FINAL
EXPANDED ENGINEERING EVALUATION/ COST ANALYSIS FOR THE HIGHLAND MINE SITE

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1.0 INTRODUCTION

1.1 PURPOSE AND OBJECTIVES

This Expanded Engineering Evaluation/Cost Analysis (EEE/CA) was prepared for the Montana Department of Environmental Quality/Mine Waste Cleanup Bureau (DEQ/MWCB), formerly referred to as the Abandoned Mine Reclamation Bureau, by Pioneer Technical Services, Inc. (Pioneer), under Engineering Services agreement DEQ/AMRB 94-006, Task Order No. 38.

The primary purpose of this report is to present the detailed analysis of reclamation alternatives for the Highland Mine site in accordance with the National Contingency Plan (NCP). Additionally, the site background, waste characteristics, applicable or relevant and appropriate requirements (ARARs), risk assessment, and preliminary development and screening of reclamation alternatives are presented herein. The purpose of providing this supplemental information with the detailed analysis of alternatives is to give the reviewers and risk managers a comprehensive "stand-alone" decision making tool.

The Highland Mine is an abandoned hardrock mine site listed on the DEQ/MWCB Abandoned Hardrock Mine Priority Sites List. The Highland Mine Site (PA No. 47-028) was ranked according to the Abandoned and Inactive Mines Scoring System (AIMSS); the rank was 37 out of 330 ranked sites.

The Highland Mine is located approximately 19 miles south of Butte, Montana, in the Highland Mountain Range. The entire Highland Mine is comprised of eight patented mining claims, including: Main Ripple, J.B. Thompson, Murphy, Purchance, Red Mountain, Main Chance, Only Chance, and Island. The current owners also claim 108 unpatented lode mining claims in the same township. None of these claims are currently active, but several explorations have been conducted in recent years by companies such as: Battle Mountain and Placer Dome (1989-1990); Orvana Resources Corporation; Butte Highlands Mining Company; and ASARCO (1993 and 1994).

The scope of this EEE/CA is to exclusively focus on a reclamation plan for the Main Ripple Claim (MS# 10742). The additional claims mentioned above represent minimal risk to human health and the environment and are also currently undergoing mine exploration; the ranking score (37 out of 330 ranked) was based on the Main Ripple Claim alone. The high ranking is primarily due to the City of Butte water system intake located downstream at the Basin Creek Reservoir.

The Main Ripple Claim is located in Township 1 North, Range 7 West, Section 31 (Figure 1-1) and will be referred to as the Highland Mine site throughout the entire EEE/CA, as it is listed on the DEQ/MWCB Priority Sites List.

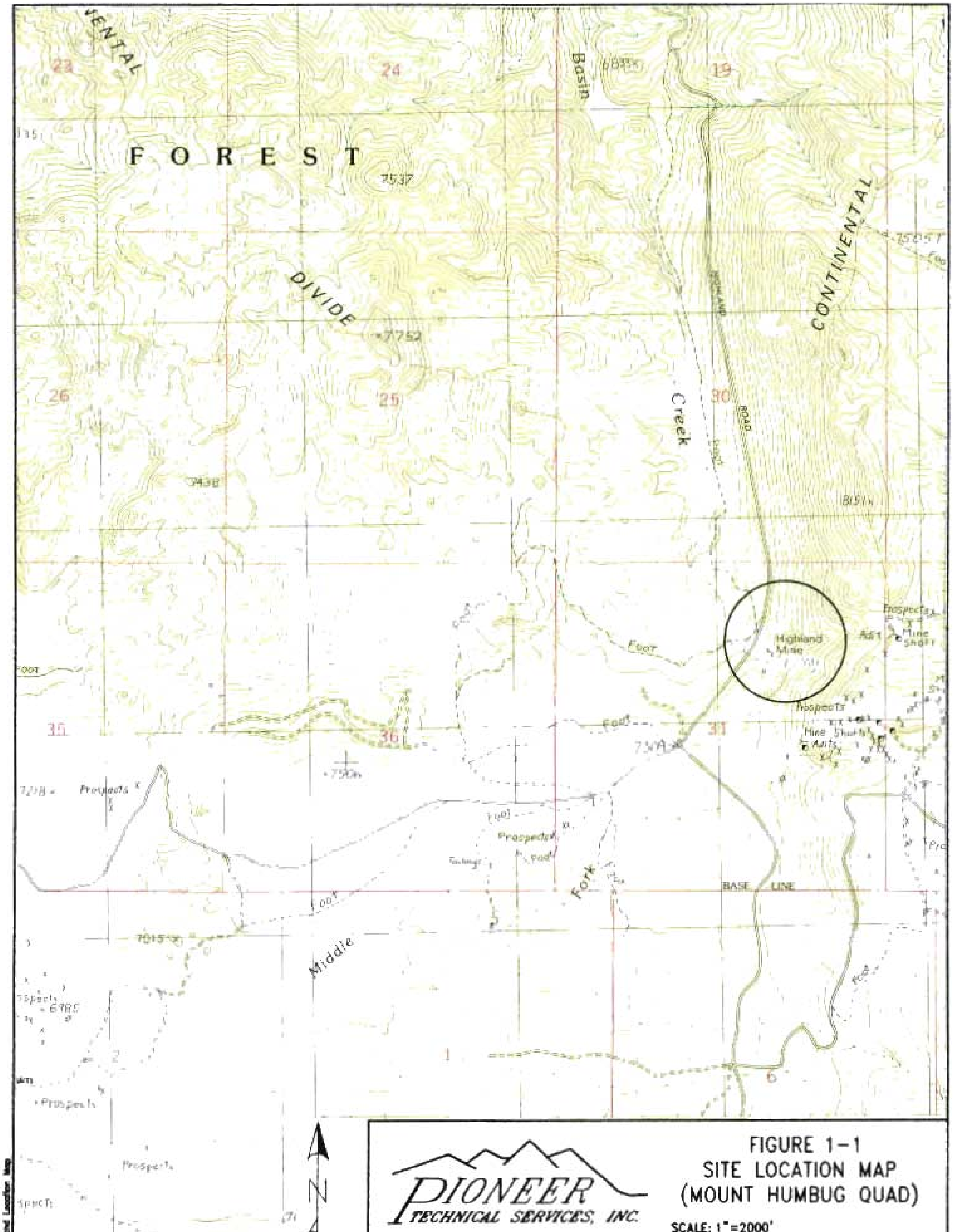

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FIGURE 1–1
SITE LOCATION MAP
(MOUNT HUMBUG QUAD)

SCALE: 1"=2000'
DATE: 3/97

The Highland Mine site is comprised of one waste rock dump (WR1), three tailing piles (TP1 through TP3) and two tailing ponds (TP4 and TP5), one discharging adit, and several collapsed structures. The adit discharge makes up a majority of the Basin Creek headwaters, which is a fraction of the City of Butte's water supply system (Basin Creek Reservoir). The preliminary risk analysis identified the adit discharge (AD1) as the principal source of concern at the site, and surface water as the primary pathway of concern. The volume of the waste rock dump (WR1) is approximately 8,800 cubic yards (cy) and contains arsenic, copper, mercury and iron at concentrations greater than three times background soil concentrations. Tailings were recently discovered at the site during the Reclamation Investigation field study. The tailings consist of three piles along the road (TP1 through TP3), and two tailing ponds west of the road (TP4 and TP5); the volume of tailings is estimated to be 2,000 cy. The tailings contain arsenic, copper, iron, and mercury at concentrations greater than three times background soil concentrations.

1.2 REPORT ORGANIZATION

This EEE/CA is organized into 11 sections. The contents of Sections 2 through 11 are briefly described in the following paragraphs:

SECTION 2.0 BACKGROUND - presents a background description of the Highland Mine site. Significant site features; a detailed history of past mining and milling activities; geologic, hydrologic, and climatic characteristics of the site; the biological setting, such as the wildlife and fisheries resources and the vegetation indigenous to the area; and threatened and endangered species concerns, as well as the cultural setting issues, such as present and future land uses, are described in this section.

SECTION 3.0 WASTE CHARACTERISTICS - describes the characteristics of the wastes present at the site, including waste types, volume estimates, and contaminant concentrations, as well as an evaluation of existing data derived from previous response actions or investigations.

SECTION 4.0 SUMMARY OF THE APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS - presents the Montana State and Federal government requirements which are considered applicable or relevant and appropriate requirements (ARARs) for the reclamation effort. Requirements discussed in this section are chemical-, location-, and action-specific in nature.

SECTION 5.0 SUMMARY OF THE RISK ANALYSIS - presents a summary of the risk analysis performed for the site. Contaminant sources, routes of exposure, and receptors are evaluated to determine the relative threats posed by each source within the project boundary and each exposure pathway.

SECTION 6.0 PRELIMINARY RECLAMATION GOALS - presents the reclamation objectives and applicable clean-up standards. Where appropriate, these objectives specify contaminants of concern (CoCs), media affected, exposure pathways, and preliminary remedial goals (PRGs) for each environmental medium. PRGs are numerical values based on identified chemical-specific ARARs.

SECTION 7.0 DEVELOPMENT AND SCREENING OF RECLAMATION ALTERNATIVES - identifies and screens potentially applicable reclamation alternatives. Reclamation alternatives are evaluated based on effectiveness, implementability, and cost.

SECTION 8.0 DETAILED ANALYSIS OF RECLAMATION ALTERNATIVES - presents the detailed analysis of reclamation alternatives pertaining to the seven NCP evaluation criteria.

SECTION 9.0 COMPARATIVE ANALYSIS OF RECLAMATION ALTERNATIVES - presents a comparative analysis of the reclamation alternatives consistent with the NCP.

SECTION 10.0 PREFERRED ALTERNATIVE - presents the recommended preferred alternative and summarizes the reasoning behind selecting this alternative.

SECTION 11.0 REFERENCES - lists the references cited in the text.

2.0 BACKGROUND

2.1 MINING HISTORY

The Highland Mining District is located south of Butte, Montana, in the Highland Mountains and is comprised of several mining claims located along major drainages. The first gold discovery in the area occurred at the upper end of Fish Creek in July, 1866. Shortly thereafter, mining began in the Upper Basin Creek and Moose Creek Districts. Later, mining districts were formed at Upper Camp Creek, Soap Gulch, and Climax Gulch. By the early 1870's, placer mining had played out and the mining towns were abandoned with the exception of a few prospectors. In 1895, the Butte Water Company (BWC) purchased much of the land and placer claims in the area to control and protect the drainages leading to the new reservoir on Basin Creek (DEQ/MWCB-RTI, 1995).

During the 1930's, the Butte Highlands Mining Company (BHMC) consolidated several older claims, known as the Butte Highlands Mine, and began large-scale mining and milling. The Butte Highlands Mine was comprised of three properties: the Only Chance, Murphy, and J. B. Thompson mines. The properties are located on Nevin Hill, a three-way divide between Fish Creek, Moose Creek, and Basin Creek, in Sections 31 and 32 of Township 1 North, Range 7 West. In more recent years, several other claims were staked, including: Main Ripple, Island, Purchance, Red Mountain, Main Chance, Only Chance (DEQ/MWCB-RTI, 1995).

The BHMC proposed a "Main Tunnel" at the 600-foot level beginning on the Main Ripple Claim, which would under-cut the Murphy and Only Chance Claims, thereby draining them of water. The "Main Tunnel" began approximately 1,000 feet northwest of the Murphy Claim on the Main Ripple Claim and extended over 2,600 feet. When the Main Ripple was patented in 1938, several buildings and structures were located near the adit. These included a frame mill building, a blacksmith shop, a carpenter shop, and six frame buildings of unidentified function (DEQ/MWCB-RTI, 1995).

In December, 1933, the BHMC announced plans to build a mill at the mine. The mill was financed by the sale of 35,000 shares of stock at $0.25 per share; the shares were donated by a stockholder specially for the purpose of building a mill. The 100-ton cyanide mill was built at the head of Basin Creek. In 1936, the mine was forced to close the mill and rebuild in the Moose Creek drainage in order to protect Butte's municipal water supply. The Moose Creek mill was located approximately 1.5 miles southwest of the mine (Middle Fork Millsite, PA No. 47-081; DEQ/MWCB-RTI, 1995).

The Butte Highlands Mine closed in April, 1942, in accordance with Federal Order L-208 because there was not enough quality ore to justify the cost of operating the mill. Production of the Highland Mine between November, 1937, and April, 1942, was over 75,000 tons of ore, valued at $1,225,732.00, giving the mine a net profit of $90,000.00 (DEQ/MWCB, 1995).

In 1993, the Montana Department of State Lands (now the Montana Department of Environmental Quality)/MWCB inventoried the sites for inclusion on the Abandoned Hardrock Mines Priority Sites List; the Highland Mine site scored relatively high using the AIMSS, primarily due to the Butte water system intake located downstream at the Basin Creek Reservoir.

2.2 CLIMATE

Climatological data indicates that the Highland Mine/Basin Creek area is semi-arid and often experiences extreme temperature fluctuations and precipitation events. Weather is influenced by continental weather patterns typically approaching from the west and north-west. During winter months, chinook winds from the south often produce unexpected warmth for periods of time. The region's temperature is generally low and is marked by wide seasonal and daily variations. During winter, the temperature often drops to zero degrees Fahrenheit (°F) with extended periods of temperatures lower than 20°F below zero. During summer, many days are fairly warm, but due to the generally arid climate and elevation (7,300 to 8,000 feet above mean sea level), temperatures decrease rapidly at night.

Precipitation is not abundant in the region (averaging between 20 and 30 inches annually), with most of the annual precipitation falling as snow during winter (100 to 200 inches average annual snowfall). Stormy weather usually brings the first snows during September; however, they are generally succeeded by several weeks of fair weather. By November, the area is usually covered with snow. Heavy snows are frequent in the winter, as are periods of melting and refreezing in spring. The snowpack generally remains in the area for seven months or longer, with spring thaw occurring in May or June. The area is subject to a distinct spring/summer rainy season with May and June usually being the wettest months of the year. On average, May and June each receive 3.0 inches of precipitation. The frost-free period (32°F or more) averages 90 to 100 days annually, from mid-June to mid-August (MAPS, 1995).

2.3 GEOLOGY, HYDROGEOLOGY, AND HYDROLOGY

2.3.1 Regional Setting

The Highland Mine site is located within the Highland (or Fish Creek) Mining District, 19 miles south of Butte, Montana. The site is situated at the headwaters of the main fork of Basin Creek, which flows 3.5 miles north to the Basin Creek Reservoir. The region is dominated by Middle Cambrian sedimentary rocks and late Cretaceous granodiorite (Boulder batholith). There are also Quaternary surficial deposits associated with drainage bottoms which include alluvium, colluvium, and glacial deposits.

2.3.2 Local Geologic Setting

The literature indicates the Highland deposit occurs in the middle Cambrian Meagher dolomite (also identified as the Gallatin and Hasmark formations) adjacent to a border phase of the quartz monzonite of the Boulder batholith (later reclassified as granodiorite). Also present locally are the Cambrian Pilgrim dolomite and a phyllitic unit, believed to be the Cambrian Park shale (now known as Wolsey Shale). The mineralization is described as a replacement deposit in fractured dolomitic limestone along the crest of a steeply plunging fold in the Meagher dolomite. Mineralization consists of quartz and pyrite with a small amount of galena, sphalerite, and chalcopyrite. Fine-grained gold occurs in the oxidized zone of the pyritic ore body. Quaternary alluvium is present north and west of the mine area in the Basin Creek drainage.

2.3.3 Hydrogeologic Setting

No published hydrogeologic information specific to this area is readily available. The conclusions regarding hydrogeologic conditions are, therefore, based on accepted hydrologic and geologic principals and local observations. The Highland Mine is located within the main fork of the Basin Creek groundwater basin. This basin eventually drains into the Silver Bow Creek (Summit valley) basin.

The hydrogeologic system contains two components: the fractured Cambrian, mostly dolomitic sedimentary bedrock, and the Quaternary alluvium valley fill. The bedrock is moderately fractured and contains secondary solution and dolomitization features. The solution of carbonate minerals from the host rock and the dolomitization process has caused many secondary groundwater flow pathways to be created, and reprecipitation of carbonate minerals has also sealed off groundwater flow pathways within the bedrock system. Due to the complex and unpredictable nature of this secondary mineralization, it is likely that the rate and direction of groundwater flow is widely variable over short distances. Prediction of the permeability and transmissivity of the bedrock aquifer system is not possible. The alluvial deposits are thin, shallow, and discontinuous and likely transmit both surface water from local streams and discharging bedrock groundwater.

Groundwater is present in the Highland Mine area at a shallow depth, evidenced by the discharging adit and several springs in the mine area. Groundwater flow likely follows local stream gradients and topography, with groundwater discharging to gaining alluvial streams, which is typical of high mountain drainage systems. Local bedrock fault systems and secondary solution/precipitation features probably exert significant control on the direction and rate of groundwater flow, as do the underground workings associated with the mines in the area.

2.3.4 Surface Water Hydrology

The majority of the flow in the headwaters of Basin Creek is derived from the adit discharge at the Highland Mine site. The adit, previously known as the "Main Tunnel", discharges water south, then west, away from the site into the Basin Creek drainage (which flows north approximately 0.5 mile from the discharge point). Marsh lands develop approximately 300 feet below the site and continue for approximately 1 mile downstream, several small tributaries feed the marsh area. Another major tributary does not join the Basin Creek drainage until 2.25 miles north of the site. The Basin Creek drainage enters the lower Basin Creek reservoir 3.5 miles north (downstream) of the site.

During the September, 1993 DEQ/MWCB Hazardous Materials Inventory documented the adit flow at 100 gallons per minute (gpm; DEQ/MWCB-Pioneer, 1993), whereas, tests conducted in October, 1995, show a flow rate of 135 gpm. According to the May 23,1996, Reclamation Investigation, the flow from the adit was measured at an average of 176 gpm. This demonstrates that different seasons and climatological events will modify the flow of the adit discharge.

The Basin Creek drainage is one of two drainage systems that have been developed as watersheds for the City of Butte water supply. The Basin Creek drainage is the primary drainage, and is approximately 7,700 acres in area and ranges between 5,800 and 8,000 feet in elevation. The Continental Divide borders approximately two-thirds of the Basin Creek drainage, which includes several tributaries. Water from the Basin Creek drainage was once stored in the upper and lower reservoirs. The upper reservoir is now breached and no longer provides storage. The lower reservoir has an approximate capacity of 360 million gallons. Statistical analysis performed on weir measurements made by BWC staff since 1946, indicates an average monthly flow of 2.12 million gallons per day (mgd) from the Basin Creek drainage into the reservoir, indicating that the adit discharge contributes up to 8 percent of the reservoir's inflow. Water is released from the reservoir as needed to supplement the Big Hole River/Moulton Reservoir water supply (BWC, 1990).

Basin Creek is a cold water fishery, supporting Brook and Rainbow Trout. The creek is rated as a Class 4 fishery, which considers habitat, fish species, and recreational fishing use. The DEQ/Water Quality Bureau (WQB) has classified the Basin Creek drainage and the Basin Creek Reservoir, south of Butte, as A-Closed. Waters classified A-Closed (ARM 16.20.616) are suitable for drinking and culinary and food processing purposes after simple disinfection. Classification of the waters flowing between the Basin Creek Reservoir and Silver Bow Creek, south of Butte, is B-1. Waters classified as B-1 (ARM 16.20.618) are suitable for drinking and culinary and food processing purposes after conventional treatment. The creek supports bathing, swimming and recreation; growth and propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.

2.4 CURRENT SITE SETTING

2.4.1 Location and Topography

The entire Highland Mine site is located approximately 19 miles south of Butte, in Silver Bow County, Montana. The legal description of the Highland Mine site is Township 1 North, Range 7 West, NE¼ of the SW¼ of the NE¼ of Section 31; the NE¼ of the SE¼ of Section 31; the S½ of the NW¼ of Section 32; and the N½ of the SW¼ of Section 32. The site is comprised of eight patented mining claims within and bordered by lands administered by the U.S. Department of Agriculture/Deerlodge National Forest, Butte Ranger District (USFS). The elevation of the site ranges between 7,300 and 8,000 feet above mean sea level. The entire Highland Mine site resides on both the east and west sides of the Continental Divide; however, this EEE/CA concentrates on the Main Ripple Claim, located in Section 31 on the west side of the Continental Divide at the headwaters of Basin Creek. The Main Ripple Claim is referred to as the Highland Mine in this EEE/CA.

The site is easily accessible, located approximately 8 miles off of Highway 2 on the Roosevelt Drive/Moose Creek Road. Terrain surrounding this area is generally rugged and consists of 6.2% North facing slopes and 10.9% East facings slopes. Mining-related features associated with the Highland Mine include one waste rock dump, three tailing piles, two tailing ponds, one discharging adit, and several collapsed wooden structures.

2.4.2 Vegetation/Wildlife

The Highland Mine is located on a timbered subalpine slope. The site is capable of supporting an *Abies lasiocarpa / Menzesia ferruginea* plant association. The current dominant vegetation is listed in Appendix A. No sensitive, threatened, or endangered species of plants have been found or are known to exist in the study area. Spotted Knapweed does exist in the area; therefore, extra precaution will have to be taken during reclamation activities to not spread this noxious weed.

In general, the area is fairly continuously forested and is important habitat for a variety of big game animals, fur bearers, and birds. Basin Creek is ingress limited, but some fishing is allowed. Brook Trout are the most common fish species.

2.4.3 Historic or Archaeologically Significant Features

An initial Cultural Resource Inventory was completed for the Highland Mine and Millsite by Renewable Technologies, Inc. (RTI), in January, 1997 (DEQ/MWCB-RTI, 1997). The inventory states:

> "The Highland Mine and Millsite has been assessed for its eligibility for listing in the National Register of Historic Places. It has been determined that although it derives significance under Criterion A as one of the major gold-mining operations in the Highland Mining District, the site has lost integrity due to the extreme decay or near-complete destruction of most of the former buildings and structures. The site also lacks archaeological integrity, as it contains insufficient physical remains to answer important research questions about mining community. Due to the lack of integrity, the Highland Mine and Millsite is not recommended eligible for listing in the National register as either an independent site, historic district or cultural landscape district.
>
> In addition, the Highland Mine and Millsite (24SB589) also cannot be considered a contributing element to the Highland Mining Historic District (24SB187). Although GCM Services Inc. (Moore and Fredlund 1988), found the physical remains at the site to

be extensive and recommended that they could contribute to the district, RTI's intensive field inventory determined that the site lacked sufficient integrity of design and materials to convey its important association as the one of the district's major gold-mining operations."

2.4.4 Land Use and Population

The City of Butte is located close to the Highland Mountains, which draw many recreationalists into the area. The Highland Mine itself is located along the main access route through the Highland Mountains and is subject to many recreational activities, including: hunting, hiking, four wheeler and motor bike riding, horseback riding, and cross country skiing. Automobile traffic is estimated to be heavy in late spring, summer, and fall, with little to no usage in the winter and early spring. During the winter and early spring, the roads are closed when snow cover is deep or the road is excessively wet and muddy.

An estimated 30 to 100 residents live within a 4-mile radius of the mine; the closest resident is approximately 2.5 miles northeast of the site.

3.0 WASTE CHARACTERISTICS

The Reclamation Investigation field activities conducted at the Highland Mine on May 23, 1996, focussed on collecting sufficient data to perform a human health and ecological risk assessment, as well as a detailed analysis of reclamation alternatives. Data required to support the risk assessment include the following:

- characterize heavy metal concentrations both vertically and laterally in each mine waste source, and isolating the 0 to 6 inch depth zone for direct contact and wind erosion (air release) exposure evaluation;
- establish background soil concentrations with multiple background samples;
- evaluate the physical and chemical properties of the source materials that may effect contaminant migration, including: pH, buffering capacity, organic carbon content, and particle size distribution;
- characterize groundwater, if groundwater is encountered at any of the proposed test pit locations; and
- characterize impacts to surface water (Basin Creek) with regularly spaced surface water and corresponding stream sediment samples located upstream, adjacent to, and downstream from the site.

Data required to support the detailed analysis of reclamation alternatives (Feasibility Study) include the following:

- accurate areas and volumes of the contaminant sources (waste rock dump and mill tailings);
- contaminant concentration variations and leaching characteristics of the wastes (Toxicity Characteristic Leaching Procedure [TCLP], porosity, hydraulic conductivity, pH);
- revegetation parameters for the waste rock dump and cover soil sources including: liming requirements, soil texture and particle size, fertilizer recommendation, organic matter content, and identification of suitable native plant species; and
- characteristics of the adit discharge (flow rate and physical and chemical properties).

The field activities were designed to efficiently collect the appropriate data that can be utilized for evaluating each of the reclamation alternatives proposed for the Highland Mine site.

The field activities included collecting solid-matrix waste samples for in-the-field analyses (total metals via X-ray Fluorescence [XRF] spectrometer), as well as collecting samples for multiple laboratory analyses. Discrete subsamples for XRF analyses were collected from the 0- to 6-inch depth range from the waste sources to evaluate the air pathway risk, as well as the direct contact risk. The XRF results were also used to make logical decisions for compositing certain subsamples for laboratory analyses (and possibly decrease the number of samples requiring laboratory analysis). The XRF results are presented in Table B-1 (Appendix B).

The following subsections specifically address the field activities conducted at the site. Each environmental medium (background soil, solid media waste sources, adit discharge, and surface water) is discussed individually and includes sample locations and descriptions, rationale for compositing certain subsamples for laboratory analyses, any deviation from the sampling plan, and analytical results.

3.1 BACKGROUND SAMPLES

A total of five background samples were collected in the vicinity of the Highland Mine, three from the ridge above the site and two adjacent to the mine. Table 3-1 briefly describes the location of each background sample; Table B-2 (Appendix B) contains the analytical results. Refer to the report entitled *1996 Data Validation and Evaluation Report* (Pioneer, 1996) for discussions regarding XRF and laboratory data quality and validation results for the metals data obtained for this project.

3.2 MINE WASTE SOURCES

The following sections discuss each individual mine waste source present at the Highland Mine site. Figure 3-1 shows the location of each waste source, illustrates the major site features (topography, roads, waste sources, surface water, etc.), and indicates the location of each sample collected at the site during the reclamation investigation field activities.

3.2.1 Waste Rock Dump #1

Waste rock dump #1 (WR1) is the only waste rock dump associated with the Highland site. The dump is located approximately 100 feet east of the main Highland Road and adjacent to Basin Creek, approximately 7,340 feet above mean sea level. Sediments from the dump are being transported into Basin Creek by the adit discharge that traverses the dumps southern end. The dump is easily accessed by a road which branches off of the main USFS road and travels directly toward it from the west. Vegetation is abundant on the surface of WR1, and the dump is quite steep.

Seven test pits were excavated on the dump for sampling purposes. The test pits were excavated through the dump material as far as the excavater bucket would reach or to underlying soil, whichever came first. Disposable scoops were used to collect discrete soil samples. The

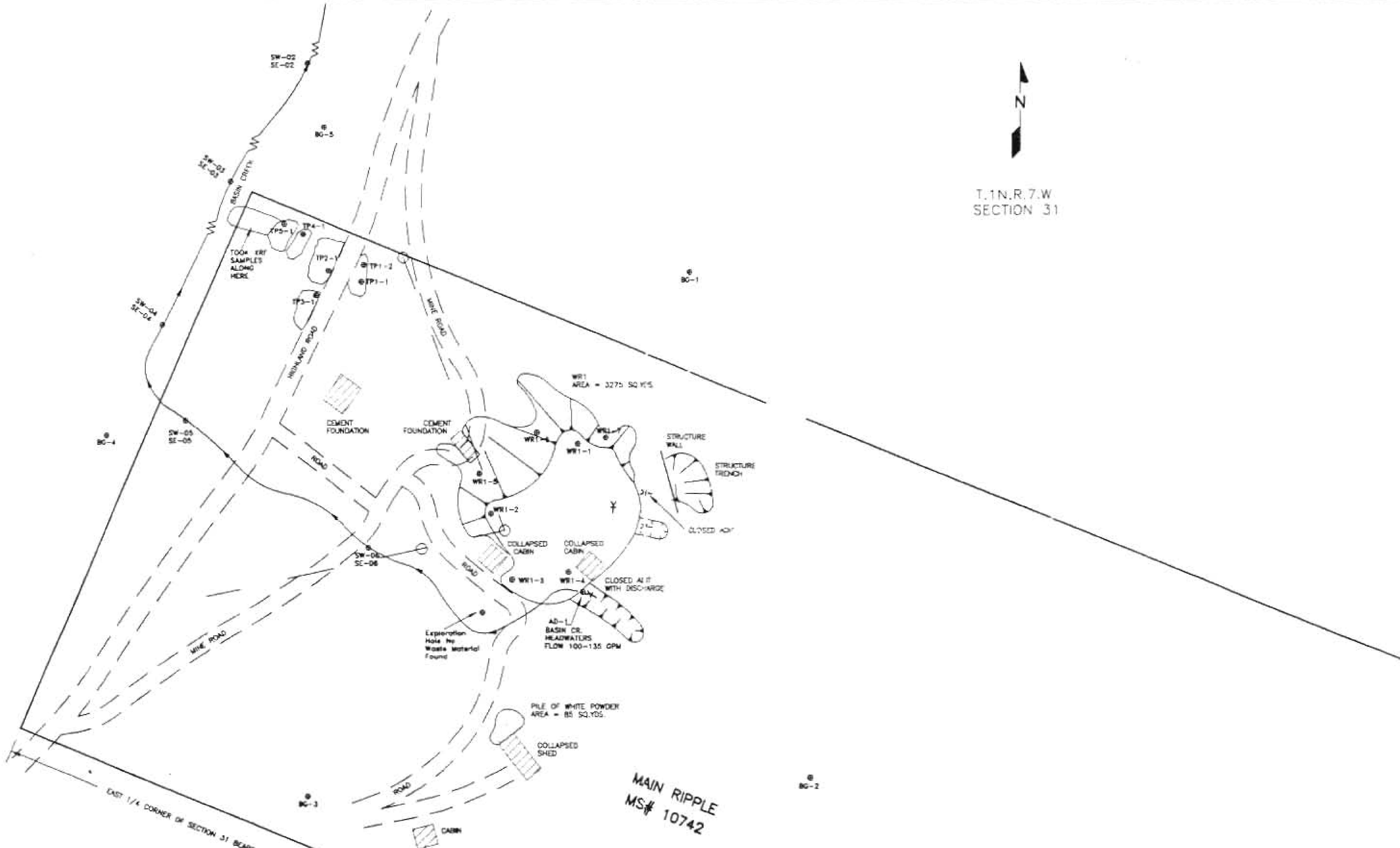

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FIGURE 3-1
RI Sample Locations
HIGHLAND MINE

SCALE: 1"=30'
DATE: 5/96

TABLE 3-1: HIGHLAND MINE (47-028) SOURCE SAMPLING SUMMARY

SOURCE	SAMPLE NO.	SAMPLE DEPTH (feet)	DESCRIPTION	pH	RADIOACTIVITY (mR/hr)	XRF	TAL	ABA	TCLP	CYANIDE	AGRONOMIC	PHYSICAL
BACKGROUND SOIL	47-028-BG1	0.0 - 0.2	Background sample collected 300 ft. NE of site on topsoil/forest duff				Table B-2					
	47-028-BG2	0.0 - 0.2	Background sample collected 450 ft. SE of site B Horizon material				Table B-2					
	47-028-BG3	0.0 - 0.2	Background sample collected 250 ft. SW of site below road cut.				Table B-2					
	47-028-BG4	0.0 - 0.2	Background sample collected 1000 ft. NW of site just above creek				Table B-2					
	47-028-BG5	0.0 - 0.2	Background sample collected 450 ft. south of site approx. 200 ft. south of creek				Table B-2					
WR-1	47-028-WR1-1	0.0 - 8.5	Upper North end of Dump	6.8	0.040	Table B-1		Table B-4			Table B-5	Table B-6
	47-028-WR1-2	0.0 - 8.0	Upper Center of Dump	6.4	0.040	Table B-1		Table B-4			Table B-5	Table B-6
	47-028-WR1-3	0.0 - 7.0	Upper South end of Dump	6.9	0.035	Table B-1		Table B-4			Table B-5	Table B-6
	47-028-WR1-4	0.0-5.0	Upper southern end of Dump	6.6	0.04	Table B-1		Table B-4			Table B-5	Table B-6
	47-028-WR1-5	0.0-4.0	Lower South end of Dump	6	0.04	Table B-1						
	47-028-WR1-6	0.0-4.0	Lower Center of Dump	6.4	0.045	Table B-1						
	47-028-WR1-7	0.0 - 5.0	Lower Northen end of Dump	6.9	0.046	Table B-1		Table B-4			Table B-5	Table B-6
	47-028-WR1-C1	Composite	Composite of WR1-1 thru WR1-7, 0" - 0.6"				Table B-2					
	47-028-WR1-C2	Composite	Composite of WR1-1A and WR1-1B				Table B-2		Table B-3			
	47-028-WR1-C3	Composite	Composite of WR1-2 thru WR1-7				Table B-2		Table B-3			
TAILINGS	47-028-TP1-1	0.0 - 3.0	On East side of road, orange silt and sand	6.2	0.025	Table B-1						
	47-028-TP1-2	0.0-3.0	East side of road, orange silt and sand	6.2	0.020	Table B-1						
	47-0228TP2-1	0.0-3.5	West side of road, orange silt and sand	5.6	0.025	Table B-1						
	47-028-TP3-1	0.0-3.5	West side of road orange silt and sand	6	0.020	Table B-1						
	47-028-TP4-1	0.0-4.5	West side of road, approx. 70 feet, orange silt and sand (Tails pond 1)	5.8	0.020	Table B-1						
	47-028-TP5-1	0.0-4.0	West side of road, approx. 100 feet, orange silt and sand (Tailings pond 2)	5	0.030	Table B-1						
	47-028-TP1-C	Composite	Composite of TP1-1, TP1-2, TP2-1 and TP3-1				Table B-2	Table B-4	Table B-3	Table B-2	Table B-5	Table B-6
	47-028-TP2-C	Composite	Composite of TP4-1 and TP5-1				Table B-2	Table B-4	Table B-3	Table B-2	Table B-5	Table B-6

samples were collected from the 0 to 6 inches layer, and from 6 inches to the underlying soil at various depth intervals. Soils were collected for total metals, TCLP, acid-base accounting (ABA), and physical and agronomic properties. The samples were not sieved, but coarse materials larger than approximately 3/4-inch in diameter were selectively removed from the sample. The samples consisted mostly of intermixed orange/brown sand.

Bulk samples were collected from the entire depth of each borehole and placed in labeled gallon size ziplock bags; the bagged samples were thoroughly mixed. Sample No. 47-028-WR1-1, Sample No. 47-028-WR1-2, Sample No. 47-028-WR1-3, and Sample No. WR1-4 were collected from the upper northern, center, and southern locations of the dump, respectively. Sample No. 47-028-WR1-5, Sample No. 47-028-WR1-6, and Sample No. 47-028 were collected on the lower northern, center, and southern locations of the dump, respectively; Sample No. 47-028-WR1-7 was collected on the northwestern side of dump (Figure 3-1). Discrete samples were collected from each bag for XRF analysis. The composite samples 47-028-WR1-C1, 47-028-WR1-C2, and 47-028-WR1-C3 were analyzed for TCLP and total metals; the remaining soil from each excavated hole was analyzed for ABA, agronomic properties, and physical properties; Tables B-3, B-4, B-5, and B-6 (Appendix B) list the analytical results.

The volume of WR1 has been estimated at 8,800 cy. Table B-2 (Appendix B) presents the metals data obtained for WR1; the concentrations of the following metals are significantly elevated above background (>3X) in the dump: arsenic, copper, and mercury. Refer to the *1996 Validation and Evaluation Report* (Pioneer, 1996) for discussion regarding XRF and laboratory data quality and validation results for the metals data obtained for this project.

The ABA results obtained for WR1 indicate a significant neutralization potential coupled with a very low sulfur content in the waste; consequently, the dump is not considered a potential acid producer. However, one particular area of the dump (approximately 0.17 acre in the northeast section) shows a significant amount of acidic soils that will require an estimated 135 tons of lime per acre to neutralize the rooting zone to successfully establish vegetation. The remaining soil within the dump will not require lime addition. The lowest pH of the dump material is 6.0; many state regulatory programs consider pH levels less than 5.5 as unsuitable for plant growth. Organic amendment of the dump surface is advised due to the low organic carbon content (1.8%). In addition to providing temporary stabilization of the disturbed erodible surfaces, application of wheat or barley straw mulch would provide the necessary organic material to help promote successful revegetation.

Fertilizer recommendation analyses provided the following results for WR1: 55 pounds nitrogen required per acre; 35 pounds phosphorus required per acre; and 50 pounds potassium required per acre. Using an approximate total disturbed surface area of 0.68 acre for WR1 (and surrounding area), a 530 pound mixture of fertilizer consisting of 245 pounds urea (45% N), 125 pounds phosphorus pentoxide (45% P), and 160 pounds potassium oxide (60% K) would provide optimum nutrient concentrations for establishing vegetation directly on the surface of WR1.

Mine wastes such as those associated with the Highland Mine are specifically excluded from regulation under the Resource Conservation Recovery Act (RCRA) through the Bevill Amendment to the Act. TCLP analysis were conducted on numerous waste sources at the site to evaluate the potential toxicity associated with these sources and to determine the relevance of RCRA hazardous waste requirements which would otherwise pertain to the mine waste. Waste samples from WR1 passed the TCLP analyses; hence, the material does not demonstrate hazardous properties as described under RCRA.

3.2.2 Tailings Piles 1, 2, and 3

Tailings piles one, two, and three (TP1, TP2, and TP3) are located approximately 150 feet west of WR1. These piles are approximately 300 feet north of Basin Creek at its closest point, and adjacent to the USFS Road (# 84). The elevation of the piles is approximately 7,220 feet above mean sea level, which is approximately 60 feet higher in elevation than Basin Creek. These three piles encompass a relatively small area, and are approximately five feet deep at the deepest point. Vegetation is well established on approximately 90% of the surface of these tailings piles.

Soil auger boreholes were excavated through each tailings pile to accurately determine the depth of the tailings, as well as characterize possible physical and chemical changes in the material at varying depths. Borehole TP1-1 was augered on the southeast side of the easternmost pile (east of road), and borehole TP1-2 was augered near the northern end of the same pile. Borehole TP2-1 was augered on the southeast side of the northwest pile (west of road), and borehole TP3-1 was augered near the northeast end of the southwest pile (west of road). The locations of the boreholes are indicated on Figure 3-1; Table 3-1 indicates the depth of the boreholes and gives a brief description of the observed stratigraphy. The tailings piles consisted mostly of orange silt and sand.

The subsamples from TP1, TP2, and TP3 were composited (47-028-TP1-C) and analyzed for total metals, cyanide, TCLP metals, ABA, agronomic properties, and physical properties to assess revegetation characteristics; the results are discussed in Section 3.2.4 (Composite Tailings). The volume of TP1, TP2, and TP3 has been estimated at 1,200 cy. Table B-2 (Appendix B) presents the metals data obtained for composite tailings samples.

3.2.3 Tailings Ponds 4 and 5

Tailings ponds 4 and 5 (TP4 and TP5) are constructed tailings impoundments located approximately 350 feet west of WR1. These ponds are approximately 300 feet east of Basin Creek at its closest point. The elevation of the ponds' surface is approximately 7,200 feet above mean sea level, which is approximately 40 feet higher in elevation than Basin Creek. These two ponds differ from the other tailings deposits at the Highland Mine in that they encompass a smaller area, are slightly shallower (less than 4 feet deep at the deepest point), and represent a smaller volume (800 cy) than the upper tailings piles (TP1, TP2 and TP3). Dense vegetation of

Lodgepole Pine has been established on TP4; TP5 does not harbor any vegetation due to heavy downfall on the surface of the pond.

Soil auger boreholes were excavated through both TP4 and TP5 to accurately determine the depth of the tailings, as well as to characterize possible physical and chemical changes in the material at varying depths. Borehole TP4-1 was augered on the north side of the eastern pond, and borehole TP5-1 was augered near the northwest end of the western impoundment. The location of each borehole is indicated on Figure 3-1; Table 3-1 indicates the depth of the boreholes and gives a brief description of the observed stratigraphy. The tailings contained in TP4 and TP5 consisted mostly of orange silt and sand.

The subsamples from TP4 and TP5 were composited (47-028-TP2-C) and analyzed for total metals, cyanide, TCLP metals, ABA, agronomic properties, and physical properties to assess revegetation characteristics; the results are discussed in Section 3.2.4 (Composite Tailings). The volume of TP4 and TP5 has been estimated at 800 cy. Table B-2 (Appendix B) presents the metals data obtained for composite tailings samples.

3.2.4 Composite Tailings

Sample No. 47-028-TP1-C is a composite of the three tailings piles near the road (TP1, TP2, and TP3), and Sample No. 47-028-TP2-C is a composite of the two tailings ponds (TP4 and TP5) located west of the road and closer to Basin Creek. The total volume of tailings at the Highland site has been estimated at 2,000 cy. Table B-2 (Appendix B) presents the metals data for the composite tailings samples. The concentrations of the following metals are significantly elevated above background (>3X) in the tailings: arsenic, copper, iron, and mercury. Refer to the *1996 Validation and Evaluation Report* (Pioneer, 1996) for discussion regarding XRF and laboratory data quality and validation results for the metals data obtained for this project.

Samples from tailing composites pass TCLP analyses; hence, the material does not demonstrate hazardous properties as described under RCRA.

