	Surficial waste rock, soil, and tailings are contaminated with arsenic and metals. These hazardous substances are susceptible to chemical mobilization and transport by snow melt and acid mine drainage percolating through the contaminated materials. Contaminated water drains from mine openings and/or seeps from the toe of waste rock dumps at eight of ten mines included in the EECA.	**Yes**
(4) Weather conditions that may cause hazardous substances or pollutants or contaminants to migrate or be released	High runoff conditions, particularly in late spring, are known to erode and transport downstream contaminated waste rock and tailings that are located within the floodplains.	**Yes**
(5) The availability of other appropriate federal or state mechanisms to respond to the release	The Site has mixed ownership and is not currently listed or proposed for listing on the National Priorities List. Thus, the Forest Service is the agency with CERCLA authority over the National Forest System land. A comprehensive response will require coordination between the Forest Service and Ecology, which has cleanup authority on the private land under MTCA.	**Yes**
(6) Other situations or factors that may pose threats to public health or welfare of the United States or the environment.	There are numerous physical hazards associated with the Site – open mine workings, steep waste rock dumps, and the ruins of mining and processing facilities – that pose a risk to workers conducting the cleanup, as well as recreationalists who visit/explore these features.	**Yes**

5.2 Scope of the Removal Action

The scope of the Removal Action is to minimize or eliminate human and ecological exposure to identified hazardous substances and to reduce risk to humans posed by physical hazards at the 14 mining- and

processing-related features on the Site. The proposed Removal Action should begin to reduce hazardous substance loading to lower Glacier Creek, lower Seventysix Creek, South Fork Sauk River, and MCL, but a response to contamination already in these surface waters is beyond the scope of this Removal Action. Additional investigation is needed to delineate the human health and ecological risks posed by these hazardous substances before sound Response Action alternatives can be developed and considered.

5.3 Removal Action Schedule

Depending on the preferred alternative, the Removal Action could vary greatly (minimum of three years) to implement, not including the post monitoring of the Removal Action. The time period includes allotment for assessing data gaps, design and review of the recommended Removal Action, public comment, preparation of bid documents, completion of the Removal Action, and completion of the final Removal Action Report.

A conceptual Removal Action sequence and schedule for the MCMA is presented in Section 8 (Recommended Removal Action Alternative - Conclusion and Cost). A specific schedule will be finalized once final agreement is reached on the preferred alternative.

6.0 IDENTIFICATION AND ANALYSIS OF REMOVAL ACTION ALTERNATIVES

This section describes the selection of a Removal Action using a four-step process:

- Identify technologies and processes potentially applicable to the Site;
- Screen technologies and processes to eliminate ineffective or unfeasible technologies;
- Develop Removal Action alternatives using combinations of technologies that pass the screening process; and
- Evaluate the alternatives according to criteria described in Section 6.2.

6.1 Identification and Screening of Removal Action Options and Alternatives

The purpose of identifying and screening technology types and processes is to eliminate those technologies and process options that are unfeasible and/or do not meet potential key ARARs. General Removal Actions are refined into technology types and process options. This removal considers options for addressing impacted soils/wastes and water treatment.

The technology and process options are screened for Removal Action on impacted soil/waste material at the Site. Although many treatment technologies and process options have been evaluated for mine/mill waste, most of these are not considered feasible. These technologies involve a variety of techniques related to physical/chemical processes. At present, most of these technologies would require extensive treatability studies, are not applicable to the Site, require unavailable infrastructure (power, access), or incur excessive costs to benefit received, and thus are not considered appropriate. Therefore, the screening process has evaluated a limited number of treatment technologies. Technologies and processes considered for impacted soils and solid wastes include the following:

- Access Restrictions
- Engineering Controls
  - Source Containment/Control
  - Surface Controls
- Land Disposal
- Treatment

Table 10 summarizes the results of the screening process for developing Removal Action alternatives for impacted soils/wastes.

Available technology and process types for treatment of drainage water from the subject mines described below were also screened. Adit drainage or seepage from six mines infiltrates into surrounding talus/soil material.

- Pride of the Mountains Mine
- New Discovery Mine
- Mystery Mine
- Justice Mine
- Rainy Mine
- Boston-American Mine

Adit drainage or seepage from two mines flows directly to surface water.

- Pride of the Woods Mine waste pile
- Sidney Mine

Technologies and processes considered for impacted waters include the following:

- Engineering Controls
  - Source Containment/Control
- Treatment
  - Passive
  - Active

Table 10 summarizes the results of the screening process for developing Removal Action alternatives for impacted waters.

The remote and rugged physical characteristics of the Site and sensitive resource values present limits to the available technologies and processes for addressing impacted waters. The use of active treatment systems requiring unavailable infrastructure (power/access) and extensive operations and maintenance, especially for locations within Wilderness are not feasible. Construction within the area is difficult; there is limited space for treatment structures at most features; construction and maintenance of complex systems in the Wilderness area is problematic. Settlement basins are difficult to construct and maintain at rugged, isolated locations and are inconsistent with a Wilderness setting. Similarly the sealing of mine adits to control water flow was screened out due to the access constraints, the poor physical condition of the underground workings, the uncertain likelihood of success, and the costs and hazards associated with entering, reconditioning and plugging the mines.

CES concluded that the most applicable treatment system is passive in nature requiring no power and no moving parts. The simplest approach is the diversion of drainage mine water away from wastes and waste rock for infiltration into native soils. Adequate treatment relies on the geochemistry of the mine water infiltrated and the physical and chemical properties of the soil (e.g., cation exchange capacity, infiltration capacity, soil thickness, etc.). Another passive system which may be applicable to the Site uses polyacrylamide logs (FlocLogs) containing a pH modifier and a chelating agent to attenuate dissolved metals. Adit water dissolves the logs to add reagents to the treatment system. It is expected that hydrated iron oxides and other insoluble metallic compounds will precipitate, collecting in the soil/talus material. This technology can be easily combined with the diversion/infiltration approach. Additional testing/studies will be required to customize the FlocLog composition at each locality and to determine the log volume necessary to achieve a 12-month useful life.

Other passive treatment systems may also be considered in place of or in addition to the diversion and infiltration system or FlocLog passive treatment and infiltration systems described above, including addition of calcium carbonate to neutralize acidity and other alternatives under consideration by the Bureau of Land Management (BLM; Ford, 2003). In addition, a promising new hazardous substance (primarily arsenic) treatment technology called Nano-Composite Arsenic Sorbent (N-CAS) was recently developed by the Idaho National Laboratory. This technology can remove arsenic and metals from water to very low concentrations. Much more information is needed on the product with respect to operation and maintenance, costs, long-term effectiveness, and operation in remote settings; therefore, it was not further considered for this EECA. Site impacts will be similar for any of the potential passive water treatment systems. Therefore, CES proposes that these technologies be evaluated and a specific selection made in the removal design.

Conceptual removal alternatives were developed from the technologies that passed the screening process. Fourteen significant mine workings and related facilities have been identified as likely significant contributors to elevated human health risk and environmental risk at the Site (Table 1). These features were examined in detail, and individual Removal Action alternatives developed for each. The features fall into two distinct access categories: 1) Near features with potential road access, and 2) Remote features in extremely rugged terrain. Access to the Remote features is further complicated by the location of five mines within the HMJ Wilderness Area. The use of helicopters will be necessary to safely access these Remote features for the purposes transporting heavy equipment, supplies, and contaminated wastes to and/or from the mines without constructing difficult and obtrusive roads into these sensitive areas. The loading of hundreds of tons of contaminated wastes using hand tools or very light equipment and its transport down steep mountain trails is neither safe or practical using foot or pack animal access. Key design features are estimates only and provided for comparison purposes. The material quantities and flow rates provided in this section are estimates only and should be more accurately quantified during the final design and Removal Action. Using the retained process options, the following alternatives have been developed for detailed analysis:

Mine Waste (MW) Alternatives

- Alternative 1: No Action
- Alternative 2: Institutional Controls
- Alternative 3: Mine Waste Cover
- Alternative 4: Removal and Disposal in MCMA Repository
- Alternative 5: Removal and Off-Site Disposal

Adit/Seep Water (AW) Alternatives

- Alternative 1: No Action
- Alternative 2: Diversion and Infiltration
- Alternative 3: Passive Treatment and Infiltration

Site Access

Long-term road access to the MCMA is necessary to implement any of the Removal Action alternatives, to carry out extended monitoring, operations and maintenance related to the removal and to conduct future removal/remedial investigations and actions. The existing road alignment is unsafe due to the unstable geologic formations along the alignment and would require significant rebuilding, repair, and stabilization. In addition, the SFSR crossing is washed out and would require redesign and reconstruction of the bridge structure and abutments/approaches. Given the current damage to the existing MCMA access road alignment and well-known historical problems associated with maintaining the road, all action alternatives include realignment and some new road construction. The proposed new alignment would bypass the entire section along the west flank from Barlow Summit to and including the washed out bridges near Twin Bridges Campsites (Plate 3) by beginning near Mowich Camp on the Mountain Loop Road and continuing about 2

miles in a southerly direction on the east side of and approximately parallel the SFSR to the Weden Station area. Plate 3 illustrates a conceptual-only representation of the proposed road. The actual route would depend on several factors including engineering and geological conditions, ecological and environmental considerations, protection of historical features, and Forest Service Guidelines. The road southeast of Weden Station would follow the existing trail to the MCMA. This new route would provide for greater safety and long-term reliability, avoid the SFSR crossing between SFSR-4 and SFSR-5, reduce the potential sedimentation to the SFSR and tributaries, better meets the Forest Plan Riparian Standards and Guidelines, and reduce costs (i.e., the new road is estimated to be ¾ the cost of repairing the existing road and would result in lower maintenance costs as well).

Depending on the alternative that is selected, the type of road will vary. For MW Alternatives 2, 3, and 4, a Forest Service Maintenance Level 2 road would be required. MW Alternative 5 would require a Forest Service Maintenance Level 3 road, because of the heavy truck traffic in and out of the MCMA, as well as added environmental safety such as decreasing siltation and minimizing spill potential. Additional details regarding the construction of the access road are described in the alternatives below.

6.1.1 Mine Waste Alternatives

This section provides a summary of the general MW alternatives considered for the Site. Due to the numerous features with varying characteristics and access, CES elected to provide general approaches and scopes of the alternatives, not detailed specifics on each alternative for each mine/facility. CES does not suggest that one alternative be selected for the entire MCMA, but rather alternatives at each feature can be mixed as appropriate to achieve the RAOs.

MW Alternative 1 - No Action

No Removal Action would be completed to control hazardous substance migration or reduce the toxicity or volume. This alternative is used as baseline against which other removal options can be compared as suggested by the NCP.

Removal Action Elements Common to MW Alternatives 2, 3, 4, and 5

Certain work elements, such as addressing best management practices (BMPs), should be implemented regardless of the action alternative selected.

Best Management Practices

During Removal Action activities, BMPs will be used to minimize and control erosion and the sedimentation of surface waters surrounding the Site. These may include the use of silt fences, straw bales, run-on and run-off diversion ditches lined with “rip-rap (up to 500 bcy), fugitive dust control, etc. Stream crossings will be designed to minimize to the extent practical, sedimentation and impacts to aquatic species. In addition, special care will be taken to avoid the introduction of noxious weeds during the Removal Action. Specifically the contractor will work with the Forest Service to use approved borrow sources when available, all straw/hay used (i.e., for mulch and silt fence) will be certified “weed free,” and all off-road equipment will be washed and inspected prior to entering and leaving the Site. Other resource protection BMPs may be identified in the Removal Design.

Road Maintenance and Decommissioning

CES has assumed that at such time that there are no longer needed for the purposes of Site cleanup/operations/maintenance, the access road constructed and used for Alternative 3, 4, and 5 will be decommissioned to the original or existing condition, unless otherwise determined by the local Forest Service manager. All structures subject to severe erosion damage such as culverts and bridges will be removed and the approaches excavated to match stream banks. Road shoulders would be scarified to a width of eight feet to expedite volunteer re-vegetation by native species.

Preservation of Historically Significant Areas

Three locations are expected to be considered Historically Significant by State Historic Preservation Office criteria. CES proposes the following preservation procedures at each feature.

- Collector and Concentrator
  - If Alternative 3 is applied, impacted material will be graded and a coir mat or cover soil will be placed in a manner that preserves and exposes the existing wooden structure to the most practical extent. Burned debris will be covered or removed; metal artifacts will be saved and possibly stored.
  - If Alternative 4 or 5 are used, contaminated soil and waste will be carefully removed to preserve wooden structures as much a practical. Some of the waste may be replaced with clean soil or gravel to support the structures as necessary and mimic the original appearance.
- Assay Shack
  - If Alternative 3 is applied, no preservation will occur, and all artifacts will remain in place and buried.
  - If Alternative 4 or 5 are used, impacted material will be carefully removed, examined, and important artifacts recorded by a qualified archeologist.

Restrict or Close the Area to Fishing

Due to the elevated concentrations of hazardous substances in the surface water and stream sediment in MCL, the SFSR, Glacier Creek, and Seventysix Creek, it is recommended that the area above MCL either be: 1) closed to fishing, 2) catch and release only, or 3) warning signs erected to educate the public of the risk posed to consumption of fish. It is anticipated that this would initially be a temporary measure; additional information on the concentration of hazardous substances in the aquatic media, including fish tissue, needs to be further evaluated as part of the data gap assessment.

Physical Hazards

Because physical hazards identified at features in the MCMA represent an immediate and significant potential hazard to the public and workers, CES is including selected physical hazard reduction measures in all action alternatives. Physical hazards may be mitigated through institutional controls such as fencing, gating and/or signage which limit public access, or by removal of the hazard (e.g., plugging with foam or filling the openings). While eliminating the hazard is preferable, it may not be feasible or economical at most features. Physical hazard mitigation technologies applicable to the MCMA were identified based on a review of applicable technical literature and previous experience at similar mines. Regardless of the Removal Action alternative selected, the following mine access closures and other mitigation measures would be undertaken at the features described below. In order to limit public access while maintaining potential bat habitat, bat gates or culverts would be installed at all adits and shafts, where feasible. The conceptual design for proposed bat gates is illustrated in Figure 15; the conceptual design for a bat culvert is also illustrated in Figure 15 (MSE, 2008). In the event that water diversion and treatment alternatives are implemented at mines that flow water, modifications and improvements made at the portals would be coordinated with implementation of mine closures. Bat gates would include removable bars to allow access for periodic monitoring or maintenance of water impoundments and diversions.

Debris from ruins at many of the mine workings, particularly the Pride of the Mountains, New Discovery, Mystery, Golden Cord, and Justice Mines, and at the Ore Collector and Concentrator should be removed as part of any of the selected alternatives.

- **Pride of the Mountains**: The hazards presented by two partially-caved adits and a largely-caved inclined shaft at this mine (Figure 1) would be mitigated by application of bat closures. The Main

Adit that flow water would be opened and stabilized, and a standard bat gate would be constructed inside the portal. Two 24- to 36-inch-diameter by 10-foot-long bat culverts would be installed at Adit 2 and the inclined shaft. The adit opening would be widened as needed, the culvert would be placed about 6 feet into the working, and rocks and/or Polyurethane Foam would be placed around the exposed end of the culvert to fill the opening. Approximately 900 feet of chain-link or 4-strand barbed wire fencing and selective warning signage (one every 100 feet) would be placed around the entire feature if the waste rock dump if Alternative 2 is selected. Otherwise, selected local signage would be utilized to warn the public about the feature.