The ABA results obtained for tailings indicate a significant neutralization potential coupled with a very low sulfur content in the waste; consequently, the tailings are not considered a potential acid producer. The lowest pH of the tailings material was 5.0; many state regulatory programs consider pH levels less than 5.5 as unsuitable for plant growth. Consequently some limited lime amendment will be necessary to neutralize the pH. Organic amendment of the tailings surface is advised due to the low organic carbon content (1.8%). In addition to providing temporary stabilization of the disturbed erodible surfaces, application of wheat or barley straw mulch would provide the necessary organic material to help promote successful revegetation.

Fertilizer recommendation analyses provided the following results for the TP1 through TP5: 60 pounds nitrogen required per acre; 40 pounds phosphorus required per acre; and 30 pounds potassium required per acre. Using an approximate total disturbed surface area of 0.63 acre for

TP1 through TP5 (and surrounding area), a 530 pound mixture of fertilizer consisting of 245 pounds urea (45% N), 125 pounds phosphorus pentoxide (45% P), and 160 pounds potassium oxide (60% K) would provide optimum nutrient concentrations for establishing vegetation directly on the surface of the tailings.

3.2.5 Source Comparison

Six discrete sources were originally characterized at the Highland Mine site, including five tailings deposits and one waste rock dump; samples from the five tailings deposits were composited into two samples for laboratory analysis, and three discrete analyses were performed on the waste rock material. The sources were compared to one another to ascertain whether characteristic elements or suites of elements were uniquely associated with any one source at the site. This analysis assists in the determination of effects due to specific contaminant sources(s) at the site. Surface water impacts are especially important, so measured effects to surface water (or stream sediments) may be evident due to unique mineralogy and/or transport phenomena, such that impacts due to specific source(s) may be qualitatively assessed. Obviously, the sources at the Highland site have a similar suite of contaminants due to the nature of the ore materials mined and milled there; however, the relative magnitude of contaminant concentrations varies between the sources. Table 3-2 lists each source, the relatively high concentrations found in that source, and any contaminants that may be useful to uniquely identify that source in surface water. This identification also considers the sources location relative to each other and to the surface water receptor.

TABLE 3-2: HIGHLAND SOURCE CHARACTERISTICS

SOURCE	HIGH CONCENTRATION ELEMENTS	UNIQUE SUITE
TP1, 2, 3	As, Cu, Hg, Fe	Fe
TP4, TP5	As, Cu, Hg, Fe	Fe, Hg
WR1	As, Cu, Hg	

The metals data indicate that few differences exist between the sources. The tailings and waste rock dump have similar contaminant suites and can only be distinguished from one another by the relatively higher concentration of iron in the tailings.

3.3 SURFACE WATER

During the field reclamation investigation, surface water and paired stream sediment samples were collected from Basin Creek downstream and adjacent to the Highland site. Table 3-3 briefly describes the sample locations and presents stream flow data and field parameter results

TABLE 3-3
HIGHLAND MINE
SURFACE WATER SAMPLES

SAMPLE NO.	DESCRIPTION	pH	S.C. (umhos/cm)	ALKALINITY (mg CaCO3/L)	TEMP. (C)	FLOW (ft^3/sec)
47-028-AD-1	Adit discharge point .	7.42	378	191	4.60	0.29
47-028-SW-6 47-028-SE-6	In Basin Creek, 150 ft. from the adit discharge point.	7.20	374	194	4.20	0.25
47-028-SW-5 47-028SE-5	In Basin Creek, on opposite side of Highland Road.	7.56	374	192	4.60	0.23
47-028-SW-4 47-028-SE-4	In Basin Creek, 250 ft. downstream from Highland Road.	7.97	372	189	3.90	0.37
47-028-SW-3 47-028-SE-3	In Basin Creek, 500 ft. downstream from Highland Road.	7.82	373	199	3.90	0.31
47-028-SW-2 47-028-SE-2	In Basin Creek, 750 feet downstream from Hiighland Road, Beginning of Wetlands.	7.73	387	195	3.80	0.29
47-028-SW-1 47-028-SE-1	In Basin Creek, 1 mile downstream opposite side of Wetlands area.	6.40	193	102	2.90	0.56

for the surface water samples collected at the Highland site. Figure 3-1 illustrates the sample locations.

Only the surface water data collected during the May 23, 1996, field reclamation investigation are used for this evaluation.

Surface water data collected during the field reclamation investigation includes seven stations along Basin Creek, including the adit discharge (47-028-SW/SE1 through SW/SE6 and AD1/SE7). Water analyses included the target analyte list (TAL) for: total metals, total recoverable metals, dissolved metals (adit discharge only). Other measurements included: field parameters (pH, SC, temperature, alkalinity, discharge), and wet chemistry (sulfate, total dissolved solids [TDS], hardness). Sediment analyses included TAL for total metals only. All reclamation investigation surface water and sediment data are located in Tables B-2, B-7, and B-8 (Appendix B).

Metals concentrations in surface water samples were mostly below their respective detection limits. Exceptions to this include: total metals analysis for As (7 of 7 detected), Ba (7 of 7), Cd (1 of 7), Fe (7 of 7), Hg (4 of 7), Mn (7 of 7), Pb (1 of 7), Sb (4 of 7), and Zn (2 of 7); total recoverable metals analysis for As (7 of 7 detected), Ba (7 of 7), Cu (4 of 7), Fe (7 of 7), Hg (5 of 7), Mn (4 of 7), Ti (1 of 7), Sb (4 of 7), and Zn (6 of 7); and dissolved metals in the adit discharge for As, Ba, Cd, Mn, Hg, Sb, and Ti. Locations of those analytes detected above their respective detection limit, though limited in number, may assist in identifying sources of contaminants to Basin Creek and transport mechanisms.

Increases in Hg and Fe concentrations at SW5 and elevated Hg at stations SW4 and SW3 could be caused by waste rock entrainment. Increases of several metals at station SW1 (As, Fe, Hg, Mn, Pb) are probably due to the influence of the wetlands with the lower pH releasing some metals.

No Federal Maximum Contaminant Levels (MCLs) established by U.S. Environmental Protection Agency (EPA) were exceeded in Basin Creek. Montana Human Health Standards (HSSs; DEQ/WQB, 1995) were exceeded for Hg at stations SW5, SW4, SW3, and SW1 and for Fe at station SW1.

No acute water quality criteria were exceeded at the site; however, the chronic water quality criteria was exceeded for Hg at stations SW5 through SW1 in the total recoverable metals analysis. The chronic Hg criteria (0.012) is less than the detection limit for Hg at other stations and analyses that are below detection may also exceed this criteria.

Field parameters and wet chemistry results were relatively constant across all stations (Table 3-5) except for a slight decrease in pH, alkalinity, and specific conductivity at SW1. These changes are likely due to the influence of the wetlands upstream of this station.

Metals concentrations in streambed sediments at station SE6 are elevated for As, Cu, Fe, Hg, Mn, Pb, and Zn. These metals decrease abruptly downstream at station SE5 (except Pb). Concentrations of Cu, Hg, and Zn then increase at SE4, adjacent to the tailings deposits (TP4 and TP5). Metals concentrations decrease downstream until the last station (SW1 below the wetlands) where As, Fe, and Zn increase.

Surface water discharge was measured at each sampling station along Basin Creek. Increases and decreases in discharge (Q) were observed (Table 3-3), indicating that exchanges of water occur between the alluvial aquifer and the creek and influxes of surface water (SW1). Changes in discharge of more than 5% should be considered significant and within the measurement accuracy of the flow instrument.

3.4 PREVIOUS TESTING

Table 3-4 presents analytical results compiled during the 1993 and 1995 investigations. The 1995 analytical results indicate that the adit discharge contains no elevated levels of any analyte as compared to MCLs, HHSs, and acute or chronic aquatic life standards. The waste rock at the Highland Mine contains arsenic, copper, mercury, and iron at concentrations greater than three times background soil concentrations. Below the site, the water in Basin Creek contains elevated mercury (above the chronic aquatic life standard). Additionally, sediment sampling conducted in Basin Creek below the site indicated elevated zinc in downstream sediments compared to background zinc (no upstream sample). The few elevated metals are likely entering the surface water system as suspended sediment from the physical transport of fine-grained mineralized waste rock as the discharge flows through the dump. The discharge flows directly into Basin Creek after flowing over/through a portion of the waste rock dump.

TABLE 3-4
ADIT DISCHARGE DATA FOR HIGHLAND SITE (µg/L)

	Highland GW1 (1993)		Highland GW1 (1995)	
	Standard	Data	Standard	Data
Sb-MCL	6	<31.7*	6	<2.7
As-HHS	18	1.88	18	2.9
As-Acute	360	1.88	360	2.9
As-Chronic	190	1.88	190	2.9
Cd-MCL	5	<4.59	5	<0.05
Cd-Acute	9.1	<4.59	8.6	<0.05
Cd-Chronic	2.04	<4.59*	1.96	<0.05
Cu-HHS	1000	<2.33	1000	<4.4
Cu-Acute	35.8	<2.33	34.2	<4.4
Cu-Chronic	22.4	<2.33	21.5	<4.4
Fe-HHS	300	116	300	70.5
Fe-Chronic	1000	116	1000	70.5
Pb-HHS	15	1.12	15	0.74
Pb-Acute	211	1.12	190	0.74
Pb-Chronic	8.23	1.12	7.74	0.74
Mn-HHS	50	10	50	9.3
Hg-HHS	0.14	<0.12	0.14	<0.16*
Hg-Acute	2.4	<0.12	2.4	<0.16
Hg-Chronic	0.012	<0.12*	0.012	<0.16*
Ag-Acute	14.7	NM	13.5	0.88
Zn-MCL	5000	<8.7	5000	<7.6
Zn-Acute	220	<8.7	211	<7.6
Zn-Chronic	200	<8.7	190	<7.6

Data that exceeds (bolded) a standard, or may exceed (*) a standard because the standard is below the detection limit.

4.0 SUMMARY OF THE APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

Section 121(d)(2) of the CERCLA, 42 United States Code (USC) § 9621(d)(2), requires that clean-up actions conducted under CERCLA achieve a level or standard of control which at least attains "any standard, requirement, criteria, or limitation under any Federal environmental law or any [more stringent] promulgated standard, requirement, criteria or limitation under a State environmental or facility siting law... [which] is legally applicable to the hazardous substance concerned or is relevant and appropriate under the circumstances of the release of such hazardous substance or pollutant, or contaminant..." The standards, requirements, criteria, or limitations identified pursuant to this section are commonly referred to as "applicable or relevant and appropriate requirements (ARARs)."

Two general types of clean-up actions are recognized under CERCLA: removal actions and remedial actions. A removal action is an action to abate, prevent, minimize, stabilize, mitigate, or eliminate a release or threat of release. This action is often temporarily taken to alleviate the most acute threats or to prevent further spread of contamination until more comprehensive action can be taken. A remedial action is a thorough investigation, evaluation of alternatives, and determination and implementation of a comprehensive and fully protective remedy for the site.

ARARs may be either "applicable" or "relevant and appropriate" to remedial activities at a site but not both. Applicable requirements are those standards, requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site. A remedial action must satisfy all the jurisdictional prerequisites of a requirement for it to be applicable to the specific remedial action at a CERCLA site.

Relevant and appropriate requirements are those standards, requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that, while not "applicable" to hazardous substances, pollutants, contaminants, remedial actions, locations, or other circumstances at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site. Factors which may be considered in making this determination, when the factors are pertinent, are presented in 40 Code of Federal Regulations (CFR) § 300.400(g)(2). They include, among other considerations, examination of the purpose of the requirement and of the CERCLA action, the medium and substances regulated by the requirement and at the CERCLA site, the actions or activities regulated by the requirement and the remedial action contemplated at the site, and the potential use of resources affected by the requirement and the use or potential use of the affected resource at the CERCLA site.

ARARs are divided into contaminant-specific, location-specific, and action-specific requirements. Contaminant-specific requirements govern the release of materials possessing certain chemical or physical characteristics or containing specific chemical compounds into the environment. Contaminant-specific ARARs generally set human or environmental risk-based criteria and protocol which, when applied to site-specific conditions, result in the establishment of numerical action values. These values establish the acceptable amount or concentration of a chemical that may be found in, or discharged to, the ambient environment.

Location-specific ARARs relate to the geographic or physical position of the site, rather than to the nature of site contaminants. These ARARs place restrictions on the concentration of hazardous substances or the conduct of clean-up activities due to their location in the environment.

Action-specific ARARs are usually technology- or activity-based requirements or are limitations on actions taken with respect to hazardous substances. A particular remedial activity will trigger an action-specific ARAR. Unlike chemical- and location-specific ARARs, action-specific ARARs do not, in themselves, determine the remedial alternative. Rather, action-specific ARARs indicate how the selected remedy must be achieved.

Non-promulgated advisories or guidance documents issued by federal or state governments do not have the status of potential ARARs. However, these advisories and guidance documents are "To Be Considered (TBC)" when determining protective clean-up levels. The TBC category consists of advisories, criteria, or guidance that were developed by the EPA, other federal agencies, or states that may be useful in developing CERCLA remedies. These categories may be considered as appropriate in selecting and developing clean-up actions.

As provided by Section 121 of CERCLA, 42 USC § 9621, only those state standards that are more stringent than any federal standard and that have been identified by the State in a timely manner are appropriately included as ARARs. Some state standards that are potentially duplicative of federal standards are identified here to ensure their timely identification and consideration in the event that they are not identified or retained in the federal ARARs. Duplicative or less stringent standards will be deleted as appropriate when the final determination of ARARs is presented.

CERCLA defines only federal environmental laws and state environmental or facility siting laws as ARARs. Remedial design, implementation, and operation and maintenance must, nevertheless, comply with all other applicable laws, both state and federal. Many such laws, while not strictly environmental or facility siting laws, have environmental impacts. Moreover, applicable laws that are not ARARs because they are not environmental or facility siting laws are not subject to the ARAR waiver provisions, and the administrative, as well as the substantive, provisions of such laws must be observed. A separate list attached to the state ARARs' list is a non-comprehensive identification of other state law requirements, which must be observed during remedial design, remedy implementation, operation, or maintenance.

Appendix D provides detailed descriptions of potential Federal and State ARARs. The description of the Federal and State ARARs that follows includes summaries of legal requirements that in many cases attempt to set out the requirement in a simple fashion useful in evaluating compliance with the requirement. In the event of any inconsistency between the law itself and the summaries in this section, the ARAR is ultimately the requirement as set out in the law, rather than any paraphrase provided here. Table 4-1 presents the potential federal ARARs for the Highland site. Potential state ARARs are presented in Table 4-2.

TABLE 4-1

SUMMARY OF FEDERAL PRELIMINARY APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

STANDARD, REQUIREMENT CRITERIA, OR LIMITATION	CITATION	DESCRIPTION	APPLICABLE/RELEVANT AND APPROPRIATE?
CONTAMINANT-SPECIFIC			
Safe Drinking Water Act	40 USC § 300		Relevant and Appropriate
National Primary Drinking Water Regulations	40 CFR Part 141	Establishes health-based standards for public water systems (maximum contaminant levels).	Relevant and Appropriate
National Secondary Drinking Water Regulations	40 CFR Part 143	Establishes aesthetic standards for public water systems (secondary maximum contaminant levels).	Relevant and Appropriate
Water Pollution Prevention and Control Act	33 USC § 1251-1387		Relevant and Appropriate
Water Quality Regulations	40 CFR Part 131 Quality Criteria for Water 1976, 1980, 1986	Sets criteria for water quality based on toxicity to aquatic organisms and human health.	Relevant and Appropriate
National Pollutant Discharge Elimination System (NPDES)	40 CFR Part 122	General permits for discharge from construction.	Relevant and Appropriate
Clean Air Act	42 USC § 7409		
National Primary and Secondary Ambient Air Quality Standards	40 CFR Part 50	Air quality levels that protect public health.	Applicable
Resource Conservation and Recovery Act			
Lists of Hazardous Wastes	40 CFR Part 261, Subpart D	Defines those solid wastes which are subject to regulation as hazardous wastes under 40 CFR Parts 262-265 and Parts 124, 270, and 271.	Applicable
ACTION-SPECIFIC			
Clean Water Act	33 USC § 1342		Relevant and Appropriate
NPDES	40 CFR Part 122	Requires permits for the discharge of pollutants from any point source into waters of the United States.	Relevant and Appropriate

TABLE 4-1 (Cont'd)

SUMMARY OF FEDERAL PRELIMINARY APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

Surface Mining Control and Reclamation Act	30 USC §§ 1201-1328	Protects the environment from effects of surface mining activities.	Relevant and Appropriate
	30 CFR Part 784	Governs underground mining permit applications and minimum requirements for reclamation and operations plans.	Relevant and Appropriate
	30 CFR Part 816	Outlines permanent program performance standards for surface mining activities	Relevant and Appropriate
Hazardous Materials Transportation Regulations	49 USC §§ 1801-1813		Relevant and Appropriate
Standards Applicable to Transporters of Hazardous Waste	40 CFR Part 263	Regulates transportation of hazardous waste.	Relevant and Appropriate
Resource Conservation and Recovery Act			
Land Disposal	40 CFR Part 268	Establishes a timetable for restriction of burial of wastes and other hazardous materials.	
Criteria for Classification of Solid Waste Disposal Facilities and Practices	40 CFR Part 257	Establishes criteria for use in determining which solid waste disposal facilities and practices pose a reasonable probability of adverse effects on health or the environment and thereby constitute prohibited open dumps.	Applicable
Standards Applicable to Transporters of Hazardous Waste	40 CFR Part 263	Establishes standards which apply to persons transporting hazardous waste within the U.S. if the transportation requires a manifest under 40 CFR Part 262.	Applicable
Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities	40 CFR Part 264	Establishes minimum national standards which define the acceptable management of hazardous waste for owners and operators of facilities which treat, store, or dispose of hazardous waste.	Applicable

TABLE 4-1 (Cont'd)

SUMMARY OF FEDERAL PRELIMINARY APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

LOCATION-SPECIFIC			
National Historic Preservation Act	16 USC § 470; 36 CFR Part 800; 40 CFR 6.310(b)	Requires Federal Agencies to take into account the effect of any Federally-assisted undertaking or licensing on any district, site, building, structure, or object that is included in or eligible for inclusion in the National Register of Historic Places and to minimize harm to any National Historic Landmark adversely or directly effected by an under taking.	Applicable
Archeological and Historic Preservation Act	16 USC § 469; 40 CFR § 6.301(c)	Establishes procedures to provide for preservation of historical and archeological data which might be destroyed through alteration of terrain as a result of a Federal construction project or a Federally licensed activity or program.	Applicable
Protection of Wetlands Order	40 CFR Part 6, Appendix A, Executive Order No. 11,990	Avoid adverse impacts associated with the destruction or loss of wetlands and avoid support of new construction in wetlands if a practicable alternative exists.	Applicable
Historic Sites, Buildings and Antiquities Act Appendix A, Executive Order No. 11, 990	16 USC §§ 461-467; 40 CFR § 6.301(a)	Requires Federal agencies to consider the existence and location of landmarks on the National Registry of Natural Landmarks to avoid undesirable impacts on such landmarks.	Applicable
Fish and Wildlife Coordination Act	16 USC § 2901-2912; 40 CFR 6.302(g)	Requires consultation when Federal department or agency proposes or authorizes any modification of any stream or other water body and adequate provision for protection of fish and wildlife resources.	Applicable

TABLE 4-1 (Cont'd)

SUMMARY OF FEDERAL PRELIMINARY APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

Floodplain Management Order	40 CFR Part 6	Requires Federal agencies to evaluate the potential effects of actions they may take in a floodplain to avoid the adverse impacts associated with direct and indirect development of a floodplain.	Applicable
Endangered Species Act of 1973	16 USC §§ 1531-1543; 40 CFR 6.302(h); 50 CFR Part 402	Activities may not jeopardize the continued existence of any threatened or endangered species or destroy or adversely modify a critical habitat.	Applicable
Bald Eagle Protection Act	16 USC §§ 668	Requires consultation with the USFWS during reclamation design and reclamation construction to ensure that any cleanup of the site does not unnecessarily adversely affect the Bald Eagle or Golden Eagle.	Applicable
Migratory Bird Treaty Act	16 USC § 703	Establishes a federal responsibility for the protection of the international migratory bird resource and requires consultation with the USFWS during reclamation design and reclamation construction to ensure the cleanup of the site does not unnecessarily impact migratory birds. Specific mitigative measures may be identified for compliance with this requirement.	Applicable

TABLE 4-2

SUMMARY OF STATE PRELIMINARY APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

STANDARD, REQUIREMENT CRITERIA, OR LIMITATION	CITATION	DESCRIPTION	APPLICABLE/RELEVANT AND APPROPRIATE?
CONTAMINANT-SPECIFIC			
Montana Water Quality Act	75-5-101 et seq., MCA	Laws to prevent, abate, and control the pollution of state waters.	Applicable
Regulations Establishing Ambient Surface Water Quality Standards	ARM 16.20.604-624	Provides the water use classification for various streams and imposes specific water quality standards per classification.	Applicable
Regulations Establishing Ambient Surface Water Quality Nondegradation Standards	ARM 16.20.708-714	Applies nondegradation requirements to any activity which could cause a new or increased source of pollution to state waters and outlines review procedures.	Applicable
Regulations Establishing Waste Treatment Standards	ARM 16.20.631-633	Imposes waste treatment requirements to restore and maintain the quality of surface water to applicable water use categories. Treatment standards are based on the State's policy of nondegradation, and present and anticipated beneficial uses of the receiving waters.	Applicable
	ARM 16.20.925	Technology-based treatment for MPDES permits.	Applicable
Public Water Supplies Act	75-6-101, MCA	Establishes applicable public policy of Montana to "protect, maintain, and improve the quality and potability of water for public water supplies and domestic uses."	
Public Water Supplies Regulations	ARM 16.20.204	Establishes the maximum contaminant levels ("MCL's") for inorganic chemicals in community water systems.	Relevant and Appropriate
	ARM 16.20.205	Establishes the maximum turbidity contaminant levels for public water supply systems which use surface water in whole or in part.	Relevant and Appropriate
	ARM 16.20.922	Adopts and incorporates language for toxic pollutant effluent standards found in 40 CFR Part 129.	Relevant and Appropriate
	ARM 16.20.923	Adopts and incorporates language for effluent limitations and standards of performance found in 40 CFR Subpart N (except 40 CFR Part 403).	Relevant and Appropriate

TABLE 4-2 (Cont'd)

SUMMARY OF STATE PRELIMINARY APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

Montana Water Use Act			
Montana Groundwater Pollution Control System Regulations	ARM 16.20.1011	Requires that any groundwater whose existing quality is higher than the standard for its classification must be maintained at that high quality unless degradation is allowed under the principles established in 75-3-303, MCA, and the nondegradation rules at ARM 16.20.706 et.seq.	Applicable
	ARM 16.20.1002	Classifies groundwater into Classes I through IV based on the present and future most beneficial uses of the groundwater, and states that groundwater is to be classified to actual quality or actual use, which ever places the groundwater in a higher class.	Applicable
	ARM 16.20.1003	Establishes the groundwater quality standards for groundwater classification, and should be consulted.	Applicable
Clean Air Act of Montana	75-2-102, MCA	It's Montana's policy to achieve and maintain such levels of air quality as will protect human health and safety and, to the greatest degree practicable, prevent injury to plant and animal life and property, foster the comfort and convenience of the people, promote the economic and social development of this state, and facilitate the enjoyment of the natural attractions of the State.	
Air Quality Regulations	ARM 16.8.815	No person shall cause or contribute to concentrations of lead in the ambient air which exceed the following 90-day average: 1.5 micrograms per cubic meter of air.	Applicable
	ARM 16.8.818	No person shall cause or contribute to concentrations of particulate matter in the ambient air such that the mass of settled particulate matter exceeds the following 30-day average: 10 grams per square meter.	Applicable
	ARM 16.8.821	No person may cause or contribute to concentrations of PM-10 (particulate matter that is 10 microns in diameter or smaller) in the ambient air which exceed the following standard: 1) 24-hour average: 150 micrograms per cubic meter of air, with no more than one expected exceedance per calendar year; 2) Annual average: 50 micrograms per cubic meter of air, not to be exceeded.	Applicable

TABLE 4-2 (Cont'd)

SUMMARY OF STATE PRELIMINARY APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

	ARM 16.8.1401	States "no person shall cause or authorize the production, handling, transportation or storage of any material unless reasonable precautions to control emissions of airborne particulate matter are taken."	Applicable
	ARM 16.8.1404	States no person shall cause opacity of 20% over 6 minutes.	Applicable
	ARM 16.8.1424	Sets forth emission standards for hazardous air pollutants.	Applicable
	ARM 26.4.761	Requires a fugitive dust control program be implemented in reclamation operations, and lists specific components of such a program.	Relevant and Appropriate
	ARM 16.8.1302	Lists certain wastes that may not be disposed of by open burning, including oil or petroleum products, RCRA hazardous wastes, chemicals, and treated lumber and timbers.	Relevant and Appropriate
Occupational Health Act of Montana	50-70-101, et seq., MCA	The purpose of this act is to achieve and maintain such conditions of the work place as will protect human health and safety.	Applicable
Occupational Air Contaminants Regulations	ARM 16.42.102	Establishes maximum threshold limit values for air contaminants under which it is believed that nearly all workers may be repeatedly exposed day after day without adverse health effects.	Applicable
Occupational Noise Regulations	ARM 16.42.101	Addresses occupational noise levels and provides that no worker shall be exposed to noise levels in excess of specified levels.	Applicable
		LOCATION-SPECIFIC	
Floodplain and Floodway Management Act	76-5-401, MCA	Lists the uses permissible in a floodway which do not require structures other than portable structures, fill, or permanent storage of materials or equipment.	Applicable
	76-5-402, MCA	Lists the permissible uses within the floodplains but outside of floodway.	Applicable

TABLE 4-2 (Cont'd)

SUMMARY OF STATE PRELIMINARY APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

	76-5-403, MCA	Lists certain uses which are prohibited in a designated floodway, including: any change that will cause water to be diverted from the established floodway, cause erosion, obstruct the natural flow of water, or reduce the carrying capacity of the floodway, or the concentration or permanent storage of an object subject to floatation or movement during flood level periods.	Applicable
Floodplain Management Regulations	ARM 36.15.216	The factors to consider in determining whether a permit should be issued to establish or alter an artificial obstruction or nonconforming use in the floodplain or floodway are set forth in this section.	Applicable
	ARM 36.15.601	Open space uses allowed in the floodway without a permit.	Applicable
	ARM 36.15.602	Permitted uses allowed in the floodway requiring a permit.	Applicable
	ARM 36.15.603	Proposed diversions or changes in place of diversions must be evaluated by the DNRC to determine whether they may significantly affect flood flows and, therefore, require a permit.	Applicable
	ARM 36.15.604	Prohibits new artificial obstructions or nonconforming uses that will increase the upstream elevation of the base flood 0.5 of a foot or significantly increase flood velocities.	Applicable
	ARM 36.15.605	Identifies artificial obstructions and nonconforming uses that are prohibited within the designated floodway except as allowed by permit and includes "a structure or excavation that will cause water to be diverted from the established floodway, cause erosion, obstruct the natural flow of water, or reduce the carrying capacity of the floodway...". Solid waste disposal and storage of highly toxic, flammable, or explosive materials are also prohibited.	Applicable
	ARM 36.15.606	Identifies flood control works that are allowed with designated floodways pursuant to permit and certain conditions including: flood control levies and flood walls, riprap, channelization projects, and dams.	Applicable
	ARM 36.15.701	Describes allowed uses in the flood fringe.	Applicable

TABLE 4-2 (Cont'd)

SUMMARY OF STATE PRELIMINARY APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

	ARM 36.15.703	Prohibited uses within the flood fringe including solid and hazardous waste disposal and storage of toxic, flammable, or explosive materials.	Applicable
	ARM 36.15.801	Allowed uses where the floodway is not designated or where no flood elevations are available.	Applicable
Natural Streambed and Land Preservation Standards	87-5-501, 502, and 504, MCA	Fish and wildlife resources are to be protected and no construction project or hydraulic project shall adversely affect game or fish habitat.	Applicable
	ARM 36.2.404	Proposed projects are to be evaluated by the appropriate conservation district based on criteria, including: 1) whether the project will pass anticipated sediment loads without creating harmful flooding or erosion problems upstream or downstream; 2) whether the project will minimize the amount of stream channel alteration; 3) whether the project will be as permanent a solution as possible and whether the method used will create a reasonably permanent and stable situation; 4) whether the project will minimize effects of fish and aquatic habitat; 5) whether the project will minimize turbidity or other water pollution problems; and, 6) whether the project will minimize adverse effects on the natural beauty of the area.	Applicable
Antiquities Act	22-3-424, MCA	Heritage and paleotological sites are given appropriate consideration.	Relevant and Appropriate
	22-3-433, MCA	Evaluation of environmental impacts include consultation with State Historic Preservation Officer.	Relevant and Appropriate
	22-3-435, MCA	A heritage or paleotological site is to be reported to the State Historic Preservation Officer.	Relevant and Appropriate
Cultural Resource Regulations	ARM 12.8.503-508	Procedures to ensure adequate consideration of cultural values.	Relevant and Appropriate

TABLE 4-2 (Cont'd)

SUMMARY OF STATE PRELIMINARY APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

ACTION-SPECIFIC			
Clean Air Act of Montana	75-2-102, MCA	It's Montana State policy to "achieve and maintain such levels of air quality as well as protect human health and safety and, to the greatest degree practicable, prevent injury to plant and animal life and property, foster the comfort and convenience of the people, promote the economic and social development of this state, and facilitate the enjoyment of the natural attractions of this state."	
Air Quality Requirements	ARM 16.8.815	No person shall cause or contribute to concentrations of lead in the ambient air which exceed the following 90-day average: 1.5 micrograms per cubic meter of air.	Applicable
	ARM 16.8.1302	Lists certain wastes that may not be disposed of by open burning.	Applicable
	ARM 16.8.1401 and 1404	No person shall cause or authorize the production, handling, transportation, or storage of any material unless reasonable precautions to control emissions of airborne particulate matter are taken.	Applicable
Montana Water Quality Act	75-5-605, MCA	Pursuant to this section, it is unlawful among other things to cause pollution of any state waters, to place any wastes in a location where they are likely to cause pollution of any state waters, to violate any permit provision, to violate any provision of the Montana Water Quality Act, to construct, modify, or operate a system for disposing of waste (including sediment, solid waste and other substances that may pollute state waters) which discharge into any state waters without a permit or discharge waste into any state waters.	Applicable
Montana Surface Water Quality Regulations	ARM 16.20.631	Industrial waste must receive treatment equivalent to the best practicable available control technology.	Applicable
	ARM 16.20.604-624	Provides for classification of state waters.	Applicable
	ARM 16.20.925	Technology-based treatment for MPDE permits.	Applicable

TABLE 4-2 (Cont'd)

SUMMARY OF STATE PRELIMINARY APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

	ARM 16.20.633	Requires that the State's surface waters be free from, among other things, substances that will create concentrations or combinations of materials that are harmful to human, animal, plant or aquatic life. Moreover, no waste may be discharged and no activities may be conducted that can reasonably be expected to violate any of the standards.	Applicable
Nondegradation of Water Quality	ARM 16.20.708-714	Applies nondegradation requirements to any activity which could cause a new or increased source of pollution to state waters and outlines review procedures.	Applicable
Montana Groundwater Act			
Montana Groundwater Pollution Control System Regulations	ARM 16.20.1011	Requires that any groundwater whose existing quality is higher than the standard for its classification must be maintained at that high quality in accordance with 75-5-303, MCA, and ARM 16 2.701 et.seq.	Applicable
	ARM 16.20.1002	Classifies groundwater into Classes I through IV based on the present and future most beneficial uses of the groundwater, and states that groundwater is to be classified to actual quality or actual use, which ever places the groundwater in a higher class.	Applicable
	ARM 16.20.1003	Establishes the groundwater quality standards for groundwater classification, and should be consulted.	Applicable
Montana Solid Waste Management Act	75-10-201 et seq, MCA	The Montana Legislature has found that the "health and welfare of Montana citizens are being endangered by improperly operated solid waste management systems and by the improper and unregulated disposal of wastes." Therefore, Montana has declared that it is the State's public policy to "control solid waste management systems to protect the public health and safety and to conserve natural resources whenever possible."	Applicable

TABLE 4-2 (Cont'd)

SUMMARY OF STATE PRELIMINARY APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

Solid Waste Management Regulations	ARM 16.14.505 and 508-509	The standards for solid waste disposal are set forth in this provision and include: preclusion against location of solid waste disposal sites in a 100-year floodplain, a requirement that sites be located only in areas that will prevent the pollution of ground and surface waters and public and private water supplies, a requirement for drainage structures to be installed where necessary to prevent surface runoff from entering disposal areas and a requirement that sites be located to allow for reclamation. The standards also provide the process for applying for a solid waste management system license and operation and maintenance plan requirements.	Applicable
	ARM 16.14.520-521	General operational and maintenance requirements for solid waste management facilities.	Applicable
	ARM 16.14.523	Solid waste must be transported in such a manner as to prevent its discharge, dumping, spilling or leaking from the transport vehicle.	Applicable
Montana Hazardous Waste and Underground Storage Tank Act	75-10-402, MCA	It is the policy of the State to "protect the public health and safety, the health of living organisms, and the environment from the effects of the improper, inadequate, or unsound management of hazardous wastes..."	Applicable
Montana Hazardous Waste Regulations	ARM 17.54.701-705	By reference to federal regulatory requirements, these sections establish the standards for all permitted hazardous waste management facilities. 1) 40 CFR 264.11 (incorporated by reference in ARM 17.54.702) establishes that hazardous waste management facilities must be closed in such a manner as to minimize the need for further maintenance and to control, minimize or eliminate, to the extent necessary to protect public health and the environment, post-closure escape of hazardous wastes, hazardous constituents, leachate, contaminated runoff or hazardous waste decomposition products to the ground or surface waters or to the atmosphere.	Relevant and Applicable

TABLE 4-2 (Cont'd)

SUMMARY OF STATE PRELIMINARY APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

		2) 40 CFR 264.228(a) (incorporated by reference by ARM 17.54.702) requires that at closure, free liquids must be removed or solidified, the wastes stabilized and the waste management unit covered. 3) 40 CFR 264.228 and 310 (incorporated by reference by ARM 17.54.702) requires that surface impoundments and landfill caps must: (a) provide long-term minimization of migration of liquids through the unit; (b) function with minimum maintenance; (c) promote drainage and minimize erosion or abrasion of the final cover; (d) accommodate settling and subsidence; and (e) have a permeability less than or equal to the permeability of the natural subsoils present. 4) 40 CFR 264.119 (incorporated by reference in ARM 17.54.702) requires that, no later than 60 days after certification of closure of each hazardous waste disposal unit, the owner or operator submit a record of the type, location, and quantity of hazardous waste disposed of in each unit. The regulation also gives time limits for recording a deed restriction, in accordance with state law, that will, in perpetuity, notify potential purchasers that the property has been used for waste disposal and that its use is restricted.	
	ARM 17.54.111-119	Establishes permit conditions, duration of permits, schedules of compliance, and requirements for recording and reporting.	
	ARM 17.54.130-131	Establishes contents of a permit application.	
Montana Strip and Underground Mine Reclamation Act	82-4-231, MCA	Operators shall reclaim and revegetate the land affected by his operation as rapidly, completely, and effectively as the most modern technology and the state of the art will allow. The operator must prepare and carry out a method of operation plan to grade, backfill, topsoil, reduce highwalls, stabilize subsidence, control water, and reclaim the land. In so doing, all measures must be taken to eliminate damage from soil erosion, subsidence, land slides, water pollution, and hazards dangerous to life and property. This section contains specific reclamation objectives and should be consulted.	Relevant and Appropriate

TABLE 4-2 (Cont'd)

SUMMARY OF STATE PRELIMINARY APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

	82-4-233, MCA	Requires that after the operation has been backfilled, graded, topsoiled and approved, the operator "shall prepare the soil and plant such legumes, grasses, shrubs, and trees as are necessary to establish on the regraded areas an all other lands affected a diverse, effective and permanent vegetative cover of the same seasonal variety native to the area of land to be affected and capable of self-regeneration and plant succession at least equal in extent of cover to the natural vegetation of the area..." The vegetative cover must be capable of feeding and withstanding grazing pressure from wildlife and livestock regenerating under natural conditions prevailing at the site and preventing soil erosion.	Relevant and Appropriate
Backfilling and Grading Requirements	ARM 26.4.501	These sections give general backfilling and grading requirements.	Relevant and Appropriate
	ARM 26.4.501A	Final grading requirements.	Relevant and Appropriate
	ARM 26.4.504	Provides that permanent impoundments may be retained under certain circumstances	Relevant and Appropriate
	ARM 26.4.514	Give contouring requirements.	Relevant and Appropriate
	ARM 26.4.519	The operator may be required to monitor settling of regraded areas.	Relevant and Appropriate
	ARM 26.4.520	Spoil materials may be disposed of on-site in accordance with the requirements of this section. This section contains specific requirements for siting, surface runoff, construction of underdrains and revegetation and should be consulted.	Relevant and Appropriate

TABLE 4-2 (Cont'd)

SUMMARY OF STATE PRELIMINARY APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

Hydrology Requirements	ARM 26.4.631	In accordance with this section, reclamation operations must be planned and conducted to minimize disturbance to the prevailing hydrologic balance and to prevent material damage to the prevailing hydrologic balance. Thus, changes in water quality and quantity must be minimized and reclamation practices that will prevent or minimize water pollution should be emphasized. Proper pollution control and minimization practices include but are not limited to stabilizing disturbed areas, diverting runoff, regulating channel velocity of water, achieving quickly germinating and growing stands of temporary vegetation, regulating channel velocity of water, lining drainage channels with proper vegetation, and mulching, selectively placing waste materials in backfill areas..	Relevant and Appropriate
	ARM 26.4.633	Specifies that "all surface drainage from the disturbed area, including disturbed areas that have been graded, seeded, or planted, must be treated by the best technology currently available..." Sediment control must be maintained until the disturbed area has been restored and revegetation requirements have been met.	Relevant and Appropriate
	ARM 26.4.634	Drainage design shall emphasize channel and floodplain premining configuration that blends with the undisturbed drainage system above and below, and will meander naturally, remain in dynamic equilibrium with the system, improve unstable premining condition, provide for floods, provide for long term stability of landscape, and establish a premining diversity of aquatic habitats and riparian vegetation.	Relevant and Appropriate
	ARM 26.4.635-637	Set forth requirements for temporary and permanent diversions.	Relevant and Appropriate
	ARM 26.4.638	Sediment control measures shall be designed using the best technology currently available to prevent additional sediment to streamflows, meet the more stringent of federal or state effluent limitations, and minimize erosion.	Relevant and Appropriate

TABLE 4-2 (Cont'd)

SUMMARY OF STATE PRELIMINARY APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

	ARM 26.4.640	Provides that discharge from sedimentation ponds, permanent and temporary impoundments, and diversions shall be controlled by energy dissipaters, riprap channels, and other devices, where necessary, to reduce erosion, prevent deepening or enlargement of stream channels, and to minimize disturbance of the hydrologic balance.	Relevant and Appropriate
	ARM 26.4.641	Sets forth methods for prevention of drainage from acid-and toxic-forming spoils into ground and surface waters.	Relevant and Appropriate
	ARM 26.4.642	Prohibits permanent impoundments with certain exceptions, and set standards for temporary and permanent impoundments.	Relevant and Appropriate
	ARM 26.4.643-646	Provide for groundwater protection, groundwater recharge protection, and surface and groundwater monitoring.	Relevant and Appropriate
	ARM 26.4.649	Prohibits the discharge, diversion, or infiltration of surface and groundwater into existing underground mine workings.	Relevant and Appropriate
	ARM 26.4.650	All permanent sedimentation ponds, diversions, impoundments, and treatment facilities must be renovated postmining, to meet criteria specified in the design plan. All such temporary structures shall be regraded to the approximate original contour.	Relevant and Appropriate
	ARM 26.4.701-702	Requirements on stockpiling soil.	Relevant and Appropriate
Top Soiling, Revegetation, and Protection of Wildlife and Air Resource Regulations	ARM 26.4.703	Materials other than, or along with, soil for final surfacing of disturbances may be allowed if the resulting medium is at least as capable as soil of supporting the approved vegetation and post-remedial activity land use. Moreover, the medium must be the best available within the area to support vegetation.	Relevant and Appropriate
	ARM 26.4.711	In accordance with this section, "[a] diverse, effective, and permanent vegetative cover of the same seasonal variety and utility as the vegetation native to the area of land to be affected must be established. This vegetative cover must alsobe capable of meeting the criteria set forth in 82-4-233, MCA and must be established on all areas of land affected except on road surfaces and below the low-water line of permanent impoundments that are approved as a part of the postmining land use."	Relevant and Appropriate

TABLE 4-2 (Cont'd)

SUMMARY OF STATE PRELIMINARY APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

	ARM 26.4.713	Specifies that seeding and planting of disturbed areas must be conducted during the "first appropriate period for favorable planting after final seedbed preparation but may not be more that 90 days after soil has been replaced..."	Relevant and Appropriate
	ARM 26.4.714	Pursuant to this section, as soon as practicable, a mulch or cover crop of small grains, grasses or legumes or both must be used on all regraded and resoiled areas to control erosion, promote germination of seeds and increase the moisture retention of the soil until adequate permanent cover is established.	Relevant and Appropriate
	ARM 26.4.716	Establishes the required method of revegetation and provides that introduced species may be substituted for native species as part of an approved plan.	Relevant and Appropriate
	ARM 26.4.717	Whenever tree species are necessary, trees adapted for local site conditions and climate shall be used.	Relevant and Appropriate
	ARM 26.4.718	Soil amendments must be used as necessary to aid in the establishment of permanent vegetative cover. Irrigation, management, fencing, or other measures may also be used after review and approval by the department.	Relevant and Appropriate
	ARM 26.4.719	Livestock grazing on reclaimed land is prohibited until revegetation is established to sustain managed grazing.	Relevant and Appropriate
	ARM 26.4.721	In accordance with this section, rills and gullies may need to be filled, graded or otherwise stabilized and the area reseeded.	Relevant and Appropriate
	ARM 26.4.723	Monitoring of vegetation, soils, and wildlife.	Relevant and Appropriate
	ARM 26.4.724	Success of revegetation shall be measured on the basis of unmined reference areas approved by the agencies. Reference areas shall be established for each native community if found within the area.	Relevant and Appropriate
	ARM 26.4.725	Sets periods of responsibility and evaluation.	Relevant and Appropriate
	ARM 26.4.726	Sets means of measuring productivity.	Relevant and Appropriate
	ARM 26.4.728	Sets requirements for composition of vegetation.	Relevant and Appropriate

TABLE 4-2 (Cont'd)

SUMMARY OF STATE PRELIMINARY APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

	ARM 26.4.730-731	The revegetated area must furnish palatable forage in comparable quantity and quality during the same grazing period as the reference areas. When toxicity to plants or animals is suspected due to the effects of disturbances, the department may require comparative chemical analysis of the plants or animals.	Relevant and Appropriate
	ARM 26.4.733	Sets requirements and measurement standards for trees, shrubs, and half-shrubs.	Relevant and Appropriate
	ARM 26.4.751	Pursuant to this section, required site activities must be conducted so as to avoid or minimize impacts to important fish and wildlife species, including critical habitat and any threatened or endangered species identified at the site.	Relevant and Appropriate

5.0 SUMMARY OF THE RISK ASSESSMENT

5.1 BASELINE HUMAN HEALTH RISK ASSESSMENT

The baseline human health risk assessment performed for the Highland site follows the Federal Reclamation Investigation/Feasibility Study (RI/FS) process for CERCLA (Superfund) sites (EPA, 1988a). The baseline human health risk assessment examines the effects of taking no further reclamation action at the site. This abbreviated assessment involves two steps: hazard identification and risk characterization. These tasks are accomplished by evaluating available data and selecting CoCs, comparing those concentrations to previously derived cleanup goals, and characterizing overall risk by integrating the results of the comparison.