- **New Discovery Mine**: Access to three adits open at this mine (Figure 2) would be closed by installation of standard bat gates. Implementation should include consideration of mine water treatment at the Southeast Adit. Approximately 640 feet of chain-link or 4-strand barbed wire fencing and selective warning signage (one every 100 feet) would be placed around the entire feature if the Northwest and Southeast Adit dumps if Alternative 2 is selected. Otherwise, selected local signage would be utilized to warn public about the feature.
- **Pride of the Woods**: The largely collapsed adit portal (Figure 3), which is covered with boulders, would be left as is or opened sufficiently to install a standard bat gate or bat culvert. If it is determined that water flows from the portal, a bat gate would be installed; whereas, a bat culvert would be installed if no water is observed. Approximately 470 feet of chain-link or 4-strand barbed wire fencing and selective warning signage (one every 100 feet) would be placed around the entire feature if Alternative 2 is selected. Otherwise, selected local signage would be utilized to warn the public about the mine.
- **Mystery Mine**: The portal of Adit # 3 would be stabilized and a standard bat gat would be constructed inside the portal (Figure 4). The large stope that is open to the surface presents a particularly dangerous hazard that would be difficult to gate and unfeasible to backfill; therefore, a cable-net system or a 312-foot-long, high-strength fence would be constructed to encircle the entire 120-foot-long by 6-foot-wide stope. A 1,100-foot-long, chain-link or 4-strand barbed wire fence and selective warning signage (one every 100 feet) would be required to enclose the entire mine area if Alternative 2 is fully selected. Otherwise, selected local signage would be utilized to warn the public about the hazards.
- **Golden Cord Mine**: Although there are no open workings at this mine (Figure 5); the coarse, unstable waste rock dump, the loose talus on the steep route to the location, and the ruins of an aerial tramway station present multiple physical hazards to the public. An 840-foot-long, chain-link or 4-strand barbed wire fence and selective warning signage (one every 100 feet) would be required to enclose the entire mine area if Alternative 2 is selected. Otherwise, selected local signage would be utilized to warn the public about the mine.
- **Justice Mine**: Access to the open adit at this mine (Figure 6) would be closed by installation of a standard bat gate. Implementation should include consideration of the diversion and treatment of water that flows from the adit. Coarse, unstable mine waste rock, loose talus on the steep route to the location, and the ruins of an aerial tramway station also present multiple hazards to the public. Approximately 1,500 feet of chain-link or 4-strand barbed wire fencing and selective warning signage (one every 100 feet) would be required to secure the entire mine area if Alternative 2 is selected. Otherwise, selected local signage would be utilized to warn the public about the hazards.
- **Rainy Mine**: The open cut leading to the portal of the partly-caved adit with impounded water would be carefully excavated to expose the covered shaft that is reported to be at this mine (Figure 7). Assuming that the shaft can be exposed and remains open, a bat culvert would be constructed in the shaft collar. The presence of water in the adit and open cut indicates potential need for water diversion and treatment which would be best accomplished with a standard bat gate that would allow passage into the workings. The unstable condition of the adit portal, however, may preclude installation of a bat gate; therefore, consideration would be given to installation of a bat culvert that would allow diversion of mine water. Approximately 320 feet of chain-link or 4-strand barbed wire

fencing and selective warning signage (one every 100 feet) would be required to secure the entire mine area if Alterative 2 is selected. Otherwise, selected local signage would be utilized to warn the public about the hazards.

- **Ore Collector, Concentrator and Tailings, and Assay Shack**: Should the ruins at these facilities (Figures 8, 9, 10, and 11) be left undisturbed, public access would be restricted by limiting exposure to the foundations and piles of collapsed wooden structures with associated rusty nails and machinery, broken glass, and related debris. This could be accomplished by possible construction of chain-link or 4-strand barbed wire fencing and placement of selective warning signage (one every 100 feet) around each feature: Ore Collector, 500 feet; Concentrator and Tailings, 1,100 feet; and Assay Shack, 200 feet.
- **Sheridan Mine**: Access to the open adit at this mine (Figure 13) would be closed by installation of a standard bat gate. A 500-foot-long, chain-link or 4-strand barbed wire fence and selective warning signage (one every 100 feet) would be required to enclose the entire feature if Alternative 2 is selected. Otherwise, selected local signage would be utilized to warn the public about the hazards.
- **Sidney Mine**: Access to the open adit at this mine (Figure 14) would be closed by installation of a standard bat gate. Any work at this location is complicated because the adit portal is at stream level at the base of a very steep mountainside. Furthermore, the adit portal, damaged by debris from a recent avalanche, must be stabilized. Implementation should include consideration of possible diversion and treatment of water that flows from the adit. A 260-foot-long, chain-link or 4-strand barbed wire fence and selective warning signage (one every 100 feet) would be required to enclose the entire mine area if Alternative 2 is selected. Otherwise, selected local signage would be utilized to warn the public about the mine.

Operations, Monitoring, and Maintenance

CES assumes that implementation of the Removal Action will require coordination of simultaneous operations at multiple mine and facility locations during implementation of the Removal Action. In addition, most, if not all, mines and facilities on which Removal Actions are conducted will require periodic monitoring and maintenance. Irrespective of the Removal Action alternative selected, monitoring (including surface water and mine drainage sampling and analysis), as well as that for additional Removal or Remedial Action investigations will continue in the extended term.

MW Alternative 2 - Institutional Controls

This alternative includes installing safety closures such as bat gates and cupolas, fencing, and signage (as outlined above), plus deed restrictions on private land and land status record notations on National Forest System land. This will incur relatively minor costs and will reduce human exposure and risk. However, it will provide limited to no reduction in risk to the ecological receptors. CES assumes little or no road improvement will be necessary. However, a helicopter must be used to transport supplies and materials to all locations.

MW Alternative 3 – Mine Waste Covering In Place

This alternative incorporates covering of metal-impacted materials at each mine or facility. Clean soil and/or rock was considered, but eliminated as possible cover for impacted mine waste because: 1) such a cover would likely not remain in place at most mines because of steep waste rock slopes and the indurate character of the waste rock surface; 2) an excessive volume of clean cover material needed to provide a cover of adequate thickness; and 3) the high cost of helicopter transport and placement. Therefore, under this alternative, CES proposes to install coir mats at these locations, at the Remote features. Similarly, the Collector is also too steep for soil cover, and CES recommends use of coir mats for cover at this location. The remaining Near features can be closed in place using soil cover or coir mats. Because of the lack of suitable soil in the area, CES also recommends use of coir mats for closure in place at these Near features. This alternative will reduce the human health risk by significantly reducing direct contact and fugitive dust. It

may also reduce ecological risk by reducing erosion to streams and limiting contact with fauna. This alternative will affect esthetics by covering the highly visible iron-stained waste rock with a mono-textured and earth-colored mat. However, this alternative will do little to control leaching and infiltration. In addition, as part of this alternative, physical hazard mitigation will also be incorporated. However, select fencing around the waste rock and tailings will not be necessary.

For this alternative to be implemented, an access road will be required for equipment and supply. Due to significant improvements and safety issues associated with the existing access road, CES proposed that a new access road be constructed along the northeast side of the SFSR, generally parallel to the old wagon road. The route shown on Plate 3 is conceptual only and does not imply that a specific route is recommended. The proposed road would be constructed to the requirements of a Forest Service Maintenance Level 2 road with a combination of natural grades and culverts across minor drainage/stream crossings and possibly bridges at larger stream crossings. Two temporary bridges or temporary crossings may be required near the Concentrator and Rainy Mine. Also, the existing trail/road system around the Near features would be improved for equipment access. The existing Townsite area helipad, roadways, cleared areas and campgrounds would be used as removal staging, storage and camp areas.

Road planning and construction will proceed as follows:

1. Coordinate route and road specification planning with Forest Service and Snohomish County staff as needed to determine a viable route. Considerations need to include known areas of landslides, debris avalanches and flooding, engineering and geology, ecological and historical values, short- and long-term road/trail uses, and other concerns of the Forest Service and the State.
2. Select, flag and survey the selected route (Plate 3, conceptual only), possibly paralleling the old wagon road as closely as feasible;
3. Clear and grub the route;
4. Grade the route as needed using cut and fill techniques;
5. Install up to eight culvert stream crossings with up to twin 48-inch culverts;
6. Extend the route past the campground to a point across from the Concentrator;
7. Install a temporary ford or bridge across SFSR to the Concentrator area;
8. Construct temporary Forest Service Maintenance Level 2 road quality access to the Near features;
9. Construct access to the Rainy Mine by extending the road from the Collector, including a temporary bridge or remaining on the north side of Glacier Creek if an appropriate route can be found.

The general closure sequence and approach for the Remote features is as follows:

1. Mobilize a 15-ton excavator, 25-ton dozer, and heavy-lift helicopter to the staging area. Consideration should be given to using a spider hoe. A CH-47 Chinook will be the most cost-effective heavy-lift helicopter.
2. Using light helicopter, transport crew, and general hand tools to the mine to setup a landing area and to clear and grub the waste rock dump.
3. Using the heavy-lift helicopter, sling excavator, and dozer to an initial Remote Feature.
   - Equipment must be slung in pieces and reconstructed at or near the mine.
   - To prevent multiple helicopter ferry costs, work as many Remote features simultaneously as viable; four is recommended. This will fully utilize the helicopter without paying standby time.
4. Sling all coir mats and other supplies to the feature with the heavy-lift helicopter.
5. Using the dozer as an anchor and winch, lower the excavator down the waste rock dumps, excavating a horizontal trench every 100 feet.
6. Starting at the bottom, install coir mats on the waste rock with 10 % overlap, anchoring the top in the trenches with pins and backfilling.

7. Weave all overlaps together and place a steel pin in every square yard of mat.
8. Round the top of the waste rock dump and install/anchor the last coir mats.
9. Dismantle and sling the excavator and dozer to the next feature.
10. Cover the coir mats with seed, a weed-free wood mulch, and fertilizer. The wood mulch could provide an eventual organic base from which vegetation may reproduce or volunteer; however, the chemical character of the waste rock and lack of soil make this unlikely.
11. These waste rock dumps should be periodically monitored to assure that the coir mats and cover materials remain in place. Coir mats may need to be replaced after 10 years; costs for replacement have been included.

In a similar fashion, the Near features can be covered using either coir mats or soil. The Collector will require coir mats, because of the steepness. An adequate supply of soil is probably not present at MCMA, and must be imported from off-Site; therefore, Alternative 3 costs are based on coir mats. Other Near features will require clearing and grubbing prior to coir mat installation or soil cover. These features can be completed simultaneously with the Remote features to lower costs. Helicopters will not be necessary, because track or rubber tire equipment can access the Near features.

MW Alternative 4 - Removal and Disposal in MCMA Repository

Under this alternative, all waste rock, tailings and ore material that exceed the proposed arsenic cleanup concentration of 236 mg/kg arsenic (Near features) and 659 mg/kg (Remote features) will be excavated and consolidated in a centralized repository. The maximum volume of material to be removed and consolidated is estimated at 80,000 bcy, which includes all 14 mines and facilities. The actual volume removed and stored in the repository will depend on which features are ultimately included in this alternative.

Finding a suitable location for a repository, particularly in a rugged area like the MCMA, can be problematic. The BLM developed criteria for repository site selection, design, and costs (Ford and Walker, 2003). Criteria used to evaluate potential repository locations include:

- locate on land administered by the managing agency (Forest Service in the MCMA);
- locate out of wetlands and the 100-year floodplain;
- away from shallow groundwater;
- in area of generally flat topography;
- within a reasonable haul distance;
- in area where soil borrow material is available;
- away from cultural features;
- away from threatened and endangered species habitat; and
- away from geological hazards.

CES conducted a first-order field search of Forest Service-administered lands for potentially-suitable locations that exhibit a gentle slope, would be accessible from and within a reasonable haul distance of the Townsite, and would be of sufficient area to accommodate a repository covering up to 5 acres. Three candidate repository locations were found (Plate 3): REP-1, the Assay Shack-School location near the Townsite; REP-2, the Trailside location on the Glacier Creek Trail between the Collector and the Concentrator; and REP-3, the Mystery Basin location below Mystery Mine and also near the Glacier Creek Trail. Ownership of the REP-1 and REP-3 localities is mixed Forest Service and private, and REP-2 appears to be on Forest Service-administered land. REP-3 was deemed unsuitable because it lies in coarse talus near the toe of an avalanche chute. REP-2 is on more favorable terrain; however, the available area is small (less than 5 acres) and it lies directly on the Glacier Creek Trail. CES identified the REP-1 candidate repository near the Assay Shack (Plate 3) as the most suitable location because it is readily accessible by road yet away

from the main Glacier Creek Trail, it is of adequate size, the terrain is favorable for containment, and there are no known geological hazards. Ownership of the REP-1 location must be verified by survey. If private land is located in the preferred repository location, the Forest Service would develop a plan to address ownership issues, etc.

This alternative will require extensive use of a heavy-lift helicopter with support from a light helicopter to sling all waste material from the Remote features. Conventional articulated trucks and an excavator will be used at Near features. This alternative is considered protective of human and ecological receptors because all waste rock, tailings, and ore greater than the proposed cleanup concentrations would be consolidated and isolated.

For this alternative to be implemented a Forest Service Maintenance Level 2 road will be required for equipment and supply; this road would be the same as outlined under Alternative 3. Additionally, at least 400 trees (western hemlock, western red cedar, and silver fir) must be removed from the repository locality. Although the repository size could be up to 3 acres, the area to be cleared may cover as much as 4 to 5 acres. Salvageable timber could be recovered and sold or used locally, whereas unsalvageable trees and the remainder of vegetation would be shredded and applied to the repository cap.

CES initially considered two different repository designs: 1) an unlined impoundment with a cap composed of 100-mil friction surface high density polyethylene overlain by 6 inches of capillary break material that would free-drain during cover saturation; and 2) a far more conservative lined repository with multiple membrane bedding layers in the liner and cap, and a thicker soil cover. Although the waste material to be removed from the mines and facilities is not expected to be considered a Dangerous Waste, with the exception of an estimated 100 bcy of concentrates determined during the SI that exceeded TCLP limits, a combination of factors support a conservative approach.

Based on general repository siting and design criteria developed by the BLM (Ford and Walker, 2003) for non-arid conditions (greater than 12 inches/year precipitation), a potentially shallow water table, and potential acid-generating or leachable mine wastes, several design criteria should be considered. To preclude infiltration or rain and/or snow melt water, the repository cover should include a capillary barrier (gravel) in combination with soil cover, and an impermeable liner. A bottom impermeable liner should be considered where there is potential shallow ground water (less than 15 feet), and a lime amendment should also be considered for leachable tailings. The groundwater level below the recommended repository location (REP-1) is not known; however, the high annual precipitation and voluminous snow melt characteristic of the MCMA Site suggest that a conservative repository design be adopted in order to provide encapsulation. Figure 15 provides a conceptual layout and profile of the proposed repository at the REP-1 location.