General problems at the Highland site that could impact human health include high concentrations of metals and arsenic in waste materials on-site (mill tailings and waste rock), and elevated concentrations of metals and arsenic in surface water and stream sediments downgradient from the site. The easily accessible waste materials may result in significant health-related consequences to the human population.

5.1.1 Hazard Identification

The initial task of the risk assessment is to select the CoCs at the site to identify those that pose significant potential human health risks. Standard EPA criteria for this selection include: 1) those contaminants that are associated with and are present at the site; 2) contaminants in waste sources with concentrations significantly above background levels; 3) contaminants with at least 20% of the measured concentrations above the detection limit; and 4) contaminants with acceptable QA/QC results applied to the data.

At the Highland site, mill tailings, underlying soils, waste rock, surface water, and stream sediments were analyzed for the TAL of 25 metals; some of the samples were also analyzed for cyanide (the results are presented in Appendix B of this report). Only 4 of the 25 metals analyzed are present at the site at concentrations significantly above background levels, with 20% of the samples detected above the corresponding detection limit; these include: As, Cu, Fe, and Hg. These four metals are selected for detailed evaluation because they are present in significant concentrations in wastes, soils, and stream sediments, and to a lesser extent, in surface water at the site. These contaminants are characteristic of hardrock mining wastes and represent contamination reliably associated with site activities.

5.1.2 Exposure Scenarios

The following section describes the exposure scenarios assumed for the Highland site. The previously derived risk-based cleanup goals were derived using two exposure scenarios, a recreational use scenario and a residential use exposure scenario.

The residential use risk-based concentrations involve residential occupation of the contaminated land with the maximum level of exposure occurring for a child 0-6 years old (soil ingestion route). The resultant risk-based concentrations were derived for this worst-case residential exposure scenario by USEPA Region III (Smith, 1995) and are updated semi-annually. The soil ingestion and dust inhalation exposure routes assumed a surface concentration equal to the average of composited tailings samples collected at the site in 1996. This waste represents material likely to be contacted directly prior to ingestion and most likely to be suspended as dust. The drinking water ingestion route utilized a simple model to predict on-site groundwater concentrations (Appendix C of the *Highland Mine Site Reclamation Investigation Report* includes discussion of the model).

The recreational use risk-based concentrations involve several recreational exposure scenarios occurring on the contaminated land with the maximum level of exposure occurring for either a ATV/motorcycle rider (mill tailings only), a mineral collector/gold panner (waste rock and surface water only), or a fisherman (fish consumption only). The resultant risk-based concentrations were derived for all the recreational user exposure scenarios by the Bureau (TetraTech, 1996). For this site, a high level of recreational use was assigned, based on observations at the site and accessibility. The soil ingestion and dust inhalation exposure routes assumed a surface concentration equal to the average of composited tailings samples collected at the site in 1996. This waste represents material likely to be contacted directly prior to ingestion and most likely to be suspended as dust. The water ingestion routes used surface water concentrations at station SW5 or SW6, downstream from the site for drinking water.

5.1.3 Toxicity Assessment

The toxicity assessment examines the potential for the CoCs to cause adverse effects in exposed individuals and provides an estimate of the dose-response relationship between the extent of exposure to a particular contaminant and adverse effects. Adverse effects include both noncarcinogenic and carcinogenic health effects in humans. Sources of toxicity data include EPA's IRIS, Agency for Toxic Substances and Disease Registry (ATSDR) Toxicological Profiles, Health Effects Assessment Summary Tables (HEAST), and EPA criteria documents. Individual toxicity profiles for each CoC are not presented. Tables 5-1 (residential) and 5-2 (recreational) present the existing risk-based concentrations that were used to characterize risks from exposure to the CoCs for each exposure scenario.

TABLE 5-1
RISK-BASED CONCENTRATIONS FOR CONTAMINANTS OF CONCERN FOR THE RESIDENTIAL SCENARIO (SMITH, 1995)

Contaminant of Concern	Residential Soil Ingestion mg/Kg	Residential Dust Inhalation (soil conc.) mg/Kg	Residential Water Ingestion μg/L
Arsenic	23 0.43 (Carc.)	740,000 380 (Carc.)	11 0.045 (Carc.)
Copper	3,100	NA	1,500
Iron	23,000	NA	NA
Mercury	23	7	11

NA = Not Applicable, concentration is more than unity.
* Used USEPA recommendations, not RBC table, from Smith, 1995.

TABLE 5-2
RISK-BASED CONCENTRATIONS FOR CONTAMINANTS OF CONCERN FOR THE RECREATIONAL SCENARIO (TETRATECH, 1996)

Contaminant of Concern	Recreational Soil Ing./Inh. Waste Rock mg/Kg	Recreational Soil Ing./Inh. Tailings mg/Kg	Recreational Water Ingestion μg/L	Recreational Fish Ingestion (water conc.) μg/L
Arsenic	323 1.4 (Carc.)	569 2.2 (Carc.)	153 0.66 (Carc.)	36.7
Copper	54,200	96,600	18,900	996
Iron	NA	NA	NA	NA
Mercury	440	738	153	0.294

NA = Not Applicable, concentration is more than unity.

5.1.4 Risk Characterization

5.1.4.1 Residential Land Use Scenario

The residential exposure assumptions utilized to estimate contaminant intakes were compared to the risk-based concentrations (Table 5-1). These data were used to calculate resultant human health noncarcinogenic Hazard Quotients (HQ) and carcinogenic risk values for each CoC. The results of the calculations for the residential land use scenario at the Highland site are summarized in Table 5-3.

TABLE 5-3
SUMMARY OF NONCARCINOGENIC HAZARD QUOTIENTS (HQ) AND CARCINOGENIC RISK VALUES FOR THE RESIDENTIAL LAND USE SCENARIO - HIGHLAND SITE

Noncarcinogenic HQ Summary	Soil Ingestion	Water Ingestion	Dust Inhalation	Total
Arsenic	18.4348	0.1409	0.0006	18.5763
Copper	0.5058	0.0000	0.0016	0.5074
Iron	6.1972	0.0000	0.1425	6.3397
Mercury	0.0117	0.0055	0.0386	0.0558
Total HQ - Noncarcinogenic	25.1495	0.1464	0.1832	**25.4791**
Carcinogenic Risk Summary				
Arsenic	9.86E-04	3.44E-05	1.12E-06	1.02E-03
Total Risk - Carcinogenic	9.86E-04	3.44E-05	1.12E-05	1.02E-03

Inspection of the HQs on Table 5-3 yields the following observations. First, HQ values exceed one for the residential land use scenario for two CoCs via one evaluated exposure route; HQ values greater than one indicate the potential for harmful effects by a CoC via the specified pathway(s). Secondly, the arsenic HQ value of 18.43 and the iron HQ of 6.20 via the soil ingestion route comprises the majority of the total noncarcinogenic HQ and this value is much greater than one. The soil ingestion pathway total HQ of 25.15 indicates that this exposure pathway presents the greatest likelihood of adverse human health effects for this scenario and these effects are likely since the HQ is much greater than one.

The lower part of Table 5-3, carcinogenic risk, reveals that this RME to CoCs (only arsenic has an CPF) at the site results in a total carcinogenic risk of 1.02E-03, which exceeds one per million (1.00E-06) exposed individuals by three orders of magnitude. The EPA utilizes this 1.00E-06 value as a point of departure in assessing the need for contaminant cleanup at a particular site. The carcinogenic risk estimates for arsenic of 9.86E-04 via soil ingestion, 3.44E-05 via water ingestion, and 1.12E-06 via dust inhalation are of concern. The primary pathway and CoC is arsenic via soil ingestion, with water ingestion and dust inhalation of arsenic secondary pathways; reclamation alternatives should focus on addressing these exposure pathways.

5.1.4.2 Recreational Land Use Scenario

The recreational exposure assumptions utilized to estimate contaminant intakes were compared to the risk-based concentrations (Table 5-2). These data were used to calculate resultant human health noncarcinogenic HQs and carcinogenic risk values for each CoC. The results of the calculations for the recreational land use scenario at the Highland site are summarized in Table 5-4.

TABLE 5-4
SUMMARY OF NONCARCINOGENIC HAZARD QUOTIENTS (HQ) AND CARCINOGENIC RISK VALUES FOR THE RECREATIONAL LAND USE SCENARIO - HIGHLAND SITE

Noncarcinogenic HQ Summary	Soil Ingestion/ Dust Inhalation	Water/Fish Ingestion	Total
Arsenic	0.7452	0.0845	0.8296
Copper	0.0162	0.0021	0.0183
Iron	0.1425	0.0001	0.1426
Mercury	0.0009	0.6122	0.6131
Total HQ - Noncarcinogenic	0.9048	0.6989	1.6037
Carcinogenic Risk Summary			
Arsenic	1.95E-04	1.96E-05	2.15E-04
Total Risk - Carcinogenic	1.95E-04	1.96E-05	2.15E-04

NC = Not Calculated because no RBC is provided.

Inspection of the HQs on Table 5-4 yields the following observations. First, HQ values do not exceed one for the recreational land use scenario for any individual CoC or any individual exposure route; HQ values greater than one indicate the potential for harmful effects by a CoC via the specified pathway(s). However, the total HQ for the recreational scenario does exceed one, indicating possible harmful effects from cumulative exposures. Secondly, the arsenic HQ value of 0.75 via the soil/dust route and the mercury HQ value of 0.61 comprise the majority of the total noncarcinogenic HQ and although these values are less than one, their cumulative HQ exceeds one. The soil/dust pathway total HQ of 0.90 indicates that this exposure pathway presents the majority of adverse human health effects for this scenario.

The lower part of Table 5-4, carcinogenic risk, reveals that this RME to CoCs (only arsenic has a CPF) at the site results in a total carcinogenic risk of 2.15E-04, which exceeds one per million (1.00E-06) exposed individuals by two orders of magnitude. The EPA utilizes this 1.00E-06 value as a point of departure in assessing the need for contaminant cleanup at a particular site. The carcinogenic risk estimates for arsenic of 1.95E-04 via soil ingestion/dust inhalation and 1.96E-05 via water/fish ingestion are of concern. The primary pathway and CoC is arsenic via soil ingestion/dust inhalation; reclamation alternatives should focus on addressing this exposure pathway.

5.2 ECOLOGICAL RISK ASSESSMENT

5.2.1 Introduction

The ecological risk assessment was performed for the Highland site following Federal RI/FS guidance for CERCLA (Superfund) sites (EPA, 1988a). The key guidance documents used were EPA's Risk Assessment Guidance for Superfund, Volume II, Environmental Evaluation Manual (EPA, 1989b), and Ecological Assessment of Hazardous Waste Sites (EPA, 1989c). The waste materials present at the site pose a potential risk not only to humans, but also to other species that come into contact with them. Due to the sparse and indirect nature of the ecologic data available for the site, this evaluation is intended as a screening-level ecological risk assessment, and the results are of a qualitative nature.

The ecological risk assessment estimates the effects of taking no action at the site and involves four steps: 1) identification of contaminants and ecologic receptors of concern; 2) exposure assessment; 3) ecologic effects assessment; and 4) risk characterization. These four tasks are accomplished by evaluating available data and selecting contaminants, species and exposure routes of concern, estimating exposure point concentrations and intakes, assessing ecologic toxicity of the CoCs, and characterizing overall risk by integrating the results of the toxicity and exposure assessments.

Problems at the Highland site that could impact ecologic receptors include high concentrations of metals and arsenic in waste materials on-site (mill tailings and waste rock), and elevated concentrations of metals and arsenic in surface water and stream sediments downgradient from the site. The easily accessible waste materials may result in significant ecological effects; the objective of this ecological risk assessment are to estimate current and future effects of implementing the no-action alternative at the Highland site.

5.2.2 Contaminants and Receptors of Concern

As in the human health risk assessment, contaminants that are significantly above background concentrations and are associated with the site are retained as CoCs. Only 4 of the 25 metals analyzed are present at the site at concentrations significantly above background levels, with 20% of the samples detected above the corresponding detection limit: As, Cu, Fe, and Hg. These four metals are selected for evaluation because they are present in significant concentrations in wastes, soils, and stream sediments, and to a lesser extent in surface water and groundwater. These contaminants are characteristic of hardrock mining wastes and represent contamination reliably associated with site activities. However, several of these contaminants have no ecologic toxicity data with which to evaluate potential effects.

Three groups of ecologic receptors have been identified as potentially affected by site contamination. The first group of receptors are those associated with Basin Creek downgradient from the Highland site, and include fisheries, aquatic life, and wetlands. These surface water receptors are evaluated using EPA aquatic life criteria, which apply to aquatic organisms only; there are no criteria with which to evaluate wetlands.

The second group of receptors are terrestrial wildlife that may use this area as part of their summer range, including deer and elk. The possibility exists for use by wildlife, both for water and possibly for consuming evaporative salts that can form on the wastes. This poses a potential for contaminant accumulation and subsequent health effects in the wildlife populations that visit the site. The only terrestrial wildlife receptor evaluated are deer which probably represent the highest level of exposure to site contaminants; the effects to deer can be assumed to apply to other wildlife receptors.

The third group of receptors are native terrestrial plant communities, which are notably sparse on many of the waste sources at the Highland site. They are of concern because native vegetation has not become well established on the tailings or the waste rock dumps.

5.2.3 Exposure Assessment

The three exposure scenarios can be semi-quantitatively assessed; however, only the deer ingestion of salts and water scenario involves the calculation of a dose. Both the surface water-aquatic life and plant-phytotoxicity scenarios can be compared directly to existing toxicity standards that apply to the respective environmental media.

5.2.3.1 Surface Water/Sediment - Aquatic Life Scenario

Ecologic exposures via this pathway are threefold: direct exposure of aquatic organisms to surface water concentrations that exceed toxicity thresholds; ingestion of aquatic species (e.g., insects) that have bioaccumulated contaminants to the extent that they are toxic to the predator (e.g., fish); and exposure of aquatic organisms (e.g., fish embryos) to sediment pore water environments that are toxic due to elevated contaminant concentrations in the sediments. Data used for this assessment were collected in Basin Creek during the 1996 Reclamation Investigation (sediment and surface water). Selected water quality and sediment concentration data are presented in Table 5-5.

TABLE 5-5
WATER QUALITY (μg/L) AND SEDIMENT (mg/Kg) DATA

Surface Water Data	As	Cu	Hg	Fe
Basin Ck. maximum downstrm	6.4	9.6	0.25	644
Stream Sediment Data	**As**	**Cu**	**Hg**	**Fe**
Basin Ck. maximum downstrm	163	356	0.37	60,500

5.2.3.2 Deer Ingestion Scenario

The only wildlife salt uptake data available were found in "Elk of North America" as ranging from 1 to 11 pounds in one month for a herd of 50 to 75 elk (USDA, 1995). Using a median exposure (non-conservative) approach, the average salt usage (6 lbs/mo) was divided by the average herd size (63) for an average individual salt uptake of 0.0032 lbs/day, or 0.00144 Kg/day. This intake is modified by the uptake of an additional 50% (0.00072 Kg/day) of non-salt wastes associated with the evaporative salt deposits at the site and then divided in half to account for the lower body weight of deer with respect to elk, for a total uptake of 0.0011 Kg/day. The salts are assumed to have the same concentrations as the surface tailings, since they are solubilized and reprecipitated from minerals near the surface. For the purpose of this calculation, the concentration data used were from sample 47-028-TP2-C. The average deer is assumed to weigh 150 lbs (68 Kg) and consume 10 liters of water per day. The water concentrations of the SW5 or SW6 (higher of the two) were used as the deer drinking water source. Table 5-6 summarizes the data used to estimate the total Deer intake dose.

TABLE 5-6: DEER INTAKE DOSE ESTIMATES

	As	Cu
Wastes & Salt in mg/Kg	530	1,550
Drinking Water in μg/L	3.1	<4.1
Total Intake Dose (mg/Kg-day)	0.0089	0.0249

5.2.3.3 Plant - Phytotoxicity Scenario

This scenario involves the limited ability of various plant species to grow in soils or wastes with high concentrations of site-related contaminants. Table 5-7 summarizes concentrations measured in waste materials on-site during the 1996 Reclamation Investigation.

TABLE 5-7
CONTAMINANT CONCENTRATIONS (mg/Kg) IN SOURCES ON-SITE

Source Material	As	Cu	Hg	Fe
WR1-C1 (surface)	158	458	0.39	61,600
Tailings (TP2-C)	530	1,550	0.40	151,000

5.2.4 Ecological Effects Assessment

The known effects of the site CoCs are available from several literature sources and are not repeated here. No site-specific toxicity tests were performed to support the ecologic risk assessment, either in-situ or at a laboratory. Only existing and proposed toxicity-based criteria and standards were used for this ecological effects assessment.

5.2.4.1 Surface Water/Sediment - Aquatic Life Scenario

Freshwater acute (1-hour average) water quality criteria have been promulgated by EPA for many of the CoCs. Several of these criteria are calculated as a function of water hardness and a few are numerical standards. The numerical water quality standards are presented in Table 5-8 and apply to all surface waters at and downstream from the Highland site Those criteria that are a function of hardness have been calculated for the maximum stations and are presented in Table 5-9; however, since hardness changes downstream from the site, the calculated water quality criteria also change.

TABLE 5-8: NUMERICAL WATER QUALITY CRITERIA

Acute Criteria in μg/L	As	Hg
All stations	360	2.4

TABLE 5-9: HARDNESS-DEPENDENT WATER QUALITY CRITERIA

Acute Criteria	Cu
Basin Ck. minimum downstream	16.1

Presently, EPA has not finalized sediment quality criteria. Proposed sediment criteria for metals currently consist of the Effect Range - Low (ER-L) and Effect Range - Median (ER-M) values generated from the pool of national freshwater and marine sediment toxicity information (Long and Morgan, 1991). The ER-M values are probably most appropriate to use for comparison to Basin Creek sediment data, and are presented on Table 5-10.

TABLE 5-10: SEDIMENT QUALITY CRITERIA (PROPOSED)

Criteria in mg/Kg	As	Cd	Cu	Pb	Zn
Effect Range - Median (ER-M)	85	9	390	110	270

5.2.4.2 Deer Ingestion Scenario

Adverse effects data for test animals were obtained from the Agency for Toxic Substances and Disease Registry toxicological profiles (ATSDR 1991), and from other literature sources (NAS, 1980). The data consist of dose (intake) levels that either cause no adverse effects (NOAELs) and/or the lowest dose observed to cause an adverse effect (LOAELs) in laboratory animals. The use of effects data for alternative species introduces an uncertainty factor to the assessment; however, effects data are not available for the species of concern (deer), so the effects data for laboratory animals (primarily rats) are adjusted only for increased body weight. These data are listed in Table 5-11.

TABLE 5-11
TOXICOLOGICAL EFFECTS LEVELS FOUND IN THE LITERATURE

Dose (mg/Kg-day)	**As**	**Cu**
LOAEL - Rat	6.4	90
Reference:	ATSDR, 1991a, p30	NAS, 1980

LOAEL = Lowest observed adverse effect level.

5.2.4.3 <u>Plant - Phytotoxicity Scenario</u>

Information is available on the phytotoxicity for some of the CoCs (Kabata-Pendias and Pendias, 1989) and these are listed in Table 5-12. The availability of contaminants to plants and the potential for plant toxicity depends on many factors including soil pH, soil texture, nutrients, and plant species.

TABLE 5-12: SUMMARY OF PHYTOTOXIC SOIL CONCENTRATIONS

	As	**Cu**
Concentration Range (mg/Kg, dry wt.)	15-50	60-125

5.2.5 Risk Characterization

This section combines the ecologic exposure estimates and concentrations presented in Section 5.2.3 and the ecologic effects data presented in Section 5.2.4 to provide a screening level estimate of potential adverse ecologic impacts for the three scenarios evaluated. This was accomplished by generating ecologic impact quotients (EQs), analogous to the health HQs calculated for human exposures to noncarcinogens. CoC-specific EQs were generated by dividing the particular intake estimate or concentration by available ecological effect values or concentrations. As with HQs, if EQs are less than one, adverse ecological impacts are not expected at the Highland site.

5.2.5.1 <u>Surface Water/Sediment - Aquatic Life Scenario</u>

For this scenario, surface water concentration data are compared to acute aquatic life criteria. Limitations of this comparison include that the EPA water quality criteria are not species-specific toxicity levels. They represent toxicity to the most sensitive species, which may or may not be present at the Highland site, and toxicity to the most sensitive species may not in itself be a limiting factor for the maintenance of a healthy, viable fishery and/or other aquatic organisms. The results of the EQ calculations for this scenario are presented in Table 5-13.

TABLE 5-13
ECOLOGIC IMPACT QUOTIENTS (EQs) FOR THE SURFACE WATER - AQUATIC LIFE SCENARIO

Criteria / Location	As	Cu	Hg
Acute - Downstream Maximum	0.02	0.29	0.10

Examination of Table 5-13 indicates little potential for aquatic life impacts (acute EQs greater than 1).

Similarly, stream sediment concentration data are compared to proposed sediment quality criteria (Median Effect Range). Limitations of this comparison include that these sediment quality criteria are preliminary and are also not species-specific. They represent sediment toxicity to the most sensitive species, which may or may not be present at the Highland site, and toxicity to the most sensitive species may not in itself be a limiting factor for the maintenance of a healthy, viable fishery and/or other aquatic organisms. The results of these EQ calculations are presented in Table 5-14.

TABLE 5-14
ECOLOGIC IMPACT QUOTIENTS (EQs) FOR THE SEDIMENT - AQUATIC LIFE SCENARIO

	As	Cu
Basin Ck. maximum downstrm	1.92	0.91

Table 5-14 indicates the potential for aquatic life impacts (EQs greater than 1) due to apparent sediment toxicity for As in Basin Creek below the Highland site. The elevated and persistent EQs for arsenic suggest that it has the potential to adversely affect sediment benthos, fish embryos, and/or macroinvertebrate communities. However, the sediment criteria used to calculate these EQs may not apply to species found in this system.

5.2.5.2 Deer Ingestion Scenario

Estimated deer ingestion doses were compared to the higher of the literature derived toxicological effect level (the LOAEL) and CoC-specific EQs were generated by dividing the intake estimates by the toxicological effect value. Again, the comparison is limited because of the use of effects data for alternate species, adjusted only for increased body weight; the species used for the toxicology studies may be more or less susceptible to the contaminant being studied than deer. The results of the EQ calculations for this scenario are presented in Table 5-15.

TABLE 5-15
ECOLOGIC IMPACT QUOTIENTS (EQs) FOR THE DEER INGESTION SCENARIO

Effect Level	As	Cu
LOAEL	0.0014	0.0003

LOAEL = Lowest observed adverse effect level.

Table 5-15 indicates little potential for adverse ecologic impacts to deer (EQ greater than 1) due to uptake of waste salts and ponded water. This potential for no adverse effect can be extended to any wildlife that also use the area for salt or water.

5.2.5.3 Plant - Phytotoxicity Scenario

Source area average concentrations collected at the Highland site are compared to high values of the range of plant phytotoxicity derived from the literature. Limitations of this comparison include that the phytotoxicity ranges are not species-specific; they represent toxicity to species which may or may not be present at the Highland site. Additionally, other physical characteristics of the waste materials may create microenvironments which limit growth and survival of terrestrial plants directly or in combination with substrate toxicity. Waste materials are likely to have poor water holding capacity, low organic content, limited nutrients, and may harden enough to resist root penetration. The results of the EQ calculations for this scenario are presented in Table 5-16.

Table 5-16 indicates the potential for adverse ecologic impacts to plant communities at the Highland site with calculated EQs greater than one for As and Cu. The non-conservative assumption of using the high end of the phytotoxicity range to derive the EQs, probably underestimates the potential phytotoxic effect to the plant community. However, several other factors in addition to phytotoxicity combine to adversely affect plant establishment and success on the waste materials.

TABLE 5-16
ECOLOGIC IMPACT QUOTIENTS (EQs) FOR THE PLANT - PHYTOTOXICITY SCENARIO

Source Area	As	Cu
Highland Site	10.6	12.4

5.2.5.4 Risk Characterization Summary

The calculated EQs can be used to determine whether ecologic receptors are exposed to potentially harmful doses of site-related contaminants via the three ecologic scenarios evaluated. The EQs for each of the three scenarios are presented in Table 5-17 to estimate a combined ecologic EQ for each scenario and each contaminant. The EQ values in the table are the maximum value for the respective scenario or CoC. The results of combining the ecologic scenarios is also summarized in Table 5-17.

TABLE 5-17
SUMMARY OF COMBINED ECOLOGIC IMPACT QUOTIENTS (EQ) VALUES FOR THE HIGHLAND SITE

Ecologic EQ Summary	Surface Water	Sediment	Deer Ingestion	Plant Toxicity	Total
Arsenic	0.018	1.92	0.0014	10.6	12.54
Copper	0.293	0.91	0.0003	12.4	13.61
Mercury	0.104	NC	NC	NC	0.10
Iron	NC	NC	NC	NC	0.00
Total EQ	0.415	2.83	0.0017	23.0	**26.25**

NC = Not Calculated because no applicable standard exists.

The aquatic life scenario results in EQs of as high as 0.29 (surface water - Cu), and 1.92 (sediments - As) in Basin Creek. The deer scenario results in a maximum EQ of 0.001 (LOAEL - As). The plant toxicity EQs are as high as 12.4 (Cu). These EQs show that even at the lower bound of these calculated risk estimates, the ecologic risk characterization demonstrates that contaminants at the site constitute a probable adverse ecologic effect via two exposure scenarios and justify appropriate cleanup. Copper and arsenic are the primary CoCs, and aquatic sediments and the plant community are the primary receptors.

6.0 RECLAMATION GOALS AND OBJECTIVES

The primary objective of the Highland site reclamation project is to protect human health and the environment in accordance with the guidelines set forth by the NCP. Specifically, the reclamation alternative selected shall limit human and environmental exposure to the CoCs and reduce the mobility of those contaminants to reduce impacts to the local surface water and groundwater resources.

6.1 ARAR-BASED PRELIMINARY REMEDIATION GOALS

6.1.1 Groundwater

The groundwater at the Highland Mine site is not currently used as a drinking water source, nor is it likely to be; however, groundwater does discharge to surface water which is used for drinking water. The potential CoCs at the site include: arsenic, copper, iron, and mercury; additional potential CoCs are chromium, antimony, titanium, lead, selenium, and manganese.

ARAR-based preliminary remediation goals (PRGs) are most often the MCLs, non-zero maximum contaminant level goals (MCLGs), or state drinking water standards, whichever are more stringent. Potential ARAR-based PRGs for the CoCs in the groundwater medium are presented in Table 6-1.

6.1.2 Surface Water

Aquatic Life Standards and HHSs are common ARARs for the surface water medium. The more stringent of the two standards is identified as the ARAR-based PRG. The surface water is a source of drinking water as well as a cold water fishery. The CoCs are arsenic, copper, iron, and mercury; potential CoCs at the site are chromium, antimony, titanium, lead, selenium, and manganese. Table 6-2 presents the preliminary remediation goals for surface water.

6.1.3 Soil

Chemical-specific ARARs are not available at this time for the soil medium.

6.2 RISK-BASED CLEANUP GOALS

Risk-based cleanup goals are summarized below (Table 6-3) for significant carcinogenic and non-carcinogenic estimates of human health and ecologic risks at the Highland site, as calculated in the risk assessment (section 5.0). These cleanup concentrations were also presented in the risk assessment. The residential use risk-based concentrations were derived by USEPA Region III (Smith, 1995), and the recreational use risk-based concentrations were derived by MDEQ/MWCB (TetraTech, 1996). These cleanup goals denote average surface concentrations remaining in on-site soils and wastes after cleanup activities are complete, that would result in acceptable levels of risk to human health and the environment. Arsenic is the primary contaminant of concern for human health risks at the site, responsible for driving the carcinogenic risk and the noncarcinogenic risk. This contaminant will drive the cleanup and risks due to other CoCs will be reduced well below target levels.

TABLE 6-1
ARAR-BASED PRELIMINARY REMEDIATION GOALS FOR GROUNDWATER (μg/L)

CHEMICAL	TYPE	CONCENTRATION
Arsenic	HHS	18
Antimony	HHS	14
Cadmium	MCL	5
Copper	HHS	1,000
Chromium	HSS	100
Iron	HHS	300
Lead	HHS	15
Manganese	HHS	50
Mercury	HHS	0.14
Selenium	HHS	50
Zinc	HHS	5,000

HHS - Human Health Standards for Surface Water (DEQ/WQB, 1995).
MCL - Maximum Contaminant Level Drinking Water Regulations and Health Advisories (EPA, 1993).

TABLE 6-2
ARAR-BASED PRELIMINARY REMEDIATION GOALS FOR SURFACE WATER (μg/L)

CHEMICAL	TYPE	CONCENTRATION
Arsenic	HHS	18
Antimony	HHS	14
Cadmium	CALS	1.1 @ 100 mg/L hardness
Copper	CALS	12 @ 100 mg/L hardness
Chromium	HHS	100
Iron	HHS	300
Lead	CALS	3.2 @ 100 mg/L hardness
Manganese	HHS	50
Mercury	CALS	0.012
Selenium	CALS	5
Silver	AALS	4.1 @ 100 mg/L hardness
Zinc	CALS	110 @ 100 mg/L hardness

HHS - Human Health Standards for Surface Water (DEQ/WQB, 1995).
CALS - Freshwater Chronic Aquatic Life Standards (DEQ/WQB, 1995).
AALS - Freshwater Acute Aquatic Life Standards (DEQ/WQB, 1995).

TABLE 6-3
PROPOSED CLEANUP GOALS AT THE HIGHLAND MINE SITE*

Contaminant of Concern	Risk Scenarios: Residential	Recreational	Ecologic
Arsenic (non-Carcinogenic) - Soil	23 mg/Kg	323 mg/Kg	50 mg/Kg
Arsenic (Carcinogenic) - Soil	0.43 mg/Kg	1.4 mg/Kg	--
Iron - Soil	23,000 mg/Kg	--	--
Copper - Soil	--	--	125 mg/Kg
Mercury - Water	--	--	0.294 μg/L

* See risk assessment (section 5.0) for sources and references for cleanup goals.

7.0 DEVELOPMENT AND SCREENING OF RECLAMATION ALTERNATIVES

To facilitate the evaluation of potentially applicable reclamation technologies, the contaminated waste sources present at the Highland Mine site can be divided into four general categories based on their physical and chemical characteristics. These categories include:

- dry tailings;
- waste rock;
- demolition debris and municipal solid waste; and
- mine drainage (adit discharge).

Treatment of these various media is dependent on the concentration of contaminants in the media, as well as the physical characteristics of the media. The potential applicability of a technology is dependent on the interrelationship of reclamation technologies and the volume of material requiring treatment. A brief definition of each medium follows.

Dry Tailings - Dry or alternately wet and dry tailings tend to contain oxidized forms of metals. These oxidized metals are easily mobilized during precipitation (infiltration) or high run-off events. Dry tailings are located in the northwest region of the Highland Mine/Main Ripple Claim; the majority of the tailings are outside of the boundary of the Main Ripple Claim.

Waste Rock - Consists of overburden and gangue materials that generally do not contain sufficient quantities of target metals for economic recovery. The dumps contain non-mineralized and low-grade mineralized rock removed from the adit (Main Tunnel) adjacent to the existing ore pile. The nature and extent of the mineralization, climatic conditions, and buffering capacity of the foundation soil determine the potential of the material to impact water quality.

In general, the waste rock dump at the site contains oxidizing sulfide minerals and is subject to percolation of precipitation and run-off. The sulfide minerals within the dump may react with percolating water in the presence of oxygen to form sulfuric acid. Migration of sulfuric acid through the dump results in the further mobilization of solubilized metal oxides. The dump is located adjacent to the headwaters of Basin Creek and is intermittently being eroded into the stream.

Mine Drainage (Adit Discharge Water) - Water draining from underground mine workings often exhibits elevated concentrations of heavy metals and low (acidic) pH conditions due to chemical reactions that occur when the water comes in direct contact with soluble mineralized rock and oxygen. The Highland Mine adit discharge contains elevated concentrations of several metals (As, Fe, Cu, Hg); the pH of the discharge is in the neutral to slightly alkaline range (between 7.05 and 7.42 S.U.). Mercury is the only metal that may exceed an established water quality standard, only because the chronic aquatic life standard for mercury (0.012 μg/L) is less than the reported detection limit (0.15 μg/L [avg.]). However, an actual exceedence is not likely because inorganic Hg species are not very soluble in general, and are even less soluble at the adit pH. The discharge flow varies with seasonal and climatic variations, but is generally significant (100 to 176 gpm).

Demolition Debris and Municipal Solid Waste - Several collapsed buildings and various wooden and concrete debris are located at the site. The debris may (or may not) include elevated metals concentrations on their external surfaces and may require sorting to isolate the contaminated material for special handling or decontaminating. One structure at the site remains standing and will be left in place for historical purposes. Other wooden debris will be burned, or disposed of at a licensed disposal facility. One pile of unidentified white powder material (approximately 10 cy) remains on-site. XRF analysis of the substance shows a high percentage of calcium, which indicates it to be a lime material.

7.1 IDENTIFICATION AND SCREENING OF RECLAMATION TECHNOLOGIES AND PROCESS OPTIONS

The purpose of identifying and screening technology types and process options is to eliminate those technologies that are obviously infeasible, while retaining potentially effective options. General response actions are progressively refined into technology types and process options. The process options are screened, and those retained are used to develop reclamation alternatives. General response actions, technology types, and process options potentially applicable to the waste sources present at the Highland Mine site are briefly discussed in this section.

General response actions and process options are evaluated for the contaminated solid media and adit discharge only. No evaluation has been conducted for surface water (below the site), groundwater, or off-site stream sediments. This decision was based primarily on the presumption that remediating the contamination at the source(s) will subsequently reduce/eliminate the problems associated with these other environmental media. General response actions potentially capable of meeting the reclamation objectives are identified in Table 7-1. Response actions for the contaminated solid media include: no action; institutional controls; engineering controls; excavation and treatment, and/or disposal; and in-situ treatment. Response actions for the adit discharge include: no action, institutional controls, source controls, physical/chemical treatment, and biological treatment. Table 7-2 contains the screening rationale that was used to eliminate or retain the various reclamation technologies for potential application at the Highland Mine site.

In Section 7.2, feasible technologies are presented as reclamation alternatives and are subjected to an initial/preliminary screening based on effectiveness, implementability, and cost. The purpose of the initial screening of alternatives is to identify those alternatives appropriate for a subsequent, detailed analysis. The initial screening also helps identify technology-specific data needs for detailed site characterization as well as needs for possible treatability studies.

TABLE 7-1
GENERAL RESPONSE ACTIONS, TECHNOLOGY TYPES, AND PROCESS OPTIONS FOR CONTAMINATED SOLID MEDIA AT THE HIGHLAND MINE SITE

GENERAL RESPONSE ACTION	TECHNOLOGY TYPE	PROCESS OPTIONS
No Action	Not Applicable	Not Applicable
Institutional Controls	Access Restrictions	Fencing Land Use Control
Engineering Controls	Containment	Soil Cover Multimedia Cover Asphalt/Concrete Cover
	Surface Controls	Consolidation Grading Revegetation Erosion Protection Run-on/Run-off Control
	On-Site Disposal	RCRA Repository Solid Waste Repository
	Off-Site Disposal	RCRA Landfill Solid Waste Landfill Permitted Tailings Facility
Excavation and Treatment	Fixation/Stabilization	Pozzolan/Cement Based
	Reprocessing	Milling/Smelter
	Physical/Chemical Treatment	Soil Washing Acid Extraction Alkaline Leaching
	Thermal Treatment	Fluidized Bed Reactor Rotary Kiln Multi-Hearth Kiln Vitrification
In-situ Treatment	Physical/Chemical Treatment	Stabilization/Solidification Soil Flushing
	Thermal Treatment	Vitrification

TABLE 7-1 (cont'd)
GENERAL RESPONSE ACTIONS, TECHNOLOGY TYPES, AND PROCESS OPTIONS FOR ADIT DISCHARGE AT THE HIGHLAND MINE SITE

GENERAL RESPONSE ACTION	TECHNOLOGY TYPE	PROCESS OPTIONS
Water Treatment (Adit Discharge)	Access Restrictions	Fencing Land Use Control
	Source Controls	Physical Isolation Bulkheading/Mine Flooding Biocides/Surfacants Surfacant Treatment Groundwater Pumping
	Physical/Chemical Treatment	Oxidation Neutralization/Precipt. Flocculent Addition Adsorption Filtration Distillation Evaporation Chelation Flotation Solvent Extraction Electrochemical
	Biological Treatment	Biological Reduction Bioadsorption
	Wetlands Treatment	Natural or Constructed

TABLE 7-2

RECLAMATION TECHNOLOGY SCREENING SUMMARY

GENERAL RESPONSE ACTIONS	RECLAMATION TECHNOLOGY	PROCESS OPTIONS	DESCRIPTION	SCREENING COMMENT
NO ACTION	None	Not Applicable	No Action	
INSTITUTIONAL CONTROLS	Access Restrictions	Fencing	Security fences installed around contaminated areas to limit access.	Potentially effective in conjunction with other technologies. Readily implementable.
		Land Use Control	Restrictions to control current and future land use.	Potentially effective in conjunction with other process options. Readily implementable.
ENGINEERING CONTROLS	Containment	Soil Cover	Application of soil and establishment of vegetative cover to stabilize surface of contamination source	Surface infiltration and runoff potential would be reduced, but not prevented. Readily implementable
		Multilayered RCRA Cap	Compacted clay covered with soil/vegetation over areas of surface contamination.	Potentially effective for some waste sources in conjunction with regrading. Readily implementable
		Asphalt/Concrete Cover	Application of layer of asphalt or concrete over areas of surface contamination	Limited feasibility due to remoteness of area and steep slopes. Would require extensive grading and compaction
		Wet Closure	Applicable to wet tailings. Construct dam to flood tailings with water and provide anaerobic environment to limit oxidation/migration of contaminants.	Potentially effective if adequate coverage is provided during dry seasons. Readily implementable, but not widely accepted as a viable option.
	Surface Controls	Consolidation	Combining similar waste types in a common area	Potentially effective in conjunction with other process options. Involves removing wastes from particularly sensitive areas (e.g. floodplain). Readily implementable
		Grading	Level out waste piles to reduce slopes for managing surface water infiltration, runoff, and erosion.	Potentially effective in conjunction with other process options. Readily implementable.
		Revegetation	Adding amendments to waste and seeding with appropriate vegetative species to establish an erosion resistant ground surface.	Potentially effective in arid climates if waste does not contain high concentrations of phytotoxic chemicals. Readily implementable.