The repository would be constructed in the following sequence following road construction:

1. Clear and grub REP-1, a relatively flat forested area east and south of the Assay Shack;
2. Grade the area and stockpile material usable as cover soil;
3. Track compact the base;
4. Apply 0.2 yd of –¾ in rounded bedding rock;
5. Install 60-mil Gundle HyperFrictionFlex or similar liner;
6. Apply 0.2 yd of –¾ in rounded bedding rock;
7. Install Gundle 12 oz nonwoven geotextile fabric or similar material;
8. Construct appropriate run-on/run-off diversions and control;
9. Construct access improvements and turnaround;
10. Clear helicopter off-loading approaches;
11. Transport and place waste from identified sources;

12. Blended CaO at 0.16 lbs/bcy waste for acid neutralization, and compact material after blending;
13. Grade final repository for positive drainage with track compaction;
14. Apply 0.2 yd of –¾ in rounded bedding rock;
15. Install 60-mil Gundle HyperFrictionFlex or similar liner;
16. Apply 0.2 yd of –¾ in rounded bedding rock;
17. Install Gundle 12 oz nonwoven geotextile fabric or similar material;
18. Apply 0.2 yd washed -3/8" capillary break;
19. Install Gundle 12 oz nonwoven geotextile fabric or similar material;
20. Apply 0.35 yd of soil, some of which will require importing from off-Site;
21. Cover with 0.2 yd stockpiled topsoil, additional material will require importing from off-Site; and
22. Revegetate with seed, a weed-free wood straw, and fertilizer.
23. Demobilization

The volume of cover soil and topsoil needed will vary greatly depending on which mines and facilities are selected, for 80,000 cy of waste rock (3.1 acre repository) approximately 5,000 cy of cover soil and 2,500 cy of topsoil would be required; for 25,000 cy of waste rock (1.5 acre repository) approximately 2,400 cy of cover soil and 1,200 cy of top soil would be required. Diversion ditches lined with rip-rap will be placed along the upslope side of the repository to redirect runoff water. It is assumed that suitable rip-rap material can be found on the MCMA Site, the volume of rip-rap needed will vary greatly depending on the size of the repository and will be determined during the design of the Removal Action. Three monitoring wells are also proposed, one upgradient and two downgradient to monitor groundwater around the repository. The repository cap would be covered with a weed-free wood mulch, seed, and fertilizer. Inspection and physical or chemical control of volunteer tree growth will be performed on an annual basis to maintain the integrity of the cap.

Because this alternative removes all waste rock, it may be necessary to install institutional controls and part of the adit/seep water treatment system (discussed below) prior to material removal. Without doing so at many mines there would be no dump staging area from which to work. A small staging area must be left at mines that require maintenance such as pipe cleaning.

The general sequence and approach for the Remote features is as follows:

1. Mobilize a 15-ton excavator (a spider hoe may also be suitable) and heavy-lift helicopter to the staging area.
2. Using light helicopter, transport crew, and general hand tools to the mine to setup a landing area and to clear and grub the waste rock dump.
3. Using the heavy-lift helicopter, sling excavator to an initial Remote Feature.
   - The excavator must be slung in pieces and reconstructed at or near the mine.
   - To prevent multiple helicopter ferry costs, work as many Remote features simultaneously as viable; four is recommended.
4. Sling all supplies to the location with the light helicopter.
5. Using the excavator begin removing waste rock by dumping the material into a 10-ton capacity sling box for heavy-lift helicopter transport.
6. The helicopter will leave an empty sling box each time it returns to remove a full box.
7. As each lift is removed, a trench for the adit/seep water treatment system line can be extended and pipeline installed.
8. When all material is removed, dismantle and sling the excavator and dozer to the next work location.
9. Seed the disturbed area with seed, a weed-free wood, and fertilizer.

Unlike Alternative 3, slinging waste rock from a Remote feature will fully utilize a heavy-lift helicopter. Only one location at a time can be worked unless additional helicopters are used.

The general sequence and approach for the Near features is as follows:

1. Mobilize a 15-ton excavator and articulated truck to the Near features;
2. Clean and grub as needed;
3. Excavate and transport waste to the repository;
4. Prior to demobilization from each mine, install the treatment system if needed;
5. Revegetate with a weed-free wood mulch, seed, and fertilizer.

More than one Near Feature can be excavated simultaneously. The number selected will depend on the ability of the repository and the road system equipment to keep up with capacity.

MW Alternative 5 - Removal and Off-Site Disposal

Under this alternative, all mine wastes (waste rock, tailings and ore material) that exceed the proposed arsenic cleanup concentrations of 236 mg/kg (Near features) and 659 mg/kg (Remote features) will be excavated and transported to an off-Site repository. The maximum volume of material to be removed is estimated at 80,000 bcy, which includes all mines and facilities; this volume will vary depending on which features are included in this alternative. This alternative will require extensive use of a heavy-lift helicopter with support from a light helicopter to sling all waste from Remote features; conventional articulated trucks and an excavator will be used at Near features. All material will be transported via heavy-lift helicopter or articulated truck to the loadout/staging area near REP-1 for transfer to trucks. Alternatively, sling loads could be taken to the Townsite helipad for loadout, depending on safety considerations. This alternative is considered protective of human and ecological receptors, because all waste rock, tailings, and ore greater than the proposed cleanup concentrations would be removed from the feature and disposed off-Site. Only a fraction of the material to be removed (~100 bcy) is known to exceed the RCRA TCLP limits and is considered a Dangerous Waste. However, due to the nature of the material as mining waste, CES recommends that for this alternative, the material be disposed of in a Subtitle C landfill. The nearest landfill for Subtitle D (non-hazardous) solid wastes is the Waste Management landfill located in Wenatchee; whereas, the nearest facility for Subtitle C (hazardous) solid wastes is the ChemWaste facility located in Arlington, OR. Materials would be trucked to the appropriate facility from the selected loadout area.

For this alternative to be implemented, a semi-permanent road will be required for equipment and supply, because of heavy truck traffic in and out of the MCMA, as well as added environmental safety such as decreasing siltation and minimizing spill potential. As with the road in Alternatives 2 and 3, CES proposes that a new access road be constructed along the northeast side of the SFSR that possibly parallels the old wagon road (Plate 3, conceptual only) because of safety and construction issues with the existing access road. The proposed road would be constructed to the specifications of a Forest Service Maintenance Level 3 road. A bridge or temporary ford would be installed near the Concentrator, and the road may be extended southeast to access the Rainy Mine if a suitable route can be found. Also, the existing trail/road system around the Near features would be greatly improved for equipment access and hauling. The existing Townsite area helipad, roadways, cleared areas and campgrounds would be used as removal staging, storage and camp areas.

6.1.2 Adit/Seep Water Alternatives

This section provides a summary of the general AW alternatives considered for the Site. Due to the numerous discharging mines with varying qualities and access, CES elected to provide general approaches and scopes of the alternatives, not detailed specifics on each alternative for each mine/facility. CES does not suggest that one alternative be selected for the entire MCMA, but rather alternatives can be mixed as

appropriate to achieve the RAOs. Additional research should be done on new and promising water treatment technologies, in addition to performing bench testing with water samples collected from the Site, during removal design (Table 10).

AW Alternative 1 - No Action

No Removal Action would be completed to control the adit/seep water. This alternative is used as baseline against which other removal options can be compared as suggested by the NCP.

AW Alternative 2 - Diversion and Infiltration

This alternative is an enhanced version of natural infiltration that is actively occurring in the area. Water will be captured inside the portal and diverted away from contaminated waste rock into a buried pipeline that transports the water to a rapid infiltration basin (RIB) constructed in undisturbed soils. The RIB can be filled with coarse rock to prevent any exposure and hide it from casual observers. The primary purpose is to control surface flow, eliminate leaching from waste rock and promote infiltration in addition to limiting direct human contact. Some treatment of the filtrated water is expected from soil sorption and related natural processes. Helicopter access will be required at most mines to bring supplies and equipment; construction of new road will not be necessary. Construction cost estimates assume that this work will be done in conjunction with Alternative 3, 4, or 5, and the selected treatment alternative will be added to the selective removal alternative.

AW Alternative 3 - Passive Treatment and Infiltration

This alternative is very similar to Alternative 2, with the addition of an inline system that uses custom manufactured FlocLogs. The primary component of FlocLogs is polyacrylamide to enhance flocculation and settlement. However, a base can be added to neutralize limited acidity, and chelating agents can be added to extract dissolved metals. This system should remove a higher percentage of metals and modify the pH of the water. However, without additional bench testing of each water source, it is not known whether the system will be able to meet ARARs at the respective RIBs. Again, further treatment of the filtrated water is expected from soil sorption and related natural processes. Helicopter access will be required at most locations to bring supplies and equipment; construction of new road will not be necessary. The flocculent logs must be replenished once a year. Construction cost estimates assume that this work will be done in conjunction with Alternative 3, 4, or 5, and the selected treatment alternative will be added to the selective removal alternative.

6.2 Analysis of Selected Removal Action Alternatives

As required by the CERCLA guidance (USEPA, 1993) and the NCP (40 CFR 300.415), Removal Action alternatives retained after the initial evaluation and screening have been evaluated individually against the following three criteria (effectiveness, implementability, and cost) and listed subcriteria) for each of the 14 mines/facilities (Tables 15-28).

- **Effectiveness**
  - Compliance with Removal Action goals and objectives
  - Overall protection of human health and the environment
  - Compliance with potential ARARs
  - Long-term effectiveness and permanence
  - Reduction of toxicity, mobility, or volume through treatment
  - Short-term effectiveness

- **Implementability**
  - Administrative feasibility
  - Technical feasibility
  - Availability of services and materials
  - State and community acceptance
- **Cost**
  - Direct capital costs
  - Indirect capital costs
  - Annual maintenance and inspection costs

Evaluation of costs consists of developing estimates (±30%) based on the description of work items developed for each Removal Action alternative. These costs do not necessarily represent those that may be incurred during construction of the alternative, because many design details are preliminary at this stage. However, a similar set of assumptions is used for all the alternatives, so that the *relative* difference in cost between alternatives can be considered.

6.3 Identification of Data Gaps

CES has identified multiple data gaps based on the information gathered during the SI (2008a) and this EECA. Some of the data gaps are immediately relevant to completing the Removal Design/Action, whereas others are beyond the scope of the Removal Design and are recommended as part of future investigations. The immediately-relevant data gaps are presented first followed by the out-of-scope data gap.

1. Data gaps relevant to Removal Design/Action for current Removal Action alternatives:
   - Mine Waste Delineation: The extent and depth of waste at the Ore Collector, the Concentrator and associated tailings, local ore Haulage Ways, and the Assay Shack require more detailed delineation. CES recommends that additional sampling be completed at these locations with the aid of a small excavator and portable XRF instrument to complete this deficiency. Investigation of these data gaps could be performed as part of a Removal Action. **Cost Estimate = $10,000.**
   - Comet Mine Terminal: The terminal ore bunker of the Comet Mine's aerial tramway reportedly has concentrations of arsenic (as high as 31,200 mg/kg) and other contaminants (Table 6) that are above background and has thus far not been thoroughly investigated (Crofoot and O'Brien, 2004). The ore bunker is located adjacent to the Forest Service Glacier Basin Trail near the Concentrator and is frequently visited by the public. CES recommends that sampling be conducted at this facility as described in and in conjunction with item (1), above. This investigation could be performed as part of a Removal Action. **Cost Estimate = $10,000.**
   - Ownership Survey: Land ownership within the MCMA, particularly in the Townsite and near the Concentrator and Ore Collector, is a complex mix of privately-owned lands and Forest Service-administered public lands. Boundaries should be surveyed and clearly marked so owners can be notified rapidly about potential activity on their properties. **Cost Estimate = $25,000.**
   - Topographic surveys: These have only been completed for the Concentrator, Ore Collector, Assay Shack, and the associated Haulage Ways. CES recommends that detailed topographic surveys be completed at each mine or facility for which a Removal Action is proposed. This data gap could be performed as part of the Removal Design so that detailed plans and profiles can be developed for the removal activities. **Cost Estimate = $40,000** (will vary depending on the selected mines/facilities).

- Mine Water: Additional investigation and research is needed before implementation of water mitigation at the mines. This data gap could be performed during Removal Design.
    - Additional field examinations of mine water treatment localities to design portal capture, water pipeline routes, and RIB locations - limited survey of mines.
    - Water samples are needed for bench testing to determine the most effective treatment approach, and to determine the size needs for the customized FlocLogs, if selected as the preferred alternative. Up to 20 gallons of water may be required for the bench testing, which would require helicopter access into the HMJ Wilderness Area.
    - **Cost Estimate (7 features) = $70,000** (could be lower if fewer features are considered).

- Repository – Mine Wastes: Additional testing (i.e., kinetic), should be considered on selected mine waste material (tailings, concentrates, and waste rock) in order to better quantify the projected long-term behavior - acid generation characteristics and neutralization potential (e.g., addition of lime) - of material planned for placement in MCMA repository. This data gap could be performed as part of the Removal Design. **Cost Estimate = $15,000.**
- Additional Mine Wastes: A small road-side exposure of apparent tailings or concentrates, about 30 feet long by two to three feet thick, was observed by CES field staff at the Weden Station (Plate 1) along the county road between Barlow Pass and the Townsite. Ecology (Crofoot and O'Brien, 2004) noted suspected spillage along the railroad route from the Concentrator to the ASARCO smelters in Everett or Tacoma, Washington. Such materials, especially concentrates, would likely contain high concentrations of the hazardous substances known to be associated with mines in the MCMA. CES recommends that a DGI is warranted along the four-mile-long county road from Barlow Summit to the Townsite. The investigation would include a thorough visual reconnaissance supplemented by portable XRF reconnaissance and limited sampling. This DGI could be performed during the Removal Action, with any contaminated material addressed in a similar manner to already identified contamination. **Cost Estimate = $10,000.**
- Additional Mine Hazards: Two additional locations of concern encountered in the Seventysix Gulch area by CES staff during the EECA-DGI, the Lincoln Mine and the Liberty Prospect, should be investigated during the Removal Action; each is discussed below.
    - Lincoln Mine: Although no open working was found at the Lincoln Mine, located about 800 feet downstream from the Sidney Mine (Plate 1), the waste rock dump is positioned adjacent to and is eroded by Seventysix Creek, similar to that of the Sidney. The waste rock materials also appear to be geologically similar to those at the Sidney Mine. An XRF sample analysis (Crofoot and O'Brien, 2004) that was possibly collected from the waste rock dump at this location showed an arsenic concentration of 17,996 mg/kg.
      Cost Estimate = $10,000.
    - Liberty Prospect: An open adit observed at the Liberty Prospect, located less than 50 feet from the main trail up Seventysix Gulch, constitutes a physical hazard to visitors and should be closed with a bat gate. In that it lies close to a public trail, waste rock at the Liberty Prospect should also be sampled and analyzed to determine if it constitutes a risk to casual recreational visitors and ecological receptors. **Cost Estimate = $10,000.**
- Total estimated cost for the Removal Action relevant data gaps is approximately **$200,000**

2. Data gaps that can be addressed in future investigations:

- SFSR and MCL: The SI (CES, 2008a) noted an unknown volume of tailings had apparently been discharged from the Concentrator to Glacier Creek and that the extent of downstream transport and any attendant contamination should be investigated in more detail. The EECA-DGI has demonstrated that contaminants associated with mining and processing in the MCMA

have indeed been transported down Glacier Creek, Seventysix Creek, and SFSR, particularly into and at least 0.25 mile downstream from MCL. The aquatic sample intervals in the SFSR do not allow detailed delineation of the distribution and volumes of hazardous substances. CES recommends a robust, multidisciplinary, multi-seasonal aquatic sampling program be designed and undertaken in the near future to delineate hazardous substance distribution and extent, determine seasonal dynamics, and assess environmental and ecological impacts and associated risks. The studies should include sampling and analysis of benthic macroinvertebrates and fish tissue to determine the extent of contaminants in the food chain. The geographic extent of the study should include the full reach of the SFSR to and including its confluence with the Sauk River.