Legend

(shaded box) - Technologies Process options that are screened out

TABLE 7-2 (Cont'd)

REMEDIAL TECHNOLOGY SCREENING SUMMARY

GENERAL RESPONSE ACTIONS	REMEDIAL TECHNOLOGY	PROCESS OPTIONS	DESCRIPTION	SCREENING COMMENT
		Erosion Protection/Runon Control	Erosion resistant materials/fabrics placed directly on waste sources to reduce surface erosion. Surface water diversion structures constructed to direct runoff away from waste source(s).	Potentially effective at reducing contaminant mobility. Readily implementable.
	On-site Disposal	RCRA Landfill	Excavated contaminated soil deposited on-site in RCRA landfill.	Potentially effective and readily implementable. Depends on site-specific groundwater characteristics (i.e., depth to groundwater).
		Sanitary Landfill	Excavated contaminated soil deposited on-site in sanitary landfill.	Potentially effective for non-hazardous materials or non-hazardous residues from other treatment process options. Readily implementable.
	Off-site Disposal	RCRA Landfill	Wastes permanently disposed of in RCRA-permitted facility.	Potentially effective and readily implementable.
		Sanitary Landfill	Non-hazardous solid wastes permanently disposed of in non-RCRA facility.	Potentially effective for non-hazardous materials or non-hazardous residues from other treatment process options. Readily implementable.
		Permitted Tailings Facility	Depositing tailings in a permitted off-site impoundment.	Potentially effective if facility with adequate capacity is willing to accept waste. Potentially implementable, but may be cost-prohibitive due to liability considerations.
EXCAVATION AND TREATMENT	Fixation Stabilization	Pozzolan/Cement Based	Hazardous constituents are incorporated into non-leachable cement or pozzolan solidifying agents.	Extensive treatability testing required. Proper disposal of stabilized product would be required. Potentially implementable, but cost-prohibitive.
	Reprocessing	Milling/Smelter	Shipping wastes to existing milling/smelter facility for economic extraction of metals.	Potentially effective if a facility is located and willing to accept waste. Potentially implementable, but cost-prohibitive due to liability considerations.
	Physical Chemical Treatment	Soil Washing	Separate hazardous constituents from solid media via dissolution and subsequent precipitation.	Effectiveness is questionable. Potential exists to increase mobility by providing partial dissolution of contaminants. More difficulty encountered with wider range of CoCs.
		Acid Extraction	Mobilize hazardous constituents via acid leaching and recover by subsequent precipitation.	Effectiveness is questionable. Sulfides would be acid soluble only under extreme conditions of temperature and pressure.
		Alkaline Leaching	Use alkaline solution to leach contaminants from solid media in a heap, vat, or agitated vessel.	Effectiveness not well-documented for arsenic.

Legend

[shaded box] - Technologies/Process options that are screened out

TABLE 7-2 (Cont'd)

REMEDIAL TECHNOLOGY SCREENING SUMMARY

GENERAL RESPONSE ACTIONS	REMEDIAL TECHNOLOGY	PROCESS OPTIONS	DESCRIPTION	SCREENING COMMENT
	Thermal Treatment	Fluidized Bed Reactor/Rotary Kiln/Multi-Hearth Kiln	Concentrate hazardous constituents into a small volume by volatilization of metals and formation of metallic oxides as particulates	Further treatment is required to treat process by-products. Potentially implementable, but cost-prohibitive
		Vitrification	Extremely high temperature used to melt and/or volatilize all components of the solid media. The molten material containing contaminants is cooled and, in the process, vitrified into a non-leachable form	Further treatment is required to treat process by-products. Potentially implementable, but cost-prohibitive
IN-SITU TREATMENT	Physical Chemical Treatment	Stabilization	Waste constituents stabilized in place when combined with injected stabilizing agents	Extensive treatability testing required. Potentially implementable but cost-prohibitive
		Solidification	Solidifying agents used in conjunction with deep soil mixing techniques to facilitate a physical or chemical change in mobility of the contaminants	Extensive treatability testing required. Potentially implementable but cost-prohibitive
		Soil Flushing	Acid/base reagent or chelating agent injected into solid media to solubilize metals. Solubilized reagents are subsequently extracted using dewatering techniques	Effectiveness not certain. Innovative process currently in its pilot stage
	Thermal Treatment	Vitrification	Contaminated solid media subjected to extremely high temperature in-place. During cooling, material is vitrified into non-leachable form	Difficulties may be encountered in establishing adequate control. Potentially implementable but cost-prohibitive
WATER TREATMENT (ADIT DISCHARGE)	Access Restrictions	Fencing	Security fences installed around contaminated areas to limit access	Potentially effective in conjunction with other technologies. Readily implementable
	Source Controls	Physical Isolation	Isolate mine workings from groundwater infiltration	Must have access to mine workings to fill workings with grout or foam. Install grout curtains and engineered cap, to prevent groundwater recharge. Not feasible without additional information on state of mine workings

Legend

[shaded box] - Technologies/Process options that are screened out

TABLE 7-2 (Cont'd)

REMEDIAL TECHNOLOGY SCREENING SUMMARY

GENERAL RESPONSE ACTIONS	REMEDIAL TECHNOLOGY	PROCESS OPTIONS	DESCRIPTION	SCREENING COMMENT
		Bulkheading/Mine Flooding	Bulkheading of discharge adit and subsaquent flooding of mine workings which creates reducing environmenmt and retards oxidation.	Groundwater will backup behind bulkhead creating a reservoir. Bulkhead could blow out or contaminated water will exit through existing faults and fissures. Not feasible without additional information on site geological conditions.
		Biocide/Surfactant Treatment	Treat exposed surfaces within workings with biocides to prevent oxidation by bacteria or surfactants to coat mineral surfaces to prevent oxidation.	Requires access to mine workings so they can be treated. Not feasible without additional information on state of mine workings.
		Groundwater Pumping	Pump groundwater to draw down groundwater level below mine workings.	Groundwater of unknown quality (possibly requiring treatment) would have to be pumped in perpituity.
	Physical Chemical Treatment	Oxidation	Water is oxidized (physically or chemically) to induce metal hyroxide and oxide precipitate formation.	Process dependent on pH, oxidation, alkalinity to initiate precipitation of contaminants.
		Neutralization/ Precipitation	Chemical reagents are added to the waste stream to alter the pH to optimize the formation of insoluble metal precipitates.	Process is widely used and proven successful. Many reagents different reagents can be used, but hydroxide and sulfide precipitation are most common.
		Coagulation/ Sedimentation/ Flocculation	Coagulants and/or flocculants are added to the water to promote the formation of larger particlulates, which are more easily removed from the water column.	Widely used in conjunction with neutralization precipitation. Sedimentation is commonly all that is required, but flocculants and or coagulants are added if particles formed during precipitation process are small and difficult to remove from the water column.
		Adsorption	Process where dissolved metals are adsorbed to the surface of another material, usually solids. Many materials are used for adsorption, including activated carbon, biomass, coals, and ion exchange resins.	Limited in practice to the removal of low concentrations of dissolved metals. May be applicable as a polishing process to mine acit discharge waters.
		Filtration	Removing suspended solids be passing solution through a medium which retains the solids but allows the water to pass. In reverse osmosis processes, solutes (dissolved metal ions) can be retained on the filter, also, while allowing the solvent (water) to pass.	Filtration most likely not applicable to removal of suspended solids at abandoned mine sites. Most contaminants are dissolved and a combination of neutralization precipitation and coagulation flocculation sedimentation is expected to be more effective. Iron precipitates could be expected to plug reverse osmosis membranes used for primary treatment. Reverse osmosis could be considered as a polishing process, but may be cost prohibitive at remote mine sites.

Legend

[shaded box] Technologies Process options that are screened out

TABLE 7-2 (Cont'd)

REMEDIAL TECHNOLOGY SCREENING SUMMARY

GENERAL RESPONSE ACTIONS	REMEDIAL TECHNOLOGY	PROCESS OPTIONS	DESCRIPTION	SCREENING COMMENT
		Distillation	Water is boiled to distill solid and dissolved phase contaminants from solution	Inefficient and very high energy costs make process cost prohibitive. Also, process is functionally limited to a maximum of 5000 mg/L total dissolved solids
		Evaporation	Construct settling evaporation basin to concentrate contaminants into relatively small volume	Large discharge rate of adit precludes the use of total evaporation
		Chelation	Complex organic chemicals (chelating agents) added to solution to bind, via ionic bonds, dissolved contaminants.	Process is expensive and labor intensive. Other process as effective, less costly, and more proven.
		Flotation	Gas (usually air) is bubbled through a solution, particulates attached to gas bubble and are brought to the surface where they are removed from the solution	Not applicable to the dissolved phase contaminants at the site.
		Solvent extraction	Organic liquids (solvents) are mixed with aqueous heavy metal solutions, metals become concentrated in organic liquid	Although widely used for metals recovery in industry, process would be labor intensive and cost-prohibitive for treating the relatively dilute solutions at the site
		Electrochemical	Electrocoagulation, electrochemical precipitation, electrodialysis, etc.	Processes are typically geared toward the recovery of specific metals. High capital costs would not normally be offset by value of recovered metals
	Biological Treatment	Biological Reduction	Chemical reduction of dissolved species through biological processes, such as sulfate reducing bacteria.	Has shown promise in testing, but not proven at full-scale over the long term. Requires ability to form an anaerobic environment, either in situ (i.e. within a shaft) or in a reactor after discharge has occurred
		Bioadsorption	Biomass is used to adsorb contaminants from solution	Not considered applicable as a stand alone process; media would become fouled by precipitates
	Wetlands Treatment	Natural or Constructed	Utilize chemical and physical characteristics of wetlands to concentrate constituents through settling and adsorption to organic matter	Wetlands are limited to contaminant concentrations that are not toxic to vegetation. Performance may be inhibited due to low temperatures, ice formation in winter. Not demonstrated to be effective at higher flow rates

Legend

[shaded box] - Technologies/Process options that are screened out

7.1.1 No Action

Under the no action option, no future reclamation or monitoring would occur at the site. The no action response is a stand-alone response that is used as a baseline against which candidate reclamation alternatives are compared.

7.1.2 Institutional Controls

Potentially applicable institutional controls consist of land use and access restrictions. Land use restrictions would limit the potential future uses for the land in the event of a sale. Limitations may be applicable in the case of no action, on-site disposal, capping in place, or other reclamation alternatives that would result in leaving contaminated material on-site that could be compromised by future activities. Institutional controls that are developed as part of an alternative are enforced by the local government. Therefore, the local government must be involved in the development and eventual implementation of an institutional control.

Institutional controls involve implementing access restrictions, such as fencing, and land use control. These restrictions are implemented to preclude the future development of impacted areas or to protect an implemented remedy. This type of action does not, in itself, achieve a specific clean-up goal. However, institutional controls will be considered as adjacent technologies to accompany other reclamation alternatives.

7.1.3 Engineering Controls

Engineering controls are used primarily to reduce the mobility of contaminants by creating a barrier that prevents the transport of waste from the contaminated source to the surrounding environment. Engineering controls do not reduce the volume or toxicity of the hazardous material. Engineering controls typically applied include containment/capping, revegetation, run-on/run-off control, and/or disposal.

7.1.3.1 Containment

Containment technologies are used as source control measures to isolate surface water from the contaminated media, to minimize infiltration (and subsequent formation of leachate) of surface water/precipitation into the underlying contaminated media by increasing evapotranspiration processes, and to reduce the potential health risk that may be associated with exposure (direct contact or airborne releases of particulate) to the contaminated media. The cap or cover design is a function of the degree of hazard posed by the contaminated media and may vary in complexity from a simple vegetated soil cover to a multi-layered RCRA cap. RCRA cap performance standards are included in 40 CFR 264.310 which addresses RCRA landfill closure requirements. These performance standards may not always be appropriate, particularly in instances where the toxicity of the contaminated media is relatively low, where the cap is intended to be temporary, where there is very low precipitation, or where the waste is not leached by infiltrating rain water. Specific cap construction is partially driven by the desired land use following cap construction.

Capping is appropriate whenever contaminated materials are to be left in place at a site, such as when total excavation and removal or treatment would be cost prohibitive. Capping is considered to be a standard construction practice. Equipment and construction methods associated with capping are readily available, and design methods and requirements are well understood.

7.1.3.2 Surface Controls

Similar to containment, surface control measures are used primarily to reduce contaminant mobility. Surface controls may be appropriate in more remote areas where direct human contact is not a primary concern (human receptors not living or working directly on or near the site). Surface control process options include consolidation, grading, revegetation, and erosion protection. These process options are usually integrated as a single reclamation alternative.

Consolidation involves grouping similar waste types in a common area for subsequent management or treatment. Consolidation is especially applicable when multiple waste sources are present at a site and one or more of the sources require removal from particularly sensitive areas (i.e., floodplain, residential area, or heavy traffic area) or when treating one large combined waste source in a particular location rather than several smaller waste sources dispersed throughout an area.

Grading is the general term for techniques used to reshape the ground surface to reduce slopes, manage surface water infiltration and run-off, and to aid in erosion control. The spreading and compaction steps used in grading are routine construction practices. The equipment and methods used in grading are similar for all surfaces, but will vary slightly depending on the waste type and the surrounding terrain (i.e., steepness). Periodic maintenance and regrading may be necessary to eliminate depressions formed as a result of settlement/subsidence or erosion.

Revegetation involves adding soil amendments and/or topsoil to the waste's surface to provide nutrients, organic material, and neutralizing agents and/or improve the water storage capacity of the contaminated media, as necessary. This action is used to establish native vegetative species to provide an erosion resistant ground surface that helps protect the ground surface from surface water and wind erosion and reduces net infiltration through the contaminated media by increasing evapotranspiration processes. In general, revegetation includes the following steps: 1) selecting appropriate plant species; 2) preparing the seed bed, which may require deep application (tilling) of soil amendments as necessary; 3) seeding/planting; 4) mulching and/or chemical stabilization; and 5) fertilizing and maintenance.

Erosion protection includes using erosion resistant materials, such as mulch, natural or synthetic fabric mats, riprap, and/or surface water diversion ditches, to reduce the erosion potential at the contaminated media's surface. The erosion resistant materials are placed in areas susceptible to surface water erosion (concentrated flow or overland flow) or wind erosion. Proper erosion protection design requires knowledge of drainage area characteristics, average slopes, soil texture, vegetation types and abundance, and precipitation data.

7.1.3.3 On-Site Disposal

Permanent, on-site disposal is used as a source control measure. On-site disposal involves placing the contaminated media in an engineered containment facility located within the site boundary. On-site disposal options may be applied to pre-treated or untreated contaminated materials, depending upon the chemical characteristics of the material. The design configuration of an on-site containment facility would depend on the toxicity and type of material requiring disposal. The design could range in complexity from a relatively simple, unlined and covered impoundment to a double-lined impoundment equipped with double leachate collection systems and RCRA-type cap. Materials failing to meet the TCLP criteria may require disposal in a repository conforming to the performance standards for a RCRA landfill closure.

7.1.3.4 Off-Site Disposal

Off-site disposal involves placing excavated contaminated material in an engineered containment facility located outside the site boundary. Off-site disposal options may be applied to pre-treated or untreated contaminated materials and would depend on TCLP results. Materials failing to meet the TCLP criteria would require disposal in a RCRA-permitted treatment, storage, and disposal (TSD) facility. Conversely, less toxic materials could possibly be disposed of in an off-site permitted sanitary landfill or tailings disposal facility in compliance with other applicable laws. Off-site disposal is most attractive when dealing with relatively small quantities of wastes located relatively near the disposal facility.

7.1.4 Excavation and Treatment

Excavation and treatment incorporates the removal of contaminated media and subsequent treatment via a specific treatment process that chemically, physically, or thermally results in a reduction of contaminant toxicity and/or volume. Treatment processes have the primary objective of either: 1) concentrating the metal contaminants for additional treatment or recovery of valuable constituents; or 2) reducing the toxicity of the hazardous constituents.

Excavation can be completed using conventional earth moving equipment and accepted hazardous materials handling procedures. Precautionary measures, such as stream diversion or isolation, would be necessary for excavating materials contained in the floodplain of a stream. Containment and/or treatment of water encountered during excavation may also be necessary.

7.1.4.1 Fixation/Stabilization

Fixation/stabilization technologies are used to treat materials by physically encapsulating them in an inert matrix (stabilization) and/or chemically altering them to reduce the mobility and/or toxicity of their constituents (fixation). These technologies generally involve mixing materials with binding agents under prescribed conditions to form a stable matrix. Fixation/stabilization is an established technology for treating inorganic contaminants. The technology incorporates a reagent or combination of reagents to facilitate a chemical and/or physical reduction of the mobility of contaminants in the solid media. Lime/fly ash-based treatment processes and pozzolan/cement-based treatment processes are potentially applicable fixation/stabilization technologies.

7.1.4.2 Reprocessing

Reprocessing involves excavating and transporting the waste materials to an existing permitted mill or smelter facility for processing and economic recovery of target metals. Applicability of this option depends on the willingness of an existing permitted facility to accept and process the material and dispose of the waste. Although reprocessing at active facilities has been conducted in the past, permit limitations, CERCLA liability, and process constraints all limit the feasibility of this process option. In addition to these limitations, costs associated with this alternative are very high (transportation costs in addition to processing costs). In order for a milling facility or smelter to accept the material, pre-concentration of the target metals would likely be required, and the by-product waste resulting from pre-concentrating would still contain elevated metals concentrations requiring proper disposal.

7.1.4.3 Physical/Chemical Treatment

Physical treatment processes use physical characteristics to concentrate constituents into a relatively small volume for disposal or further treatment. Chemical treatment processes treat contaminants through adding a chemical reagent that removes or fixates the contaminants. The net result of chemical treatment processes is a reduction of toxicity and/or mobility of contaminants in the solid media. Chemical treatment processes often work in conjunction with physical processes to wash the contaminated media with water, acids, bases, or surfactants. Potentially applicable physical/chemical treatment process options include: soil washing, acid extraction, and alkaline leaching.

Soil washing is an innovative treatment process which consists of washing the contaminated media (with water) in a heap, vat, or agitated vessel to dissolve water soluble contaminants. Soil washing requires that contaminants be readily soluble in water and sized sufficiently small so that dissolution can be achieved in a practical retention time. Dissolved metal constituents contained in the wash solution are precipitated as insoluble compounds, and the treated solids are dewatered before additional treatment or disposal. The precipitates form a sludge which would require additional treatment, such as dewatering or stabilization prior to disposal.

Acid extraction applies an acidic solution to the contaminated media in a heap, vat, or agitated vessel. Depending on temperature, pressure, and acid concentration, varying quantities of the metal constituents present in the contaminated media would be solubilized. A broader range of contaminants can be expected to be acid soluble at ambient conditions using acid extraction versus soil washing; however, sulfide compounds may only be acid soluble under extreme conditions of temperature and pressure. Dissolved contaminants are subsequently precipitated for additional treatment and/or disposal.

Alkaline leaching is similar to acid extraction in which a leaching solution (in this case ammonia, lime, or caustic soda) is applied to the contaminated media in a heap, vat, or agitated vessel. Alkaline leaching is potentially effective for leaching the majority of metals from the contaminated media; however, the removal of arsenic is not well documented.

7.1.4.4 Thermal Treatment

Under thermal treatment technologies, heat is applied to the contaminated media to volatilize and oxidize metals and render them amenable to additional processing and/or to vitrify the contaminated media into a glass-like, non-toxic, non-leachable matrix. Potentially applicable moderate temperature thermal processes, which volatilize metals and form metallic oxide particulates, include the fluidized bed reactor, the rotary kiln, and the multi-hearth kiln. Potentially applicable high temperature thermal treatment processes include vitrification. All components of the contaminated media are melted and/or volatilized under high temperature vitrification. Volatile contaminants and gaseous oxides of sulfur are driven off as gases in the process, and the non-volatile, molten material containing contaminants is cooled and, in the process, vitrified.

Thermal treatment technologies can be applied to wet or dry contaminated media; however, the effectiveness may vary somewhat with variable moisture content and particle size. Crushing may be necessary as a pre-treatment step, especially for large and/or variable particle sizes, such as in waste rock dumps. Moderate temperature thermal processes should only be considered as pre-treatment for other treatment options. This process concentrates the contaminants into a highly mobile (and potentially more toxic) form. High temperature thermal processes immobilize most metal contaminants into a vitrified slag which would have to be properly disposed. The volatile metals would be removed and/or concentrated into particulate metal oxides which would likely require disposal as hazardous waste. Thermal treatment costs are extremely high compared to other potentially applicable reclamation technologies.

7.1.5 In-Situ Treatment

In-situ treatment involves treating the contaminated media in place. In-situ technologies reduce the mobility and toxicity of the contaminated media and may reduce worker exposure to the contaminated materials; however, in-situ technologies allow a lesser degree of control, in general, than ex-situ treatment options.

7.1.5.1 Physical/Chemical Treatment

Potentially applicable in-situ physical/chemical treatment technologies include stabilization/ solidification, soil flushing, and dewatering.

In-situ stabilization/solidification is similar to conventional stabilization in that a solidifying agent (or combination of agents) is used to create a chemical or physical change in the mobility and/or toxicity of the contaminants. The in-situ process uses deep mixing techniques to allow maximum contact of the solidifying agents with the contaminated media.

Soil flushing is an innovative process that injects an acidic or basic reagent or chelating agent into the contaminated media to solubilize metals. The solubilized metals are extracted using established dewatering techniques, and the extracted solution is then treated to recover metals or is disposed as aqueous waste. Low permeability materials may hinder proper circulation, flushing solution reaction, and ultimate recovery of the solution. Currently, soil flushing has only been demonstrated at pilot scale.

Dewatering is a common pre-treatment process used to extract water from contaminated solid media. Common dewatering options include well-field extraction, extraction trenches, surface water diversion, and gravity draining of stockpiled saturated materials. Dewatering is most effective in conjunction with additional reclamation technologies that reduce contaminant toxicity, mobility, or volume.

7.1.5.2 Thermal Treatment

In-situ vitrification is an innovative process used to melt contaminated solid media in place to immobilize metals into a glass-like, inert, non-leachable solid matrix. Vitrification requires significant energy to generate sufficient current to force the solid media to act as a continuous electrical conductor. This technology is seriously inhibited by high-moisture content. Gases generated by the process must be collected and treated in an off-gas treatment system. In-situ vitrification has only been demonstrated at pilot scale, and treatment costs are extremely high compared to other treatment technologies.

7.1.6 Water Treatment (Adit Discharge)

Water treatment involves treating the contaminated adit discharge water at or near the location of the discharge at the ground surface. Water treatment technologies can be used to reduce the toxicity, mobility, and/or volume of the contaminated media.

7.1.6.1 Source Controls

Source control measures are used primarily to reduce the oxidation and subsequent mobilization of contaminants from the underground mine workings. The objective of these controls is to isolate the source minerals (sulfides) from oxygen in the ambient air and/or infiltrating groundwater, and create a reducing environment where sulfide oxidation is considerably impaired. Source controls are appropriate in locations where mine workings are accessible and where specific mineral oxidation reactions can effectively be reduced or eliminated. Source control options include physical isolation, which would include separation of mine waste materials from clean materials (i.e., rerouting surface water away from contaminated waste materials), bulkheading and subsequent mine flooding, chemical treatment of exposed surfaces with biocides or surfactants, and groundwater pumping and drawdown below the mine workings. One or more of these controls could be combined as a single reclamation alternative.

7.1.6.2 Physical/Chemical Treatment

Physical treatment processes use physical characteristics (such as flocculation and adsorption) to concentrate constituents into a relatively small volume (bottom sludge or activated carbon) for disposal or further treatment. Chemical treatment processes treat contaminants through the addition of a chemical reagent that precipitates and/or flocculates contaminants. The net result of chemical treatment processes is a reduction of toxicity, mobility, and/or volume of contaminants in the water medium. Chemical treatment processes often work in conjunction with physical processes to treat contaminated water with pH adjusting acids or bases to induce precipitation to a solid phase and the addition of flocculents or surfactants to aid in the separation of the solid phase from the water. Potentially applicable physical/chemical treatment process options include: oxidation (chemical or physical), lime addition, flocculent addition, and activated carbon adsorption.

7.1.6.3 Wetlands Treatment

Wetlands treatment essentially uses the same physical and chemical treatments described above. Certain wetlands characteristics, such as extensive retention times in a large basin, assist the settling of particulates and precipitates. Other processes include creation of a reducing environment and subsequent re-precipitation of metal sulfides, and extensive contaminant adsorption to organic matter (as in carbon treatment). Wetlands treatment also concentrates constituents into a relatively small volume (organic sludge) with disposal or further treatment required eventually. Wetlands are limited to contaminant concentrations that are not toxic to the host vegetation, and performance is severely inhibited due to ice formation in winter. The net result of properly designed wetlands treatment is a reduction of toxicity, mobility, and/or volume of contaminants in the water medium.

7.2 IDENTIFICATION AND EVALUATION OF ALTERNATIVES

This section assembles potential reclamation alternatives from the remedial technology types and associated process options that passed the initial screening effort presented in Section 7.1. The Highland Mine site has been divided into two distinct units based on the waste types and applicable reclamation technologies: 1) contaminated mine waste (waste rock and tailings); and

2) the adit discharge. Tables 7-3 and 7-4 present the preliminary reclamation alternatives for these two subunits. These retained alternatives are further screened in this section on the basis of effectiveness, implementability, and relative costs. The preliminary screening has been conducted to reduce the number of possible reclamation alternatives requiring detailed evaluation. Ultimately, the reclamation actions taken at the site will be a combination of an alternative addressing the waste rock and tailings and an alternative addressing the adit discharge.

TABLE 7-3
RECLAMATION ALTERNATIVES FOR THE WASTE ROCK AND TAILINGS AT THE HIGHLAND MINE SITE

ALTERNATIVE 1:	NO ACTION
ALTERNATIVE 2:	INSTITUTIONAL CONTROLS
ALTERNATIVE 3:	IN-PLACE CONTAINMENT
ALTERNATIVE 4:	REMOVAL AND DISPOSAL IN A ON-SITE CONSTRUCTED REPOSITORY
ALTERNATIVE 5:	OFF-SITE DISPOSAL IN AN EXISTING WASTE DISPOSAL FACILITY

TABLE 7-4
RECLAMATION ALTERNATIVES FOR THE ADIT DISCHARGE AT THE HIGHLAND MINE SITE

ALTERNATIVE 1:	NO ACTION
ALTERNATIVE 2:	INSTITUTIONAL CONTROLS
ALTERNATIVE 3:	ADIT DISCHARGE COLLECTION AND DIVERSION
ALTERNATIVE 3a:	PIPING DISCHARGE AWAY FROM CONTAMINATED SOURCE
ALTERNATIVE 3b:	CONTAMINANT REMOVAL/CHANNEL RESTORATION

The evaluation of effectiveness of each of the alternatives includes determining the ability of the alternative to process the contaminated media sufficiently to achieve the reclamation goals. The reclamation goals include overall protection of human health and the environment, compliance with ARARs, and short- and long-term effectiveness and/or performance related to reducing toxicity, mobility, and/or volume of contaminants. The effectiveness screening criteria included consideration of the nature and extent of the contamination, as well as site-specific conditions, such as geology, hydrology, hydrogeology, climate, and land use.

The implementability of each alternative has been evaluated to consider the technical and administrative feasibility of constructing, operating, and maintaining a reclamation alternative. Technical feasibility considerations included applicability of the alternative to the waste source(s), availability of the required equipment and expertise to execute the alternative, and overall reliability of the alternative. Administrative feasibility considerations include logistical and scheduling constraints. The evaluation of implementability also considers appropriate combinations of alternatives with respect to site-specific conditions.

Cost screening consists of developing conservative, order-of-magnitude cost estimates for each remedial alternative based on available data and the assumptions described for each alternative. Costs have been developed by analyzing data available from screening and implementing reclamation alternatives at similar sites, including bid tabulations from recent DEQ/MWCB and USFS reclamation activities. Where adequate actual cost data are not available, the EPA Cost of Remedial Alternatives (CORA) Model, Version 3.0, was employed. Unit and total costs presented in the cost evaluations are present-worth values structured to account for contaminated materials handling, adverse site conditions, administrative and engineering costs, and contingency. Total costs were derived by applying estimated unit costs to assumed volumes of contaminated media. The volumes of contaminated materials present at the Highland Mine site are assumed to be 8,800 cy of waste rock, 2,000 cy of tailings, and a combined total of 100 to 175 gpm of water discharging from the adit. These estimated volumes were obtained from the 1995 DEQ/MWCB Adit Mine Discharge Baseline Study Characteristics and the Reclamation Investigation (DEQ/MWCB-Pioneer, 1996). Cost estimates for each alternative are summarized below. Detailed cost estimates are included in Appendix E.

A screening summary is presented after evaluating each alternative to identify alternatives retained for further consideration (detailed evaluation/analysis) and to offer rationale for exclusion of those alternatives that will not be considered further.

7.2.1 Alternative 1 (Solid Media): No Action

The no action alternative means that no actual reclamation activities would occur at the site to control contaminant migration or to reduce toxicity or volume.

<u>Effectiveness</u> - Protection of human health and the environment would not be achieved under the no action alternative. Prevention of direct human contact would not be achieved. The contaminant sources present at the Highland site contribute to surface water/sediment contamination and possibly groundwater contamination, which presents long-term risks

to important environmental resources as well as potential human health risks. No action continues to provide a pathway to affect human health through consumption of surface water and through the food-chain due to uptake of contaminants by fish, other aquatic life, streamside vegetation, wildlife, and livestock. Toxicity, mobility, and volume of contaminants would not be reduced under the no action alternative.

Implementability - Technical and administrative feasibility evaluation criteria do not apply to this alternative.

Cost Screening - No capital or operating costs would be incurred under this alternative.

Screening Summary - This alternative has been retained for further evaluation as suggested by the NCP.

7.2.2 Alternative 2 (Solid Media): Institutional Controls

The institutional control alternative includes erecting fences to restrict access to contaminated sources and land use restrictions to prevent land development on or near the affected areas.

Effectiveness - This alternative is not protective of the important environmental resources. It is not fully protective of human health if implemented as a stand alone alternative due to allowing the waste sources to continue to contribute to surface water and groundwater contamination. Toxicity, mobility, and volume of the contaminated media would not be reduced under this alternative.

Implementability - Institutional controls are easily implementable based on the criteria of applicability, availability, and reliability. This alternative is considered applicable for minimizing the potential for direct contact and restricting future inappropriate land development; however, due to the low number of residents and lack of workers directly on or near the site, direct contact may not be a primary route of exposure. Fencing materials and construction contractors are readily available should direct contact with the area become a problem. Reliability of this alternative for its intended purpose (protection from direct contact) is considered good as long as enforcement of the institutional controls is maintained by the regulatory agencies and landowners. Due to the logistical simplicity of implementing institutional controls, administrative feasibility is considered very good.

Cost Screening - Costs associated with institutional controls would be relatively low compared to other reclamation options; however, a considerable amount of fencing materials would be required to fully enclose the contaminated sources present at the site. Capital costs associated with construction of an 8-feet tall, chain-link fence would run approximately $30,000.00 assuming no consolidation of contaminated materials and a fencing requirement of approximately 1,500 linear feet at approximately $20.00 per linear foot. Maintenance costs would likely be less than $1,000.00 per year.

Screening Summary - Institutional controls will not be considered further as a stand-alone reclamation alternative, but may be used in conjunction with other selected treatment alternatives.

7.2.3 Alternative 3 (Solid Media): In-Place Containment

In general, in-place containment technologies involve establishing vegetation on the surface of a solid media contaminant source. The purpose of establishing vegetation is to stabilize the surface (provide erosion protection) and to decrease net infiltration through the waste by increasing evapotranspiration. Containment technologies may involve establishing vegetation directly on the waste source or involve applying a cover over the waste source upon which the vegetation is established. Covers may range from a simple, single-layered soil cover to a complex, multi-layered cover consisting of various synthetic materials. In-place containment could be expanded to include some level of in-situ stabilization (as described in Section 7.1.5.1).

This alternative involves complete removal of the tailings and consolidation with the waste rock. The tailings are currently situated downgradient of the site and upgradient of Basin Creek; this leaves the tailings susceptible to erosion into the water system due to the surrounding steep terrain. Under this alternative the tailings would be hauled out of the erosion path and placed directly below the waste rock, the waste rock would be used as a cover to contain the tailings. The entire waste rock area would be recontoured and revegetated in a nearby area isolated from all water sources.

Given the available physical and chemical data on the waste sources present at the Highland Mine site, it is reasonable to expect that vegetation could be successfully established on the waste rock dump by incorporating proper quantities and types of amendments into the material before seeding. None of the solid media sources at the site appear to be significant acid producers; consequently, adequate soil amendments (nutrients, organics, etc.) could likely be incorporated into the dump to successfully establish vegetation. However, the proper types and application rates of amendments must be carefully determined; it is possible that cover soil may be necessary or recommended to establish a healthy stand of vegetation. Extensive run-on/run-off controls would be designed as an integral part of the containment strategy. The general construction steps for implementing Alternative 3, as conceptualized, are as follows:

- removing, treating, and storing existing trees from the dump area, to be replanted after remediation;
- diverting the adit discharge away from the waste rock;
- excavating and hauling approximately 2,000 cy of tailings to be placed below the waste rock dump;

- grading out the waste rock dump to: contain the tailings, remove the contaminated material from the adit discharge flow path, reduce slopes, and provide surfaces amenable to revegetation;

- establishing vegetation directly on the waste rock dump material by incorporating proper amendments and seeding/fertilizing;

- applying a soil cover to the excavated tailings area, fertilizing and seeding;

- applying erosion control mat (for slopes greater than 2.5:1) and wood debris or windrowed slash along the toe of WR1 to armor the dump material and provide erosion protection against precipitation events;

- replanting stored trees;

- disposing of the dilapidated buildings/structures at the site;

- constructing surface water diversion ditches/structures throughout the site to route run-off away from the reclaimed source areas; and

- constructing a temporary fence around reclaimed areas until vegetation is established.

Specific conceptual design details are presented in the cost screening summary of this section.

Effectiveness - The primary purpose of establishing vegetation on a waste source is to limit the mobility of the contaminants. A healthy stand of vegetation effectively stabilizes the surface against wind and surface water erosion and minimizes the potential for migration of vadose zone contaminants from water infiltration by increasing evapotranspiration and decreasing infiltration. Vegetation would help minimize human and terrestrial biota exposure to the contaminants via direct contact and inhalation of entrained dust. The toxicity or volume of the wastes would not be reduced under this alternative since no actual treatment of the contaminants would be conducted. The overall effectiveness of the containment/revegetation program would be enhanced by carefully selecting appropriate plant species that are metal tolerant and adapted to relatively high altitudes and relatively short growing seasons.

Implementability - This alternative is both technically and administratively feasible. Incorporation of amendments and establishing vegetation are readily implementable technologies which use conventional construction techniques. Design methods and requirements have been thoroughly tested, and the necessary construction equipment and methods are readily available and widely used. Construction methods may vary depending upon the complexity of the terrain and the required depth of amendment incorporation.

Cover soil, if required, would need to be obtained from a licensed topsoil borrow area, if there is not an adequate amount of salvageable topsoil on-site.

<u>Cost Screening</u> - The total present-worth cost, based on a 30-year project life, for this alternative has been estimated at $235,900.00, which includes $181,000.00 in capital costs and $5,700.00 in annual operation and maintenance (O&M) costs. The cost covers the reclamation of all solid media contaminant sources present at the Highland site. Table C-1 (Appendix C) presents the cost details associated with implementing this alternative. The total cost includes the present-worth value of 30 years of annual maintenance and monitoring costs in addition to capital/construction costs.

Conceptual Design and Assumptions

The access road to the Highland Mine is in good condition, being wide enough to mobilize heavy equipment and machinery to the site; however, suitable roads would have to be constructed in the vicinity of the waste sources located off the main access road to allow the required heavy equipment to access and grade out the wastes. A surface water diversion structure may also be necessary to isolate the adit discharge from the construction activities while grading and armoring dumps near the channel, and to minimize the potential for erosion after the construction is completed.

The waste source areas would be graded out to reduce slopes and eliminate depressions/ irregularities and to allow placement of cover soil and the incorporation of amendments. Seeding would likely take place during the fall of the year. The seed mixture and fertilizer would be applied simultaneously to the prepared seed beds via drill application, where feasible. Mulch would be applied to promote temporary protection of the disturbed erodible surfaces. Wheat or barley straw mulch (certified weed-free) would be applied over the reclaimed dump with a tow spreader or pneumatic spreader utilizing tucking/crimping as the anchoring mechanism. Where slopes are too steep for equipment necessary to drill seed (approximately 2.5:1), a hydromulch slurry, with an adhesive anchoring mechanism, would be sprayed over the reclaimed waste rock dump. Erosion control mat would be placed over slopes steeper than 2.5:1 to minimize erosion potential. Run-on/run-off control would be designed as an integral part of the in-place containment scheme. Run-on/run-off control would consist of constructing ditches to divert run-off generated upgradient from the reclaimed sources to flow around each source. Run-off controls would also be installed where necessary to minimize run-off lengths along disturbed slopes.

The following assumptions were used to develop costs directly and to calculate associated costs for this alternative:

- Approximately 20 tons of lime per acre of WR1 would be required as an amendment for the waste source. The limited data available indicate that lime addition may not be necessary. However, recent DEQ/MWCB experience at similar sites has shown that post-grading, discrete sampling (the currently accepted method for determining lime requirements) often results in much larger lime requirements than inventory-phase composite samples indicate.

- The total cost for materials and construction of the surface water diversion structure used to divert the adit flow is estimated to be $5,000.00.
- The total surface area of the reclaimed waste sources requiring revegetation is approximately 2.0 acres (includes estimated tailings and recontoured dump areas).
- Erosion control mat would be placed on all areas greater than 2.5:1 slope and potentially affected run-off areas.
- Cover soil would need to be imported from an off-site licensed borrow area. Therefore, cover soil is estimated at $12.00 per cubic yard, delivered to the site.
- The cover soil may require organic amendments to support a healthy vegetative cover.
- Temporary fences would be installed around reclaimed areas.
- The total length of required run-on/run-off control diversion ditches is approximately 500 linear feet.

These estimates are based on analysis of available data for the site and engineering judgement. Data collected during the reclamation investigation may show that the waste rock can be amended directly with organics, fertilizer, and lime to support vegetation, negating the use of coversoil.

<u>Screening Summary</u> - This alternative has been retained for detailed analysis since in-place containment may be a feasible and cost-effective remedy for the site.

7.2.4 Alternative 4 (Solid Media): Removal and Disposal in a On-Site Constructed Repository

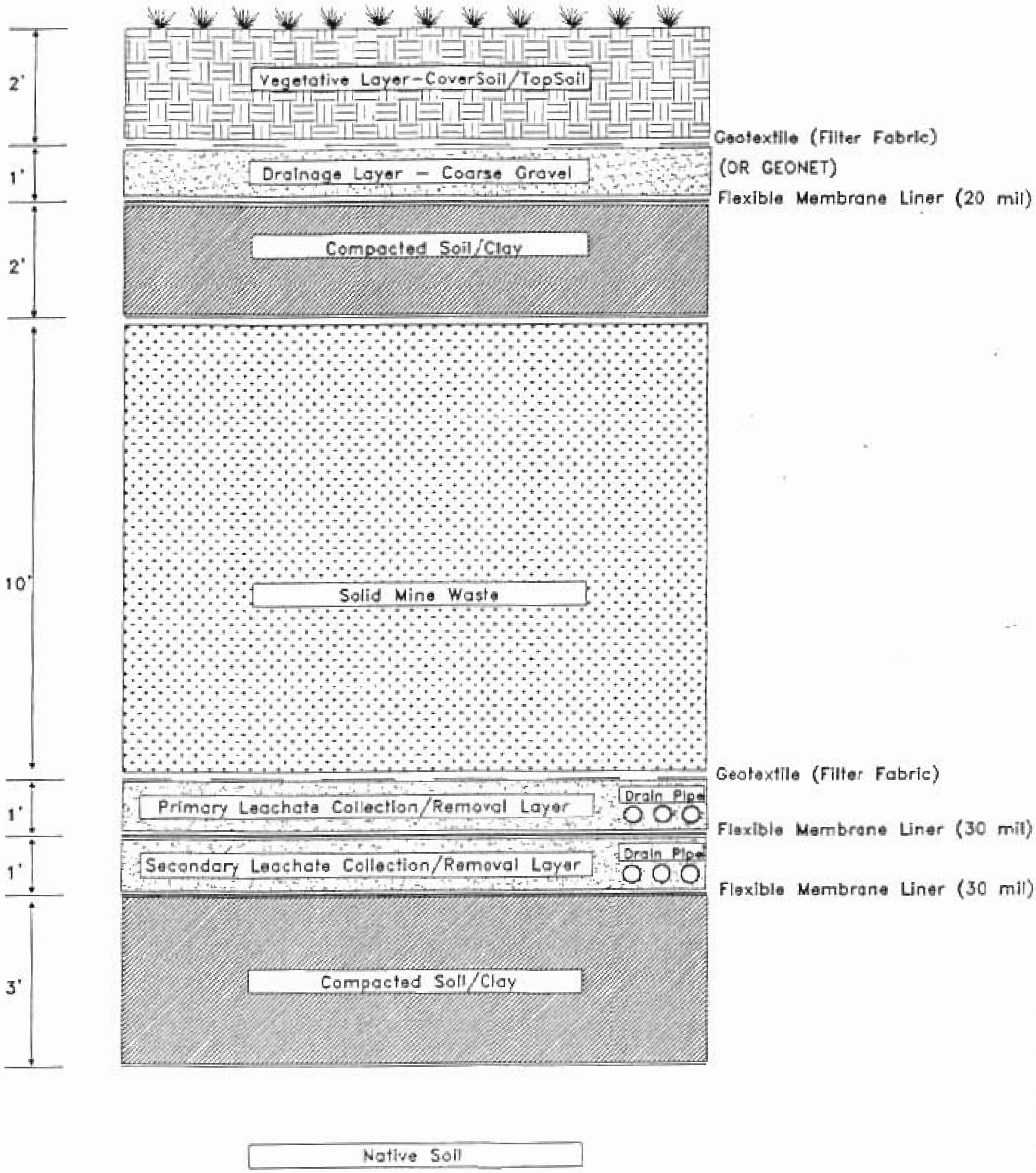
This alternative is included to evaluate a repository specifically constructed for disposal of waste materials from the Highland Mine site. This repository would either be constructed on-site or at a suitable, nearby location. Three reclamation scenarios are evaluated under Alternative 4. The major difference between the three scenarios has to do with the design of the liner system which would underlay the encapsulated wastes. The three scenarios considered include: 1) construction of a repository which complies with all RCRA Subtitle C (hazardous waste) regulations (this scenario includes a double-liner system with integral primary and secondary leachate collection and removal systems) and a multi-layered cap; 2) construction of a modified RCRA repository which includes a single liner with an integral leachate collection and removal system, also with a multi-layered cap; and 3) installation of a multi-layered cap with no bottom liner system installed under the wastes.

Design and construction costs associated with the three scenarios will vary according to the relative degree of protection provided by the bottom liner system (i.e., the higher the relative degree of protection provided by the liner system, the higher the associated costs). It is not known at this time if any of the materials present at the site exhibit hazardous waste characteristics as defined by RCRA. If they do not, then compliance with the substantive requirements of RCRA Subtitle C would not be necessary. Nonetheless, the materials would still be considered solid wastes under Montana regulations, and thus the substantive requirements for the design and operation of a solid waste landfill would apply. Design standards include the installation of a composite (clay and flexible membrane) liner, leachate collection system, and a cap no less permeable than the liner system. Two of the above scenarios (Scenarios 2 and 3) do not fully comply with EPA's Minimum Technology Guidance for hazardous waste landfill closures. However, the scenarios may still provide adequate environmental protection considering the chemical and physical characteristics of the Highland Mine waste, in conjunction with the area's generally arid climate.

Each repository design scenario will be individually evaluated (when the reclamation alternatives are analyzed in detail) using the Hydrologic Evaluation Landfill Performance (HELP) Model, in conjunction with risk analysis, to determine the relative effectiveness of each design and ultimately conclude which design is most appropriate considering the anticipated expenditure (i.e., which design is most cost-effective considering the relative reduction in risk). Although costs have been developed for each of these scenarios, only one of the scenarios (Scenario 2, single bottom liner) is evaluated in this section. Evaluating each scenario would be overly redundant because the only significant differences in the evaluation of each scenario would include the estimated cost and the relative risk reduction. The costs associated with each scenario are included in the cost section.

The remedial strategy for Alternative 4 involves removing the two waste sources (waste rock and tailings) at the Highland Mine site and disposing of this waste in a constructed repository. Based on the data available at this time, it is assumed that a total of 12,900 cy (including potentially contaminated underlying soil) of waste would be placed in the constructed repository. Construction would include excavation of the repository, installation of a liner and leachate collection and removal system, depositing and compacting the wastes in the repository, and constructing the repository cap.

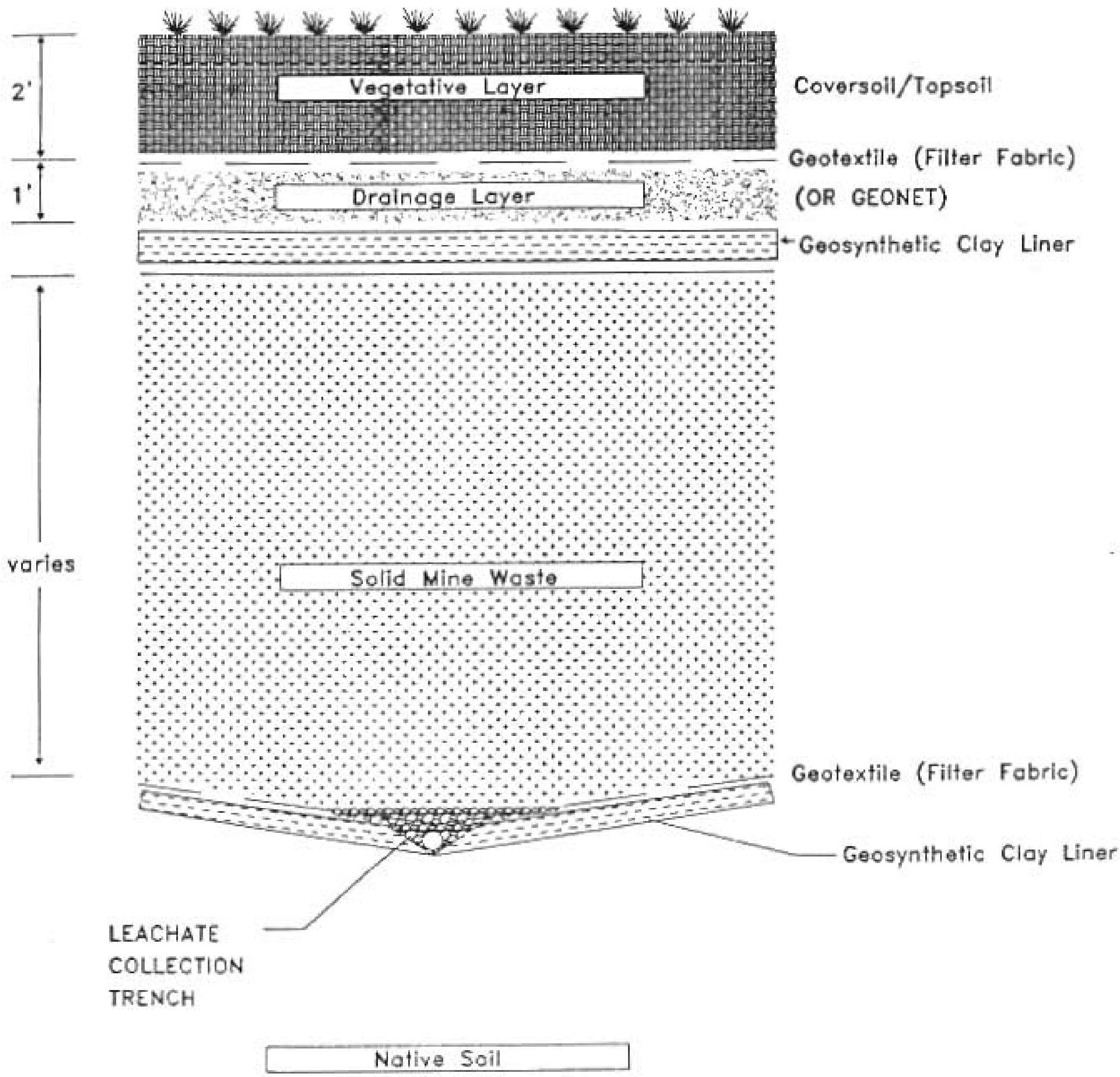
Conceptually, the repository would consist of a single liner (most likely a geosynthetic clay liner [GCL]) with an integral leachate collection/removal system and a multi-layered cap (Figure 7-2). Figures 7-1 and 7-3 illustrate the conceptual designs for the other potential repository scenarios: a RCRA Subtitle C repository (a GCL liner could be substituted for the compacted clay layer); and a repository consisting of a multi-layered cap (no bottom liner system), respectively.



PIONEER TECHNICAL SERVICES, INC.

FIGURE 7–1
ALTERNATIVE 4a
RCRA SUBTITLE C
REPOSITORY, CROSS SECTION

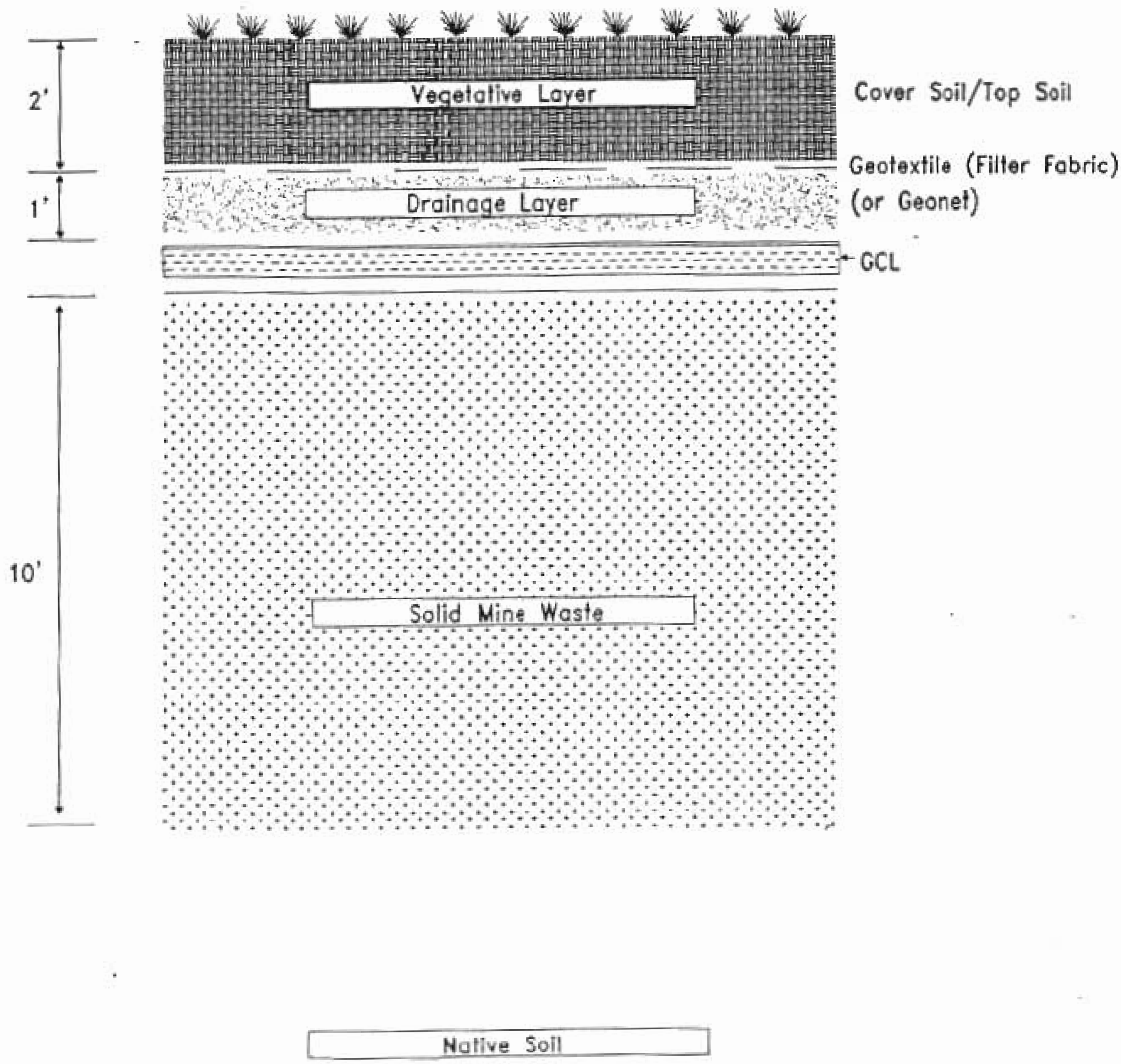
SCALE: N/A
DATE: 2/97



PIONEER TECHNICAL SERVICES, INC.

FIGURE 7-2
ALTERNATIVE 4b
MODIFIED RCRA REPOSITORY
CROSS SECTION

SCALE: N/A
DATE: 2/97



PIONEER TECHNICAL SERVICES, INC.

FIGURE 7-3
ALTERNATIVE 4c
LINED REPOSITORY CAP
CROSS SECTION

SCALE: N/A
DATE: 2/97

A considerable amount of heavy equipment/machinery would be necessary to efficiently implement this alternative. To construct the repository and load out the contaminated material, as well as construct run-on/run-off control structures, equipment requirements would include, but not necessarily be limited to, multiple bulldozers, front end loaders, and excavators. Haul trucks would also be required to transport and deposit the contaminated material in the constructed repository. The field procedure would involve constructing suitable access roads between the waste sources and the repository site to allow unobstructed access for heavy equipment.

After the waste sources are excavated and loaded out, the excavated areas would be revegetated. The excavated areas would be backfilled (with clean soil excavated from the repository) and graded; erosion control mat may be installed in areas due to the steep slopes involved, and run-on/run-off control diversion ditches would be constructed. The adit discharge drainage channel would be re-established in a natural configuration. Conceptual design details are presented in the cost screening summary of this section.

Effectiveness - This alternative would effectively reduce contaminant mobility at the site by removing the highest risk solid media contaminant sources and disposing of the waste in a secure, engineered disposal facility. Consequently, the surface water contamination problems associated with the site are expected to be corrected. Contaminant toxicity and volume would not be reduced; however, the waste mobility would be minimized in an engineered structure protected from erosion problems. Long-term monitoring and control programs would be established to ensure continued effectiveness.

Implementability - This alternative is technically feasible. The construction steps required are considered standard/conventional construction practices. Key project components, such as the availability of equipment, materials, and construction expertise, are all present and would help ensure the timely implementation and successful execution of the proposed plan. Depth to groundwater and the repository siting considerations could potentially complicate technical implementability.

Cost Screening - The total present-worth cost for this alternative, assuming a Modified RCRA repository, has been estimated at $460,900.00. This cost represents the reclamation of all solid contaminated media present at the Highland Mine site (WR1 and tailings). Table C-3 (Appendix C) presents the cost details associated with implementing this alternative. The total cost includes the present-worth value of 30 years of annual maintenance and monitoring costs in addition to capital costs.

Table C-2 (Appendix C) presents the costs associated with constructing a RCRA Subtitle C repository (Scenario 1). The present worth cost for this scenario is estimated at $503,400.00. The total present worth cost for a repository consisting of a multi-layered lined cap (Scenario 3, no bottom liner system) has been estimated at $407,800.00. These costs are summarized on Table C-4 (Appendix C).

Conceptual Design and Assumptions

Suitable roads would be constructed in the vicinity of the waste sources and the repository site to allow access for the required equipment to loadout and deposit the waste. A temporary surface water diversion structure would be installed in the drainage to isolate the stream from the construction activities while excavating materials from the channel/floodplain. Cover soil would be borrowed from an off-site source to backfill the excavated areas. After the repository construction, waste excavation, and deposition are complete, all disturbed areas at the site would be revegetated. Run-on/run-off control would consist of constructing ditches to divert run-off generated upgradient from the reclaimed areas to flow around the areas. A run-on/run-off control ditch would also be constructed in the area of the repository to divert run-off away from the repository cap.

The following assumptions were used to develop costs directly and to calculate associated costs for this alternative:

- The total cost for materials and installation for the temporary surface water diversion structure to be placed in the stream is assumed to be $5,000.00.

- The total volume of waste material to be excavated and disposed in the repository is 12,900 cy.

- The total surface area of the repository would be approximately 0.8 acre.

- Bottom Liner--A GCL would be installed and anchored in the repository excavation, and the side slopes of the repository would be 4:1.

- Leachate Collection/Removal System--The leachate collection/removal system would consist of a 6-inch diameter, perforated PVC pipe installed in a lined, sloping trench running the entire length of the repository floor. The perforated pipe would be joined to a solid wall pipe which would drain to an evaporation pond. Geotextile filter fabric and synthetic geonet material would be installed over the liner system to convey leachate laterally to the leachate collection/removal pipe.

- The mine waste would be re-deposited over the bottom liner system in the repository at a depth of approximately 10 feet.

- Repository Cap--The multi-layered repository cap would consist of a geosynthetic clay liner placed over the prepared and compacted wastes. Geonet drainage material, sandwiched between layers of geotextile filter fabric, would overlay the liner to laterally convey infiltrating precipitation and moisture.

- Vegetative Cover--A two-feet-thick layer of native soil would overlay the cap drainage layer.

- Techniques applicable to steep slopes would be incorporated for applying soil amendments and preparing seed beds in several of the reclaimed source areas.

- Temporary fences would be installed around reclaimed areas.

- Erosion control mat would be required for reclaimed slopes steeper than a 2.5:1.

- The total length of required run-on/run-off control diversion ditches is 800 lineal feet.

Screening Summary - Alternative 4a has not been retained for further evaluation due to its inability to satisfy the criteria of the reclamation goals. Alternatives 4b and 4c have been retained for detailed analysis due to their potential to effectively meet the reclamation goals, both economically and technically.

7.2.5 Alternative 5 (Solid Media): Off-Site Disposal in an Existing Waste Disposal Facility

The remedial strategy for Alternative 5 involves removing the waste sources at the Highland Mine site and disposing of the waste in an existing, permitted waste disposal facility. Based on the available data, it is assumed that the waste rock source would be excavated and disposed.

Three general options are available for off-site disposal in an existing facility: a RCRA-permitted hazardous waste disposal facility; a DEQ-permitted solid waste (Class II) landfill; or a currently proposed mine waste facility that may exist in proximity of the Basin Creek Mine, near Basin, Montana. Each is discussed briefly below.

The two nearest RCRA-permitted hazardous waste disposal facilities with the capacity to dispose of the wastes are both located several hundred miles from the site (one facility is located in Idaho, the other in Oregon). Wastes could be transported and disposed at these facilities if they are considered characteristically hazardous (TCLP analyses are planned as part of the field investigation to make this determination). The waste would require profiling and acceptance by the disposal facility (the wastes may possibly require pre-treatment, in accordance with RCRA land disposal restrictions, prior to disposal at a hazardous waste facility).

If the wastes are not classifiable as hazardous waste (as determined by TCLP analyses), the wastes could possibly be disposed at a Class II solid waste disposal facility within the state of Montana for a lesser cost (assuming that a Class II facility would be willing to accept the volume of waste involved). Most likely, this would mean disposal at the Butte solid waste landfill. Alternatively, the wastes could conceivably be hauled to Helena, Missoula, or Great Falls, Montana.

A third option for off-site disposal is at the Luttrell pit at the Basin Creek mining operation, located north of the town of Basin. The USFS and the DEQ/MWCB are currently exploring the feasibility of constructing a facility near the Basin Creek Mine; this facility would be dedicated to accepting wastes from abandoned mines in the vicinity of the site. Disposal of the Highland Mine waste using this option would be impossible for 1997, since this option is still in the preliminary stages.

One major difference between this option and the other options is that this option would not require treatment of the materials prior to disposal to comply with ARARs. The materials are excluded from hazardous waste regulations under the Bevill Amendment. Therefore, disposal in a dedicated mine waste facility would not require treatment to remove hazardous characteristics prior to disposal.

A considerable amount of heavy equipment/machinery would be necessary to efficiently implement this alternative. To load out the contaminated material and construct run-on/run-off control structures, equipment requirements would include, but not necessarily limited to, multiple bulldozers, front end loaders, and excavators. Haul trucks would be used to transport and dispose of the material at the disposal facility. The field procedure would first involve constructing suitable access roads (and possible turnout points) in the vicinity of the waste sources at the site to allow unobstructed access for haul trucks. Consequently, the number of haul trucks and loaders would have to be determined/scheduled carefully to optimize loading cycle times and reduce construction costs as much as possible.

After the waste sources are excavated and loaded out, the excavated areas would be backfilled as necessary, graded, and revegetated. Run-on/run-off control diversion structures would be constructed. Conceptual design details are presented in the cost screening summary of this section.

Effectiveness - This alternative would effectively reduce contaminant mobility at the site by completely removing the highest risk contaminant sources; consequently, the site problems associated with the contaminated solid media are expected to be permanently corrected. Contaminant toxicity and volume would not be reduced, but would be permanently transferred to a different physical location. Disposal at a permitted facility establishes long-term monitoring and control programs to ensure continued effectiveness. However, short-term risks of exposure to the contaminated material would occur during transport to the disposal facility.

Implementability - This alternative is both technically and administratively feasible. The construction steps required (excavation and loadout) are considered standard construction practices. Key project components, such as the availability of equipment, materials, and an off-site facility with adequate capacity, are all present and would help ensure the timely implementation and successful execution of the proposed plan. Implementation of this alternative is contingent upon disposal facility acceptance.

A factor that could possibly limit the implementability of this alternative as planned includes the possible presence of shallow groundwater in the general vicinity of the waste sources. If significant groundwater is encountered when excavating the wastes, pre-treatment of the wet material may be necessary to eliminate free liquids (paint-filter testing criteria). Pre-treatment may simply involve stockpiling the material and allowing it to drain naturally or possibly solidification/stabilization either on-site or at the disposal facility. Pre-treatment may also be required to reduce leachable concentrations of land-banned contaminants (i.e., arsenic, lead, etc.). Pre-treatment, if required, would significantly increase project costs.

<u>Cost Screening</u> - The total present-worth cost for the RCRA hazardous waste disposal facility option of this alternative, as shown in Table C-5 (Appendix C), has been estimated at $5,241,800.00, which represents the remediation of all solid media contaminant sources present at the Highland Mine site. The total cost includes the present-worth value of 30 years of annual maintenance and monitoring costs in addition to capital costs. The total present worth cost associated with disposing of the wastes at a Montana Class II disposal facility has been estimated at $1,072,400.00. These costs are detailed on Table C-6 (Appendix C). Disposal at the proposed Basin Creek facility is estimated to cost $1,040,500.00, as shown on Table C-7 (Appendix C).

Conceptual Design and Assumptions

Suitable roads would be required to be constructed in the immediate vicinity of the waste sources to allow access for large haul trucks and loadout of the waste. A temporary surface water diversion structure would be installed in the adit discharge (Basin Creek headwaters) to isolate the creek from the construction activities while excavating materials from the channel/floodplain. The number of loaders and haul trucks would be maximized to the extent possible to reduce the overall time required to complete the project's construction phase.

After the excavation and loadout are complete, the excavated areas would be revegetated. Cover soil may be required in the excavated areas to level out and contour the areas to match the surrounding terrain. The seed beds would be prepared using techniques applicable to steep slopes in the area of WR1. It would be recommended that seeding take place during the fall of the year. The seed mixture and fertilizer would be applied simultaneously to the prepared seed beds via drill application. Disturbed surfaces are susceptible to erosion until vegetation is established; therefore, mulch would be applied to promote temporary protection of exposed erodible surfaces. Wheat or barley straw mulch (certified weed-free) would be applied over the excavated areas with a tow spreader or pneumatic spreader utilizing tucking/crimping as the anchoring mechanism. A hydromulch slurry, with an adhesive anchoring mechanism, would be sprayed over steep grades (greater than approximately 2.5:1 slope) reclaimed areas. Run-on/run-off control would consist of constructing ditches to divert run-off generated upgradient from the reclaimed sources to flow around the sources. After excavation of waste materials, the adit discharge would be re-established in it's native drainage.

The following assumptions were used to develop costs directly and to calculate associated costs:

- Total cost for materials and installation for the temporary surface water diversion structure to be placed in the adit discharge is assumed to be $5,000.00.

- Based on the estimated volume (12,900 cy) and an estimated density of 1.6 tons of waste rock per cubic yard, and 1.55 tons of tailings per cubic yard, the total tonnage of waste material to be removed from the site has been estimated at approximately 21,000 tons.

- Techniques applicable to steep slopes would be incorporated for applying amendments and preparing seed beds in the steeper excavated areas.

- The total area requiring revegetation would be approximately 2.0 acres.

- The total length of required run-on/run-off control and diversion ditches is approximately 800 linear feet.

- Temporary fences would be installed around reclaimed areas.

- Erosion control mat may be required on the majority of the slopes (greater than 2.5:1) requiring revegetation.

<u>Screening Summary</u> - This alternative has not been retained for further evaluation due to extremely high costs. A similar degree of relative effectiveness can be obtained by other alternatives being evaluated at significantly reduced costs.

7.2.6 Adit Discharge Alternatives

The following summarizes general information collected to date (1993 and 1995) regarding the adit discharge at the Highland Mine site:

pH	6.40 to 7.97
Adit Flow	100 to 175 gpm
Oxidation Reduction Potential	171 to 221 mV
Dissolved Oxygen	3.0 to 9.0 mg/L
Bicarbonate Alkalinity	100 to 189 mg/L as $CaCO_3$
Contaminants of Concern	Hg (HHS); Hg (MCL)
Percent of contaminant in dissolved (<0.45 um) phase	Hg (unknown, total and dissolved not detected)

This data indicates a few important chemical properties of the discharge; the water has a neutral to slightly alkaline pH and significant buffering capacity (bicarbonate alkalinity). The Highland

Mine adit discharge does not contain any elevated concentrations of metals. Mercury is the only metal that may exceed an established water quality standard, only because the chronic aquatic life standard for mercury (0.012 μg/L) is less than the reported detection limit (0.18 μg/L) in the 1996 Reclamation Investigation.

Thermodynamic stability diagrams for these conditions (pH as measured, oxidized waters) indicate that Hg should exist primarily as an uncharged aqueous species (Hg^0); however, mercury in this state tends to readily volatilize. Since the chronic standard is so low, it is not possible to verify the presence of this contaminant.

Surface water data collected during the field reclamation investigation includes seven stations along Basin Creek, including the adit discharge (47-028-SW/SE1 through SW/SE6 and AD1/SE7). Water analyses included: total metals (TAL), total recoverable metals (TAL), dissolved metals (TAL, adit discharge only), field parameters (pH, SC, temperature, alkalinity, discharge), and wet chemistry (sulfate, TDS, hardness). Sediment analyses included total metals (TAL) only. All reclamation investigation surface water and sediment data are located in Tables B-2, B-7, B-8, and B-9 (Appendix B).

Increases in Hg and Fe concentrations at SW5 could be caused by waste rock entrainment, the same for elevated Hg at stations SW4 and SW3. Increases of several metals at station SW1 (As, Fe, Hg, Mn, Pb) are probably due to the influence of the wetlands with the lower pH releasing some metals.

No Federal MCLs established by the EPA were exceeded in Basin Creek. Montana HHSs (DEQ/WQB, 1995) were exceeded for mercury at stations SW5, SW4, SW3, and SW1 and for iron at station SW1.

No acute ambient water quality criteria were exceeded for any element at the site. The chronic ambient water quality criteria was exceeded for mercury at stations SW5 down through SW1 in the total recoverable metals analysis. The chronic mercury criteria (0.012 μg/L) is less than the detection limit for mercury at other stations and those analyses that are below detection may also exceed this criteria.

Field parameters and wet chemistry results were relatively constant across all stations (Table 3-3 in Section 3) except for a slight decrease in pH, alkalinity, and S.C. at SW1. These changes are likely due to the influence of the wetlands upstream of this station.

Metal concentrations in streambed sediments at station SE6 are elevated for As, Cu, Fe, Hg, Mn, Pb, and Zn. These metals decrease abruptly downstream at station SE5 (except Pb). Concentrations of Cu, Hg, and Zn then increase at SE4, adjacent to the tailings deposits (TP4 and TP5). Metals concentrations decrease downstream until the last station (SW1 below the wetlands) where As, Fe, and Zn increase.

No water treatment, either active or passive, appears to be necessary for this "source". Without treatment, no standards are exceeded and the only impact probably occurs from the interaction of the discharge water with the waste rock dump. Therefore, no treatment alternatives are evaluated below; however, two discharge diversion options are preliminarily evaluated.

7.2.6.1 Alternative 1 (Adit Discharge): No Action

The no action alternative means that no actual reclamation activities will occur at the site to control contaminant migration or to reduce toxicity or volume.

Effectiveness - Protection of human health and the environment would be maintained under the no action alternative since the adit discharge present at the Highland site does not appear to contribute significantly to surface water contamination. It also does not present long-term risks to important environmental resources as well as potential human health risks.

Implementability - Technical and administrative feasibility evaluation criteria do not apply to this alternative.

Cost Screening - No capital or operating costs would be incurred under this alternative.

Screening Summary - This alternative has been retained for further evaluation as suggested by the NCP.

7.2.6.2 Alternative 2 (Adit Discharge): Institutional Controls

The institutional control alternative includes erecting fences to restrict access to the adit discharge and land use restrictions to prevent land development on or near the affected areas.

Effectiveness - Protection of human health and the environment would be achieved under this alternative since the adit discharge present at the Highland site does not appear to contribute significantly to surface water contamination. It also does not appear to present long-term risks to important environmental resources as well as potential human health risks.

Implementability - Institutional controls are easily implementable based on the criteria of applicability, availability, and reliability. This alternative is considered applicable for minimizing the potential for direct contact and restricting future inappropriate land development. Fencing materials and construction contractors are readily available should direct contact with the discharge be identified as a problem. Reliability of this alternative for its intended purpose (protection from direct contact) is considered good as long as enforcement of the institutional controls is maintained by the regulatory agencies and landowners. Due to the logistical simplicity of implementing institutional controls, administrative feasibility is considered very good.

Cost Screening - Costs associated with institutional controls would be relatively low as compared to other remedial measures. Capital costs associated with construction of an 8-feet tall, chain-link fence would run approximately $2,500.00 assuming no consolidation of contaminated materials and a fencing requirement of approximately 125 linear feet at approximately $20.00 per linear foot. Maintenance costs would be limited to periodic inspections and maintenance of the fence.

Screening Summary - Institutional controls will not be considered further as a stand-alone alternative, but may be used in conjunction with other treatment alternatives.

7.2.6.3 Alternative 3 (Adit Discharge): Adit Discharge Collection and Diversion

As previously mentioned, the Highland Mine adit discharge does not contain any elevated concentrations of metals; pH of the discharge has been measured in the neutral to slightly alkaline range (between 6.40 and 7.97 S.U.). Mercury is the only metal that may exceed an established water quality standard. Arsenic, copper, and iron are slightly elevated relative to background. These elevated concentrations occur only after the flow travels through the waste rock, indicating that the metals are being entrained by the physical transport of fine-grained mineralized rock from the dump. A potential remedy to this situation is to isolate the dump material from the adit flow. This alternative describes two ways to mitigate the interaction of the adit discharge with the dump material: 1) piping the discharge through and away from the contaminated source; and 2) contaminant removal/channel restoration.

The piping option consists of collecting the adit flow (at the discharge point), into a grated basin, where it would be piped under the dump area and released back into its natural channel downgradient from the site. The dump material above of the piping system would be recontoured and amended for revegetation. The new channel construction option would consist of stream reconstruction within the natural flow path. All contaminants would be removed from within and around the stream channel. The stream channel would then be reconstructed and revegetated to prevent potential erosion.

Alternative 3a (Adit Discharge): Piping Discharge through the Contaminated Source

The remedial strategy for Alternative 3a includes controlling and rerouting the adit discharge by using a piping system. Run-on controls would be designed as an integral part of this alternative to control non-adit water flow from entering the diversion system. The general construction steps for implementing Alternative 3a, as conceptualized, are as follows:

- rerouting the adit discharge until excavation of the contaminated materials from the stream area is completed and the piping system is installed;
- constructing a drop inlet collection basin (using concrete and a manufactured drop inlet pipe) at the discharge point of the adit;

- installing a metal grate for the top of the collection basin to prevent large debris from plugging the pipe;

- placing HDPE pipe (sized for maximum flow) underground at an approximate 2% slope from the drop inlet catch basin to the outside of the contaminated area and into its natural flow path;

- building stream structures (step pools) from the release point through the lateral extent of the site boundary (approximately 100 feet) to inhibit soil contaminant mobility during large precipitation events;

- regrading and establishing vegetation on the materials above the pipe; and

- constructing a fence around the reconstruction area to prevent disturbance until vegetation can be established.

Effectiveness - This alternative is expected to be effective at reducing the mobility of the CoCs. The system as described would provide a route for adit discharge water to travel to a surface water conveyance without contacting other mine waste materials. Uncontaminated adit water would then be discharged back into the natural Basin Creek flow path. The system will likely be able to attain discharge standards defined by ARARs.

Implementability - This alternative is technically and administratively feasible. The construction materials and equipment necessary are readily available. Adequate space is available to construct the alternative as described.

Cost Screening - Estimated costs for implementing this alternative are summarized on Table C-8 (Appendix C). These costs include estimated capital costs of $44,700.00 and annual O&M costs of $3,500.00. The present worth value of the alternative, based on a 30-year project life is estimated at $77,800.00.

Conceptual Design and Assumptions

The focus of Alternative 3a is to separate the waste rock materials from the stream to prevent the transportation of contaminated materials into the Basin Creek drainage and the Butte Water System. This can be done by constructing a diversion structure that will route the adit discharge to the outer boundaries of the mine area. The water would be collected and controlled by a constructed concrete basin/drop inlet from the discharge point of the adit. The flow would then be transported to the outer limits of the mine site through a diversion pipe, where it would be placed back into its natural flow path. The diversion system would be sized to accommodate the maximum adit flow.

Stream structures (step pools) would be constructed from the outlet of the diversion pipe to the intersection of the Highland Road (approximately 100 linear feet) to ensure immobilization of sediments or remaining contaminants that may erode into the structure or outlet area during extreme precipitation events. The soil layer covering the pipe diversion structure would be regraded and vegetated.

Periodic inspections would be necessary to detect possible system failures such as: improper function of run-on controls, pipe obstruction from debris that may pass through the grate, possible freezing within the pipe during the winter months, and pipe failures that may occur due to flow and material stresses. Fencing (approximately 125 linear feet) would be constructed around the perimeter of the construction area to prevent any contact with the reconstructed site until vegetation can be established.

Screening Summary - This alternative has been retained for detailed analysis since it may be an effective remedy for the adit discharge. It is also implementable, potentially cost-effective, and would comply with ARAR's for surface water.

Alternative 3b (Adit Discharge): Contaminant Removal/Channel Restoration

The remedial strategy for Alternative 3b involves practically the same maneuvers as Alternative 3a with the exception of the permanent drop inlet/diversion pipe. For this alternative the adit discharge would remain above ground in a reconstructed channel. The new reconstructed stream channel will begin at the discharge point and extend throughout the excavated area, where it would then join the natural stream channel. Structures would be constructed within the stream channel to ensure immobilization of sediments or remaining contaminated soils that may erode into the water path during extreme precipitation events. Run-on controls would be designed as an integral part of this alternative to control non-adit water flow from entering the diversion. The general construction steps for implementing Alternative 3b, as conceptualized, are as follows:

- rerouting the adit discharge (via pump and/or diversion pipe) until excavation of the contaminated materials from the stream area is completed and stream structures are built;
- excavating the contaminated materials from the stream area (streambed and banks) and replacing with clean soils where needed;
- reconstructing the stream channel with riprap, gravel and clean soils;
- building stream structures to eliminate the transportation of sediments into the Basin Creek drainage and Butte Water System;
- replanting (via seed and amendments) vegetation around the constructed stream to prevent erosion of the stream banks; and

- fencing around the construction to prevent disturbance to the revegetated areas.

Effectiveness - This alternative is expected to be effective at reducing the mobility of the CoCs. The alternative as described would provide a contaminant free route for the adit discharge water to travel to a surface water conveyance. The stream structures further guarantee the immobilization of contaminated soils. The system will likely be able to attain discharge standards defined by ARARs.

Implementability - This alternative is both technically and administratively feasible and implementable. The construction materials and equipment necessary are readily available. Adequate space is available to construct the alternative as described.

Cost Screening - Estimated costs for implementing this alternative are summarized on Table C-9 (Appendix C). These costs include estimated capital costs of $48,500.00 and annual O&M costs of $2,400.00. The present worth value of the alternative, based on a 30-year project life is estimated at $71,300.00.

Conceptual Design and Assumptions

The focus of Alternative 3b is to remove the waste rock materials from the stream to prevent the transportation of contaminated materials into the Basin Creek drainage and the Butte Water System. This alternative can be accomplished by excavating the contaminated materials from the existing discharge route, including the stream bed and banks. A temporary water diversion would be utilized during the excavation/reconstruction phase. Stream structures (step pools) would be constructed on the steeper grades of the stream (approximately 100 linear feet) to catch any mobile contaminants that may erode into the stream structures during extreme precipitation events during the reclamation stage. Vegetation would be established along the stream banks to prevent the banks from eroding into the stream channel, and erosion control blanket would be used where necessary. Fencing would be placed around the reconstructed area (approximately 125 linear feet) until vegetation can be established.

Screening Summary - This alternative has been retained for detailed analysis since it may be an effective remedy for the adit discharge. It is also implementable, potentially cost-effective, and will comply with ARARs for surface water.

7.3 ALTERNATIVES SCREENING SUMMARY

7.3.1 Solid Media Alternatives Screening Summary

Table 7-5 summarizes the findings of the solid media alternatives screening exercise. Costs generated and summarized in Table 7-5 are estimated present-worth values which include construction costs, as well as operation/monitoring and maintenance costs for a 30-year period. These cost estimates are order-of-magnitude estimates, generated for planning purposes. Cost estimates will be refined during the detailed analysis of alternatives after the site has been more accurately characterized. Alternative 4a, Disposal in an On-site RCRA Subtitle C Repository, will not be retained for detailed analysis because the modified RCRA design would provide a similar reduction in risk for a substantially reduced cost. Additionally, off-site disposal in a licensed and permitted RCRA disposal facility, Class II disposal facility, or transport to a regional repository will not be retained for detailed analysis because other proposed alternatives could provide a similar reduction in risk at a significantly lower cost.

7.3.2 Adit Discharge Alternatives Screening Summary

Table 7-6 summarizes the findings of the adit discharge alternatives screening exercise. Costs generated and summarized in Table 7-6 are estimated present-worth values which include construction costs, as well as operation/monitoring and maintenance costs, for a 30-year period. Alternative 2, Institutional Controls, has not been retained for detailed analysis because it would be no more effective than the no action alternative. Rerouting the adit discharge, via piping the discharge away from the contaminated source, will reduce the mobilization of contaminated soils. It may be a cost effective alternative for addressing the adit discharge. Alternative 3b, New Channel Construction, has been retained for detailed analysis. Excavating the contaminants in and around the stream area is expected to be effective in addressing the transport of waste materials into the Basin Creek drainage and the Butte Water System. This alternative is both cost effective and easy to implement.

TABLE 7-5

HIGHLAND MINE
SOLID MEDIA ALTERNATIVES SCREENING SUMMARY

ALTERNATIVE DESCRIPTIONS	EFFECTIVENESS	IMPLEMENTABLE	COST ESTIMATE	RETAINED FOR DETAILED ANALYSIS
ALT. 1: No Action	NA	NA	$0.00	Yes
ALT. 2: Institutional Controls	Low	Questionable	$30,000.00	Yes
ALT. 3: In-Place Containment	High	Yes	$236,000.00	Yes
ALT. 4a: Disposal in A Site-Specific RCRA Subtitle C Repository	High	Questionable	$503,000.00	No
ALT. 4b: Disposal in a Site-Specific Modified Repository w/Lined Cap	High	Questionable	$461,000.00	Yes
ALT. 4c: Disposal in a Site-Specific Unlined Repository w/Lined Cap	High	Questionable	$409,000.00	Yes
ALT. 5a,b,c: Disposal at Regional RCRA TDS Facility, Class II FAcility, or Basin Creek Regional Repository	High	Yes	$1,040,000 - $5,200,00	No

TABLE 7-6

HIGHLAND MINE
ADIT DISCHARGE ALTERNATIVES SCREENING SUMMARY

ALTERNATIVE DESCRIPTIONS	EFFECTIVENESS	IMPLEMENTABLE	COST ESTIMATE	RETAINED FOR DETAILED ANALYSIS
ALT. 1: No Action	NA	NA	$0.00	Yes
ALT. 2: Institutional Controls	Low	Yes	$8,000.00	No
ALT. 3a: Piping Discharge from the Contaminated Source	High	Yes	$78,000.00	Yes
ALT. 3b: Contaminant Removal / Channel Restoration	High	Yes	$71,000.00	Yes

8.0 DETAILED ANALYSIS OF RECLAMATION ALTERNATIVES

The purpose of this analysis is to evaluate, in detail, reclamation alternatives for their effectiveness, implementability, and cost to control and reduce the toxicity, mobility, and/or volume of contaminated mine wastes at the Highland Mine site. Only those reclamation alternatives which were retained after the preliminary evaluation and screening (as presented in the Section 7) are included. For clarity, the retained alternative numbers are carried over from Section 7. Each reclamation alternative currently being considered for implementation at the Highland site is classifiable as an interim or removal action and is not a complete remedial action. The reclamation alternatives evaluated in detail are applicable to the contaminated solid media and the adit discharge only; no reclamation alternatives for groundwater, surface water, or contaminated stream sediments are analyzed in detail. The rationale for not directly developing reclamation alternatives for these environmental media was based primarily on the presumption that reclaiming the contaminant source(s) will subsequently reduce any problems associated with groundwater, surface water, or stream sediments at a significantly reduced cost.

As required by the CERCLA and the NCP, reclamation alternatives that were retained after the initial evaluation and screening have been evaluated individually against the following criteria:

- overall protection of human health and the environment;
- compliance with ARARs;
- long-term effectiveness and permanence;
- reduction of toxicity, mobility, or volume through treatment;
- short-term effectiveness;
- implementability; and
- cost.

Supporting agency acceptance and community acceptance are additional criteria that will be addressed after DEQ and the public have a chance to review the evaluations presented. The analysis criteria have been used to address the CERCLA requirements and considerations with EPA guidance (EPA, 1988a), as well as additional technical and policy considerations. These criteria serve as the basis for conducting the detailed analysis and subsequently selecting the preferred reclamation alternative(s). The criteria listed above are categorized into three groups, each with distinct functions in selecting the preferred alternative. These groups include:

- Threshold Criteria - overall protection of human health and the environment and compliance with ARARs;

- Primary Balancing Criteria - long-term effectiveness and permanence; reduction of toxicity, mobility, or volume through treatment; short-term effectiveness; implementability; and cost; and

- Modifying Criteria - state and community acceptance.