- The EECA addresses the 10 mines and 4 processing-related facilities believed to have the greatest potential to cause release of hazardous substances into the environment. However, at least 44 additional mines and prospects are located within the Glacier Creek and Seventysix Gulch drainage basin, with additional features in the greater SFSR drainage basin. Although this study has demonstrated that mining- and processing-related hazardous substances have been transported from the MCMA down the SFSR to and beyond MCL, the overall distribution of hazardous substance contribution (including natural contribution) is unknown. CES recommends that the Forest Service and/or Ecology expand the basin-wide assessment approach in Glacier Creek, Seventysix Gulch, and the SFSR to better understand relative contaminant source contribution. Because of the number of mines and prospects, CES recommends that future work begin with mines very near the major surface water bodies. This type of effort should be expanded as information is gained.

7.0 COMPARATIVE ANALYSIS OF REMOVAL ACTION ALTERNATIVES

The comparative analysis of Removal Action alternatives is described in the following sections for the ten mines and four facilities in the MCMA based on the effectiveness, implementability, and cost criteria outlined in Section 6.2, above. Four action alternatives (MW Alternatives 2-5) are considered for contaminated solid materials (waste rock, tailings, soil, etc.) at each of the ten mines and four processing-related facilities, and two action alternatives (AW Alternatives 2-3) are considered for each of the eight mines with contaminated water (adit drainage and dump seeps). Action alternatives are compared to each other and to the respective No Action alternatives (Alternative 1), see Tables 15-28. Physical hazards were assumed to be equally addressed in all of the action alternatives as discussed in Section 6.1.

For each mine and facility feature, MW Alternative 2 focuses on institutional controls, MW Alternative 3 consists of covering mine wastes in place, and MW Alternatives 4 and 5 include excavation and transport to, respectively, an MCMA central repository and an off-Site repository. Where applicable, AW Alternative 2 proposes diversion of mine water and natural infiltration into native soils, whereas AW Alternative 3 includes a passive treatment system, in addition to diversion and infiltration, to remove selected hazardous substances. At mines with contaminated water flows, both MW and AW alternatives are considered. The RAOs focus on mitigation of contaminant sources in the MCMA; therefore, none of the alternatives address contaminated sediments in SFSR, except to limit contributions of additional contaminated materials from the MCMA Site. As a consequence, none of the Removal Action alternatives would likely meet potential sediment and other aquatic ARARs. These features would require further analysis and possible action.

For the comparative analysis, the five mines that are within the HMJ Wilderness Area are grouped separately, three in Glacier Basin and two in Seventysix Gulch, from the other mines due to the environmental and administrative sensitivities associated with the wilderness designation. Three mines in the Mystery Basin area - Mystery, Golden Cord, and Justice Mines - are also addressed as a group because of their proximity to the HMJ Wilderness Area boundary and similarly difficult terrain. Likewise, the four processing-related facilities are grouped as they are in or near the Townsite, constitute the key historical elements of the

Townsite, and none are known to flow contaminated water. The two remaining mines - Rainy and Boston-American Mines - are treated separately in the comparative analysis. Costing data supporting the comparative analysis of the action alternatives are presented in Table 29.

Cleanup costs by action alternative will vary depending on the number of and which MCMA features are addressed. Table 29 presents costs by feature and alternative. Cost comparisons described in the evaluations below assume the same mix of features are being considered.
Review of EECA Removal Action alternatives by federal (non-Forest Service), and local communities will come primarily after publication of the EECA during the formal comment period. The Forest Service has consulted with potentially affected Native American Tribes. The Forest Service also consulted with Ecology, which reviewed and commented on the draft EECA. A summary document describing cleanup alternatives was also provided to the public and a public meeting held on September 28, 2009. Following the public meeting, the Forest Service received a wide range of comments from the public ranging from no action as the preferred alternative to complete cleanup of the Site. Following the official public comment period, general acceptance from the community, state, and other federal agencies will be summarized in the Action Memorandum.

7.1 Glacier Basin Mines in the HMJ Wilderness Area - Pride of the Mountains, New Discovery, and Pride of the Woods Mines

7.1.1 Effectiveness of MW Alternatives

- MW Alternative 1 – No Action.
  - This is the least effective alternative. It would provide no reduction of toxicity, mobility, or volume, waste rock would continue to pose a risk to public visitors and to ecological receptors, and it would not comply with potential ARARs or achieve the RAOs.
  - Furthermore, the toe of the Pride of the Woods waste rock dump lies at about the level of Glacier Creek making it susceptible to erosion by flood waters.

- MW Alternative 2 – Institutional Controls.
  - This alternative has low effectiveness as it would provide no reduction of toxicity, mobility, or volume. Despite signage, waste rock would continue to pose a risk to public visitors and to ecological receptors.
  - It would not comply with potential chemical-specific ARARs and proposed cleanup goals (Table 14), or achieve the RAOs.
  - Waste rock at the Pride of the Woods Mine would continue to be susceptible to erosion by Glacier Creek.
  - Negative short-term impact on the HMJ Wilderness Area is less with this alternative than MW Alternatives 3, 4, and 5.

- MW Alternative 3 – Mine Waste Cover.
  - This alternative is more effective than MW Alternatives 1 and 2 by isolating exposure to human receptors, but there would be little or no reduction in exposure to ecological receptors.
  - It would not comply with all potential chemical-specific ARARs, but does achieve the RAOs.
  - Proximity of Pride of the Woods Mine to stream reduces potential effectiveness of this alternative.
  - Higher negative short-term impact on the HMJ Wilderness Area than MW Alternative 2; however, long-term effects would be more beneficial than MW Alternative 2.

- MW Alternative 4 – Removal and Disposal in MCMA Repository.
  - This alternative provides higher effectiveness than MW Alternatives 2 and 3 by removing hazardous substances from the mines and disposal in a controlled facility in the MCMA.
  - It provides greater reduction of the mobility of hazardous substances and more effective protection for human health, ecological receptors, and the environment than MW Alternatives 2

and 3 (due to removal and consolidation of mine waste in a repository), but it is less effective than MW Alternative 5.
    - It provides the most effective compliance with chemical-specific potential ARARs and the proposed cleanup goals (Table 14) as compared with MW Alternatives 2 and 3, and similar to MW Alternative 5. RAOs are achieved.
    - This alternative will have a higher negative short-term impact on the HMJ Wilderness Area than MW Alternatives 2 and 3 and is similar to MW Alternative 5 in its impact (due to the closure of the wilderness area, use of helicopters, and increased activity); however, the long-term effects would be more beneficial than MW Alternatives 2 and 3, and similar to MW Alternative 5.

- MW Alternative 5 – Removal and Off-Site Disposal.
    - This alternative provides the most effective reduction of the mobility of hazardous substances and thus the most effective protection to human health, ecological receptors and the environment compared with the other alternatives by removing hazardous substances from the mines and MCMA to an off-Site disposal facility.
    - It provides the most effective compliance with chemical-specific potential ARARs and the proposed cleanup goals (Table 14) as compared with MW Alternatives 2 and 3, and similar to MW Alternative 4. RAOs are achieved.
    - It would have a higher negative short-term impact on the HMJ Wilderness Area than MW Alternative 2 and 3 and is similar to MW Alternative 4; however, the long-term effects would be more beneficial than MW Alternatives 2 and 3, and similar to MW Alternative 4.

7.1.2 Implementability of MW Alternatives

- MW Alternative 1 – No Action.
    - This alternative is the most technically feasible and is easiest to implement.

- MW Alternative 2 – Institutional Controls.
    - This alternative is technically and administratively feasible and easy to implement compared to MW Alternatives 3, 4, and 5.

- MW Alternative 3 – Mine Waste Cover.
    - This alternative is technically very difficult to implement due to steep terrain, remote location, avalanche hazard, and limited availability of cover soil material.
    - Administrative feasibility is more difficult to implement than MW Alternatives 1 and 2, but it is similar to MW Alternatives 4 and 5.

- MW Alternative 4 – Removal and Disposal in MCMA Repository.
    - MW Alternatives 4 and 5 are technically and administratively feasible, but are the most difficult to implement due to operating equipment on steep terrain and in remote locations and utilization of a heavy-lift helicopter.
    - Necessary removal equipment is less available than for MW Alternatives 2 and 3 (e.g., heavy-lift helicopter), but more available than MW Alternative 5 (e.g., off-Site transport).

- MW Alternative 5 – Removal and Off-Site Disposal.
    - MW Alternatives 4 and 5 are technically and administratively feasible but the most difficult to implement due to operating equipment on steep terrain and in remote locations and utilization of a heavy-lift helicopter.
    - Necessary equipment and supplies are least available for this alternative because of the distant location of the disposal facility.

7.1.3 Cost of MW Alternatives

- MW Alternative 1 – No Action.
  - No cost alternative.
- MW Alternative 2 – Institutional Controls.
  - Total cost is lower than other action alternatives (Table 29).
  - Higher O&M costs than MW Alternatives 4 and 5, but less than MW Alternative 3. Higher O&M related to ongoing annual monitoring of the mine waste and surrounding aquatic resources.
- MW Alternative 3 – Mine Waste Cover.
  - Total cost higher than MW Alternative 2, but less than MW Alternatives 4 and 5 (Table 29).
  - Highest O&M of any alternative, which is associated with ongoing annual monitoring of the mine waste and surrounding aquatic resources, and complete replacement of mine waste cover every 10 years.
- MW Alternative 4 – Removal and Disposal in MCMA Repository.
  - Relatively high cost action alternative, second highest of the alternatives (Table 29).
  - This alternative has lower O&M costs than MW Alternative 2 and 3, but higher than MW Alternative 5. O&M cost associated with annual inspection and sampling at the MCMA Repository.
- MW Alternative 5 – Removal and Off-Site Disposal.
  - This is the highest cost action alternative (Table 29).
  - This alternative has the lowest O&M costs of all the alternatives.

7.1.4 Effectiveness of AW Alternatives

- AW Alternative 1 – No Action
  - This is the least effective alternative with no reduction of toxicity, mobility, or volume, and it would not be protective of human health, ecological receptors, or the environment.
- AW Alternative 2 – Diversion and Infiltration.
  - This alternative provides higher short- and long-term effectiveness than AW Alternative 1, but is less effective than AW Alternative 3. There would be no reduction of volume.
  - Although this alternative will reduce the metal loading to the environment by diverting away from the mine waste, it would not comply with all potential chemical-specific ARARs and proposed cleanup goals (specifically arsenic, copper, iron, lead, and zinc – Table 12), but does achieve RAOs.
- AW Alternative 3 – Passive Treatment and Infiltration.
  - This alternative provides the highest short- and long-term effectiveness by reducing toxicity and mobility through both treatment and infiltration; however, there is no reduction of volume.
  - This alternative offers the greatest reduction of metal loading to the environment and delivers the best mine water quality to the RIBs through diversion and treatment. It would likely not comply with all potential chemical-specific ARARs and proposed cleanup goals (specifically arsenic, copper, iron, lead, and zinc), but does achieve RAOs.
  - Bench testing is needed to design the passive treatment.

7.1.5 Implementability of AW Alternatives

- AW Alternative 1 – No Action.
  - This alternative is technically and administratively feasible and the easiest to implement.

- AW Alternative 2 – Diversion and Infiltration.
  - This alternative is more technically difficult to implement than AW Alternative 1 due to irregular steep terrain, remote location, avalanche potential, and limited native soils, but less difficult than AW Alternative 3.
- AW Alternative 3 – Passive Treatment and Infiltration.
  - This alternative is technically more difficult to implement than AW Alternative 2 because additional passive treatment components must be installed and periodically replenished.

7.1.6 Cost of AW Alternatives

- AW Alternative 1 – No Action.
  - No cost alternative.
- AW Alternative 2 – Diversion and Infiltration.
  - The cost of installing AW Alternative 2 is similar to, but slightly lower, than AW Alterative 3 (Table 29).
  - This alternative has lower O&M costs than AW Alternative 3.
- AW Alternative 3 – Passive Treatment and Infiltration.
  - The cost of installing AW Alternative 3 is slightly higher than AW Alterative 2 (Table 29).
  - It has the highest O&M cost due to the annual purchase and installation of new FlocLogs.

7.2 Seventysix Gulch Mines in the HMJ Wilderness Area - Sheridan and Sidney Mines

7.2.1 Effectiveness of MW Alternatives

- MW Alternative 1 – No Action.
  - This is the least effective alternative. It would provide no reduction of toxicity, mobility, or volume. Waste rock would continue to pose a risk to public visitors and to ecological receptors, and it would not comply with potential ARARs or achieve the RAOs.
  - Furthermore, waste rock at Sidney Mine would continue to be susceptible to erosion by and into Seventysix Creek.
- MW Alternative 2 – Institutional Controls.
  - This alternative has low effectiveness as it would provide no reduction of toxicity, mobility, or volume, despite signage waste rock would continue to pose a risk to public visitors and to ecological receptors.
  - It would also not comply with potential chemical-specific ARARs and proposed cleanup goals (Table 14), or achieve the RAOs.
  - Waste rock at Sidney Mine would continue to be susceptible to erosion by and into Seventysix Creek.
  - Negative short-term impact on the HMJ Wilderness Area is less with this alternative than MW Alternatives 3, 4, and 5.
- MW Alternative 3 – Mine Waste Cover.
  - This alternative is more effective than MW Alternatives 1 and 2 by isolating exposure to human receptors, but there would be little or no reduction in exposure to ecological receptors.
  - Provides more effective compliance with proposed cleanup goals and chemical-specific potential ARARs than MW Alternatives 1 and 2, but less effective than mine waste removal. RAOs are achieved.
  - Proximity of Sidney Mine to stream reduces potential effectiveness of this alternative.
  - Higher negative short-term impact on the HMJ Wilderness Area than MW Alternative 2; however, long-term effects would be more beneficial than MW Alternative 2.

- MW Alternative 4 – Removal and Disposal in MCMA Repository.
  - This alternative provides higher effectiveness than MW Alternatives 2 and 3 by removing hazardous substances from the mine and disposal in a controlled facility in the MCMA.
  - It provides greater reduction of the mobility of hazardous substances and more effective protection for human health, ecological receptors, and the environment than MW Alternatives 2 and 3, but it is less effective than MW Alternative 5.
  - It provides the most effective compliance with chemical-specific potential ARARs and the proposed cleanup goals (Table 14) as compared with MW Alternatives 2 and 3, and similar to MW Alternative 5. RAOs are achieved.
  - This alternative will have a higher negative short-term impact on the HMJ Wilderness Area than MW Alternatives 2 and 3 and is similar to MW Alternative 5 in its impact; however, the long-term effects would be more beneficial than MW Alternatives 2 and 3, and similar to MW Alternative 5.

- MW Alternative 5 – Removal and Off-Site Disposal.
  - This alternative provides the most effective reduction of the mobility of hazardous substances and thus the most effective protection to human health, ecological receptors and the environment than other alternatives by removing hazardous substances from the facilities and MCMA to an off-Site disposal facility.
  - It provides the most effective compliance with chemical-specific potential ARARs and the proposed cleanup goals (Table 14) as compared with MW Alternatives 2 and 3, and similar to MW Alternative 4. RAOs are achieved.

7.2.2 Implementability of MW Alternatives

- MW Alternative 1 – No Action.
  - This alternative is the most technically feasible and is easiest to implement.

- MW Alternative 2 – Institutional Controls.
  - This alternative is technically and administratively feasible and easy to implement compared to MW Alternatives 3, 4, and 5.

- MW Alternative 3 – Mine Waste Cover.
  - This alternative is technically very difficult to implement due to irregular terrain, remote location, and limited availability of cover soil material.
  - Administrative feasibility is more difficult to implement than MW Alternatives 1 and 2, but it is similar to MW Alternatives 4 and 5.
  - The proximity of the Sidney Mine to Seventysix Creek increases difficulty to work at this location.