"Overall protection of human health and the environment and compliance with applicable or relevant and appropriate requirements" are threshold criteria that must be satisfied for an alternative to be eligible for selection. Long-term effectiveness and permanence; reduction of toxicity, mobility, or volume; short-term effectiveness; implementability; and cost are the primary balancing factors used to weigh major trade-offs between alternative hazardous waste management strategies. State and community acceptance are modifying considerations that are formally considered after public comment is received on the proposed plan and the Expanded EE/CA report" (Federal Register, No. 245, 51394-50509, December 1988). Each of these criteria are briefly described in the following paragraphs.

The overall protection criterion evaluates how the alternative, as a whole, protects and maintains human health and the environment. The overall assessment of protection is based on a combination of factors assessed under other evaluation criterion, especially long-term effectiveness and permanence, short-term effectiveness, and compliance with ARARs.

Compliance with ARARs criterion assesses how each alternative complies with applicable or relevant and appropriate standards, criterion, advisories, or other guidelines. Waivers will be identified, if necessary. The following factors will be addressed for each alternative during the detailed analysis of ARARs:

- compliance with chemical-specific ARARs;
- compliance with action-specific ARARs;
- compliance with location-specific ARARs; and
- compliance with appropriate criterion, advisories, and guidelines.

Long-term effectiveness and permanence evaluates the alternative's effectiveness in protecting human health and the environment after response objectives have been met. The following components of the criterion will be addressed for each alternative:

- magnitude of remaining risk;
- adequacy of controls; and
- reliability of controls.

The reduction of toxicity, mobility, or volume assessment evaluates anticipated performance of the specific treatment technologies. This evaluation focusses on the following specific factors for a particular reclamation alternative:

- the treatment process, the remedies they will employ, and the materials they will treat;
- the amount of contaminated materials that will be destroyed or treated, including how principal threat(s) will be addressed;
- the degree of expected reduction in toxicity, mobility, or volume measured as a percentage of reduction (or order of magnitude);
- degree to which the treatment will be irreversible; and

- the type and quantity of treatment residuals that will remain following treatment.

Short-term effectiveness evaluates an alternative's effectiveness in protecting human health and the environment during the construction and implementation period until the response objectives are met. Factors that will be considered under this criterion include:

- protection of the surrounding community during reclamation actions;
- protection of on-site workers during reclamation actions;
- protection from environmental impacts; and
- time until removal response objectives are achieved.

Implementability evaluates the technical and administrative feasibility of alternatives and the availability of required resources. Analysis of this criterion will include the following factors and subfactors:

Technical Feasibility

- construction and operation;
- reliability of the technology;
- ease of undertaking additional reclamation actions (if necessary); and
- monitoring considerations.

Administrative Feasibility

- RCRA disposal restrictions;
- institutional controls; and
- permitting requirements.

Availability of Services and Materials

- adequate off-site treatment, storage capacity, and disposal services;
- necessary equipment and specialists, and provisions to ensure any necessary additional resources;
- timing of the availability of technologies under considerations; and
- services and materials.

The cost assessment evaluates the estimated capital and maintenance and monitoring costs associated with each alternative. A present-worth analysis based on a 4-percent inflation rate and a maximum design life of 30 years is used to compare alternatives. Cost screening consists of developing conservative, order-of-magnitude cost estimates based on similar sets of site-specific assumptions. Cost estimates for each alternative will consider the following factors:

Capital Costs

- construction costs;
- equipment costs;
- land and site development costs;
- disposal costs;
- engineering design;
- legal fees, license, and permit costs;
- startup and troubleshooting costs; and
- contingency allowances.

Annual Costs

- operating labor;
- maintenance and monitoring materials and labor;
- auxiliary materials and energy;
- disposal residues;
- purchased services (i.e., sampling costs, laboratory fees, professional fees);
- administrative costs;
- insurance, taxes, and licensing;
- maintenance reserve and contingency funds;
- rehabilitation costs; and
- periodic site reviews.

Cooperating Agency acceptance will evaluate the technical and administrative issues and concerns the state may have regarding each of the alternatives. State acceptance will also focus on legal issues and compliance with state statutes and regulations. ***Community acceptance*** will incorporate public concerns into the analyses of the alternatives.

The final step of this analysis is to conduct a comparative analysis of the alternatives. The comparative analysis includes a discussion of the alternative's relative strengths and weaknesses with respect to each of the criterion and how reasonable key uncertainties could change expectations of their relative performance.

Once completed, this evaluation will be used to select the preferred alternative(s). The selection of the preferred alternative(s) will be documented in a Notice of Decision by the MWCB. Public meetings to present the alternatives will be conducted and significant oral and written comments will be addressed in writing.

8.1 QUANTITATIVE EVALUATION OF THRESHOLD CRITERIA

In the following detailed evaluations of the threshold criteria, each reclamation alternative contains quantitative estimates of risk reduction as well as estimates regarding whether ARARs would be attained by implementing the alternative. To quantitatively assess the threshold criteria (overall protection of human health and the environment and attainment of ARARs), the exposure pathways of concern that were identified in the baseline risk assessment (human health and ecologic) were evaluated to determine the risk reduction required in order to achieve the desired residual risk level (Hazard Quotient ≤1 and Ecologic Quotient ≤1). Each alternative was then modeled to ascertain the degree of risk reduction achieved, either through reduced contaminant loadings to an exposure pathway or reduced surface area available for certain exposures. The resulting risk reduction estimates are then compared to one another to determine whether the relative risk reduction provided by a specific alternative is greater than another; these risk reductions are also compared to the reduction required to alleviate excess risk via the specific pathway or media, as determined in the risk assessments. The risk reduction models also estimate resultant contaminant concentrations in the various media, which are then compared to media- and contaminant-specific ARARs. The groundwater model uses a downgradient, off-site exposure point, while the surface water/sediment model uses the maximum concentration sample station location in Basin Creek along the site as the worst-case exposure point.

Modeling estimates and assumptions are used in an attempt to quantify risk reduction and determine whether ARARs will be attained. In the course of performing this quantitative analysis, several assumptions and estimates are necessarily employed. Some of the assumptions are based on standard CERCLA risk assessment guidance, while others are based on site-specific observation and professional judgement. Many of the estimates are based on conservative (worst case) scenarios, but since alternatives are compared to one another, these assumptions are consistent. The evaluation findings should, therefore, not be considered absolute (e.g., ARARs); however, the relative risk reduction differences between alternatives are meaningful and can be used to evaluate this criteria.

The human health baseline risk assessment determined that the pathways and CoCs at the Highland site were soil ingestion of As and Fe for the residential exposure; no HQs greater than one were calculated for the recreational exposure. To effect risk reduction for this contaminant via the corresponding pathways, two scenarios are modeled: a recreational exposure and a residential exposure. Each alternative is modeled for the two scenarios and the resultant risk reductions are compared to the reduction required to achieve the two levels of protectiveness (recreational and residential).

The ecologic risk assessment identified three exposure scenarios: Basin Creek aquatic life receptors exposed to As and Cu in sediments and plant phytotoxicity to As and Cu. The aquatic life scenario requires a sediment loading reduction of 47.8% to achieve preliminary sediment quality criteria - median effect range (As). The plant phytotoxicity scenario requires a 92.6% reduction in surface concentrations or area to achieve no phytotoxic effects from Cu.

The exposure pathways were modeled to evaluate the relative risk reductions and attainment of ARARs afforded by each alternative. These calculations involved a combination of measured data collected at the site (waste and surface water concentrations), and modeled impacts (e.g., groundwater loading). A discussion of how the evaluations were performed and the assumptions used follows for each pathway.

The groundwater pathway was modeled using a simple mathematical model which utilized two components: estimates of leachate concentrations for precipitation water that flows through the waste sources and/or repository and ultimately into groundwater; and estimates of the rate that this water flows through the wastes and/or repository (flux). The first component, leachate concentrations, were obtained by using the TCLP analyses performed on the wastes. The second component, water flux through the sources, was estimated using the HELP (Version 3.0) model which uses a variety of site meteorological and physical data to determine the water balance at a site, including estimating the volume of water flux through the bottom of an impoundment. Each source was evaluated as was the background groundwatershed.

Assumptions used to evaluate groundwater impacts (loadings) include the following: inputs from the sources and background were summed, which has the effect of assuming complete dilution and not considering any other attenuation mechanisms; on-site repository loads were summed with the other loads as a total loading to groundwater; the off-site, downgradient groundwater modeling assumed no dilution/attenuation factor despite the more distant exposure point.

The surface water pathway was also modeled using a simple mathematical model which utilized measured surface water concentrations in Basin Creek. For modeling purposes, the maximum concentration measured in Basin Creek was used as the exposure point (water and sediment).

Assumptions used to evaluate surface water impacts (loadings) include the following: a 75% long-term effectiveness for preventing erosion into surface water was assigned due to the likelihood of long-term deterioration or partial failure of the on-site covering and revegetation. Sources placed in the on-site or off-site repository were assumed to have been 100% removed from exposures via this pathway.

The soil exposure pathway was empirically modeled using only reductions in surface area to estimate reduction in exposures. Both pathways assumed a 75% long-term effectiveness for maintaining adequate cover for preventing exposure, due to the likelihood of long-term deterioration of the covers. Sources placed in the on-site or off-site repository were assumed to have been 100% removed from exposures via these pathways.

The risk assessment results indicate that no HQs or EQs greater than one are present for the following scenarios/pathways: Human Health-Residential (groundwater ingestion and dust inhalation); Human Health-Recreational (all pathways); and Ecologic (aquatic life-surface water and deer ingestion). Consequently, the only risk reductions evaluated are: Human Health-Residential (soil ingestion route); and Ecologic (aquatic life-sediment and plant phytotoxicity). Risk reduction required to attain noncarcinogenic human health and ecologic reclamation goals for each CoC (by each pathway) is shown on Table 8-1. Water quality ARARs are currently being met at the site and downstream from it, including the adit discharge. These ARARs will not be evaluated for each alternative as they are currently being achieved and any reclamation activity at the site is assumed to have a positive overall effect on both surface water and groundwater quality.

TABLE 8-1
RISK REDUCTION NECESSARY TO ATTAIN NONCARCINOGENIC HUMAN HEALTH AND ECOLOGIC CLEANUP GOALS

PATHWAY	RISK REDUCTION REQUIRED (%)			
	As	Cu	Hg	Fe
Human Health Exposure Pathways:				
Soil Ingestion (Res.)	94.6	--	--	83.9
Water Ingestion (Res.)	--	--	--	--
Soil Ing./Inh. (Recr.)	--	--	--	--
Water Ingestion (Recr.)	--	--	--	--
Ecologic Exposure Pathways:				
Surface Water	--	--	--	--
Sediments	47.8	--	--	--
Deer Salt Ingestion	--	--	--	--
Plant Phytotoxicity	90.6	91.9	--	--

-- = Risk reduction not required for the contaminant for that pathway.

8.2 ALTERNATIVE 1 (Solid Media): NO ACTION

The no action alternative is required for analysis by CERCLA and the NCP when evaluating alternatives in detail; the no action alternative is used to provide a baseline for comparing other alternatives. Under this alternative, no permanent reclamation activities would be implemented. Consequently, long-term human health and environmental risks associated with the on-site contamination would remain unchanged, with the contaminant sources at the site continuing to pose a threat to human health and environmental resources.

8.2.1 Overall Protection of Human Health and the Environment

The no action alternative provides no control of exposures to the contaminated materials and no reduction in risk to human health or the environment. It allows for the continued migration of contaminants and potential degradation of groundwater and surface water quality.

Adequate protection of human health would not be achieved under the no action alternative. Prevention of human exposure to the CoCs via the pathways of concern, as identified in the human health risk assessment, would not occur. Soil ingestion exposure to As and Fe via contaminated surface soil would not be reduced.

Adequate protection of the environment would also not be achieved under the no action alternative. Prevention of ecologic exposures via the scenarios identified in the ecologic risk assessment, would not occur; aquatic life exposure to As via sediment would be remain unchanged and phytotoxic levels of As and Cu to plants would persist.

A risk reduction achievement matrix (Table 8-2) was developed to assess whether the alternative affords sufficient protection to human health and the environment for the pathways and CoCs identified in the human health risk assessment (Section 5.1) and the ecological risk assessment (Section 5.2). The conclusions presented in the table are based on worst-case modeling results subject to the limitations and assumptions used in the models (see Section 8.1 for discussion).

TABLE 8-2
RISK REDUCTION ACHIEVEMENT MATRIX FOR ALTERNATIVE 1

Alternative 1	As	Cu	Fe	Overall
Human Health Exposure Pathways:				
Soil Ingestion	Recr.	--	Recr.	Recr.
Ecologic Exposure Pathways:				
Sediments	No	--	--	No
Plant Phytotoxicity	No	No	--	No

-- = Risk reduction not required for the contaminant for that pathway.
None = Does not achieve required risk reduction for any exposure scenario.
Recr. = Achieves required risk reduction for the recreational exposure scenario.
Res. = Achieves required risk reduction for the residential exposure scenario (most protective).

8.2.2 Compliance with ARARs

A comprehensive list of Federal and State ARARs has been developed for the Highland site and is summarized in Section 4.0 and presented in detail in Appendix C of this report. ARARs are divided into contaminant-specific, location-specific, and action-specific requirements. Contaminant-specific ARARs are waste-related requirements which specify how a waste must be managed, treated, and/or disposed depending upon the classification of the waste material. Location-specific ARARs specify how the remedial activities must take place depending upon where the wastes are physically located (i.e., in a stream or floodplain, wilderness area, or sensitive environment, etc.), or where the wastes may be treated or disposed, and what authorizations (permits) may be required. Action-specific ARARs are technology- or activity-based requirements, or are limitations on actions taken with respect to hazardous substances. Action-specific ARARs do not determine the preferred reclamation alternative, but indicate how the selected alternative must be achieved.

Under the no action alternative, no contaminated materials would be treated, removed, or actively managed. Consequently, the no action alternative would not satisfy Federal or State ARARs. All water quality ARARs would be attained as discussed previously.

8.2.3 Long-Term Effectiveness and Permanence

No controls or long-term measures would be placed on the contaminated materials at the site; consequently, all current and future risks would remain the same as described in the baseline risk assessment (Section 5). Therefore, the no action alternative would not be effective at minimizing risks from exposure to these materials.

8.2.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

The no action alternative would provide no reduction in toxicity, mobility, or volume of the contaminated materials.

8.2.5 Short-Term Effectiveness

In the short-term, the no action alternative would pose no additional threats to the community or the environment as the current site conditions. The time required until reclamation objectives are reached (by natural contaminant degradation and erosion) would be indefinite and would most likely be measured in terms of geologic time frames.

8.2.6 Implementability

There would be no implementability concerns posed by the no action alternative since no action would be taken.

8.2.7 Cost

The cost for implementing this alternative would be zero since no action would be taken.

8.3 ALTERNATIVE 2 (Solid Media): INSTITUTIONAL CONTROLS

The institutional control alternative includes erecting fences to restrict access to the contaminated sources, as well as establishing land use restrictions to prevent land development on or near the affected areas. Fencing and/or posting may discourage access to the contaminated sources, and land use restrictions would prevent inappropriate land development on or near the contaminated areas.

Limitations may also be applicable for the action alternatives being proposed for the site (e.g., in-place containment, on-site disposal, etc.) that would result in leaving contaminated materials on-site that could be compromised by future activities.

This alternative does not, in itself, achieve a specific cleanup goal. However, institutional controls may be considered as adjacent actions to accompany other reclamation alternatives.

8.3.1 Overall Protection of Human Health and the Environment

This alternative provides no long-term control of exposures to contaminated materials, since fences will eventually fail and are easy to circumvent. Consequently, no reduction in risk to human health or the environment is achieved. It allows for the continued migration of contaminants and potential degradation of groundwater and surface water quality, though it does provide limited, short-term control of some exposures.

Protection of human health (residential) would not be achieved under this alternative. Prevention of human exposure to the CoCs via the pathways of concern, as identified in the human health risk assessment, would not occur. Soil ingestion exposure to As and Fe via contaminated surface soil would not be reduced.

Protection of the environment would also not be achieved under the no action alternative. Prevention of ecologic exposures via the scenarios identified in the ecologic risk assessment, would not occur: aquatic life exposure to As via sediment and plant phytotoxicity to As and Cu.

A risk reduction achievement matrix (Table 8-3) was developed to assess whether the alternative affords sufficient protection to human health and the environment for the pathways and CoCs identified in the human health risk assessment (Section 5.1) and the ecological risk assessment (Section 5.2). The conclusions presented in the table are based on worst-case modeling results subject to the limitations and assumptions used in the models (see Section 8.1 for discussion).

TABLE 8-3
RISK REDUCTION ACHIEVEMENT MATRIX FOR ALTERNATIVE 2

Alternative 2	As	Cu	Fe	Overall
Human Health Exposure Pathways:				
Soil Ingestion	Recr.	--	Recr.	Recr.
Ecologic Exposure Pathways:				
Sediments	No	--	--	No
Plant Phytotoxicity	No	No	--	No

-- = Risk reduction not required for the contaminant for that pathway.
None = Does not achieve required risk reduction for any exposure scenario.
Recr. = Achieves required risk reduction for the recreational exposure scenario.
Res. = Achieves required risk reduction for the residential exposure scenario (most protective).

8.3.2 Compliance with ARARs

Under this alternative, no contaminated materials would be treated, removed, or actively managed. Consequently, the alternative would not satisfy Federal or State ARARs. All water quality ARARs would be attained as discussed previously.

8.3.3 Long-Term Effectiveness and Permanence

Under this alternative, physical and administrative barriers would be used to prevent direct contact with the contaminated materials and to restrict inappropriate land development in the future, no controls or long-term measures would be used to actively manage the contaminated materials with respect to mobilization/erosion, etc. The semi-remoteness of the site would make land use control difficult to enforce. All current and future human health risks would remain the same as described in baseline ecological risk assessment (Section 5); in other words, there would be no reduction in the overall human health risk. There would be a slight reduction in the overall ecological risk because of the reduction in risk to wildlife as a result of the fences.

8.3.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

Toxicity, mobility, or volume of the contaminated materials would not be reduced under this alternative.

8.3.5 Short-Term Effectiveness

Community and on-site worker health risks associated with implementing this alternative would be minimal. Construction would likely be accomplished in a very short time period (approximately one month on-site); therefore, impacts associated with the construction phase would be short-term and insignificant. On-site workers would be adequately protected via utilizing proper personal protective equipment and following proper safety procedures. Fugitive emissions may occur during the construction phase due to limited excavation and increased vehicular traffic; however, this could be easily remedied by applying water to the excavation sites and road surfaces if necessary.

8.3.6 Implementability

Institutional controls are easily implementable based on the criteria of applicability, availability, and reliability. Fencing materials and construction contractors are readily available. Reliability of this alternative for its intended purpose (protection from direct contact) is considered good as long as enforcement of the institutional controls is maintained by the regulatory agencies and landowners. Due to the logistical simplicity of implementing institutional controls, administrative feasibility is considered very good.

8.3.7 Costs

The costs exhibited in this section are the same as presented in Section 7. The costs were refined in Section 7 to accommodate for the remediation of the tailings, which were found during the Reclamation Investigation field study, in May of 1996.

Costs associated with institutional controls would be very low compared to the other proposed reclamation alternatives; however, a considerable amount of fencing materials would be required to fully enclose the contaminated sources present at the site. Capital costs associated with construction of an 8-feet tall, chain-link fence would run approximately $30,000, assuming no consolidation of contaminated materials and a fencing requirement of approximately 1,500 linear feet at approximately $20.00 per linear foot. Maintenance costs would likely be less than $1,000 per year.

8.4 ALTERNATIVE 3 (Solid Media): IN-PLACE CONTAINMENT

Generally, in-place containment strategies for reclaiming mined lands involve establishing vegetation on the surfaces of the solid media contaminant sources. The purpose of establishing vegetation is to stabilize the surface (provide erosion protection) and to decrease net infiltration through the waste medium by increasing evapotranspiration processes. Containment technologies may involve establishing vegetation directly on the waste source or may involve applying a cover over the waste source upon which the vegetation is established. Covers may range from a simple, single-layered soil cover to a complex, multi-layered cover consisting of various composite materials.

8.4.1 Overall Protection of Human Health and the Environment

This alternative would provide a means of reducing soil ingestion exposure to the CoCs and would stabilize the surfaces of the waste sources with respect to contaminant migration; a significant reduction in risk to human health would result. Reduction of human exposures to the CoCs via the pathways of concern, as identified in the human health risk assessment, would occur. Soil ingestion exposure to As and Fe via contaminated surface soil would be reduced by 75%, meeting the recreational level.

This alternative would also provide significant environmental protection. Plant phytotoxicity exposure to As and Cu would be reduced by 75%, which is significant, but is slightly lower than ideal, targeted levels. Aquatic life exposure to As via sediment would be reduced by 75%, which attains the targeted risk reduction level.

A risk reduction achievement matrix (Table 8-4) was developed to assess whether this alternative affords sufficient protection to human health and the environment for the pathways and CoCs identified in the human health risk assessment (Section 5.1) and the ecological risk assessment (Section 5.2). The conclusions presented in the table are based on worst-case modeling results subject to the limitations and assumptions used in the models (see Section 8.1 for discussion).

TABLE 8-4
RISK REDUCTION ACHIEVEMENT MATRIX FOR ALTERNATIVE 3

Alternative 3	As	Cu	Fe	Overall
Human Health Exposure Pathways:				
Soil Ingestion	Recr.	--	Recr.	Recr.
Ecologic Exposure Pathways:				
Sediments	Yes	--	--	Yes
Plant Phytotoxicity	No	No	--	No

-- = Risk reduction not required for the contaminant for that pathway.
None = Does not achieve required risk reduction for any exposure scenario.
Recr. = Achieves required risk reduction for the recreational exposure scenario.
Res. = Achieves required risk reduction for the residential exposure scenario (most protective).

8.4.2 Compliance with ARARs

There are no media-specific ARARs that are directly applicable to in-place containment/stabilization of contaminated solid media. All water quality ARARs would be attained by this alternative, as discussed previously.

8.4.3 Long-Term Effectiveness and Permanence

Under this alternative, the soil covers, stabilization structures installed on WR1 and the tailings, and run-on controls would have to be maintained to ensure that they continue to perform as designed; consequently, long-term monitoring and regular inspection and maintenance would be required. The soil covers would be susceptible to settlement, ponding of surface water, erosion, and disruption of cover integrity by vehicles, deep-rooting vegetation, and burrowing animals. However, the covers could be easily inspected and the required maintenance could be easily determined.

Grading and revegetation of the mine wastes would stabilize these sources by providing an erosion-resistant, vegetated surface that would provide protection from surface water and wind erosion, and would reduce net infiltration through the contaminated media by increasing evapotranspriation processes. Revegetation would consequently reduce the threat of direct contact and inhalation of airborne contaminants by on-site and nearby receptors. The long-term effectiveness of revegetation would be enhanced by carefully determining proper amendments and selecting appropriate plant species adapted to short growing seasons and high altitudes (as opposed to selecting native species exclusively).

Over the long-term, the water quality and sediment environment in Basin Creek is expected to be improved by implementing this alternative. Additionally, the in-place containment strategy would improve the aesthetic quality of the area. The long-term effectiveness should be monitored by frequent inspections of the reclaimed wastes and subsequent maintenance (when necessary), and by extended surface water and sediment monitoring in Basin Creek.

8.4.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

The primary objective of this alternative is to provide a significant reduction in contaminant mobility; the volume or toxicity of the contaminants would not be physically reduced by implementing this alternative. Covering and revegetation of the tailings and in-place grading and revegetation of the waste rock would stabilize these sources and reduce contaminant mobility via surface water and wind erosion. Potential groundwater impacts would also be reduced by decreasing infiltration through the waste sources by increasing evapotranspiration processes. The mobility of the on-site contaminants is expected to be reduced to an extent that would result in an overall (all pathways and all routes of exposure considered) risk reduction of 75% (based on modeling results).

8.4.5 Short-Term Effectiveness

It is anticipated that the construction phase of this alternative would be accomplished in a relatively short time period; therefore, impacts associated with construction would be short-term and minimal. On-site workers would be adequately protected during the construction phase by utilizing appropriate personal protective equipment and by following proper operating and safety procedures. Short-term air quality impacts to the surrounding environment may occur due to the relatively large volume of waste to be handled. Control of fugitive dust emissions would be provided by applying water (via water trucks) to surfaces receiving heavy vehicular traffic, or in excavation areas, etc. The only measurable short-term impacts would involve increased vehicle traffic and associated safety hazards, noise, and dust generation. Also, equipment working in the mine area may cause temporary inconvenience to the public who travel the road for recreational purposes (there are no residences in the immediate area). The short-term impacts associated with this alternative would not be significant.

8.4.6 Implementability

This alternative is both technically and administratively feasible, and could be implemented in a relatively short period of time. The excavation, consolidation, grading, covering, and revegetation steps required are considered conventional construction practices; materials and construction methods are readily available. Also, design methods and requirements are well documented and well understood. However, the terrain at the Highland Mine is relatively steep and the required work should only be completed by experienced contractors/operators utilizing the proper equipment.

8.4.7 Costs

The costs exhibited in this section are the same as presented in Section 7. The costs were refined in Section 7 to accommodate for the remediation of the tailings, which were found during the Reclamation Investigation field study, in May of 1996.

The total present worth cost for this alternative has been estimated at $235,900.00, which represents the reclamation of all solid media contaminant sources present at the Highland Mine site. Table C-1 (Appendix C) presents the costs details and assumptions associated with implementing this alternative. The total costs includes the present worth value of 30 years of annual maintenance and monitoring costs in addition to capital cost.

8.5 ALTERNATIVE 4 (Solid Media): ON-SITE DISPOSAL IN A CONSTRUCTED REPOSITORY

In Section 7.0 three separate reclamation scenarios were preliminarily evaluated under Alternative 4 for the Highland Mine site. The major differences between the three scenarios had to do with the design of the liner system which would underlay the encapsulated wastes. The three scenarios considered include: 1) construction of a repository which complies with all RCRA Subtitle C regulations for hazardous waste landfill closures which includes a double-liner system with integral primary and secondary leachate collection and removal systems and a multi-layered cap (Alternative 4a); 2) construction of a modified RCRA repository which includes a single composite liner with an integral leachate collection and removal system, also with a multi-layered cap (Alternative 4b); and 3) installation of a multi-layered cap with no bottom liner system installed under the wastes (Alternative 4c). As discussed in Section 7.0, Alternative 4a has not been retained for detailed analysis; relative risk reduction modeling conducted for similar abandoned mine sites has demonstrated that the overall risk reduction attained by the full RCRA Subtitle C design compared to a modified (single liner system) design does not justify the additional cost for a facility of this type. This is especially true for the Highland Mine site, where none of the wastes involved are considered characteristically hazardous according to TCLP testing. Although costs have been developed and risk reduction modeling has been performed for the remaining repository scenarios (Alternatives 4b and 4c), only one of the scenarios (Alternative 4b) is evaluated in detail in this section. Evaluating the scenarios independently would be overly redundant because the only significant differences in the detailed evaluation of each scenario would include cost estimates and relative risk reduction.

Design and construction costs associated with the two remaining scenarios vary according to the degree of protection provided by the liner system; the higher the relative degree of protection provided by the liner system, the higher the associated costs. These two scenarios do not comply with EPA's Minimum Technology Guidance for hazardous waste landfill closures. However, either scenario would provide adequate environmental protection considering the chemical and physical characteristics of the Highland Mine site wastes (not characteristically hazardous), in conjunction with the area's generally arid climate. The variation of Alternative 4 evaluated in detail (Alternative 4b) includes encapsulating the tailings (TP1 through TP5) and waste rock (WR1) in a modified (single bottom liner system) RCRA repository. For illustrative purposes, the conceptual designs for the two repository options are presented in Section 7.0 (Figures 7-2 and 7-3).

8.5.1 Alternative 4b (Solid Media): On-Site Disposal in a Constructed Modified RCRA Repository

The reclamation strategy for Alternative 4b involves complete removal of the mine wastes at the Highland site and disposing of the wastes in a constructed repository. The sources to be disposed in the repository include WR1 and the tailings. The exact location of the repository has not yet been determined, but several potential areas at or near the site would be acceptable for siting the repository. The repository would have to be constructed on a flat to mildly sloped area (no steeper than 3:1 slope), physically separated from surface water, and adequately isolated from groundwater. According to the volume of waste to be disposed (approximately 12,900 cy), the repository would be constructed to cover an area of approximately 0.8 acre.

The bottom of the repository (subgrade) would be constructed with a vertical separation from groundwater of at least 10 feet. The repository would consist of a single geocomposite liner with an integral leachate collection/removal system and a multi-layered, impermeable cap (Figure 7-2 in Section 7.0). Figure 7-3 (Section 7.0) illustrates the conceptual design for a repository consisting of a multi-layered cap only (no bottom liner system).

8.5.1.1 Overall Protection of Human Health and the Environment

This alternative would provide a means of significantly reducing soil ingestion exposure to the CoCs and would stabilize the surfaces of the waste sources with respect to contaminant migration. Complete protection of human health would be achieved under this alternative (100% risk reduction). Reduction of human exposures to CoCs via the pathways of concern, as identified in the human health risk assessment, would occur. Soil ingestion exposure to As and Fe via contaminated surface soil would be reduced, meeting residential levels.

Complete protection of the environment would also be achieved under this alternative. Reduction of all ecologic exposures, via the scenarios identified in the ecologic risk assessment, would occur; aquatic life exposure to As via sediment and plant phytotoxicity exposure to Cu and As would be reduced to acceptable levels.

A risk reduction achievement matrix (Table 8-5) was developed to assess whether the alternative affords sufficient protection to human health and the environment for the pathways and CoCs identified in the human health risk assessment (Section 5.1) and the ecological risk assessment (Section 5.2). The conclusions presented in the table are based on worst-case modeling results subject to the limitations and assumptions used in the models (see Section 8.1 for discussion).

TABLE 8-5
RISK REDUCTION ACHIEVEMENT MATRIX FOR ALTERNATIVE 4

Alternative 4	As	Cu	Fe	Overall
Human Health Exposure Pathways:				
Soil Ingestion	Res.	--	Res.	Res.
Ecologic Exposure Pathways:				
Sediments	Yes	--	--	Yes
Plant Phytotoxicity	Yes	Yes	--	Yes

-- = Risk reduction not required for the contaminant for that pathway.
None = Does not achieve required risk reduction for any exposure scenario.
Recr. = Achieves required risk reduction for the recreational exposure scenario.
Res. = Achieves required risk reduction for the residential exposure scenario (most protective).

8.5.1.2 Compliance with ARARs

There are no media-specific ARARs that are directly applicable to in-place containment of contaminated solid media. All water quality ARARs would be attained by this alternative, as discussed previously.

8.5.1.3 Long-Term Effectiveness and Permanence

Under this alternative, the constructed repository would have to be maintained to ensure that it continues to perform as designed. The actual design life of the repository is not certain; consequently, long-term monitoring and routine inspection and maintenance would be required. The repository cap would be the component most vulnerable to any damage or degradation that might occur. Multilayered caps are susceptible to settlement, ponding of surface water, erosion, and disruption of cover integrity by vehicles or other human activities, deep-rooting vegetation, and burrowing animals. However, the cap could be easily inspected and the required maintenance could be easily determined and performed. Additionally, the leachate collection and removal system may require routine maintenance including clearing of piping (clearing vegetation and/or soil) and evaporation pond maintenance.

Over the long-term, the water quality and sediment environment in Basin Creek is expected to be improved by implementing this alternative. The Basin Creek fishery is expected to benefit because the contaminant sources which could potentially impact the stream would be completely removed from their current potentially unstable locations. The long-term effectiveness should be monitored by conducting routine inspections of the repository and reclaimed areas and subsequent maintenance (when necessary), and by extended surface water and sediment monitoring in Basin Creek.

8.5.1.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

The primary objective of this alternative is to provide a significant reduction in contaminant mobility; the volume or toxicity of the contaminants would not be physically reduced by implementing this alternative. The primary waste sources of concern would be rendered immobile in an engineered structure and physical location which is protected from erosion problems. Potential groundwater impacts would also be reduced by decreasing infiltration through the waste sources by increasing evapotranspiration processes. The mobility of the on-site contaminants are expected to be reduced to an extent that would result in an overall (all pathways and all routes of exposure considered) risk reduction of 100% (based on modeling results).

8.5.1.5 Short-Term Effectiveness

It is anticipated that the construction phase of this alternative would be accomplished in a relatively short time period; therefore, impacts associated with construction would be short-term and minimal. On-site workers would be adequately protected during the construction phase by utilizing appropriate personal protective equipment and by following proper operating and safety procedures; however, short-term air quality impacts to the surrounding environment may occur due to the relatively large volume of waste requiring handling. Control of fugitive dust emissions would be provided by applying water (via water truck) to surfaces receiving heavy vehicular traffic, or in excavation areas, etc. The only measurable short-term impacts would involve increased vehicle traffic and associated safety hazards, noise, and dust generation. Also, equipment working in the mine area may cause temporary inconvenience to the public who travel the road for recreational purposes (there are no residences in the immediate area). The short-term impacts associated with this alternative would not be significant.

8.5.1.6 Implementability

This alternative is both technically and administratively feasible, and could be implemented in a relatively short period of time (one construction season). The excavation, consolidation, grading, capping, and revegetation steps required are considered conventional construction practices; materials and construction methods are readily available. Also, design methods and requirements are well documented and well understood. However, the construction steps required to implement this alternative are considered moderately difficult (due mostly to the rough/steep terrain associated with the site) and should only be performed by experienced contractors utilizing proper equipment.

8.5.1.7 Costs

The costs presented in this section are the same as presented in Section 7. The costs in Section 7 had to be readjusted to accommodate the remediation of the tailings found during the Reclamation Investigation field study, in May of 1996.

The total present worth cost for this alternative has been estimated at $460,900.00, which represents the reclamation of all solid media contaminant sources present at the Highland site. Table C-3 (Appendix C) presents the cost details and assumptions associated with implementing this alternative. Table C-4 (Appendix C) presents the cost details and assumptions associated with implementing Alternative 4c (disposal in an unlined repository with a lined cap). The total present worth cost for Alternative 4c has been estimated at $407,800.00. The total cost includes the present worth value of 30 years of annual maintenance and monitoring costs in addition to capital costs.

8.6 ADIT DISCHARGE ALTERNATIVES

The risk assessment results indicate that no HQs or EQs greater than one are present for the following scenarios/pathways related to the adit discharge water: human health - residential scenario (surface water ingestion); human health - recreational (surface water ingestion); and ecologic (aquatic life-surface water). Consequently, the only risk reduction necessary for the adit discharge involves ecologic risk reduction (aquatic life-sediment). The risk reduction required to attain noncarcinogenic human health and ecologic reclamation goals for each CoC (by each pathway) is shown on Table 8-6. Water quality ARARs are currently being met at the site and downstream from it. Consequently, these ARARs are not evaluated for each alternative since they are currently being achieved and any reclamation activity conducted at the site is assumed to have a positive overall effect on surface water quality, by preventing potential impacts.

TABLE 8-6
RISK REDUCTION NECESSARY TO ATTAIN NONCARCINOGENIC HUMAN HEALTH AND ECOLOGIC CLEANUP GOALS (ADIT DISCHARGE)

PATHWAY	RISK REDUCTION REQUIRED (%)			
	As	Cu	Hg	Fe
Human Health Exposure Pathways:				
Water Ingestion (Res.)	--	--	--	--
Water Ingestion (Recr.)	--	--	--	--
Ecologic Exposure Pathways:				
Surface Water	--	--	--	--
Sediments	47.8	--	--	--

-- = Risk reduction not required for the contaminant for that pathway.

8.7 ALTERNATIVE 1 (Adit Discharge): NO ACTION

Under the no action alternative, no additional action regarding the adit discharge, other than isolation from mine wastes that may occur as part of a solid media alternative addressing WR1, would be implemented. In other words, no action to control contaminant migration or to reduce the toxicity or volume of the contaminants in the discharge would occur.

8.7.1 Overall Protection of Human Health and the Environment

The no action alternative provides no control of exposures to contaminated materials and no reduction in risk to human health or the environment. It allows for the continued migration of contaminants and continued potential degradation of surface water and sediment quality.

Adequate protection of human health (residential) would be achieved under the no action alternative since no human health exposures exceed acceptable risk levels via the adit discharge.

However, adequate protection of the environment would not be achieved under the no action alternative. Prevention of ecologic exposure via the scenario identified in the ecologic risk assessment, would not occur: aquatic life exposure to As via sediment would persist.

A risk reduction achievement matrix (Table 8-7) was developed to assess whether the alternative affords sufficient protection to human health and the environment for the pathways and CoCs identified in the human health risk assessment (Section 5.1) and the ecological risk assessment (Section 5.2). The conclusions presented in the table are based on worst-case modeling results subject to the limitations and assumptions used in the models (see Section 8.1 for discussion).

TABLE 8-7
RISK REDUCTION ACHIEVEMENT MATRIX FOR ALTERNATIVE 1

Alternative 1	As	Cu	Fe	Overall
Ecologic Exposure Pathways:				
Sediments	No	--	--	No

-- = Risk reduction not required for the contaminant for that pathway.
No = Does not achieve required risk reduction for exposure scenario.

8.7.2 Compliance with ARARs

All water quality ARARs would be attained by this alternative, as discussed previously.

8.7.3 Long-Term Effectiveness and Permanence

No controls or long-term measures would be placed on the adit discharge at the site; consequently, all current and future risks would remain the same as described in the baseline risk assessment (Section 5). Therefore, the no action alternative would not be effective at minimizing risks associated with ecologic exposure to the adit discharge.

8.7.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

The no action alternative would provide no reduction in toxicity, mobility, or volume of the contaminated materials (sediments).

8.7.5 Short-Term Effectiveness

In the short-term, the no action alternative would pose no additional threats to the community or the environment as the current site conditions. The time required until reclamation objectives are reached (by natural contaminant degradation and erosion) would be indefinite and would most likely be measured in terms of geologic time frames.

8.7.6 Implementability

There would be no implementability concerns posed by the no action alternative since no action would be taken.

8.7.7 Costs

The cost for implementing this alternative would be zero since no action would be taken.

8.8 ALTERNATIVE 2 (Adit Discharge): ADIT DISCHARGE COLLECTION AND DIVERSION

As previously mentioned, the adit discharge at the Highland Mine site does not contain any elevated concentrations of metals; pH of the discharge has been measured in the neutral to slightly alkaline range (between 6.40 and 7.97 S.U.). Mercury is the only element that may exceed an established water quality standard. Arsenic, copper, and iron are elevated relative to background; however, the increase in concentrations of these elements occur only after the adit flow travels through the waste rock, indicating that the metals are being entrained by the physical transport of fine-grained mineralized rock from the dump. Table 8-6 shows that the concentrations of copper, mercury, and iron do not need to be reduced to attain adequate risk levels for residential or recreational human health exposure, or for ecologic surface water exposure. Table 8-6 indicates that arsenic in sediment is the only requirement for surface water risk reduction at the site. A potential remedy to this situation is to isolate the dump material from the adit flow. This alternative describes two methods of mitigating the interaction of the adit discharge with the dump material: 1) collecting and piping the discharge away from the contaminated source; and 2) contaminant removal/channel restoration.

The piping option consists of collecting the adit flow (at the discharge point) into a grated basin where it would be piped beneath the dump material and released back into its natural channel downstream from the site. The dump material above the piping system would be recontoured, amended, and revegetated. The new channel construction option would consist of stream reconstruction within the natural flow path. All waste rock and contaminated sediments would be removed from within and around the stream channel, and the stream channel would be reconstructed and revegetated to prevent potential erosion. Both of these options (Alternatives 3a and 3b) are evaluated in the following subsections.

8.8.1 Alternative 3a: Piping Adit Discharge Through Source

The focus of Alternative 3a is to physically separate the waste rock from the stream to prevent the transport of contaminated materials into the Basin Creek drainage and to the Butte Water System. This would be accomplished by constructing a diversion structure that would route the adit discharge to the outer boundaries of the mine area. The water would be collected by a constructed concrete basin/drop inlet at the discharge point of the adit. The flow would be diverted to the outer limits of the mine site through a diversion pipe, where it would be placed back into its natural flow path. The diversion system would be sized to accommodate the maximum adit flow.

8.8.1.1 Overall Protection of Human Health and the Environment

This alternative would effectively isolate the adit flow from the contaminated materials and would help reduce potential risks to both human health and the environment. It would eliminate the migration of contaminants and possible degradation of surface water and sediment quality.

Protection of human health (residential exposure scenario) would be achieved under this alternative since no human health exposures currently exceed acceptable risk levels at the site via the adit discharge. Protection of the environment would also be achieved under this alternative. Prevention of ecologic exposure via the scenario identified in the ecologic risk assessment would occur; the risk associated with aquatic life exposure to As via sediment would be adequately reduced.

A risk reduction achievement matrix (Table 8-8) was developed to assess whether the alternative affords sufficient protection to human health and the environment for the pathways and CoCs identified in the human health risk assessment (Section 5.1) and the ecological risk assessment (Section 5.2). The conclusions presented in the table are based on worst-case modeling results subject to the limitations and assumptions used in the models (see Section 8.1 for discussion).

TABLE 8-8
RISK REDUCTION ACHIEVEMENT MATRIX FOR ALTERNATIVE 3A

Alternative 3a	As	Cu	Fe	Overall
Ecologic Exposure Pathways:				
Sediments	Yes	--	--	Yes

-- = Risk reduction not required for the contaminant for that pathway.
No = Does not achieve required risk reduction for exposure scenario.

8.8.1.2 Compliance with ARARs

All water quality ARARs would be attained by this alternative, as discussed previously.

8.8.1.3 Long-Term Effectiveness and Permanence

This alternative would provide adequate long-term effectiveness as long as maintenance of the collection and diversion structure is provided. The adit flow would effectively be isolated from the contaminated waste rock; consequently, the potential for future migration of the contaminants via surface water would be eliminated.

8.8.1.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

The primary objective of this alternative is to provide a reduction in contaminant mobility; the volume or toxicity of the contaminants would not be physically reduced by implementing this alternative.

8.8.1.5 Short-Term Effectiveness

It is anticipated that the construction phase of this alternative would be accomplished in a relatively short time period; therefore, impacts associated with construction would be short-term and minimal. On-site workers would be adequately protected by following proper operation and safety procedures. The adit discharge would have to be diverted for a short time during the installation of the collection basin and piping system.

8.8.1.6 Implementability

This alternative is technically feasible and could be implemented in a relatively short period of time. Materials are readily available and the construction practices necessary to implement this alternative are common.

8.8.1.7 Costs

The costs exhibited in this section are the same as presented in Section 7. The costs were refined in Section 7 to keep consistent with the other alternatives. The total present worth cost for this alternative has been estimated at $77,800.00, which includes $44,700.00 in capital costs and $3,500 in annual O&M costs. Table C-8 (Appendix C) presents the cost details and assumptions associated with implementing this alternative. The total cost includes the present worth value of 30 years of annual maintenance and monitoring costs in addition to capital costs.

8.8.2 Alternative 3b (Adit Discharge): Contaminant Removal/Channel Restoration

The remedial strategy for Alternative 3b is very similar to Alternative 3a with the exception of the permanent drop inlet/diversion pipe system. Under this alternative, the adit discharge flow would be allowed to remain above ground in a reconstructed channel. The adit discharge would be diverted and waste rock would be removed from within and around the current channel, and a new channel would be constructed. The reconstructed stream channel would begin at the discharge point and extend through the excavated area where it would enter the natural stream channel. Structures (settling basins) would be constructed within the stream channel to ensure immobilization of sediments which may erode into the water path during extreme precipitation events.

8.8.2.1 Overall Protection of Human Health and the Environment

This alternative would effectively isolate the adit flow from the contaminated materials and would help reduce potential risks to both human health and the environment. It would eliminate the migration of contaminants and possible degradation of surface water and sediment quality.

Protection of human health (residential exposure scenario) would be achieved under this alternative since no human health exposures currently exceed acceptable risk levels at the site via the adit discharge. Protection of the environment would also be achieved under this alternative. Prevention of ecologic exposure via the scenario identified in the ecologic risk assessment would occur; the risk associated with aquatic life exposure to As via sediment would be adequately reduced.

A risk reduction achievement matrix (Table 8-9) was developed to assess whether the alternative affords sufficient protection to human health and the environment for the pathways and CoCs identified in the human health risk assessment (Section 5.1) and the ecological risk assessment (Section 5.2). The conclusions presented in the table are based on worst-case modeling results subject to the limitations and assumptions used in the models (see Section 8.1 for discussion).

TABLE 8-9
RISK REDUCTION ACHIEVEMENT MATRIX FOR ALTERNATIVE 3B

Alternative 3b	As	Cu	Fe	Overall
Ecologic Exposure Pathways:				
Sediments	Yes	--	--	Yes

-- = Risk reduction not required for the contaminant for that pathway.
No = Does not achieve required risk reduction for exposure scenario.

8.8.2.2 Compliance with ARARs

All water quality ARARs would be attained by this alternative, as discussed previously.

8.8.2.3 Long-Term Effectiveness and Permanence

This alternative would provide long-term effectiveness with little maintenance. Contaminated materials would be removed from the current adit discharge pathway, thus eliminating the potential migration of contaminants. After the removal of waste rock is completed, the stream channel would be reconstructed with reinforced banks to ensure flow containment. Settling basins would be constructed in steeper areas to trap migrating sediments. Maintenance would include routine visual inspections to ensure that the banks are containing the flow and sediment basins are functioning correctly. Run-on controls would also have to be maintained to minimize the amount of run-off entering the system and possibly eroding the banks.

8.8.2.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

The primary objective of this alternative is to provide a reduction in contaminant mobility; the volume or toxicity of the contaminants would not be physically reduced by implementing this alternative.

8.8.2.5 Short-Term Effectiveness

Community and on-site worker health risks would be minimal under this alternative. Construction would be accomplished in a very short time period; therefore, impacts associated with the construction phase would be short-term and insignificant. On-site workers would be adequately protected by utilizing proper personal protective equipment and following proper safety procedures. Excessive fugitive dust or vehicle traffic would not be a significant concern during construction of this alternative.

8.8.2.6 Implementability

Construction practices associated with this alternative are common and easily implemented, with materials readily available. The adit discharge would be diverted during the excavation of the waste rock within and around the stream channel. A MDFWP 124 permit may be required as part of this alternative, since the adit discharge flow is part of the Butte Water System.

8.8.2.7 Costs

The costs exhibited in this section are the same as presented in Section 7. The costs were refined in Section 7 to keep consistent with the other alternatives. The total present worth cost for this alternative has been estimated at $71,300.00, which includes $48,481.00 in capital costs and $2,400 in annual O&M costs. Table C-9 (Appendix C) presents the cost details and assumptions associated with implementing this alternative. The total cost includes the present worth value of 30 years of annual maintenance and monitoring costs in addition to capital costs.

9.0 COMPARATIVE ANALYSIS OF ALTERNATIVES

9.1 SOLID MEDIA ALTERNATIVES COMPARISON

This section provides a comparison of the solid media (tailings and waste rock) reclamation alternatives retained for the Highland Mine site. The comparison focuses mainly on the following criteria: 1) the relative protectiveness of human health and the environment that would be provided by the alternatives; 2) the long-term effectiveness that would be provided by the alternatives; and 3) the estimated attainment of ARARs for each alternative. Modeling results are used in the comparisons to contrast the two threshold criteria of "overall protection of human health and the environment" and "compliance with ARARs" for each alternative. The primary balancing criteria are also compared; although the evaluation of each of these criteria is very similar due to the technical similarities in the alternatives themselves, with the exception of costs. Table 9-1 presents a summary of the alternatives with respect to the first seven NCP evaluation criteria.

Of the alternatives retained for the site, Alternatives 4b and 4c provide the greatest overall protectiveness of human health and the environment; in fact, these two alternatives provide identical reductions in risk for all human and ecologic pathways. Either Alternative 4b or 4c is expected to provide a risk reduction of 100%. Additionally, these alternatives are expected to achieve compliance with all action- and location-specific ARARs. Each alternative significantly reduces the potential risks to surface water by eliminating the mobility of mine waste.

The other action alternative proposed for the site (Alternative 3) is expected to satisfy all action- and location-specific ARARs, for an overall risk reduction of 75%. Due to the smaller reduction in contaminant mobility provided by this alternative, the human health and ecologic risk reduction provided by it would be 25% less than that of Alternatives 4b and 4c. Comparison of Alternative 1 (no action) and Alternative 2 (institutional controls) to the other alternatives shows that no net reduction in human or ecological risk would be provided.

Under none of the proposed alternatives would the wastes actually be treated to reduce contaminant volume or toxicity; however, each of the alternatives would provide varying degrees of reduction in contaminant mobility. In general, the greater the reduction in contaminant mobility provided by a specific alternative, the greater the cost.

The short-term effectiveness is expected to be similar for each of the action alternatives. The alternatives are all technically similar, and the construction steps required to implement them would be similar as well. It is anticipated that any of the action alternatives could be completed in a single construction season. Each of the proposed alternatives would have short-term impacts to the Basin Creek water system; however, stormwater control measures would minimize the impacts. Additionally, each of the proposed alternatives may have short-term impacts on nearby residents or recreational users in the vicinity of the site, including noise, dust, and traffic dangers.

TABLE 9-1: COMPARATIVE ANALYSIS OF ALTERNATIVES (SOLID MEDIA - TAILINGS AND WASTE ROCK)

Assessment Criteria	Alternative 1: No Action	Alternative 2: Institutional Controls	Alternative 3: In-Place Containment	Alternative 4b: Disposal in a Constructed Modified (Single Lined) RCRA Repository	Alternative 4c: Disposal in a Constructed Unlined Repository with a Multi-Layered (Lined) Cap
Overall Protectiveness of Public Health, Safety, and Welfare -	No reduction in risk	Slight reduction in direct contact risk	Containment and stabilization of sources is expected to reduce human exposure risk by 75% overall.	Encapsulation and stabilization of sources is expected to reduce human exposure risk by 100%.	Encapsulation and stabilization of sources is expected to reduce human exposure risk by 100%
Environmental Protectiveness -	No protection offered	No protection offered	Containment and stabilization of sources is expected to reduce ecological exposure risk by 75% overall	Encapsulation and stabilization of sources is expected to reduce ecological exposure risk by 100% overall	Encapsulation and stabilization of sources is expected to reduce ecological exposure risk by 100% overall
Compliance with ARARs - Chemical Specific	Will not attain concentrations of Hg Will not attain concentrations of As Will not attain concentrations of Cu Will not attain concentrations of Fe	Will not attain concentrations of Hg Will not attain concentrations of As Will not attain concentrations of Cu Will not attain concentrations of Fe	Will not attain concentrations of Hg Will not attain concentrations of As Will not attain concentrations of Cu Will not attain concentrations of Fe	All location-specific ARARs would be met.	All location-specific ARARs would be met.
Location Specific	None Apply	None Apply	All location-specific ARARs would be met.	All location-specific ARARs would be met.	All location-specific ARARs would be met.
Action Specific	None Apply	None Apply	All action-specific ARARs would be met.	All action-specific ARARs would be met.	All action-specific ARARs would be met.
Long-Term Effectiveness and Permanence - Magnitude of Residual Risk	No reduction in CoC levels in any environmental media, except by natural degradation/erosion.	No reduction in CoC levels in any environmental media, except by natural degradation/erosion.	75% risk reduction expected overall. Level of risk reduction will attain recreational user compliance for the site	100% risk reduction expected overall. Level of risk reduction would attain residential use compliance for the site.	100% risk reduction expected overall. Level of risk reduction would attain residential use compliance for the site.
Adequacy and Reliability of Controls	No controls over any on-site contamination, no reliability	Limited controls over any on-site contamination, low reliability.	Containment controls are adequate for intended purposes; however, long-term reliability is questionable due to physical location of WR1	Primary source of concern (WR1 and tailings) will be reliably isolated from human and environmental receptors. Other sources stabilized via proven methods	Primary source of concern (WR1 and tailings) will be reliably isolated from human and environmental receptors. Other sources stabilized via proven methods.
Reduction of Toxicity, Mobility, and Volume - Treatment Process Used and Materials Treated	None	Physical and administrative access restrictions	In-place containment via cover (on tailings, WR-1) and revegetation to reduce mobility of CoCs. Future impacts to surface water (Basin Creek) will be likely due to erosion from the steeper slopes which WR-1 resides on.	Removal and encapsulation of primary sources of concern expected to provide significant reduction in mobility of CoCs for all pathways	Removal and encapsulation of primary sources of concern expected to provide significant reduction in mobility of CoCs for all pathways
Volume of Contaminated Materials Treated	No reduction in CoC toxicity, mobility, or volume	No reduction in CoC toxicity, mobility, or volume	Only exposed surfaces would be treated	No volume actively treated; however, approximately 12 900 cubic yards effectively isolated from human and environmental receptors	No volume actively treated; however, approximately 12,900 cubic yards effectively isolated from human and environmental receptors
Expected Degree of Reduction	Minimal, via natural degradation only (potential for future increases in mobility of contaminants).	Minimal, via natural degradation only (potential for future increases in mobility of contaminants)	Volume of wastes would not be reduced however, mobility of CoCs would be moderately reduced	Vol. or tox. of CoCs not reduced; however significant reduction in mobility expected.	Vol. or tox. of CoCs not reduced; however, significant reduction in mobility expected.
Short-Term Effectiveness - Protection of Community During Reclamation Action	Not applicable.	Fugitive emissions control may be required during construction	Fugitive emissions control may be required during construction	Fugitive emissions control may be required during construction	Fugitive emissions control may be required during construction
Protection of On-Site Workers During Reclamation Action	Not applicable	Expected to be sufficient. Safety hazards likely more prevalent than hazards associated with wastes	Expected to be sufficient. Safety hazards likely more prevalent than hazards associated with wastes	Expected to be sufficient. Safety hazards likely more prevalent than hazards associated with wastes.	Expected to be sufficient. Safety hazards likely more prevalent than hazards associated with wastes
Environmental Impacts	Same as baseline conditions.	Same as baseline conditions	Environmental (SW) impacts possible due to waste treatment activities in active stream channel and floodplain of Basin Creek.	Environmental (SW) impacts possible due to waste excavation activities in active stream channel of Basin Creek.	Environmental (SW) impacts possible due to waste excavation activities in active stream channel of Basin Creek
Time Until Reclamation Action Objectives are Achieved	Not applicable.	Approximately one month to construct all fences.	One field season	One field season	One field season
Implementability - Ability to Construct and Operate	No construction or operation involved	Easily implemented	Moderately difficult to implement due to steepness of terrain	Moderately difficult to implement due to steepness of terrain	Moderately difficult to implement due to and steepness of terrain.
Ease of Implementing More Action if Necessary	Not applicable.	Relatively easy	Easily implementable (additional armoring/ stabilization, etc.) if determined to be necessary.	Easily implementable (additional armoring/ stabilization, etc.) if determined to be necessary	Easily implementable (additional armoring/ stabilization, etc.) if determined to be nec.
Availability of Services and Capacities	Not applicable.	Readily available locally	Available locally and within the state	Available locally and within the state	Available locally and within the state
Availability of Equipment and Materials	Not applicable.	Readily available locally.	Available locally and within the state.	Available locally and within the state	Available locally and within the state
Estimated Total Present Worth Cost	$0.00	$30,000.00	$235,864.00	$460,940.70	$407,810.70

The implementability of most alternatives is expected to be similar. All alternatives use conventional design and construction techniques. Each alternative, with the exception of Alternatives 1 and 2, would require diversion/isolation of the adit discharge to allow work to be conducted on WR1.

For ease of construction, Alternative 3 would probably be the easiest alternative to implement because tailings would simply be excavated, loaded out, and transported to the WR1 area, where the materials would then be recontoured using minimal equipment. There may be some technical difficulty associated with implementing Alternative 3, due to the steep slopes and limited space. Alternative 4b would likely be the most difficult to implement for several reasons including: finding an adequate location for the repository (a majority of the land in the mine area is privately owned); limited space on the claim for a repository (a majority of the surrounding land is steeper than 2.5:1 or is close to groundwater); and the repository would require a large amount of materials, equipment, and space in order to be constructed. Any of the alternatives would require the import of a significant amount of lime, organic material, and cover soils; availability and scheduling of delivery may make any of the alternatives somewhat difficult to implement due to the remoteness of the site.

Table 9-1 indicates the estimated total costs associated with each alternative. Of the various action alternatives considered for the site, Alternative 3 is the least costly to implement. The estimated residual risk associated with Alternative 3 would attain a level of human health risk which complies with a recreational use scenario for the site. Alternatives 4b and 4c would attain a level of human health risk reduction which complies with the residential use scenario at the site. As previously noted, Alternatives 4b and 4c would provide identical reductions in risk for all human and ecologic pathways. Alternatives 4b and 4c each provide a 100% reduction in human health risk and ecological risks. Of these two alternatives, Alternative 4b is significantly more expensive. Table 9-2 summarizes the estimated cost per unit risk reduction for each action alternative.

TABLE 9-2
ALTERNATIVE COST-EFFECTIVENESS COMPARISON SUMMARY FOR SOLID MEDIA

Alternative	Overall Human Health Risk Reduction	Estimated Present Worth Cost	Cost per 1% Reduction in Risk
Alternative 2	0%	$30,000	*****
Alternative 3	75%	$235,900	$3,145
Alternative 4b	100%	$460,900	$4,609
Alternative 4c	100%	$407,800	$4,078

Table 9-2 shows that there is a relatively wide range in overall risk reduction and cost-effectiveness provided by each of the alternatives.

9.2 ADIT DISCHARGE ALTERNATIVES COMPARISON

This section provides a comparison of the adit discharge alternatives retained for the Highland Mine site. The comparison focuses mainly on the following criteria: 1) the relative protectiveness of human health and the environment that would be provided by the alternatives; 2) the long-term effectiveness that would be provided by the alternatives; and 3) the estimated attainment of ARARs for each alternative. Table 9-3 presents a summary of the alternatives with respect to the first seven NCP evaluation criteria.

Of the adit discharge alternatives retained for the site, none provides greater protection of human health and the environment (on a relative basis) over another because the alternatives described are not intended to change the chemistry of the adit discharge (since the surface water and groundwater already meet Water Quality ARARs), but provide a variety of techniques for dealing with the adit flow to separate it from the contaminated materials (WR1). Alternative 1 (no action) would not provide any separation of the adit discharge and dump material; therefore, it would not provide any risk reduction to human health or the environment.

Both Alternatives 3a and 3b would provide substantial reductions in the mobility of contaminants migrating into the adit discharge (which is the headwaters of Basin Creek and part of the Butte Water Supply System). The decision as to which alternative would be best is based on the cost and the maintenance involved with each alternative. Alternative 3a (piping the adit discharge) is estimated to be higher in cost and maintenance than Alternative 3b (contaminant removal/stream restoration). Alternative 3a requires significantly more maintenance due to the possibility of debris or ice plugging the system in the spring (run-off) and winter seasons, or possible pipe failure. Regular maintenance would have to be provided to ensure that the system is kept clear. Alternative 3b is less expensive to install and would be practically a maintenance-free system; the majority of the cost associated with Alternative 3b is due to stream reconstruction.

The short-term effectiveness is expected to be similar for each of the action alternatives. The alternatives are both technically similar, and the construction steps required to implement them would be similar as well. It is anticipated that either of the action alternatives could be completed in a single construction season. Each of the proposed alternatives may have potential short-term impacts to Basin Creek due to the excavation of materials within and around the stream area, but would be minimized by Best Management Practices (BMPs). Additionally, each of the proposed alternatives may have short-term impacts on residents or recreational users in the vicinity of the site, including noise, dust, and traffic dangers.

The implementability of most of the alternatives is expected to be similar. All of the alternatives use conventional design and construction techniques.

TABLE 9-3: COMPARATIVE ANALYSIS OF ADIT DISCHARGE ALTERNATIVES

Assessment Criteria	Alternative 1: No Action	Alternative 3a: Piping Adit Discharge Through Contaminated Materials	Alternative 3b: Contamination Removal/Stream Restoration
Overall Protectiveness of Public Health, Safety, and Welfare -	No reduction in risk.	Piping the adit discharge will help reduce migrating Contaminants	Cleaning out contaminants and reconstructing the Stream Channel will reduce mobility of Contaminated material, increasing OPPHSW by 75%.
Environmental Protectiveness -	No protection offered.	Would provide only minimal improvement to environment due to discharge having no discernable effect on Basin Creek in its current state.	Would provide only minimal improvement to environment due to discharge having no discernable effect on Basin Creek in its current state.
Compliance with ARARs -			
Chemical Specific	SW already passes all Suface Water Quality ARARs	SW already passes all Suface Water Quality ARARs	SW already passes all Suface Water Quality ARARs
Location Specific	None Apply	All location-specific ARARs would be met.	All location-specific ARARs would be met.
Action Specific	None Apply	All action-specific ARARs would be met.	All action-specific ARARs would be met.
Long-Term Effectiveness and Permanence - Magnitude of Residual Risk	None Apply	Similar to baseline conditions because of the lack of measurable impacts the adit discharge has on Basin Creek.	Similar to baseline conditions because of the lack of measurable impacts the adit discharge has on Basin Creek.
Adequacy and Reliability of Controls	No controls over contamination, no reliability.	Reliability is considered good if adequate long term O & M is provided.	Reliability is considered good.
Reduction of Toxicity, Mobility, and Volume - Treatment Process Used and Materials Treated	None.	Mobility of Contaminated materials will be reduced.	Reduction in Mobility only
Volume of Contaminated Materials Treated	No reduction in CoC toxicity, mobility, or volume.	Not Apply	Not Apply
Expected Degree of Reduction	None.	75% - 100% reduction of contaminants in discharging water (depending on specific contaminant).	75% reduction of contaminated soils in discharging water (depending on specific contaminant).
Short-Term Effectiveness - Protection of Community During Reclamation Action	Not applicable.	Fugitive emissions control may be required during construction.	Fugitive emissions control may be required during construction.
Protection of On-Site Workers During Reclamation Action	Not applicable.	Expected to be sufficient. Safety hazards likely more prevalent than hazards associated with wastes.	Expected to be sufficient. Safety hazards likely more prevalent than hazards associated with wastes.
Environmental Impacts	Same as baseline conditions.	Environmental (SW) impacts possible due to sediment travel into Basin Creek during excavation.	Environmental (SW) impacts possible due to waste treatment activities in active stream channel and of Basin Creek.
Time Until Reclamation Action Objectives are Achieved	Not applicable.	One field season.	One field season.
Implementability - Ability to Construct and Operate	No construction or operation involved.	Moderately difficult to implement due to lack of manuverability and steepness of terrain.	Relitivley easy to implement, common construction practice.
Ease of Implementing More Action if Necessary	Not applicable.	Easily implemented, common construction practice.	Not Apply
Availability of Services and Capacities	Not applicable.	Available locally and within the state.	Available locally and within the state.
Availability of Equipment and Materials	Not applicable.	Available locally and within the state.	Available locally and within the state.
Estimated Total Present Worth Cost	$0.00	$77,844.00	$71,278.00

Table 9-3 indicates the estimated total costs associated with each alternative. Of the various action alternatives considered for the site, Alternative 3a would be the most costly (the cost is greater than Alternative 3b due to the anticipated maintenance required) to implement and is expected to be the most long-term maintenance intensive due to the need to periodically clean and dispose of the debris or ice from the piping system. As previously noted, all of the action alternatives would provide very similar reductions in risk at the site because the adit discharge is not the cause of any measurable direct impacts in Basin Creek or Butte's water supply. Consequently, the least costly and most maintenance-free alternative would provide the greatest benefit for the expenditure.

10.0 PREFERRED ALTERNATIVES

10.1 PREFERRED SOLID MEDIA ALTERNATIVE

Based on the results of the detailed analysis and comparative analysis of alternatives, Alternative 3: In-Place Containment is recommended as the preferred alternative for the solid media mine waste sources at the Highland Mine site. Alternative 3 did not rate as high as some of the other alternatives evaluated for the site (as far as overall effectiveness); however, considering the site, there are several factors that make this alternative the best choice, including: 1) the site is not overly contaminated; there are relatively few heavy metal contaminants present at the site above background concentrations, and the concentrations of these metals are not particularly high compared to other abandoned mine sites (all waste samples passed TCLP criteria); 2) Alternative 3 is roughly half the cost of the other alternatives considered for the site; and 3) due to site-specific physical characteristics (steepness, shallow groundwater, etc.) construction of an on-site waste disposal repository would not be practical. In summary, this alternative consists of installing a temporary diversion to isolate the adit discharge from the mine wastes, consolidating the solid media mine wastes (WR1 and tailings) in the area of WR1, grading and amending the mine wastes, applying cover soil over the graded materials, and fertilizing, seeding, and mulching.

The potential migration of contaminated materials into the Butte Water Supply System is a great concern associated with this site; implementation of this alternative would essentially eliminate this potential problem. Alternative 3 is estimated to reduce the overall site risks (human heath and ecological) by 75%, which would allow the site to comply with the recreational use scenario. Also, the Highland Mine is situated adjacent to the main road through the scenic Highland Mountains; implementation of Alternative 3 would greatly improve the aesthetics of the area.

10.2 PREFERRED ADIT DISCHARGE ALTERNATIVE

Based on the results of the detailed analysis and comparative analysis of alternatives, Alternative 3b: Contaminant Removal/Channel Restoration is recommended as the preferred alternative for the adit discharge at the Highland Mine site. Alternative 3b is the least costly and the most maintenance-free of the action alternatives considered for the adit discharge; it is also comparable with the other proposed alternatives on the basis of effectiveness. The objective of Alternative 3b is not to attain water quality standards (since groundwater and surface water already meet water quality ARARs at the site), but to isolate the flow from physical contact with the on-site wastes (and potential uptake of contaminants into the discharge) and to establish an effective flow channel for the discharge after the contaminants have been removed from the flow path.

In summary, Alternative 3b simply involves reconstruction of the flow channel after the mine wastes have been removed. The channel would be constructed using armored banks (i.e., riprap) to reduce erosion potential, and structures would be incorporated within the channel on the steeper slopes to act as catch basins for migrating sediments.

11.0 REFERENCES

BWC, 1990. James M. Montgomery, Butte Water Company. Butte Water System Master Plan Update for Existing Butte Sources. January 1990.

Canonie Environmental Services Corp., 1992. Remedial Technology Guidance Document for Solid Media, Clark Fork River Basin.

Caterpillar, Inc., 1986. Caterpillar Performance Handbook, Edition 17.

Colbert, T.A., 1991. Reclamation of Acid Forming Materials in the Western United States. Presented at the Engineering and Environmental Aspects of Mine Waste Disposal SME Short Course, Denver, Colorado.

DEQ/MWCB, 1990. Montana Department of Environmental Quality/Mine Waste Cleanup Bureau. Procedures Manual. October 1990.

DEQ/MWCB-Pioneer, 1993. Montana Department of Environmental Quality/Mine Waste Cleanup Bureau and Pioneer Technical Services, Inc. Hazardous Materials Inventory Site Investigation Log Sheet for Highland Mine. September 17, 1993.

DEQ/MWCB-Pioneer, 1996. Montana Department of Environmental Quality/Mine Waste Cleanup Bureau and Pioneer Technical Services, Inc. Expanded Engineering Evaluation/Cost Analysis for the Maxville Tailings/Londonderry Mine.

DEQ/MWCB-RTI, 1995. Montana Department of Environmental Quality/Mine Waste Cleanup Bureau and Renewable Technologies, Inc. Butte Highlands (PA No. 47-028), Highland Mining District, Silver Bow County, Montana, Abandoned Mines Hazardous Materials Inventory, Past and Present Landownership/Mine Operators Investigation, Phase I . October 1995.

DEQ/WQB, 1995. Montana Department of Environmental Quality/Water Quality Bureau. Circular WQB-7, Montana Numeric Water Quality Standards, July 15, 1995.

Frisbee, N.M., 1993. Four Foot Lime Incorporation at the Jewett Lignite Mine, Jewett, Texas. Presented at the Lime Products Technology and Reclamation Conference, August 19, 1993.

Montana Department of Fish, Wildlife and Parks, 1989. Montana Rivers Information System Report, Version 2.0, December 1989.

MSE, Inc., 1992b. Technical Memorandum #7, Preliminary Draft Feasibility Study for Idaho Pole Site, Bozeman, Montana.

MSE, Inc., 1990. Final RI/FS Work Plan for Idaho Pole Site, Bozeman, Montana, January 1990.

Neuman, D.R., F.F. Munshower, D.J. Dollhoph, S.R. Jennings, W.M. Schafer, and J.D. Goering, 1993. Streambank Tailings Revegetation - Silver Bow Creek, Montana.

Peccia, 1991. Robert Peccia & Associates. Basin Creek Reservoir, Watershed Control Program. November 1991.

RTI, 1997. Renewable Technologies, Inc. Highland Mine and Mill Site (24SB589): A Cultural Resource Inventory and Evaluation. January 1997.

Schafer, W.M., 1993. Mitigation of Acid Mining Waste using Lime Application in the Upper Clark Fork Basin. Presented at the Lime Products Technology and Reclamation Conference, August 19, 1993.

Smith Environmental, 1995. Personal communication with Construction Managers, Bozeman, Montana, April 1995.

Upper Clark Fork River Basin Steering Committee, 1994. Upper Clark Fork River Basin, Water Management Plan, mandated by Senate Bill 434 (MCA 85-2-335 to 338), December 1994.

U.S. Environmental Protection Agency, 1993. Drinking Water Regulations and Health Advisories.

U.S. Environmental Protection Agency, 1991. Risk Assessment Guidance for Superfund: Volume I - Human Health Evaluation Manual (Part B, Development of Risk-based Preliminary Remediation Goals), Publication 9285.7-01B, December 1991.

U.S. Environmental Protection Agency, 1990. Cost of Remedial Actions Model (CORA), Version 3.0, April 15, 1990.

U.S. Environmental Protection Agency, 1989. Hydrological Evaluation of Landfill Performance (HELP) Version 2.05, September 1989.

U.S. Environmental Protection Agency, 1988. Interim Final Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, OSWER Directive 9335.30-1, March 1988.

U.S. Environmental Protection Agency, 1987. Underground Storage Tank Corrective Action Technologies, OSWER EPA/625/6-87-015, January 1987.

U.S. Environmental Protection Agency, 1986. Superfund Remedial Design and Remedial Action Guidance, OSWER Directive 9355.0-4A, June 1986.

U.S. Geological Survey, 1985. Topographic Map, Chessman Reservoir, Montana, 7 1/2 minute Quadrangle, Provisional Edition, 1985.

APPENDIX A

LIST OF PLANT SPECIES

LIST OF PLANT SPECIES - HIGHLAND MINE SITE

COMMON NAME	SCIENTIFIC NAME
Douglas Fir	*Pseudotsuga meuziesii*
Lodgepole Pine	*Pinus contorta*
Engelmann Spruce	*Picea engelmannii*
Common Juniper	*Juniperus communis*
Strawberry	*Fragaria vesca*
Thimbleberry	*Rubus parviflorus*
Cinquefoil	*Potentilla argen*tea
Mountain Brome	*Bromus marginatus*
Yarrow	*Achillea millefolium*
Musk Thistle	Carduus nutans
Starwort	*Stellaria jamesiana*
Baltic Rush	*Juncus balticus*
Sagebrush	*Artemisia tridentata*
Willows	*Salix spp.*
Elk Sedge	*Carex geyeri*
Antelope Bitterbrush	*Purshia tridentata*
Buffaloberry	*Shepherdia canadensis*
Pasque Flower	*Pulsatilla patens*
American Vetch	*Vicia americana*
Bluegrass	*Poa spp.*
Daisy	*Erigeron spp.*
Sego-lily	*Calochortus nutallii*
Beargrass	*Xerophyllum tenax*
Fendler Meadowrue	*Thalictrum fenderli*
Shrubby Cinquefoil	*Dasiphora fruticosa*
Buckbrush	*Ceanothus fendleri*
Snowberry	*Symphoricarpos albus*
Western Wheatgrass	*Agropyron smithii*
Woods Rose	*Rosa woodsii*
Buckwheat	*Eriogonum piperi*
Grouse Whortleberry	*Vaccinium Scoparium*
Shooting Star	*Dodecatheon pulchellum*

APPENDIX B

DATA SUMMARY TABLES

TABLE [illegible]1
HIGHLAND MINE REMEDIAL INVESTIGATION
XRF FIELD RESULTS
RESULTS IN PPM

SAMPLE ID	Cr	K	Ca	Ti	CrLO	Mn	Fe	Co	Cu	Zn	As
COM1		11240.6	7709.1	1557.12		1410.15 *	37094.5		478.045	1732.67	4874.11
COM2		10990.8	10938.2	2034.33		1749.72 *	17409.5		118.467 *	1108.36	114.159 *
COM3		7752.61	12497.6	791.04 *		3856.44	29206.7		379.842 *	2889.33	2940.53
COM3 AD		7891.35	12941.4	881.724 *		4554.19	29049.7		367.502 *	2958.69	2971.41
HLWR1 1		5636.1	19440.3	1589.47		1612.55 *	105014		330.802 *		174.431 *
HLWR1 1A		1499.02 *	23745.9	548.974 *			162845		1371.72		576.579
HLWR1 1B		881.939 *	10365.3	376.026 *			100013	1049.1 *	869.246		587.248
HLWR1 2A		1818.11 *	37276.1	1234.42 *			162619		1312.91		746.691
HLWR1 2B		5360.98	89398.4	1817.55		560.005 *	22322.9		128.27 *	67.7098 *	58.1054 *
HLWR1 2BAD		5465.67	89551.6	1632.14			21777.4				74.9457 *
HLWR1 2C		29425.1	22604.9	2203.85		876.335 *	37078.6			88.6922 *	91.4344 *
HLWR1 3A			52327.3	398.298 *			12811.9			764.235	60.0177 *
HLWR1 3B			163753	198.388 *	291.774 *		1901.59				50.3389 *
HLWR1 3U		8862.15	27394.1	2031.05		839.559 *	48889.6			72.8603 *	90.2031 *
HLWR1 4A		4746.68	16455.1	432.158 *		812.805 *	26221.3				114.432 *
HLWR1 4U		15203.5	20285.7	2209.34		1139.45 *	31612.3				
HLWR1 45D		10560.4	23848	1753.52		973.707 *	28870.2				68.5534 *
HLWR1 5U		13793.2	14300.4	2395.54		670.634 *	30354.7				54.2834 *
HLWR1 6A		1513.95 *	18624.8	448.772 *			86466.6	1090.34 *	868.012	96.2695 *	304.084
HLWR1 6B		17310	16729.1	1714.9		1212.5 *	33062.3			82.579 *	44.1263 *
HLWR1 6U		12823.4	14610.8	2134.9		1000.43 *	31093.1				62.7815 *
HLWR1 7A			139843	366.199 *			14610.2				98.9569 *
HLWR1 7B		13562.1	84692.8	1512.41			29516.5				109.871 *
HLWR1 7BAD		14072.6	86370.1	1253.96 *			29997.4				70.6658 *
HLTP1 1	480	1390	28330	793	143 *	1080 *	181520	700 *	1010	171 *	574
HLTP1 2		2150	28340	471 *			135580	870 *	660	124 *	448
HLTP2 1		870	27200	530	186		108160	1400	883	174 *	
HLTP2 1DUP		780	31790	770			185030		1089	110 *	827
HLTP3 1			71430	485 *		174	245060	780 *	1462	42 *	715
HLTP4 1	150 *	3730	44070	1570		950	102170	300 *	412 *	82 *	244
HLTP5 1		1210	30790	1362		330 *	182500	1280	1285	143 *	635
HL0+50		6140	29590	1190		680 *	107150	870 *	577 *	105 *	365
HL1+50		2670	21100	965	108 *	910 *	159620	1050	824	114 *	603
HL2+50		8740	11980	1418	115 *	850 *	70060	420 *	429	150 *	337
HLCANDUMP 1		640 *	5010	163	380 *	260 *	31890	450	348 *	1119	51
HLCANDUMP 2		2100	7590	56 *	350 *	430 *	21470	290 *	93 *	223	89 *

SAMPLE ID	Sr	Zr	Hg	Mo	Pb	Rb	Cd	Sb	Ba	Ag	U	Th
COM1	276.99	174.64			4498.58	129.389	262.775 *	105.205 *	744.673			28.3861 *
COM2	443.27	122.854			151.168	144.216			977.347			
COM3	204.11	104.292			2254.11	75.8295 *			920.118		28.9807 *	
COM3 AD	219.80	93.7058		13.0483 *	2232.42	98.6794			912.91	130.539 *	18.6628 *	
HLWR1 1	296.48	66.4822				52.567 *			408.672			
HLWR1 1A	43.21 *	23.022 *		9.26838 *								
HLWR1 1B		28.4531 *					318.368 *					
HLWR1 2A	33.387 *	61.4023		9.11448 *								
HLWR1 2B	131.21	95.4596				28.7365 *	208.151 *		113.675		13.4193 *	14.2566 *
HLWR1 2BAD	134.83	129.551					212.983 *		126.139		13.3826 *	8.92797 *
HLWR1 2C	62.725	93.4319				203.174			407.315			12.9232 *
HLWR1 3A	131.89	27.5357			43.3244 *	25.2499 *			88.3435 *			
HLWR1 3B	31.196 *											
HLWR1 3U	399.3	68.9179				84.6328 *			489.104			
HLWR1 4A	192.75	118.455				30.7948 *			588.829			
HLWR1 4U	239.53	250.141				126.313			603.372		17.4148 *	25.413 *
HLWR1 45D	241.95	204.234			31.9091 *	98.7148			814.151		20.0603 *	15.7682 *
HLWR1 5U	287.59	221.232				106.305			551.948		17.9813 *	19.4309 *
HLWR1 6A	51.685	24.4962 *				21.5363 *			84.1505 *			
HLWR1 6B	204.63	179.621				128.382			468.582			15.1977 *
HLWR1 6U	237.38	236.684				143.111	247.843 *		844.312		23.3619 *	20.7333 *
HLWR1 7A	58.807	30.718 *										
HLWR1 7B	66.099	50.9699				54.9312 *			101.168 *			8.38588 *
HLWR1 7BAD	70.415	50.7[illegible]				41.724 *	299.181 *		95.1857 *			
HLTP1 1	32.4 *	51.3		6				39 *	41	216 *	8.1 *	4.9
HLTP1 2	48.2	44		2.5				32 *	77.5	160 *	7.8 *	
HLTP2 1	10.2 *	40.2						58	37.9	187	7.1	5.7
HLTP2 1DUP	28.8	44.8					80 *		44.3 *	102 *	8.2 *	
HLTP3 1	20.1	18.4 *					78 *	63 *	21.2 *	171 *	5.7 *	3.7 *
HLTP4 1	303	106.6				73.1 *		75 *	883		18.7	21.4
HLTP5 1	48.6 *	64.4		5.6 *		5.6 *	282 *	108 *	75 *		9.9 *	4.7
HL0+50	201	126.5				54.3	88 *	27 *	198	40 *	9 *	9.2 *
HL1+50	35 *	85.6				15.6 *	258 *		75.6 *	99 *	4.6 *	3.6 *
HL2+50	95.1	119.4			58 *	72.1	71 *		246	61 *	7.9 *	5.9 *
HLCANDUMP 1	22	5 *			184 *	11 *	270 *	18 *	12.2 *			
HLCANDUMP 2	32 *	9.3 *			105	6.3 *		27 *	23 *			

TABLE B-2
1996 HIGHLAND MINE REMEDIAL INVESTIGATION
METALS AND CYANIDE IN SOIL

FIELD ID	Al (mg/kg)	Sb (mg/kg)	As (mg/kg)	Ba (mg/kg)	Be (mg/kg)	Ca (mg/kg)	Cd (mg/kg)	Co (mg/kg)	Cr (mg/kg)	Cu (mg/kg)	Fe (mg/kg)	Hg (mg/kg)	Cyanide (mg/kg)
47-028-SE1	11500	7.9 UJ	47.1	116	0.69 U	5750	1.5 U	15.4	14.6	29.2	43300	0.066	
47-028-SE2	4110	5.6 UJ	15.0	26.2	0.49 U	71500	1.1 U	9.9	5.4	27.3	8970	0.040	
47-028-SE3	6370	6.2 UJ	21.6	37.1	0.55 U	70800	1.2 U	5.4	6.6	41.0	11600	0.091	
47-028-SE4	7160	7.5 UJ	39.6	46.5	0.66 U	90300	1.4 U	7.0	5.7	57.0	15800	0.28	
47-028-SWE	5120	6.0 UJ	25.4	39.0	0.53 U	89000	1.2 U	7.9	6.7	27.3	14400	0.060	
47-028-SE6	28300	9.6 UJ	163	191	0.85 U	247000	1.8 U	26.8	28.3	356	60500	0.37	
47-028-SE7	21900	6.6 UJ	70.8	121	0.58 U	59800	1.3 U	20.0	18.2	49.4	31400	0.042	
47-028-BG1	20200	5.1 UJ	25.4	160	0.45 U	2490	0.97 U	20.5	19.0	34.8	27700	0.028	
47-028-BG2	41600	5.8 UJ	71.5	234	0.51 U	13700	1.3	16.4	31.4	46.8	31000	0.077	
47-028-BG3	21500	5.1 UJ	22.6	135	0.45 U	12700	0.98 U	7.8	14.6	18.9	17900	0.034	
47-028-BG4	16700	9.1 J	43.9	92.5	0.71 U	13300	1.5 U	9.6	18.3	58.4	21900	0.11	
47-028-BG5	13700	5.1 UJ	57.8	90.5	0.45 U	2270	0.99	14.9	14.1	35.9	22200	0.055	
WR1-C1	9090	5.28 UJ	158 J	97.2 J	0.465 U	88900	1.21 J	14.2 J	10.1	458	61600 J	0.39 J	
WR1-C2	3860	11.9 J	436 J	31.4 J	0.492 U	75200	1.06 UJ	16.2 J	9.77	1720	151000 J	0.53 J	
WR1-C3	12000	4.77 UJ	40.2 J	90 J	0.419 U	70800	0.905 UJ	17.8 J	22.9	100	22700 J	0.55 J	
47-028-TP1-C	8730	5.7 UJ	354	53.9	0.50 U	48600	1.1 U	15.6	16.4	1580 J	137000 J	0.19	<0.338
47-028-TP2-C	5930	10.5 J	530	48.9	0.50 U	41600	1.1 U	16.9	8.8	1550 J	151000 J	0.40	<0.340

J = Estimated Concentration U = Analyte Not Detected X = Outlier Based on Statistical Analysis of the Data Set NR = Analysis Not Requested