- MW Alternative 4 – Removal and Disposal in MCMA Repository.
  - MW Alternative 4 is technically and administratively feasible but the most difficult to implement due to operating equipment on moderate to steep terrain and in remote locations, proximity to stream (Sidney Mine), and utilization of a heavy-lift helicopter.
  - Equipment is less available than for MW Alternatives 2 and 3 (e.g. heavy-lift helicopter), but more available than MW Alternative 5 (e.g. off-Site transport).

- MW Alternative 5 – Removal and Off-Site Disposal.
  - MW Alternatives 4 and 5 are technically and administratively feasible but the most difficult to implement due to operating equipment on moderate to steep terrain and in remote locations, proximity to stream (Sidney Mine), and utilization of a heavy-lift helicopter.
  - Equipment and supplies are least available for this alternative because of the distant location of the disposal facility.

7.2.3 Cost of MW Alternatives

- MW Alternative 1 – No Action.
  - No cost alternative.
- MW Alternative 2 – Institutional Controls.
  - Total cost is lower than other action alternatives (Table 29).
  - Higher O&M costs than MW Alternatives 4 and 5, but less than MW Alternative 3. Higher O&M related to ongoing annual monitoring of the mine waste and surrounding aquatic resources.
- MW Alternative 3 – Mine Waste Cover.
  - Total cost higher than MW Alternative 2, but less than MW Alternatives 4 and 5 (Table 29).
  - Highest O&M of any alternative, which is associated with ongoing annual monitoring of the mine waste and surrounding aquatic resources, and complete replacement of mine waste cover every 10 years.
- MW Alternative 4 – Removal and Disposal in MCMA Repository.
  - Relatively high cost action alternative, second highest of the alternatives (Table 29).
  - This alternative has lower O&M costs than MW Alternative 2 and 3, but higher than MW Alternative 5. O&M cost associated with annual inspection and sampling at the MCMA Repository.
- MW Alternative 5 – Removal and Off-Site Disposal.
  - This is the highest cost action alternative (Table 29).
  - This alternative has the lowest O&M costs of all the alternatives.

7.2.4 Effectiveness of AW Alternatives (Sidney Mine only)

- AW Alternative 1 – No Action.
  - This is the least effective alternative with no reduction of toxicity, mobility, or volume, and it would not be protective of human health, ecological receptors, or the environment.
- AW Alternative 2 – Diversion and Infiltration.
  - This alternative provides higher short- and long-term effectiveness than AW Alternative 1, but is less effective than AW Alternative 3. There would be no reduction of volume.
  - Although this alternative will reduce the metal loading to the environment by diverting away from the mine waste, it would not comply with all potential chemical-specific ARARs and proposed cleanup goals (specifically arsenic, copper, iron, lead, and zinc – Table 12), but does achieve RAOs.
- AW Alternative 3 – Passive Treatment and Infiltration.
  - This alternative provides the highest short- and long-term effectiveness by reducing toxicity and mobility through both treatment and infiltration; however, there would be no reduction of volume.
  - This alternative offers the greatest reduction of metal loading to the environment and delivers the best mine water quality to the RIBs through diversion and treatment. It would likely not comply with all potential chemical-specific ARARs and proposed cleanup goals (specifically arsenic, copper, iron, lead, and zinc), but does achieve RAOs.
  - Bench testing is needed to determine the effectiveness of the passive treatment alternatives and the reduction of metals.

7.2.5 Implementability of AW Alternatives (Sidney Mine only)

- AW Alternative 1 – No Action.
  - This alternative is technically and administratively feasible and the easiest to implement.
- AW Alternative 2 – Diversion and Infiltration.
  - This alternative is more technically difficult to implement than AW Alternative 1 due to irregular terrain, remote location, proximity of adit to Seventysix Creek (Sidney Mine), and limited native soils, but less than AW Alternative 3.
- AW Alternative 3 – Passive Treatment and Infiltration.
  - This alternative is technically more difficult to implement than AW Alternative 2 because additional passive treatment components must be installed and periodically replenished.

7.2.6 Cost of AW Alternatives (Sidney Mine only)

- AW Alternative 1 – No Action.
  - No cost alternative.
- AW Alternative 2 – Diversion and Infiltration.
  - The cost of installing AW Alternative 2 is similar to, but slightly lower, than Alterative 3 (Table 29).
  - This alternative has lower O&M costs than AW Alternative 3.
- AW Alternative 3 – Passive Treatment and Infiltration.
  - The cost of installing AW Alternative 3 is slightly higher than Alterative 2 (Table 29).
  - It has the highest O&M cost due to the annual purchase and installation of new FlocLogs.

7.3 Mystery Basin Mines near the HMJ Wilderness Area - Mystery, Justice, and Golden Cord Mines

7.3.1 Effectiveness of MW Alternatives

- MW Alternative 1 – No Action.
  - This is the least effective alternative. It would provide no reduction of toxicity, mobility, or volume, waste rock would continue to pose a risk to public visitors and to ecological receptors, and it would not comply with potential ARARs or achieve the RAOs.
- MW Alternative 2 – Institutional Controls.
  - This alternative has low effectiveness as it would provide no reduction of toxicity, mobility, or volume, despite signage waste rock would continue to pose a risk to public visitors and to ecological receptors.
  - It would also not comply with potential chemical-specific ARARs and proposed cleanup goals (Table 14), or achieve the RAOs.
  - Negative short-term impact on the nearby HMJ Wilderness Area is less with this alternative than MW Alternatives 3, 4, and 5.
- MW Alternative 3 – Mine Waste Cover.
  - This alternative is more effective than MW Alternatives 1 and 2 by isolating exposure to human receptors, but there would be little or no reduction in exposure to ecological receptors.
  - Provides more effective compliance with proposed cleanup goals and chemical-specific potential ARARs than MW Alternatives 1 and 2, but less effective than mine waste removal. RAOs are achieved.
  - Higher negative short-term impact on the nearby HMJ Wilderness Area than MW Alternative 2; however, long-term effects would be more beneficial than MW Alternative 2.

- MW Alternative 4 – Removal and Disposal in MCMA Repository.
  - This alternative provides higher effectiveness than MW Alternatives 2 and 3 by removing hazardous substances from the mine and disposal in a controlled facility in the MCMA.
  - It provides greater reduction of the mobility of hazardous substances and more effective protection for human health, ecological receptors, and the environment than MW Alternatives 2 and 3, but it is less effective than MW Alternative 5.
  - It provides the most effective compliance with chemical-specific potential ARARs and the proposed cleanup goals (Table 14) as compared with MW Alternatives 2 and 3, and similar to MW Alternative 5. RAOs are achieved.
  - This alternative will have a higher negative short-term impact on the nearby HMJ Wilderness Area than MW Alternatives 2 and 3, and is similar to MW Alternative 5 in its impact; however, the long-term effects would be more beneficial than MW Alternatives 2 and 3, and similar to MW Alternative 5.

- MW Alternative 5 – Removal and Off-Site Disposal.
  - This alternative provides the most effective reduction of the mobility of hazardous substances and thus the most effective protection to human health, ecological receptors and the environment than other alternatives by removing hazardous substances from the facilities and MCMA to an off-Site disposal facility.
  - It provides the most effective compliance with chemical-specific potential ARARs and the proposed cleanup goals (Table 14) as compared with MW Alternatives 2 and 3, and similar to MW Alternative 4. RAOs are achieved.
  - It would have a higher negative short-term impact on the nearby HMJ Wilderness Area than MW Alternative 2 and 3, and is similar to MW Alternative 4; however, the long-term effects would be more beneficial than MW Alternatives 2 and 3, and similar to MW Alternative 4.

7.3.2 Implementability of MW Alternatives

- MW Alternative 1 – No Action.
  - This alternative is the most technically feasible and is easiest to implement.

- MW Alternative 2 – Institutional Controls.
  - This alternative is technically feasible and easy to implement compared to MW Alternatives 3, 4, and 5; however, mixed federal and private ownership at the Mystery Mine make action alternatives administratively complex.

- MW Alternative 3 – Mine Waste Cover.
  - This alternative is technically very difficult to implement due to steep terrain, remote location, avalanche hazard, and limited availability of cover soil material.
  - Administrative feasibility is more difficult to implement than MW Alternatives 1 and 2, but it is similar to MW Alternatives 4 and 5.

- MW Alternative 4 – Removal and Disposal in MCMA Repository.
  - MW Alternatives 4 and 5 are technically and administratively feasible but the most difficult to implement due to operating equipment on steep terrain and in remote locations and utilization of a heavy-lift helicopter.
  - Equipment is less available than for MW Alternatives 2 and 3 (e.g. heavy-lift helicopter), but more available than MW Alternative 5 (e.g. off-Site transport).

- MW Alternative 5 – Removal and Off-Site Disposal.
  - MW Alternatives 4 and 5 are technically and administratively feasible but the most difficult to implement due to operating equipment on steep terrain and in remote locations and utilization of a heavy-lift helicopter.
  - Equipment and supplies are least available for this alternative because of the distant disposal facility.

7.3.3 Cost of MW Alternatives

- MW Alternative 1 – No Action.
  - No cost alternative.
- MW Alternative 2 – Institutional Controls.
  - Total cost is lower than other action alternatives (Table 29).
  - Higher O&M costs than MW Alternatives 4 and 5, but less than MW Alternative 3. Higher O&M related to ongoing annual monitoring of the mine waste and surrounding aquatic resources.
- MW Alternative 3 – Mine Waste Cover.
  - Total cost higher than MW Alternative 2, but less than MW Alternatives 4 and 5 (Table 29).
  - Highest O&M of any alternative, which is associated with ongoing annual monitoring of the mine waste and surrounding aquatic resources, and complete replacement of mine waste cover every 10 years.
- MW Alternative 4 – Removal and Disposal in MCMA Repository.
  - Relatively high cost action alternative, second highest of the alternatives (Table 29).
  - This alternative has lower O&M costs than MW Alternative 2 and 3, but higher than MW Alternative 5. O&M cost associated with annual inspection and sampling at the MCMA Repository.
- MW Alternative 5 – Removal and Off-Site Disposal.
  - This is the highest cost action alternative (Table 29).
  - This alternative has the lowest O&M costs of all the alternatives.

7.3.4 Effectiveness of AW Alternatives

- AW Alternative 1 – No Action.
  - This is the least effective alternative with no reduction of toxicity, mobility, or volume, and it would not be protective of human health, ecological receptors, or the environment.
- AW Alternative 2 – Diversion and Infiltration.
  - This alternative provides higher short- and long-term effectiveness than AW Alternative 1, but is less effective than AW Alternative 3. There would be no reduction of volume.
  - Although this alternative will reduce the metal loading to the environment by diverting away from the mine waste, it would not comply with potential chemical-specific ARARs and proposed cleanup goals (specifically arsenic, copper, iron, lead, and zinc – Table 12), but does achieve RAOs.
- AW Alternative 3 – Passive Treatment and Infiltration.
  - This alternative provides the highest short- and long-term effectiveness by reducing toxicity and mobility through both treatment and infiltration; however, there would be no reduction of volume.
  - This alternative offers the greatest reduction of metal loading to the environment and delivers the best mine water quality to the RIBs through diversion and treatment. It would likely not comply with potential chemical-specific ARARs and proposed cleanup goals (specifically arsenic, copper, iron, lead, and zinc), but does achieve RAOs.
  - Bench testing is needed to determine the effectiveness of the passive treatment alternatives and the reduction of metals.

7.3.5 Implementability of AW Alternatives

- AW Alternative 1 – No Action.
  - This alternative is technically and administratively feasible and the easiest to implement.
- AW Alternative 2 – Diversion and Infiltration.
  - This alternative is more technically difficult to implement than AW Alternative 1 due to irregular steep terrain, remote location, avalanche potential, and limited native soils, but less than AW Alternative 3.
- AW Alternative 3 – Passive Treatment and Infiltration.
  - This alternative is technically more difficult to implement than AW Alternative 2 because additional passive treatment components must be installed and periodically replenished.

7.3.6 Cost of AW Alternatives

- AW Alternative 1 – No Action.
  - No cost alternative.
- AW Alternative 2 – Diversion and Infiltration.
  - The cost AW Alternative 2 is similar to, but slightly lower, than Alterative 3 (Table 29).
  - This alternative has lower O&M costs than AW Alternative 3.
- AW Alternative 3 – Passive Treatment and Infiltration.
  - The cost of installing AW Alternative 3 is slightly higher than Alterative 2 (Table 29).
  - It has the highest O&M cost due to the annual purchase and installation of new FlocLogs.

7.4 Processing-Related Facilities in and near the Townsite - Ore Collector, Haulage Ways, Concentrator, and Assay Shack

7.4.1 Effectiveness of MW Alternatives

- MW Alternative 1 – No Action.
  - This is the least effective alternative.
  - It would provide no reduction of toxicity, mobility, or volume, waste rock, tailings, and contaminated soils would continue to pose a risk to public visitors and to ecological receptors, and it would not comply with potential ARARs or achieve the RAOs.
- MW Alternative 2 – Institutional Controls.
  - This alternative has low effectiveness as it would provide no reduction of toxicity, mobility, or volume, despite signage waste rock, tailings, and contaminated soils would continue to pose a risk to public visitors and to ecological receptors.
  - It would also not comply with potential chemical-specific ARARs and proposed cleanup goals (Table 14), or achieve the RAOs.
  - Residual tailings along the bank of Glacier Creek would continue to be susceptible to erosion.
  - Negative short-term impact on the Townsite is less than MW Alternatives 3, 4, and 5.
- MW Alternative 3 – Mine Waste Cover.
  - This alternative is more effective than MW Alternatives 1 and 2 by isolating exposure to human receptors, but there would be little or no reduction in exposure to ecological receptors.
  - Provides more effective compliance with proposed cleanup goals and chemical-specific potential ARARs than MW Alternatives 1 and 2, but less effective than mine waste removal. RAOs are achieved.
  - Proximity of tailings to Glacier Creek reduces potential effectiveness of this alternative.
  - Higher negative short-term impact on the Townsite than MW Alternative 2; however, long-term effects would be more beneficial than MW Alternative 2.

- MW Alternative 4 – Removal and Disposal in MCMA Repository.
  - This alternative provides higher effectiveness than MW Alternatives 2 and 3 by removing hazardous substances from the facilities (Ore Collector, Concentrator, Haulage Ways, and Assay Shack) and disposal in a controlled facility in the MCMA.
  - It provides greater reduction of the mobility of hazardous substances and more effective protection for human health, ecological receptors, and the environment than MW Alternatives 2 and 3, but it is less effective than MW Alternative 5.
  - It provides the most effective compliance with chemical-specific potential ARARs and the proposed cleanup goals (Table 14) as compared with MW Alternatives 2 and 3, and similar to MW Alternative 5. RAOs are achieved.
  - This alternative will have a higher negative short-term impact on the Townsite than MW Alternatives 2 and 3, and is similar to MW Alternative 5 in its impact; however, the long-term effects would be more beneficial than MW Alternatives 2 and 3, and similar to MW Alternative 5.

- MW Alternative 5 – Removal and Off-Site Disposal.
  - This alternative provides the most effective reduction of the mobility of hazardous substances and thus the most effective protection to human health, ecological receptors and the environment than other alternatives by removing hazardous substances from the facilities and MCMA to an off-Site disposal facility.
  - It provides the most effective compliance with chemical-specific potential ARARs and the proposed cleanup goals (Table 14) as compared with MW Alternatives 2 and 3, and similar to MW Alternative 4. RAOs are achieved.
  - It would have a higher negative short-term impact on the Townsite than MW Alternative 2 and 3, and is similar to MW Alternative 4; however, the long-term effects would be more beneficial than MW Alternatives 2 and 3, and similar to MW Alternative 4.

7.4.2 Implementability of MW Alternatives

- MW Alternative 1 – No Action.
  - This alternative is the most technically feasible and is easiest to implement.

- MW Alternative 2 – Institutional Controls.
  - This alternative is technically feasible and easy to implement compared to MW Alternatives 3, 4, and 5; however, mixed federal and private ownership make action alternatives administratively complex.

- MW Alternative 3 – Mine Waste Cover.
  - Technically this alternative is moderately difficult to implement due to irregular terrain, limited cover soil, excavation near Glacier Creek, and preserving historical values while mitigating hazards; however, mixed federal and private ownership make action alternatives administratively complex.

- MW Alternative 4 – Removal and Disposal in MCMA Repository.
  - MW Alternatives 4 and 5 are technically feasible and moderately difficult to implement due to irregular terrain, limited access, excavation near Glacier Creek, and preserving historical values while mitigating hazards; however, mixed federal and private ownership make action alternatives administratively complex.

- MW Alternative 5 – Removal and Off-Site Disposal.
  - MW Alternatives 4 and 5 are technically feasible and moderately difficult to implement due to irregular terrain, limited access, excavation near Glacier Creek, and preserving historical values while mitigating hazards; however, mixed federal and private ownership make action alternatives administratively complex.

7.4.3 Cost of MW Alternatives

- MW Alternative 1 – No Action.
  - No cost alternative.
- MW Alternative 2 – Institutional Controls.
  - Total cost is lower than other action alternatives (Table 29).
  - Higher O&M costs than MW Alternatives 4 and 5, but less than MW Alternative 3. Higher O&M related to ongoing annual monitoring of the mine waste and surrounding aquatic resources.
- MW Alternative 3 – Mine Waste Cover.
  - Total cost higher than MW Alternative 2 and 4, but less than MW Alternatives 5 (Table 29).
  - Highest O&M of any alternative, which is associated with ongoing annual monitoring of the mine waste and surrounding aquatic resources, and complete replacement of mine waste cover every 10 years.
- MW Alternative 4 – Removal and Disposal in MCMA Repository.
  - Total cost is higher than MW Alternative 2, but lower than MW Alternatives 3 and 5 (Table 29).
  - This alternative has lower O&M costs than MW Alternative 2 and 3, but higher than MW Alternative 5. O&M cost associated with annual inspection and sampling at the MCMA Repository.
- MW Alternative 5 – Removal and Off-Site Disposal.
  - This is the highest cost action alternative (Table 29).
  - This alternative has the lowest O&M costs of all the alternatives.

7.5 Other Mines in the MCMA - Rainy and Boston-American Mines

7.5.1 Effectiveness of MW Alternatives

- MW Alternative 1 – No Action.
  - This is the least effective alternative.
  - It would provide no reduction of toxicity, mobility, or volume, waste rock would continue to pose a risk to public visitors and to ecological receptors, and it would not comply with potential ARARs or achieve the RAOs.
- MW Alternative 2 – Institutional Controls.
  - This alternative has low effectiveness as it would provide no reduction of toxicity, mobility, or volume, despite signage waste rock would continue to pose a risk to public visitors and to ecological receptors.
  - It would also not comply with potential chemical-specific ARARs and proposed cleanup goals (Table 14), or achieve the RAOs.
  - Negative short-term impact on the nearby Monte Cristo Townsite is less than MW Alternatives 3, 4, and 5.
- MW Alternative 3 – Mine Waste Cover.
  - This alternative is more effective than MW Alternatives 1 and 2 by isolating exposure to human receptors, but there would be little or no reduction in exposure to ecological receptors.
  - Provides more effective compliance with proposed cleanup goals and chemical-specific potential ARARs than MW Alternatives 1 and 2, but less effective than mine waste removal. RAOs are achieved.
  - Proximity of Rainy Mine to Glacier Creek reduces potential effectiveness of this alternative.
  - Higher negative short-term impact on the nearby Townsite than MW Alternative 2; however, long-term effects would be more beneficial than MW Alternative 2.

- MW Alternative 4 – Removal and Disposal in MCMA Repository.
  - This alternative provides higher effectiveness than MW Alternatives 2 and 3 by removing hazardous substances from the mines and disposal in a controlled facility in the MCMA.
  - It provides greater reduction of the mobility of hazardous substances and more effective protection for human health, ecological receptors, and the environment than MW Alternatives 2 and 3, but it is less effective than MW Alternative 5.
  - It provides the most effective compliance with chemical-specific potential ARARs and the proposed cleanup goals (Table 14) as compared with MW Alternatives 2 and 3, and similar to MW Alternative 5. RAOs are achieved.
  - This alternative will have a higher negative short-term impact on the Townsite than MW Alternatives 2 and 3, and is similar to MW Alternative 5 in its impact; however, the long-term effects would be more beneficial than MW Alternatives 2 and 3, and similar to MW Alternative 5.

- MW Alternative 5 – Removal and Off-Site Disposal.
  - This alternative provides the most effective reduction of the mobility of hazardous substances and thus the most effective protection to human health, ecological receptors and the environment than other alternatives by removing hazardous substances from the facilities and MCMA to an off-Site disposal facility.
  - It provides the most effective compliance with chemical-specific potential ARARs and the proposed cleanup goals (Table 14) as compared with MW Alternatives 2 and 3, and similar to MW Alternative 4. RAOs are achieved.
  - It would have a higher negative short-term impact on the nearby Townsite than MW Alternative 2 and 3, and is similar to MW Alternative 4; however, the long-term effects would be more beneficial than MW Alternatives 2 and 3, and similar to MW Alternative 4.

7.5.2 Implementability of MW Alternatives

- MW Alternative 1 – No Action.
  - This alternative is the most technically feasible and is easiest to implement.

- MW Alternative 2 – Institutional Controls.
  - This alternative is technically and administratively feasible and easy to implement compared to MW Alternatives 3, 4, and 5.

- MW Alternative 3 – Mine Waste Cover.
  - Technically this alternative is moderately difficult to implement due to irregular terrain, remote locations, and limited cover material.
  - Administrative feasibility is more difficult to implement than MW Alternatives 1 and 2, but it is similar to MW Alternatives 4 and 5.

- MW Alternative 4 – Removal and Disposal in MCMA Repository.
  - MW Alternatives 4 and 5 are technically and administratively feasible and moderately difficult to implement due to irregular terrain, remote locations, and limited cover material.

- MW Alternative 5 – Removal and Off-Site Disposal.
  - MW Alternatives 4 and 5 are technically and administratively feasible and moderately difficult to implement due to irregular terrain, remote locations, and limited cover material.

7.5.3 Cost of MW Alternatives

- MW Alternative 1 – No Action.
  - No cost alternative.

- MW Alternative 2 – Institutional Controls.
  - Total cost is lower than other action alternatives (Table 29).
  - Higher O&M costs than MW Alternatives 4 and 5, but less than MW Alternative 3. Higher O&M related to ongoing annual monitoring of the mine waste and surrounding aquatic resources.
- MW Alternative 3 – Mine Waste Cover.
  - Total cost higher than MW Alternative 2 and 4, but less than MW Alternatives 5 (Table 29).
  - Highest O&M of any alternative, which is associated with ongoing annual monitoring of the mine waste and surrounding aquatic resources, and complete replacement of mine waste cover every 10 years.
- MW Alternative 4 – Removal and Disposal in MCMA Repository.
  - Total cost is higher than MW Alternative 2, but lower than MW Alternatives 3 and 5 (Table 29).
  - This alternative has lower O&M costs than MW Alternative 2 and 3, but higher than MW Alternative 5. O&M cost associated with annual inspection and sampling at the MCMA Repository.
- MW Alternative 5 – Removal and Off-Site Disposal.
  - This is the highest cost action alternative (Table 29).
  - This alternative has the lowest O&M costs of all the alternatives.

7.5.4 Effectiveness of AW Alternatives

- AW Alternative 1 – No Action.
  - This is the least effective alternative with no reduction of toxicity, mobility, or volume, and it would not be protective of human health, ecological receptors, or the environment.
- AW Alternative 2 – Diversion and Infiltration.
  - This alternative provides higher short- and long-term effectiveness than AW Alternative 1, but is less effective than AW Alternative 3. There would be no reduction of volume.
  - Although this alternative will reduce the metal loading to the environment by diverting away from the mine waste, it would not comply with potential chemical-specific ARARs and proposed cleanup goals (specifically arsenic, copper, iron, lead, and zinc – Table 12), but does achieve RAOs.
- AW Alternative 3 – Passive Treatment and Infiltration.
  - This alternative provides the highest short- and long-term effectiveness by reducing toxicity and mobility through both treatment and infiltration; however, there would be no reduction of volume.
  - This alternative offers the greatest reduction of metal loading to the environment and delivers the best mine water quality to the RIBs through diversion and treatment. It would likely not comply with potential chemical-specific ARARs and proposed cleanup goals (specifically arsenic, copper, iron, lead, and zinc), but does achieve RAOs.
  - Bench testing is needed to determine the effectiveness of the passive treatment alternatives and the reduction of metals.

7.5.5 Implementability of AW Alternatives

- AW Alternative 1 – No Action.
  - This alternative is technically and administratively feasible and the easiest to implement.
- AW Alternative 2 – Diversion and Infiltration.
  - This alternative is more technically difficult to implement than AW Alternative 1 due to moderate to steep terrain, remote locations, and limited native soils., but less difficult than AW Alternative 3.

- AW Alternative 3 – Passive Treatment and Infiltration.
  - This alternative is technically more difficult to implement than AW Alternative 2 because additional passive treatment components must be installed and periodically replenished.

7.5.6 Cost of AW Alternatives

- AW Alternative 1 – No Action.
  - No cost alternative.
- AW Alternative 2 – Diversion and Infiltration.
  - The cost of installing AW Alternative 2 is similar to, but slightly lower, than Alterative 3 (Table 29).
  - This alternative has lower O&M costs than AW Alternative 3.
- AW Alternative 3 – Passive Treatment and Infiltration.
  - The cost of installing AW Alternative 3 is slightly higher than Alterative 2 (Table 29).
  - It has the highest O&M cost due to the annual purchase and installation of new FlocLogs.

8.0 RECOMMENDED REMOVAL ACTION

The recommended Removal Action is discussed in this section. The action recommended for each of the mines and processing-related facilities vary based on the unique circumstances of each feature and the most appropriate combination of alternatives to best achieve the RAOs. Based on the information outlined in this EECA, a CERCLA Removal Action is recommended to focus on the following mines and process-related facilities with high recreational use, and/or in close proximity to surface water bodies with evidence of active erosion:

- Pride of the Woods Mine
- Rainy Mine
- Concentrator
- Ore Collector
- Assay Shack
- Boston-American Mine
- Haulage Ways
- Sidney Mine

The remaining mines, considered remote, with limited exposure, may be further addressed as part of additional CERCLA work at the Site. Therefore, Removal Action is not recommended for the following mines (with the exception of physical hazard mitigation measures) at this time:

- Pride of the Mountains Mine
- New Discovery Mine
- Mystery Mine
- Justice Mine
- Golden Cord Mine
- Sheridan Mine

Recommended Removal Actions common to the mines and process-related facilities are presented first in Section 8.1, followed by the locality-specific recommended actions in Section 8.2, and finally the repository recommendation in Section 8.3. A summary of the costs for the recommended Removal Action is presented in Table 30.

8.1 Recommended Removal Actions Common to All Mines and Facilities and the MCMA

Certain work elements, such as addressing BMPs, should be implemented regardless of the action alternative selected.

8.1.1 Best Management Practices

During Removal Action activities, BMPs will be used to minimize and control erosion and the sedimentation of surface waters surrounding the Site. These may include the use of silt fences, straw bales, run-on and run-off diversion ditches lined with "rip-rap", fugitive dust control, etc. Stream crossings will be designed to minimize to the extent practical, sedimentation and impacts to aquatic species. In addition, special care will be taken to avoid the introduction of noxious weeds during the Removal Action. Specifically, the contractor will work with the Forest Service to use approved borrow sources when available, all straw/hay used (i.e., for mulch and silt fence) will be certified "weed free," and all off-road equipment will be washed and inspected prior to entering and leaving the Site. Other resource protection BMPs may be identified in the Removal Design.

8.1.2 Road Access to MCMA and Selected Features

An access road would be constructed along the east side of SFSR, generally paralleling the old wagon road prism, from the vicinity of Mowich Camp to the vicinity of Townsite, specifically to the north side of Glacier Creek across from the Concentrator area. The route shown on Plate 3 is conceptual only and does not imply that a specific route is recommended. This new route would provide for greater safety, avoid the SFSR crossing between SFSR-4 and SFSR-5, provide greater long-term reliability, reduce the potential sedimentation to the SFSR and tributaries, better meet the Forest Plan Riparian Standards and Guidelines, and reduce costs. The proposed road would be constructed to the requirements of a Forest Service Maintenance Level 2 road with culverts at minor stream crossings/drainage crossings. A temporary crossing to the Townsite would be required near the Concentrator, and the road would be extended southeast to provide access to the Rainy Mine if a suitable route can be found. Also, the existing trail/road system around the Near features would be improved for equipment access. The existing Townsite area helipad, roadways, cleared areas and campgrounds would be used as removal staging, storage and camp areas. CES estimates the total cost for construction of a Forest Service Maintenance Level 2 road, including indirect costs and contingency, to be approximately $1.1 million.

Road planning and construction would proceed as follows:

1. Coordinate route and road specification planning with Forest Service staff as needed to determine a viable route that takes into consideration engineering, ecological, historical, and other concerns of the Forest Service and State;
2. Select, flag and survey the selected route (Plate 3, conceptual only), possibly paralleling the old railroad bed as closely as feasible;
3. Clear and grub the route;
4. Grade the route as needed using cut and fill techniques;
5. Install up to eight culvert stream crossings with up to twin 48-inch culverts;
6. Extend the route past the campground to a point across from the Concentrator;
7. Use a temporary rock crossing across Glacier Creek to the Concentrator area;
8. Construct Forest Service Maintenance Level 2 road quality access to the Near features selected for mine waste removal and the repository;
9. Construct access to the Rainy Mine by extending the road southeast along the northeast side of Glacier Creek.

CES has assumed that some to all access roads constructed to support the Removal Action will be decommissioned to the quality of a jeep or foot trail to minimize future road maintenance costs. Structures subject to severe erosion damage will be removed and the approaches excavated to match stream banks. Road shoulders will be scarified to a width of eight feet to expedite volunteer re-vegetation by native species.

8.1.3 Preservation of Historically Significant Areas

The Ore Collector, Concentrator, and Assay Shack are expected to be considered Historically Significant by State Historic Preservation Office criteria. Other features included in the EECA may also qualify; therefore, CES proposes the following preservation procedures.

- Collector and Concentrator: Contaminated soil and waste will be carefully removed to preserve wooden structures as much a practical. Some of the mine waste may be replaced with clean soil or gravel to support the structures as necessary and mimic the original appearance.
- Assay Shack: Impacted material will be carefully removed, examined, and important artifacts recorded by a qualified archeologist.
- Other features: Archeological assessments should be conducted at other potentially impacted areas to determine if artifacts or features of historical significance are present and can be preserved.

8.1.4 Mitigation of Physical Hazards

Physical hazards identified at mines and facilities in the MCMA represent an immediate and significant potential hazard to the public; therefore, selected physical hazard reduction measures are included in all action alternatives. Depending on recommendations for specific features, physical hazards may be mitigated through institutional controls such as fencing, gating and/or signage which limit public access, or by removal of the hazard. While completely eliminating the hazard is preferable, it may not be feasible or economical at most locations. Consequently, the following mine access closures and other mitigation measures would be undertaken (details described in Section 8.2). In order to limit public access while maintaining potential bat habitat, bat gates or culverts should be installed at all adits, shafts, or hazardous mine openings, where feasible. The conceptual design for proposed bat gates and the conceptual design for a bat culvert are illustrated in Figure 15. Bat gates should include removable bars to allow access for periodic monitoring or maintenance of water impoundments and diversions. In the event that water diversion and treatment alternatives are implemented at mines that flow water, modifications and improvements made at the portals should be coordinated with implementation of mine closures.

8.1.5 Warning Signage

Signage would be installed on the Glacier Basin and Seventysix Gulch trails at the edge of the HMJ Wilderness Area boundary to warn visitors about the physical hazards as well as the risk of direct contact with contaminated waste rock and mine water in the Wilderness.

8.1.6 Operations, Monitoring, and Maintenance

Implementation of the Removal Action will require coordination of simultaneous operations at multiple locations during implementation. In addition, most, if not all, mines and facilities on which Removal Actions are conducted will require periodic monitoring and maintenance.

8.1.7 Restrict or Close the Area to Fishing

The EECA-DGI demonstrates that elevated concentrations of hazardous substances are present in the surface water, pore water, and stream sediment in MCL, the SFSR, Glacier Creek, and Seventysix Creek. The Forest Service would initiate discussion with Washington Departments of Fish and Wildlife, Ecology, and Health to determine whether interim measures are needed, pending additional fish ingestion investigations.

8.2 Recommended Removal Action - Locality-Specific

The mines and processing-related facilities proposed for the Removal Action are addressed separately in this section. Relevant information on each feature is described in Table 1, and locations are shown on Plate 3.

8.2.1 Pride of the Woods Mine

MW Alternative: The recommended Removal Action would implement MW Alternative 4 - Removal and Disposal in MCMA Repository with associated physical hazard mitigation - at the Pride of the Woods Mine (Figure 3; Plate 3). This mine is estimated to contain 900 bcy of waste rock with a surface area of about 1,300 square yards, and the mine perimeter is about 900 feet. The contaminated waste rock should be removed because of the close proximity to Glacier Creek (~ 20 feet from toe) and its location in the floodplain. The Glacier Basin trail (Forest Service Trail 719) crosses the waste rock toe bringing visitors to this feature. In addition, water that intermittently seeps from the waste rock toe appears to be contaminated by infiltration of snow melt and precipitation into the dump, which mobilizes arsenic and other COCs. Excavation and removal of wastes from this mine is more feasible than other mines in Glacier Basin because there is sufficient work area and the slope is not nearly as steep.
Under this alternative, all waste rock that exceeds the proposed cleanup goals (Table 14) will be excavated and removed from the mine and consolidated in the centralized MCMA repository (see removal sequence description below). Extensive use of a heavy-lift helicopter, with support from a light helicopter, would be required to transport heavy equipment to and from the mine and sling all waste material from the mine to the repository. Hazardous debris would also be removed from the mine, and a bat culvert would be installed if the adit portal is determined to be open and presents a physical hazard.

This alternative provides protection to human health and the environment at the mine and local area. It complies with potential ARARs and proposed cleanup goals by removing hazardous substances with containment in a controlled facility in the MCMA. It offers high short-term and long-term effectiveness for human health and the environment. Although, the HMJ Wilderness Area would experience negative short-term impact through implementation of this Removal Action (due to the closure of the wilderness area, use of helicopters, and increased activity); however, the long-term effects would be beneficial. The general sequence and approach for implementation of this Removal Action is expected to be as follows (detailed description in Section 6.1.1):

1. Mobilize a 15-ton excavator (a spider hoe may also be suitable) and heavy-lift helicopter to the staging area;
2. Using light helicopter, transport crew and general hand tools to the mine to setup a landing area and to clear and grub the waste rock dump;
3. Debris that constitutes a physical hazard will be consolidated for removal;
4. Using the heavy-lift helicopter, sling excavator to the mine. The excavator must be slung in pieces and reconstructed on location;
5. Sling all supplies to the mine with the use of a light helicopter;
6. The excavator will first be used to investigate the largely collapsed adit portal, confirm whether or not water drains form the portal, and prepare working for a bat culvert and water diversion, if necessary;
7. Using the excavator, begin removing waste rock by dumping the material into a 10-ton capacity sling box for heavy-lift helicopter transport;
8. The helicopter will leave an empty sling box each time it returns to remove a full box;
9. Excavate water pipeline trench and RIB, if needed;
10. When all material is removed, smooth disturbed area and dismantle and sling the excavator to the staging area;
11. Apply seed, a weed-free wood mulch, and fertilizer to the disturbed areas;
12. Demobilization.

CES estimates the cost at this mine for implementation of the mine waste Removal Action, including physical hazard mitigation, 30-year O&M, indirect costs, and contingency, to be **$640,221.**

AW Alternative: The recommended Removal Action would implement AW Alternative 3 – Diversion, Passive Treatment, and Infiltration at the Pride of the Woods Mine (Figure 3; Plate 3) if it is determined that contaminated water flows from the adit. This system requires periodic monitoring and maintenance, and new FlocLogs must be purchased and installed each year. The primary component of FlocLogs is polyacrylamide to enhance flocculation and settlement. However, a base can be added to neutralize limited acidity, and chelating agents can be added to extract dissolved metals. Although this system will not work perfectly, it is expected to remove a high percentage of contaminants and modify the pH. Additional testing of mine water is recommended to verify effectiveness and optimize performance.

The dump seep is estimated to flow at a rate of 0.045 gpm with a total arsenic concentration of 4,060 µg/L. The water may drain directly from the adit (largely or completely collapsed) or an associated fracture zone, and through the dump, or it could merely be slightly acidic seasonal snow melt that mobilizes and transports metals as it infiltrates into the dump and flows through the waste rock. If the source is not from the adit, then implementation of the Mine Waste Removal Action would mitigate the seasonal snow melt-caused hazardous substance release. However, if the source is determined to be from the adit or an associated fracture zone, this alternative would be implemented. Water would be captured inside the portal and diverted into a buried pipeline to a vault that houses the FlocLogs, and then to an RIB. CES estimates a pipeline length of 150 feet would be required. The RIB can be filled with coarse rock to control exposure and any visual impacts.

This alternative provides reduction of toxicity and mobility by controlling and diverting flow away from the mine and Glacier Creek; however, there is no reduction of volume. Contaminated water would pose minimal threat to ecological receptors. Although the infiltration area may attract wildlife, it can be designed to control/limit access of wildlife to the water. It is expected to provide short-term and long-term effectiveness and be moderately to highly protective of human health and the environment. However, if seepage or drainage continues, the proposed treatment system may not fully comply with chemical-specific ARARs and the proposed cleanup goals (Table 12). Monitoring will determine whether ARARs are met and whether additional removal response action is needed.

The cost for AW Alternative 3 is included in the MW Removal Action cost above.

8.2.2 Sidney Mine

MW Alternative: The recommended Removal Action would implement MW Alternative 4 - Removal and Disposal in MCMA Repository with associated physical hazard mitigation at the Sidney Mine (Figure 14; Plate 3). This mine is estimated to contain 425 bcy of waste rock with a surface area of about 500 square yards, the perimeter is about 260 feet, and there is one open adit. Waste rock at this mine is tenuously placed adjacent to Seventysix Creek and has been subject to erosion during seasonal flood events since the dump was constructed. Although the Sidney Mine is located in a forested area and in the HMJ Wilderness Area, given the documented contribution of arsenic- and other COPC-bearing waste rock to the sediment bed load of Seventysix Creek, removal of the waste materials should improve the quality of this riparian habitat and the HMJ Wilderness Area. A bat gate would also be installed at the portal of the open adit to limit public access to hazardous underground workings.

Under this alternative, all waste rock that exceeds the proposed cleanup goals (Table 14) will be excavated and removed from the mine and consolidated in the centralized MCMA repository (see removal sequence description below). Extensive use of a heavy-lift helicopter with support from a light helicopter would be required to transport heavy equipment to and from the mine and sling all waste material to the repository. Hazardous debris would also be removed. The proximity of Sidney Mine to the stream increases the difficulty of working at this location. It will be difficult to implement due to the irregular terrain and the remoteness.

This alternative provides the most protection to human health and the environment for the mine and complies with potential ARARs and proposed cleanup goals by removing hazardous substances and disposal in a controlled facility in the MCMA. It offers high short-term and long-term effectiveness for human health and the environment, although the HMJ Wilderness Area would experience negative short-term impact by implementation of this Removal Action. The general sequence and approach for implementation of this Removal Action is expected to be as follows (detailed description in Section 6.1.1):

1. Mobilize a 15-ton excavator (a spider hoe may also be suitable) and heavy-lift helicopter;
2. Using light helicopter, transport crew and general hand tools to the mine to setup a landing area and to clear and grub the waste rock dump and gather and stockpile debris (access on foot may be required to prepare a temporary staging area);
3. Debris that constitutes a physical hazard will be consolidated for removal;
4. Using the heavy-lift helicopter, sling excavator to the staging area at the mine. The excavator must be slung in pieces and reconstructed on location;
5. Sling all supplies to the mine with the light helicopter;
6. Use excavator to remove waste rock nearest stream and place on rear of dump (adjacent to hillside);
7. Using the excavator begin removing waste rock by dumping the material into a 10-ton capacity sling box for heavy-lift helicopter transport;
8. The helicopter will leave an empty sling box each time it returns to remove a full box;
9. The excavator will be used to prepare the open working for a bat gate, water diversion, and to excavate a water pipeline trench and RIB;
10. When all material is removed, smooth disturbed area and dismantle and sling the excavator to the staging area;
11. Apply seed, a weed-free wood mulch, and fertilizer to the disturbed areas;
12. Demobilization.

Implementation of this alternative requires the following material and support elements: heavy-lift and light helicopters, use of an excavator and possibly a dozer, and a bat gate. CES estimates the cost for implementation of the Removal Action, 30-year O&M, indirect costs, and contingency, for this mine to be **$381,049**.

AW Alternative: The recommended Removal Action would implement AW Alternative 3 - Passive Treatment and Infiltration - at the Sidney Mine. Water from the adit flows directly into Seventysix Creek, and the adit portal was damaged and nearly covered by debris from a snow avalanche that occurred in spring 2008. Water will be captured inside the portal, then diverted into a catchment basin/vault with the FlocLog, and diverted into a buried pipeline that transports the water to an RIB. Installation of the catchment basin, diversion channel, pipeline, and RIB will require a thorough reconnaissance and careful engineering.

This alternative reduces the toxicity and mobility by diverting the water, treating it, and eliminating the direct flowing into surface water; however, there is no reduction of volume. Contaminated water would pose minimal threat to ecological receptors. Although the infiltration area may attract wildlife, the infiltration basin can be designed to control/limit access by wildlife. It is expected to provide short-term and long-term effectiveness and be moderately to highly protective of human health and the environment. While water quality may slightly exceed chemical-specific ARARs at the point of infiltration (Table 12), further attenuation of arsenic and other metal concentrations may occur as the water moves through the soil column. Monitoring will determine whether ARARs are met and whether additional removal/remedial action is needed.

The cost for AW Alternative 3 is included in the MW Removal Action cost above.

8.2.3 Rainy Mine

MW Alternative: The recommended Removal Action would implement MW Alternative 4 - Removal and Disposal in MCMA Repository with associated physical hazard mitigation at the Rainy Mine (Figure 7; Plate 3). The Rainy Mine is estimated to contain 3,300 bcy of waste rock with a surface area of about 1,300 square yards and a perimeter of about 320 feet. The contaminated waste rock should be removed because it is being eroded by Glacier Creek.

Under this alternative, all waste rock that exceeds the proposed cleanup goals (Table 14) will be excavated and removed from the mine and consolidated in the centralized MCMA repository (see removal sequence description below). Hazardous debris would also be removed from the mine. Two bat culverts would be installed in open workings at the Rainy Mine to mitigate these physical hazards.

Removal of waste rock from the Rainy Mine and disposal in the MCMA repository provides significant protection to human health and the environment and complies with potential ARARs and proposed cleanup goals by removing hazardous substances from the mine. Physical hazards would also be mitigated. It offers high short-term and long-term effectiveness for human health and the environment, and although the Townsite area would experience negative short-term impact by implementation of this Removal Action, the long-term effects would be beneficial. Low cost periodic monitoring and maintenance of physical hazard mitigation measures would be required.

The general sequence and approach for implementation of this Removal Action is expected to be as follows (detailed description in Section 6.1.1):

1. Access to the Rainy Mine will be by extension of the new road along the northeast side of Glacier Creek or crossing Glacier Creek near the Collector;
2. Debris that constitutes a physical hazard will be consolidated for removal;
3. This alternative will require extensive use of an excavator and conventional articulated trucks to remove and transport wastes from the mine to the MCMA repository;
4. As the removal process progresses at the Rainy Mine, excavate and expose the adit and covered shaft to allow for adequate examination and preparation for installation of bat culverts;
5. When all material is removed, prepare disturbed area for reclamation;
6. Apply seed, a weed-free wood mulch, and fertilizer to the disturbed area;
7. Demobilization and decommissioning of road.

Implementation of this alternative at the Rainy Mine requires the following elements: construction of a temporary road to the location, use of an excavator and conventional articulated trucks to remove and transport wastes, and two bat culverts. CES estimates the total cost for implementation of the Removal Action, 30-year O&M, indirect costs, and contingency to be **$178,349.**

AW Alternative: As part of the Removal Action, an AW Alternative is not proposed at this time. Additional investigation is needed to assess the impacts of the suspected shaft/adit water.

8.2.4 Boston-American Mine

MW Alternative: The recommended Removal Action would implement MW Alternative 1 - No Action with associated physical hazard mitigation at the Boston-American Mine (Figure 12; Plate 3). The Boston-American Mine is estimated to contain 6,000 bcy of waste rock with a surface area of about 3,000 square yards, and the mine perimeter is about 500 feet. No action is recommended at the Boston-American Mine because arsenic and other hazardous substances in the waste rock are comparatively low. The average waste rock concentrations for most hazardous substances do not exceed background. Only mercury exceeded background and that, by a factor of less than two.

This alternative includes installation of a bat gate to limit public access to physical hazards presented by the open adit on the mine, the signage would also be installed at the mine and on local trails to warn visitors about the risk of direct contact with COPCs in the waste rock dump and contaminated drainage water. This alternative is easily implemented, incurs relatively minor costs, and will reduce human exposure to physical hazards. However, there is no reduction of toxicity, mobility, or volume of hazardous substances in waste rock, and it is not fully protective of the environment. It will also slightly exceed potential chemical-specific ARARs for total mercury (Table 14).

A helicopter will be required to transport supplies and materials to install the mine closure. This Removal Action alternative will also require low cost periodic monitoring and maintenance of physical hazard mitigation measures. Implementation of this alternative requires the following material and support elements: one bat gat system, signs, and a helicopter. CES estimates the total cost for implementation of the Removal Action, 30-year O&M, indirect costs, and contingency is **$36,199**.

AW Alternative - Boston-American Mine: The recommended Removal Action would implement AW Alternative 1 - No Action at the Boston-American Mine (Figures 12; Plate 3). Although the concentration of total arsenic and some other metals in water discharging from this mine exceed maximum human health criteria, the concentrations are relatively low and the mine is a considerable distance (700 feet) above Seventysix Creek. Therefore, attenuation in the soil column may be significant. However, this alternative may not fully comply with potential chemical-specific ARARs and proposed cleanup goals (Table 12), or achieve the RAOs.

8.2.5 Ore Collector, Concentrator & Tailings, Haulage Ways, and Assay Shack

MW Alternative: The recommended Removal Action would implement MW Alternative 4 - Removal and Disposal in MCMA Repository with historic preservation and selective physical hazard mitigation - at the Ore Collector, Concentrator, Haulage Ways, and Assay Shack (Figures 8-11; Plate 3). Ore, waste rock, tailings, and soils at these locations should be removed because these materials are contaminated with arsenic and other COIs, the features are in or near the Townsite, and they attract recreational visitors. Furthermore, some structures and the steep stockpile face at the Ore Collector pose physical hazards to the public.

Under this alternative, all waste materials (tailings, soil, etc.) that exceed the proposed cleanup goals (Table 14) will be excavated and removed from each facility and consolidated in the centralized MCMA repository. Hazardous debris would also be removed. The equipment, Removal Actions, and sequence employed will be similar to those at the Rainy Mine (described above) with the exception that historic preservation measures will be implemented at the Ore Collector, Concentrator, and Assay Shack.

Removal of the waste from these facilities and disposal in the MCMA repository provides significant protection to human health and the environment and complies with potential ARARs and proposed cleanup goals by removing hazardous substances. Physical hazards would also be mitigated, and care will be taken to clean and preserve historically-significant features at the Ore Collector, Concentrator, and Assay Shack. This alternative offers high short-term and long-term effectiveness for human health and the environment, although the Townsite area would experience negative short-term impacts during the implementation phases. Low cost periodic monitoring of the facilities and maintenance of physical hazard mitigation measures would be required.

Implementation of this alternative requires the following elements: historical preservation efforts, including assessments, use of an excavator and conventional articulated trucks to remove and transport contaminated waste materials, reclamation, including seeding, and installation of warning signs. CES estimates the total cost for implementation of the Removal Action, 30-year O&M, indirect costs, and contingency, at each of these facilities to be:

- Ore Collector: **$110,249**
- Haulage Ways: **$9,210**
- Concentrator and Tailings: **$351,662**
- Assay Shack: **$21,517**

8.3 Recommended Removal Action - MCMA Repository

Based on the analyses in Sections 6.1 and 7.0 and recommended Removal Actions in Section 8.2, the recommended Removal Action would implement MW Alternative 4 – Removal and Disposal in MCMA Repository – which includes construction of an on-Site MCMA repository at the REP-1 location. Three candidate repository locations (Section 6.1.1) were examined, and CES identified the REP-1 candidate repository location near the Assay Shack (Plate 3) as the most suitable location because it is readily accessible by road, yet away from the main Glacier Creek Trail; it is of adequate size; the terrain is favorable for containment. Under this alternative, waste rock, tailings and contaminated soils that exceed the proposed cleanup goals (Table 14) from the selected mines and facilities will be excavated, transported, and consolidated in the centralized MCMA repository. The REP-1 repository was originally conceptualized to accommodate the maximum volume of material, estimated at 80,000 bcy, to be removed and consolidated from the ten mines and four facilities on the Site. However, the recommended Removal Action involves about 16,000 bcy (see matrix below), so the MCMA Repository has been reconfigured to accommodate a maximum volume of 20,000 bcy. Figure 15 provides a conceptual section view and detailed profile of the proposed repository at the REP-1 location (Plate 3). A final repository location and design will be completed after all reviews are received and final Removal Action decisions made.

Mine or Facility Recommended for MW Alternative 4 - Removal and Disposal in MCMA Repository	Volume of Waste Material (bcy)
Pride of the Woods Mine	900
Rainy Mine	3,300
Sidney Mine	425
Ore Collector	2,500
Haulage Ways	200
Concentrator and Tailings	8,200
Assay Shack	200
Total Volume Recommended - MCMA Repository	**15,725**

The cost of the on-Site MCMA repository (MW Alternative 4) compared with off-Site transport and disposal (MW Alternative 5) is much lower ($5.5 million versus ~$9.1 million). The higher costs associated with MW Alternative 5 are mainly due to the high off-Site disposal fees and the increased cost associated with the high level access road required to transport mine waste off-Site. Implementation of this alternative complies with potential ARARs (except off-Site disposal of the 200 bcy of Dangerous Waste, which would require an ARAR waiver) and proposed cleanup goals, and is considered to be protective of human and ecological receptors because contaminated waste materials from the recommended locations would be consolidated and isolated in a fully lined repository. Although construction and related elements of the recommended

Removal Action would cause considerable short-term disruption of normal activities in the Townsite and nearby areas, the long-term effectiveness and benefits after project completion and reclamation would be substantial.

This alternative will require extensive use of an excavator and conventional articulated trucks to remove and transport wastes from the Near features and a heavy-lift helicopter, with support from a light helicopter, to sling mine waste from the Pride of the Woods and Sidney Mines. As noted in Section 8.1, a Forest Service Maintenance Level 2 road will be required for equipment and supply. Additionally, approximately 400 trees (western hemlock, western red cedar, and silver fir) must be removed from the repository area. Although the repository would cover approximately 1.5 acres, the area to be cleared may cover as much as 2 to 3 acres. Salvageable timber could be recovered and sold or used locally, whereas unsalvageable trees and the remainder of vegetation would be shredded and applied to the repository cap, or dispersed as coarse-woody debris.

CES considered two different repository configurations: 1) a minimum design without a bottom liner, and 2) a far more conservative lined repository with multiple membrane bedding layers in the liner and cap, and a thicker soil cover. For this EECA, CES recommends the conservative lined design that offers full encapsulation of waste materials because of the high precipitation in the area and the acid generating potential of the waste rock/soils.

The repository would be constructed in the following sequence following road construction:

1. Clear and grub REP-1, a relatively flat forested area east and south of the Assay Shack;
2. Grade the area and stockpile material usable as cover soil;
3. Track compact the base;
4. Apply 0.2 yd of -3/4 in rounded bedding rock;
5. Install 60-mil Gundle HyperFrictionFlex or similar liner;
6. Apply 0.2 yd of -3/4 in rounded bedding rock;
7. Install Gundle 12 oz nonwoven geotextile fabric or similar material;
8. Construct appropriate run-on/run-off diversions and control;
9. Construct access improvements and turnaround;
10. Clear helicopter off-loading approaches;
11. Transport and place waste from identified sources;
12. Blended CaO @ 0.16 lbs/bcy waste for acid neutralization, and compact material after blending;
13. Grade final repository for positive drainage with track compaction;
14. Apply 0.2 yd of -3/4 in rounded bedding rock;
15. Install 60-mil Gundle HyperFrictionFlex or similar liner;
16. Apply 0.2 yd of -3/4 in rounded bedding rock;
17. Install Gundle 12 oz nonwoven geotextile fabric or similar material;
18. Apply 0.2 yd washed -3/8" capillary break;
19. Install Gundle 12 oz nonwoven geotextile fabric or similar material;
20. Apply 0.35 yd of soil, some of which will require importing from off-Site;
21. Cover with 0.2 yd stockpiled topsoil, additional material will require importing from off-Site; and
22. Revegetate with seed, a weed-free wood straw, and fertilizer.
23. Demobilization

8.4 Recommended Removal Action - Conclusion and Cost

The recommended CERCLA Removal Action would isolate a total of 15,725 bcy of waste rock, ore, tailings, and contaminated soil in the on-Site MCMA repository by implementation of MW Alternative 4. This interim action is recommended to focus on the mines or process-related facilities with high recreational use, and/or in close proximity to surface water bodies with evidence of active erosion. The remaining mines are considered remote, with limited exposure, and will be addressed as part of additional CERCLA work at the Site.

In addition, the recommended Removal Action would provide diversion, treatment, and infiltration of contaminated water at the Pride of the Woods Mine (if observed following waste rock removal) and the Sidney Mine. Additional actions would include mitigation of physical hazards by installation of bat-friendly closures at 15 open workings on 9 mines in the MCMA and selective removal of dangerous debris from facilities in the Townsite area. To support the recommended Removal Actions, a temporary Forest Service Maintenance Level 2 road must be constructed from the Mountain Loop Road to the Monte Cristo Townsite.

The total estimated cost for the recommended Removal Action alternatives, including design and oversight, 30-year of O&M, and contingency, is approximately $5.50 million. The distribution of costs by feature and recommended interim Removal Action alternative is shown in the Table 30.
A tentative project schedule would implement Removal Action activities over a three-year period to allow for logical sequencing of tasks and timely completion of recommended Data Gap Investigations.

REFERENCES

Broughton, W.A., 1942. Inventory of mineral deposits in Snohomish County, Washington. State of Washington, Division of Geology. Report of Investigations No. 6. 64 p.

CES, 2008a. Final Site Inspection Report Monte Cristo Mining Area, Mt. Baker-Snoqualmie National Forest, Snohomish County, Washington. Cascade Earth Sciences.

CES, 2008b. Field Operations Plan, Engineering Evaluation & Cost Analysis - Data Gap Investigation, Monte Cristo Mining Area, Mt. Baker-Snoqualmie National Forest, Snohomish County, Washington. Cascade Earth Sciences.

Church, S.E., Tabor, R.W., and Johnson, F.L. 1983. Mineral resource potential of the Glacier Peak Roadless Area. U.S. Geological Survey Miscellaneous Field Studies Map MF-1380-C.

Crofoot, G.W., and O'Brien, M.L. 2004. Monte Cristo Mine Area Site Hazard Assessment. Snohomish Health District and Washington Department of Ecology. January 2004.

Derkey, R.E., Joseph, N.L., and Lasmanis, R., 1990. Metal Mines of Washington-Preliminary Report: Washington Department of Natural Resources, Division of Geology and Earth Resources Open File Report 90-18. 577 p.

Ecology, 2007. *Model Toxics Control Act*. Washington State Department of Ecology. http://www.ecy.wa.gov/pubs/9406.pdf.

Ford, K.L., M. 2003. Passive Treatment Systems for Acid Mine Drainage: Bureau of Land Management, Technical Note 409 (http://www.blm.gov/nstc/library/techno2.htm).

Ford, K.L., and Walker, M. 2003. Abandoned Mine Waste Repositories: Site Selection, Design, and Cost: Bureau of Land Management, Technical Note 410 (http://www.blm.gov/nstc/library/techno2.htm).

Forest Service, 1990. Mt. Baker-Snoqualmie National Forest, Land and Resource Management Plan.

Forest Service, 2002. Abbreviated Preliminary Assessment - Monte Cristo Concentrator, Mt. Baker-Snoqualmie National Forest, Snohomish County, Washington. October 2002.

Forest Service, 2003. Abbreviated Preliminary Assessment - Mystery Mine, Mt. Baker-Snoqualmie National Forest, Snohomish County, Washington. February 2003.

Forest Service, 2006a. Abbreviated Preliminary Assessment – Sidney Mine in the Monte Cristo Mining District, Mt. Baker-Snoqualmie National Forest, Snohomish County, Washington. September 2006.

Forest Service, 2006b. Abbreviated Preliminary Assessment - Pride of Woods, New Discovery, and Pride of Mountains Mines in the Monte Cristo Mining District, Mt. Baker-Snoqualmie National Forest, Snohomish County, Washington. September 2006.

Hodges, L.K., 1897. Mining in the Pacific Northwest. Seattle Post Intelligencer. 192 p.

Huntting, M.T., 1956. Inventory of Washington Minerals: Part II- Metallic Minerals. Washington Division of Mines and Geology. Bulletin 37, Part II, 2v.

Johanson, 2009. Written Communication. October 29, 2009

Johnson, F.L., Denton, D.K., Iverson, S.R., McCulloch, R.B., Stebbins, S.A., and Stotelmeyer, R.B., 1983a. Mineral Resources and potential of the Glacier Peak RARE II Area (No. L 6031), Snohomish County, Washington, U.S. Bureau of Mines, unpublished report. 547 p.

Johnson, F.L., Denton, D.K., Iverson, S.R., McCulloch, R.B., Stebbins, S.A., and Stotelmeyer, R.B., 1983b. Summary Report – Mineral Resources of the Glacier Peak RARE II Area (No. L 6031), Snohomish County, Washington. U.S. Bureau of Mines, MLA 75-83.

Johnson, F.L., Denton, D.K., Iverson, S.R., McCulloch, R.B., Stebbins, S.A., and Stotelmeyer, R.B., 1985. Mines and prospects map of the Glacier Peak Roadless Area, Snohomish County, Washington. U.S. Geological Survey Miscellaneous Field Studies Map MF-1380-E.

Millennium Science & Engineering, Inc. (MSE), 2008. Engineering Evaluation/Cost Analysis, Sunset Mine and Millsite, Mount Baker-Snoqualmie National Forest, Washington.

NOAA, 2008. National Oceanic and Atmospheric Administration - Screening Quick Reference Tables (SQuiRTs), November 2008.

Northwest Underground Explorations, 1997. Discovering Washington's Historic Mines, Volume 1: The West Central Cascade Mountains. Oso Publishing. Arlington, WA. 230 p. (http://www.geocities.com/nwue/site/index.html)

Orr, E.L., and Orr, W.N., 2002. Geology of the Pacific Northwest. McGraw-Hill Higher Education. New York, New York. 337 p.

Raforth, R.L., Norman, D.K., and Johnson, Art, 2002. *Second Screening Investigation of Water and Sediment Quality of Creeks in Ten Washington Mining Districts, with Emphasis on Metals*. Washington State Department of Ecology Publication No. 02-03-024, June 2002.

Spurr, J.E., 1901. Ore Deposits of Monte Cristo, Washington. U.S. Geological Survey 22nd Annual Report, Part II, Ore Deposits. p 777-865.

Spurr, J.E., 1908. Mr. Spurr's Change of Heart. Northwest Mining Journal, v. 5. no. 5. p. 82.

USEPA, 1993. Guidance on Conducting Non-Tine-Critical Removal Actions Under CERCLA. EPA Publication 9360.0-32, Office of Emergency and Remedial Response. Washington, D.C.

USEPA, 1997. Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments, Interim Final. Environmental Response Team. Edison, New Jersey.

USEPA, 1999. *Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities.* Solid Waste and Emergency Response. EPA530-D-99-001C. Table E-1, Page E-13.

USEPA, 2009a. *EPA Region 9 Preliminary Remediation Goals.* Online document available at URL: http://www.epa.gov/region09/waste/sfund/prg/whatsnew.htm. December 2009.

USEPA, 2009b. National Recommended Water Quality Criteria. Online document available at URL: http://www.epa.gov/waterscience/criteria/wqctable/ December 2009.

USFW, 1995. *National Wetlands Inventory*.

USGS, 1991. Geologic Map of Washington, U.S. Geological Survey, Reston, VA.

Westby, G.C., 1939. The Peabody-Knowlton properties, Monte Cristo Mining District, State of Washington. Bear Creek Mining Company unpublished report. 10 p. 1 map.

Wolff, F.E., McKay, Jr., D.T., and Norman, D.K., 2003. Inactive And Abandoned Mine Lands – Mystery and Justice Mines, Monte Cristo Mining District, Snohomish County, Washington. Washington Department of Natural Resources, Division of Geology and Earth Resources, Open file Report 2003-7, p. 22. April 2003.

Woodhouse, P.R., 1979. Monte Cristo. The Mountaineers, Seattle, Washington, 307 p.

WRCCa, 2006. Period of Record Monthly Climate Summary for Scenic (Station 457379) Washington, Period of Record 6/1/1948 to 7/25/1970. Western Regional Climate Center. http://wrcc.dri.edu.

WRCCb, 2006. Period of Record Monthly Climate Summary for Stevens Pass (Station 458089) Washington, Period of Record 10/26/1950 to 4/30/1994. Western Regional Climate Center. http://wrcc.dri.edu.