FIELD ID	K (mg/kg)	Mn (mg/kg)	Mg (mg/kg)	Ag (mg/kg)	Na (mg/kg)	Ni (mg/kg)	Pb (mg/kg)	Hg (mg/kg)	Se (mg/kg)	Tl (mg/kg)	V (mg/kg)	Zn (mg/kg)
47-028-SE1	3920	1200	7610	2.3 U	115 J	6.4 U	14.9	0.066	23.5 U	16.6 U	99.1	56.4
47-028-SE2	973	204	42900	1.6 U	63.2 J	4.5 U	10.5	0.040	16.6 U	11.7 U	18.4	20.2
47-028-SE3	1550	228	43900	1.8 U	112 J	5.1 U	11.6	0.091	18.6 U	13.2 U	72.9	35.2
47-028-SE4	1780	318	56000	2.2 U	152 J	6.1 U	14.2	0.28	22.4 U	15.8 U	23.9	51.4
47-028-SWE	1300	482	54800	1.7 U	101 J	4.9 U	58.8	0.060	18.0 U	12.8 U	33.3	33.3
47-028-SE6	6760	1240	160000	2.8 U	330 J	19.5	45.9	0.37	28.7 U	20.3 U	77.0	186
47-028-SE7	4970	528	42600	1.9 U	334 J	10.7	12.5	0.042	19.7 U	13.9 U	64.4	44.9
47-028-BG1	6810	750	7640	1.5 U	134 J	10.2	9.6	0.028	15.2 U	10.8 U	71.8	62.7
47-028-BG2	5280	1200	34100	1.7 U	236 J	19.9	40.2	0.077	17.2 U	12.2 U	51.6	113
47-028-BG3	2390	545	13400	1.5 U	130 J	10.7	9.9	0.034	15.1 U	10.7 U	32.2	65.8
47-028-BG4	2740	305	7390	2.3 U	130 J	7.5	38.7	0.11	24.6 U	17 U	45.8	75.0
47-028-BG5	6200	392	6430	1.5 U	91.0 J	5.5	17.0	0.055	15.1 U	10.7 U	61.3	73.2
WR1-C1	3080 J	521	59300	1.52 U	111 J	9.22	31.5	0.39 J	15.7 U	11.1 U	39	121
WR1-C2	1360 J	328	26000	1.61 U	46.5 J	4.56 U	13.2	0.53 J	61.9	11.6 U	41.9	38.9
WR1-C3	6230 J	376	44700	1.37 U	104 J	17.7	9.35	0.55 J	14.2 U	10.1 U	40.7	61.5
47-028-TP1-C	1520	370	32700	2.0	62.4	8.6	10.8	0.19	17.1 UJ	12.1 U	43.6	66.9
47-028-TP2-C	1020	432	27300	1.7	42.9	5.9	10.8	0.40	17.1 UJ	12.1 U	37.7	77.9

J = Estimated Concentration U = Analyte Not Detected X = Outlier Based on Statistical Analysis of the Data Set NR = Analysis Not Requested

TABLE B-3
HIGHLAND MINE
TCLP METALS RESULTS

SAMPLE NO.	As (mg/L)	Ag (mg/L)	Ba (mg/L)	Cd (mg/L)	Cr (mg/L)	Hg (mg/L)	Pb (mg/L)	Se (mg/L)
47-028-WR1-C2	59.6 J	6.2 U	160.00	4.1 U	9.7 U	0.17	40.8 U	64.4 U
47-028-WR1-C3	43.30 UJ	6.2 U	849.00	4.1 U	9.7 U	0.16	40.8 U	64.4 U
47-028-TP1-C	43.30 UJ	6.2 U	477.00	4.1 U	9.7 U	0.17	40.8 U	64.4 U
47-028-TP2-C	44.30 J	6.2 U	536.00	4.1 U	9.7 U	0.15	40.8 U	64.4 U
MAXIMUM CONCENTRATION (REGULATORY LIMIT)	5.00	5.00	100.00	1.00	5.00	0.20	5.00	1.00

U = Analyte Not Detected
J = Estimated Concentration

TABLE B-4
HIGHLAND MINE
ACID BASE ACCOUNTING RESULTS

SAMPLE NO.	TOTAL SULFUR %	T. S. AB t/1000t	Neut. Pot. t/1000t	T. S. ABP t/1000t	Sulfate Sulfur %	Pyritic Sulfur %	Organic Sulfur %	PyrS AB t/1000t	PyrS ABP t/1000t	SMP Buffer (t/1000t)	Potential Acidity	Lime Req. Dollhopf (t/1000t)	Lime Req Dollhopf (t/ac.) 2 ft.
47-028-WR1-1A	4.93	154.00	142.00	-11.60	<0.01	5.09	0.87	159.00	-16.60	3.36	186.25	-55.31	-116.16
47-028-WR1-1B	8.83	276.00	2.35	-273.00	<0.01	8.69	1.14	271.00	-269.00	99.27	307.19	-381.05	-800.20
47-028-WR1-2A	<0.01	0.00	510.00	510.00	<0.01	0.06	0.11	1.87	508.00	-0.79	5.31	630.86	1324.80
47-028 WR1-2B	0.47	14.70	77.40	62.70	<0.01	0.04	0.12	12.50	64.90	-0.90	16.25	76.44	160.52
47-028-WR1-3A	<0.01	0.00	1036.00	1036.00	<0.01	<0.01	<0.01	0.00	1036.00	-1.27	0.00	1295.00	2719.50
47 028 WR1-4	0.47	14.70	253.00	238.00	<0.01	0.04	0.12	12.50	241.00	-0.85	16.25	295.94	621.47
47-028-WR1-7	0.06	1.87	498.00	496.00	<0.01	0.13	0.07	4.06	494.00	-1.08	6.25	614.69	1290.84
47-028-TP1-C	0.16	5.00	150.00	145.00	0.15	0.01	<0.01	0.31	150.00	-1.18	3.83	182.71	383.70
47-028-TP2-C	0.13	4.10	190.00	186.00	0.13	<0.01	<0.01	0.00	190.00	-1.12	3.05	233.89	490.75

TABLE B-5
HIGHLAND SITE
AGRONOMIC PROPERTIES

SAMPLE NO.	ORGANIC MATTER	PHOSPHORUS				POTASSIUM		MAGNESIUM		CALCIUM		SODIUM		NITRATE NO3-N		Boron	pH	C.E.C.	PERCENT BASE SATURATION					SOLUBLE SALTS
		P1		P2																				
	(%)	(ppm)	(lbs/A)*	(ppm)	(lbs/A)*	(ppm)	(lbs/A)**	(ppm)	(lbs/A)*	(ppm)	(lbs/A)*	(ppm)	(lbs/A)*	(ppm)	(lbs/A)*	(ppm)		(meq/100g)	% K	% Mg	% Ca	% H	% Na	(mmhos/cm)
47 028 WR1 1	4 7	1	4 6	4	18	4[illegible]	106	4346	19992	5546	25512	14	64 4	1	2	6 5 J	3 2		0	7	5 4	87	0	18
47 028 WR1 2	1 8	1	4 6	4	18	230	552	964	4434	3702	17029	14	64 4	1	2	6 4 J	7 7	27 2	2 2	29 5	68 1	0	0 2	2 8
47 028 WR1-3	0 1	12	55	44	202	29	70	208	957	1395	6417	12	55 2	1	2	6 4 J	9	8 8	0 8	19 6	78 9	0	0 5	0 4

ENR = ESTIMATED NITROGEN RELEASE
* = POUNDS OF ELEMENTAL P, Mg, Ca, Na, or N PER ACRE (Based on soil depth of 6 2/3 inches)
** = POUNDS OF K2O PER ACRE (Based on soil depth of 6 2/3 inches)
C.E.C. = CATION EXCHANGE CAPACITY

TABLE B-6
HIGHLAND MINE
PHYSICAL PROPERTIES

SAMPLE NO	SAMPLE TEXTURE	PARTICLE SIZE DISTRIBUTION % Retained on 1.5" Sieve	% Retained on 1" Sieve	% Retained on 3/4" Sieve	% Retained on 1/2" Sieve	% Retained on 3/8" Sieve	% Retained on #4 Sieve	% Retained on #10 Sieve	% Retained on #20 Sieve	% Retained on #40 Sieve	% Retained on #60 Sieve	% Retained on #100 Sieve	% Retained on #200Sieve
47 028 WR1 1	Poorly graded sand with silt nonplastic, trace gravel		100	98.4	92.5	88.2	75.9	60.8	52.2	45.7	39.7	34.6	27.7
47 028 WR1 2	Clayey sand with gravel	100	98.2	93.3	83.9	79.9	70	58.3	50.8	42.5	34.8	28.2	20.4
47 028 WR1 3	Sand with Silt and Gravel		100	98	88.3	81.1	65.2	52	44.5	33.5	24	16.9	10.2
47 028 TP1 C	Sand and Silt						100	99.9	99.7	99.2	95.4	85.2	67.1
47 028 TP2 C	Silt with Sand						100	99.9	99.8	99.3	96.9	88.7	70.7

PROCTOR Max. Dry Density (lbs./cu. ft.)	Optimum Moisture Content (%)	AVERAGE PERMEABILITY (cm/sec)	POROSITY (%)	FIELD CAPACITY (%)	SPECIFIC GRAVITY	WILTING POINT (%)
127.3	12.8	NR	NR	27.37	2.98	11.81
127.3	12.8	NR	NR	17.2	2.77	8.79
127.3	12.8	NR	NR	2.63	2.84	0.5
NR	14.22	NR	NR	24.89	3.11	10.77
NR	12.17	NR	NR	20.6	3.1	8.43

TABLE B-7
HIGHLAND MINE
SURFACE WATER - TOTAL METALS

SAMPLE NO.	Al (ug/L)	As (ug/L)	Ag (ug/L)	Ba (ug/L)	Be (ug/L)	Ca (ug/L)	Cd (ug/L)	Co (ug/L)	Cr (ug/L)	Cu (ug/L)	Fe (ug/L)	Hg (ug/L)
47-028 SW1	30.8 U	5.0	0.56 U	12.3	1.9 U	21100	0.1 U	7.7 U	9.7 U	4.1 U	594	0.18
47-028 SW2	46.3	2.5	0.56 U	17.6	1.9 U	41100	0.1 U	7.7 U	9.7 U	4.1 U	78.1	0.11 U
47-028 SW3	30.8 U	2.8	0.56 U	17.5	1.9 U	39900	0.1 U	7.7 U	9.7 U	4.1 U	93.8	0.15
47-028 SW4	30.8 U	2.5	0.56 U	17.4	1.9 U	38800	0.1 U	7.7 U	9.7 U	4.1 U	89.9	0.18
47-028 SW5	30.8 U	2.3	0.56 U	18.9	1.9 U	41700	0.1 U	7.7 U	9.7 U	4.1 U	102	0.18
47-028 SW6	30.8 U	3.1	0.56 U	18.3	1.9 U	40300	0.1 U	7.7 U	9.7 U	4.1 U	89.9	0.11 U
47-028 SW7	30.8 U	0.59 U	0.56 U	1.1 U	1.9 U	94.5	0.1 U	7.7 U	9.7 U	4.1 U	20.8 U	0.11 U
47-028 AD1												

SAMPLE NO.	K (ug/L)	Mg (ug/L)	Mn (ug/L)	Na (ug/L)	Ni (ug/L)	Pb (ug/L)	Sb (ug/L)	Se (ug/L)	Tl (ug/L)	V (ug/L)	Zn (ug/L)	HARDNESS (mg $CaCO_3$/L)
47-028 SW1	2430	10300	30.6	2350	17.6 U	0.49	3.5 J	1.4 U	0.8 U	3.9 U	9.8 U	191
47-028 SW2	3030	23700	10.9	2480	17.6 U	0.41 U	2.4 UJ	1.4 U	0.8 U	3.9 U	9.8 U	200
47-028 SW3	2910	22700	8.7	2410	17.6 U	0.41 U	3.2 J	1.4 U	0.8 U	3.9 U	10	193
47-028 SW4	3140	22500	7.6	2550	17.6 U	0.41 U	2.4 UJ	1.4 U	0.8 U	3.9 U	9.8 U	190
47-028 SW5	3350	24400	8.7	2760	17.6 U	0.41 U	2.4 J	1.4 U	0.8 U	3.9 U	9.8 U	205
47-028 SW6	3120	23200	6.6	2620	17.6 U	0.41 U	3.3 J	1.4 U	0.8 U	3.9 U	9.8 U	196
47-028 SW7	29.6 U	14 U	4.4 U	27	17.6 U	0.41 U	2.4 UJ	1.4 U	0.8 U	3.9 U	9.8 U	0.29
47-028 AD1												

J = Estimated Concentration   U = Analyte Not Detected   X = Outlier Based on Statistical Analysis of the Data Set

TABLE B-8
HIGHLAND MINE
SURFACE WATER - TOTAL RECOVERABLE METALS

SAMPLE NO.	Al (ug/L)	As (ug/L)	Ag (ug/L)	Ba (ug/L)	Be (ug/L)	Ca (ug/L)	Cd (ug/L)	Co (ug/L)	Cr (ug/L)	Cu (ug/L)	Fe (ug/L)	Hg (ug/L)
47-028-SW1	45.3	6.4	0.56 U	12.5	1.9 U	20600	0.09 U	7.7 U	9.7 U	7.8 J	644	0.14
47-028-SW2	103	4.4	0.56 U	16.5	1.9 U	36300	0.09 U	7.7 U	9.7 U	6.6 J	165	0.13
47-028-SW3	51	4.7	0.56 U	16.7	1.9 U	37900	0.09 U	7.7 U	9.7 U	4.1 UJ	94.3	0.15
47-028-SW4	30.8 U	4.4	0.56 U	16.6	1.9 U	36900	0.09 U	7.7 U	9.7 U	9.6 J	98.2	0.25
47-028-SW5	30.8 U	5.0	0.56 U	16.8	1.9 U	36700	0.09 U	8.2	9.7 U	4.1 UJ	106	0.2
47-028-SW6	30.8 U	4.9	0.56 U	16.9	1.9 U	37000	0.09 U	8.4	9.7 U	4.1 UJ	86.4	0.11 U
47-028-SW7	30.8 U	1.6	0.56 U	1.1 U	1.9 U	462	0.09 U	7.7 U	9.7 U	4.1 UJ	20.8 U	0.11 U
47-028-AD1	30.8 U	5.3	0.56 U	17.4	1.9 U	36500	0.09 U	7.7 U	9.7 U	9.9 J	90.3	0.11 U

SAMPLE NO.	K (ug/L)	Mg (ug/L)	Mn (ug/L)	Na (ug/L)	Ni (ug/L)	Pb (ug/L)	Sb (ug/L)	Se (ug/L)	Tl (ug/L)	V (ug/L)	Zn (ug/L)	HARDNESS (mg $CaCO_3$/L)
47-028-SW1	2230	9830	29.9	2180	17.6 U	1.4 U	4.7 J	1.2 J	0.82	3.9 U	25.7 J	191
47-028-SW2	2490	21500	4.4 U	2080	17.6 U	1.4 U	2.4 UJ	2.1 J	0.80 U	3.9 U	27.9 J	200
47-028-SW3	2500	22000	4.4 U	2120	17.6 U	1.4 U	2.7 J	2.6 J	0.80 U	3.9 U	15.8 J	193
47-028-SW4	2580	21800	4.4 U	2170	17.6 U	1.4 U	2.4 UJ	2.9 J	0.80 U	3.9 U	12.8 J	190
47-028-SW5	2680	21800	6.4	2270	17.6 U	1.4 U	3 J	2.7 J	0.80 U	3.9 U	12.9 J	205
47-028-SW6	2640	21800	8.5	2240	17.6 U	1.4 U	2.4 UJ	1.3 J	0.80 U	3.9 U	15.9 J	196
47-028-SW7	29.6 U	33.5	4.4 U	54.4	17.6 U	1.4 U	2.4 UJ	1.1 UJ	0.80 U	3.9 U	21 J	>5
47-028-AD1	2400	21100	8.6	2060	17.6 U	1.4 U	3.6 J	1.6 J	0.80 U	3.9 U	9.8 UJ	178

J = Estimated Concentration U = Analyte Not Detected X = Outlier Based on Statistical Analysis of the Data Set

TABLE C-1

PRELIMINARY COST ESTIMATE - ALTERNATIVE 3 IN-PLACE CONTAINMENT (WASTE ROCK and TAILINGS)					
	Quantity	Units	Unit Price	Cost	Unit Cost Reference
CAPITAL COSTS					
Mobilization, Bonding, & Insurance	1.00	L.S	$50,000.00	$50,000.00	Engineering Estimate
Road Improvement/Road Construction	1,000.00	FT.	$6.00	$6,000.00	DEQ Bid Tabulations
Stream Diversion	1.00	L.S.	$5,000.00	$5,000.00	Engineering Estimate
Tailings Removal and Haul	2,000.00	CY	$5.00	$10,000.00	Engineering Estimate
Waste Rock Grading	0.70	Acres	$10,000.00	$7,000.00	DEQ Bid Tabulations
Excavate/Transport/Grade Borrow Cover Soil for Waste Rock Dump and Tailings Area	2,000.00	C.Y.	$12.00	$24,000.00	Engineering Estimate
Organic Amendment (Transportation and Incorporation)	2.00	Acres	$9,000.00	$18,000.00	DEQ Bid Tabulations
Fertilize and Seed	2.00	Acres	$1,500.00	$3,000.00	DEQ Bid Tabulations
Mulch (Waste Rock and/or Tailings Area)	1.20	Acres	$1,000.00	$1,200.00	DEQ Bid Tabulations
Erosion Control Mat	4,000.00	S.Y.	$2.50	$10,000.00	DEQ Bid Tabulations
Runon Control Ditch Construction	500.00	L.F.	$5.00	$2,500.00	DEQ Bid Tabulations
Install Fences (Range Panel/Wood Post Fence)	850.00	L.F	$5.00	$4,250.00	DEQ Bid Tabulations
Obliterate and Reclaim Temporary Roads	1,000.00	L.F.	$2.00	$2,000.00	DEQ Bid Tabulations
Subtotal				$142,950.00	
Construction Oversight (15%)				$21,442.50	
Subtotal Capital Costs				$164,392.50	
Contingency (10%)				$16,439.25	
TOTAL CAPITAL COSTS				**$180,831.75**	

TABLE C-1 Continued

POST CLOSURE MONITORING AND MAINTENANCE COSTS					
Inspections	1	/Year	$500.00	$500.00	Estimate
Sampling and Analysis	2	/Year	$600.00	$1,200.00	Estimate
Maintenance	1	L.S.	$1,000.00	$1,000.00	Estimate
Subtotal				$2,700.00	
Contingency (10%)				$270.00	
ANNUAL 30 YEAR O&M COST				**$5,670.00**	

TOTAL CAPITAL COSTS	$180,832
PRESENT WORTH, POST-CLOSURE MAINTENANCE AND MONITORING (10%)	$53,451
TOTAL PRESENT WORTH COST	**$234,282.27**

TABLE C-2

PRELIMINARY COST ESTIMATE - ALTERNATIVE 4a
DISPOSAL IN A CONSTRUCTED RCRA SUBTITLE C REPOSITORY

	Quantity	Units	Unit Price	Cost	Unit Cost Reference
CAPITAL COSTS					
Mobilization, Bonding, & Insurance	1.00	L.S.	$70,000.00	$70,000.00	Engineering Estimate
Road Improvement/Road Construction	1,000.00	FT	$6.00	$6,000.00	Engineering Estimate
Temporary Stream Diversion Construction	1.00	L.S.	$5,000.00	$5,000.00	Engineering Estimate
Repository Excavation	9,100.00	C.Y.	$3.00	$27,300.00	DEQ Bid Tabulation
Grade and Compact Subgrade	4,000.00	S.Y.	$0.50	$2,000.00	DEQ Bid Tabulation
HDPE Liner (2 Layers)	8,000.00	S.Y.	$4.00	$32,000.00	EMCON
Washed Gravel (2 Layers)	1,300.00	C.Y.	$9.00	$11,700.00	Engineering Estimate
Geotextile - Filter Fabric (2 Layers)	8,000.00	S.Y.	$1.50	$12,000.00	DEQ Bid Tabulation
Leachate Collection/Removal System (Includes Pond, Piping, Fittings, ect)	1.00	L.S.	$8,000.00	$8,000.00	Engineering Estimate
Excavate/Haul/Backfill/and Compact Waste (Volume Includes Contaminated Undersoil)	12,900.00	C.Y.	$5.00	$64,500.00	DEQ Bid Tabulation
Install GCL Cap Liner	4,000.00	S.Y.	$5.00	$20,000.00	DEQ Bid Tabulation
Geocomposite (Cap)	4,000.00	S.Y.	$4.50	$18,000.00	DEQ Bid Tabulation
Backfill/Grade Cover Soil for Repository Cap	2,600.00	C.Y.	$3.00	$7,800.00	DEQ Bid Tabulation
Backfill/Grade Cover Soil for Excavated Areas	3,500.00	C.Y.	$4.00	$14,000.00	DEQ Bid Tabulation
Organic Amendment	2.80	Acres	$9,000.00	$25,200.00	DEQ Bid Tabulation
Fertilize and Seed	2.80	Acres	$1,500.00	$4,200.00	DEQ Bid Tabulation
Mulch	1.60	Acres	$1,000.00	$1,600.00	DEQ Bid Tabulation
Erosion Control Mat	4,000.00	S.Y.	$2.50	$10,000.00	DEQ Bid Tabulation
Runon Control Ditch Construction	1,000.00	L.F.	$5.00	$5,000.00	DEQ Bid Tabulation

TABLE C-2 Continued

Install Fences (Range Panel/Wood Post Fence)	2,300.00	L.F.	$5.00	$11,500.00	DEQ Bid Tabulation
Obliterate and Reclaim Temporary Roads	1,000.00	L.F.	$2.00	$2,000.00	DEQ Bid Tabulation
Subtotal				$357,800.00	
Construction Oversight (15%)				$53,670.00	
Subtotal Capital Costs				$411,470.00	
Remote/Rough Terrain Contingency (10%)				$41,147.00	
TOTAL CAPITAL COSTS				**$452,617.00**	
POST CLOSURE MONITORING AND MAINTENANCE COSTS					
Inspections	1	/Year	$500.00	$500.00	Estimate
Sampling and Analysis	4	/Year	$600.00	$2,400.00	Estimate
Maintenance	1	L.S.	$2,000.00	$2,000.00	Estimate
Subtotal				$4,900.00	
Contingency (10%)				$490.00	
ANNUAL 30 YEAR O&M COST				**$5,390.00**	

TOTAL CAPITAL COSTS	$452,617.00
PRESENT WORTH, POST-CLOSURE MAINTENANCE AND MONITORING (10%)	$50,810.99
TOTAL PRESENT WORTH COST	$503,427.99

TABLE C-3

PRELIMINARY COST ESTIMATE - ALTERNATIVE 4b
DISPOSAL IN A CONSTRUCTED MODIFIED RCRA REPOSITORY

	Quantity	Units	Unit Price	Cost	Unit Cost Reference
CAPITAL COSTS					
Mobilization, Bonding, & Insurance	1.00	L.S.	$70,000.00	$70,000.00	Engineering Estimate
Road Improvement/Road Construction	1,000.00	FT	$6.00	$6,000.00	Engineering Estimate
Temporary Stream Diversion Construction	1.00	L.S.	$5,000.00	$5,000.00	Engineering Estimate
Repository Excavation	6,500.00	C.Y.	$3.00	$19,500.00	DEQ Bid Tabulation
Grade and Compact Subgrade	4,000.00	S.Y.	$0.50	$2,000.00	DEQ Bid Tabulation
Install GCL Bottom Liner	4,000.00	S.Y.	$5.00	$20,000.00	DEQ Bid Tabulation
Geocomposite	4,000.00	S.Y.	$4.50	$18,000.00	DEQ Bid Tabulation
Leachate Collection/Removal System (Includes Pond,Piping,Fittings, ect)	1.00	L.S.	$4,000.00	$4,000.00	Engineering Estimate
Excavate/Haull/Backfill/and Compact Waste (Volume Includes Contaminated Undersoil)	12,900.00	C.Y.	$5.00	$64,500.00	DEQ Bid Tabulation
Install GCL Cap Liner	4,000.00	S.Y.	$5.00	$20,000.00	DEQ Bid Tabulation
Geocomposite	4,000.00	S.Y.	$4.50	$18,000.00	DEQ Bid Tabulation
Backfill/Grade Cover Soil for Repository Cap	2,600.00	C.Y.	$3.00	$7,800.00	DEQ Bid Tabulation
Backfill/Grade Cover Soil for Excavated Areas	3,500.00	C.Y.	$4.00	$14,000.00	DEQ Bid Tabulation
Organic Amendment	2.80	Acres	$9,000.00	$25,200.00	DEQ Bid Tabulation
Fertilize and Seed	2.80	Acres	$1,500.00	$4,200.00	DEQ Bid Tabulation
Mulch	1.60	Acres	$1,000.00	$1,600.00	DEQ Bid Tabulation
Erosion Control Mat	4,000.00	S.Y.	$2.50	$10,000.00	DEQ Bid Tabulation
Runon Control Ditch Construction	1,000.00	L.F.	$5.00	$5,000.00	DEQ Bid Tabulation

TABLE C-3 Continued

Install Fences (Range Panel/Wood Post Fence)	2,300.00	L.F.	$5.00	$11,500.00	Brooklyn Site EE/CA
Obliterate and Reclaim Temporary Roads	1,000.00	L.F.	$2.00	$2,000.00	Brooklyn Site EE/CA
Subtotal				$328,300.00	
Construction Oversight (15%)				$49,245.00	
Subtotal Capital Costs				$377,545.00	
Remote/Rough Terrain Contingency (10%)				$37,754.50	
TOTAL CAPITAL COSTS				**$415,299.50**	

POST CLOSURE MONITORING AND MAINTENANCE COSTS					
Inspections	1	/Year	$500.00	$500.00	Estimate
Sampling and Analysis	4	/Year	$600.00	$2,400.00	Estimate
Maintenance	1	L.S.	$1,500.00	$1,500.00	Estimate
Subtotal				$4,400.00	
Contingency (10%)				$440.00	
ANNUAL 30 YEAR O&M COST				**$4,840.00**	

TOTAL CAPITAL COSTS	$415,299.50
PRESENT WORTH, POST-CLOSURE MAINTENANCE AND MONITORING (10%)	$45,641 20
TOTAL PRESENT WORTH COST	$460,940.70

TABLE C-4

PRELIMINARY COST ESTIMATE - ALTERNATIVE 4c
DISPOSAL IN A CONSTRUCTED UNLINED REPOSITORY WITH A LINED CAP

	Quantity	Units	Unit Price	Cost	Unit Cost Reference
CAPITAL COSTS					
Mobilization, Bonding, & Insurance	1.00	L.S.	$70,000.00	$70,000.00	Engineering Estimate
Road Improvement/Road Construction	1,000.00	FT	$6.00	$6,000.00	DEQ Bid Tabulation
Temporary Stream Diversion Construction	1.00	L.S.	$5,000.00	$5,000.00	Engineering Estimate
Repository Excavation	6,500.00	C.Y.	$3.00	$19,500.00	DEQ Bid Tabulation
Grade and Compact Subgrade	4,000.00	S.Y.	$0.50	$2,000.00	DEQ Bid Tabulation
Excavate/Haul/Backfill/and Compact Waste (Volume Includes WR Plus Contam. Undersoil)	12,900.00	C.Y.	$5.00	$64,500.00	DEQ Bid Tabulation
Install GCL Cap Liner	4,000.00	S.Y.	$5.00	$20,000.00	DEQ Bid Tabulation
Geocomposite	4,000.00	S.Y.	$4.50	$18,000.00	DEQ Bid Tabulation
Backfill/Grade Cover Soil for Repository Cap	2,600.00	C.Y.	$3.00	$7,800.00	DEQ Bid Tabulation
Backfill/Grade Cover Soil for Excavated Areas	3,500.00	C.Y.	$4.00	$14,000.00	DEQ Bid Tabulation
Organic Amendment	2.80	Acres	$9,000.00	$25,200.00	DEQ Bid Tabulation
Fertilize and Seed	2.80	Acres	$1,500.00	$4,200.00	DEQ Bid Tabulation
Mulch	1.60	Acres	$1,000.00	$1,600.00	DEQ Bid Tabulation
Erosion Control Mat	4,000.00	S.Y.	$2.50	$10,000.00	DEQ Bid Tabulation
Runon Control Ditch Construction	1,000.00	L.F.	$5.00	$5,000.00	DEQ Bid Tabulation

TABLE C-4 Continued

Install Fences (Range Panel/Wood Post Fence)	2,300.00	L.F.	$5.00	$11,500.00	DEQ Bid Tabulation
Obliterate and Reclaim Temporary Roads	1,000.00	L.F.	$2.00	$2,000.00	DEQ Bid Tabulation
Subtotal				$286,300.00	
Construction Oversight (15%)				$42,945.00	
Subtotal Capital Costs				$329,245.00	
Contingency (10%)				$32,924.50	
TOTAL CAPITAL COSTS				**$362,169.50**	

POST CLOSURE MONITORING AND MAINTENANCE COSTS					
Inspections	1.00	/Year	$500.00	$500.00	Estimate
Sampling and Analysis	4.00	/Year	$600.00	$2,400.00	Estimate
Maintenance	1.00	L.S.	$1,500.00	$1,500.00	Estimate
Subtotal				$4,400.00	
Contingency (10%)				$440.00	
ANNUAL 30 YEAR O&M COST				**$4,840.00**	

TOTAL CAPITAL COSTS	$362,169.50
PRESENT WORTH, POST-CLOSURE MAINTENANCE AND MONITORING (10%)	$45,641.20
TOTAL PRESENT WORTH COST	**$407,810.70**

TABLE C-5

PRELIMINARY COST ESTIMATE - ALTERNATIVE 5a
OFF-SITE RCRA DISPOSAL

	Quantity	Units	Unit Price	Cost	Unit Cost Reference
CAPITAL COSTS					
Mobilization, Bonding, & Insurance	1.00	L.S	$100,000.00	$100,000.00	Engineering Estimate
Road Improvement/Road Construction	1,000.00	FT	$6.00	$6,000.00	DEQ Bid Tabulation
Stream Diversion Construction	1.00	L.S	$5,000.00	$5,000.00	Engineering Estimate
Waste Excavation/Loadout	21,000.00	Tons	$2.00	$42,000.00	MSE-ARRO FS
Transportation	21,000.00	Tons	$95.00	$1,995,000.00	MSE-ARRO FS
Disposal	21,000.00	Tons	$90.00	$1,890,000.00	MSE-ARRO FS
Excavate/Transport/Grade Borrow Soil for Excavated Areas	3,500.00	C.Y	$12.00	$42,000.00	Engineering Estimate
Organic Amendment	2.00	Acres	$9,000.00	$18,000.00	DEQ Bid Tabulation
Fertilize and Seed	2.00	Acres	$1,500.00	$3,000.00	DEQ Bid Tabulation
Mulch	1.20	Acres	$1,000.00	$1,200.00	DEQ Bid Tabulation
Erosion Control Mat	4,000.00	S.Y.	$2.50	$10,000.00	DEQ Bid Tabulation
Runon Control Ditch Construction	800.00	L.F.	$5.00	$4,000.00	DEQ Bid Tabulation
Install Fences (Range Panel/Wood Post Fence)	1,500.00	L.F.	$5.00	$7,500.00	DEQ Bid Tabulation
Obliterate and Reclaim Temporary Roads	1,000.00	L.F	$2.00	$2,000.00	Engineering Estimate

TABLE C-5 Continued

Subtotal				$4,125,700.00	
Construction Oversight (15%)				$618,855.00	
Subtotal Capital Costs				$4,744,555.00	
Contingency (10%)				$474,455.50	
TOTAL CAPITAL COSTS				**$5,219,011**	
POST CLOSURE MONITORING AND MAINTENANCE COSTS					
Inspections	1	/Year	$500.00	$500.00	Estimate
Sampling and Analysis	2	/Year	$600.00	$1,200.00	Estimate
Maintenance	1	L.S.	$500.00	$500.00	Estimate
Subtotal				$2,200.00	
Contingency (10%)				$220.00	
ANNUAL 30 YEAR O&M COST				**$2,420**	
TOTAL CAPITAL COSTS				$5,219,011	
PRESENT WORTH, POST-CLOSURE MAINTENANCE AND MONITORING (10%)				$22,796	
TOTAL PRESENT WORTH COST				**$5,241,807**	

TABLE C-6

PRELIMINARY COST ESTIMATE - ALTERNATIVE 5b OFF-SITE CLASS II FACILITY DISPOSAL					
	Quantity	Units	Unit Price	Cost	Unit Cost Reference
CAPITAL COSTS					
Mobilization, Bonding, & Insurance	1.00	L.S.	$80,000.00	$80,000.00	Engineering Estimate
Road Improvement/Road Construction	1,000.00	FT	$6.00	$6,000.00	DEQ Bid Tabulation
Stream Diversion Construction	1.00	L.S.	$5,000.00	$5,000.00	Engineering Estimate
Waste Excavation/Loadout	21,000.00	Tons	$2.00	$42,000.00	MSE-ARRO FS
Transportation	21,000.00	Tons	$9.00	$189,000.00	Engineering Estimate
Disposal	21,000.00	Tons	$20.00	$420,000.00	Engineering Estimate
Excavate/Transport/Grade Borrow Soil for Excavated Areas	3,500.00	C.Y.	$12.00	$42,000.00	Engineering Estimate
Organic Amendment	2.00	Acres	$9,000.00	$18,000.00	DEQ Bid Tabulation
Fertilize and Seed	2.00	Acres	$1,500.00	$3,000.00	DEQ Bid Tabulation
Mulch	1.20	Acres	$1,000.00	$1,200.00	DEQ Bid Tabulation
Erosion Control Mat	4,000.00	S.Y.	$2.50	$10,000.00	DEQ Bid Tabulation
Runon Control Ditch Construction	800.00	L.F.	$5.00	$4,000.00	DEQ Bid Tabulation
Install Fences (Range Panel/Wood Post Fence)	1,500.00	L.F.	$5.00	$7,500.00	Engineering Estimate
Obliterate and Reclaim Temporary Roads	1,000.00	L.F.	$2.00	$2,000.00	Engineering Estimate

TABLE C-6 Continued

Subtotal				$829,700.00	
Construction Oversight (15%)				$124,455.00	
Subtotal Capital Costs				$954,155.00	
Remote/Rough Terrain Contingency (10%)				$95,415.50	
TOTAL CAPITAL COSTS				**$1,049,571**	
POST CLOSURE MONITORING AND MAINTENANCE COSTS					
Inspections	1	/Year	$500.00	$500.00	Estimate
Sampling and Analysis	2	/Year	$600.00	$1,200.00	Estimate
Maintenance	1	L.S.	$500.00	$500.00	Estimate
Subtotal				$2,200.00	
Contingency (10%)				$220.00	
ANNUAL 30 YEAR O&M COST				**$2,420**	
TOTAL CAPITAL COSTS				$1,049,571	
PRESENT WORTH, POST-CLOSURE MAINTENANCE AND MONITORING (10%)				$22,796	
TOTAL PRESENT WORTH COST				**$1,072,367**	

TABLE C-7

PRELIMINARY COST ESTIMATE - ALTERNATIVE 5c
OFF-SITE PERMITTED FACILITY DISPOSAL

	Quantity	Units	Unit Price	Cost	Unit Cost Reference
CAPITAL COSTS					
Mobilization, Bonding, & Insurance	1.00	L.S.	$80,000.00	$80,000.00	Engineering Estimate
Road Improvement/Road Construction	1,000.00	FT	$6.00	$6,000.00	DEQ Bid Tabulation
Stream Diversion Construction	1.00	L.S.	$5,000.00	$5,000.00	Engineering Estimate
Waste Excavation/Loadout	21,000.00	Tons	$2.00	$42,000.00	MSE-ARRO FS
Transportation	21,000.00	Tons	$21.00	$441,000.00	Engineering Estimate
Disposal	21,000.00	Tons	$6.80	$142,800.00	Engineering Estimate
Excavate/Transport/Grade Borrow Soil for Excavated Areas	3,500.00	C.Y.	$12.00	$42,000.00	Engineering Estimate
Organic Amendment	2.00	Acres	$9,000.00	$18,000.00	DEQ Bid Tabulation
Fertilize and Seed	2.00	Acres	$1,500.00	$3,000.00	DEQ Bid Tabulation
Mulch	1.20	Acres	$1,000.00	$1,200.00	DEQ Bid Tabulation
Erosion Control Mat	4,000.00	S.Y.	$2.50	$10,000.00	DEQ Bid Tabulation
Runon Control Ditch Construction	800.00	L.F.	$5.00	$4,000.00	DEQ Bid Tabulation
Install Fences (Range Panel/Wood Post Fence)	1,500.00	L.F.	$5.00	$7,500.00	Engineering Estimate
Obliterate and Reclaim Temporary Roads	1,000.00	L.F.	$2.00	$2,000.00	Engineering Estimate

TABLE C-7 Continued

Subtotal				$804,500.00	
Construction Oversight (15%)				$120,675.00	
Subtotal Capital Costs				$925,175.00	
Contingency (10%)				$92,517.50	
TOTAL CAPITAL COSTS				**$1,017,693**	
POST CLOSURE MONITORING AND MAINTENANCE COSTS					
Inspections	1	/Year	$500.00	$500.00	Estimate
Sampling and Analysis	2	/Year	$600.00	$1,200.00	Estimate
Maintenance	1	L.S.	$500.00	$500.00	Estimate
Subtotal				$2,200.00	
Contingency (10%)				$220.00	
ANNUAL 30 YEAR O&M COST				**$2,420**	
TOTAL CAPITAL COSTS				$1,017,693	
PRESENT WORTH, POST-CLOSURE MAINTENANCE AND MONITORING (10%)				$22,796	
TOTAL PRESENT WORTH COST				**$1,040,489**	

TABLE C-8

PRELIMINARY COST ESTIMATE - ALTERNATIVE 3a
COLLECTION AND DIVERSION - PIPING (ADIT DISCHARGE)

	Quantity	Units	Unit Price	Cost	Unit Cost Reference
CAPITAL COSTS					
Mobilization, Bonding, & Insurance	1	L.S.	$15,000.00	$15,000.00	Engineering Estimate
Construct Adit Diversion (Concrete/Grating/Piping)	1	L.S.	$10,000.00	$10,000.00	Engineering Estimate
Stream Diversion (During Construction)	1	L.S.	$5,000.00	$5,000.00	Engineering Estimate
Run-on Control Ditch Construction	100	L.F.	$5.00	$500.00	DEQ Bid Tabulation
Install Fences (Range Panel/Wood Post Fence)	125	L.F.	$5.00	$625.00	DEQ Bid Tabulation
Stream Stuctures	100	L.F.	$42.00	$4,200.00	DEQ Bid Tabulation
Subtotal				$35,325.00	
Construction Oversight (15%)				$5,298.75	
Subtotal Capital Costs				$40,623.75	
Contingency (10%)				$4,062.38	
TOTAL CAPITAL COSTS				**$44,686.13**	

TABLE C-8 Continued

POST CLOSURE MONITORING AND MAINTENANCE COSTS					
Inspections	3	/Year	$500.00	$1,500.00	Estimate
Sampling and Analysis	2	/Year	$600.00	$1,200.00	Estimate
Maintenance	1	L.S.	$500.00	$500.00	Estimate
Subtotal				$3,200.00	
Contingency (10%)				$320.00	
ANNUAL 30 YEAR O&M COST				**$3,520.00**	

TOTAL CAPITAL COSTS	$44,686.00
PRESENT WORTH, POST-CLOSURE MAINTENANCE AND MONITORING (10%)	$33,158.40
TOTAL PRESENT WORTH COST	**$77,844.40**

TABLE C-9

PRELIMINARY COST ESTIMATE - ALTERNATIVE 3b
COLLECTION AND DIVERSION - CHANNEL RECONSTRUCTION (ADIT DISCHARGE)

	Quantity	Units	Unit Price	Cost	Unit Cost Reference
CAPITAL COSTS					
Mobilization, Bonding, & Insurance	1	L.S.	$15,000.00	$15,000.00	Engineering Estimate
Excavation of Contamimated Sediment	1	L.S.	$5,000.00	$5,000.00	Engineering Estimate
Stream Reconstruction	1	L.S.	$8,000.00	$8,000.00	Engineering Estimate
Stream Diversion (During Construction)	1	L.S.	$5,000.00	$5,000.00	Engineering Estimate
Run-on Control Ditch Construction	100	L.F.	$5.00	$500.00	DEQ Bid Tabulation
Install Fences (Range Panel/Wood Post Fence)	125	L.F.	$5.00	$625.00	DEQ Bid Tabulation
Stream Structures	100	L.F.	$42.00	$4,200.00	DEQ Bid Tabulation
Subtotal				$38,325.00	
Construction Oversight (15%)				$5,748.75	
Subtotal Capital Costs				$44,073.75	
Remote/Rough Terrain Contingency (10%)				$4,407.38	
TOTAL CAPITAL COSTS				**$48,481.13**	

TABLE C-9 Continued

POST CLOSURE MONITORING AND MAINTENANCE COSTS					
Inspections	1	/Year	$500.00	$500.00	Estimate
Sampling and Analysis	2	/Year	$600.00	$1,200.00	Estimate
Maintenance	1	L.S.	$500.00	$500.00	Estimate
Subtotal				$2,200.00	
Contingency (10%)				$220.00	
ANNUAL 30 YEAR O&M COST				**$2,420.00**	

TOTAL CAPITAL COSTS	$48,481.13
PRESENT WORTH, POST-CLOSURE MAINTENANCE AND MONITORING (10%)	$22,796.40
TOTAL PRESENT WORTH COST	**$71,277.53**

APPENDIX D

SUMMARY OF FEDERAL AND STATE APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

INTRODUCTION

Reclamation actions undertaken pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), and the Comprehensive Environmental Cleanup and Responsibility Act (CECRA), Montana Code Annotated (MCA) §§ 75-10-701 et seq., must "attain a degree of cleanup of the hazardous or deleterious substance and control of a threatened release or further release of that substance that assures protection of public health, safety, and welfare and of the environment." § 75-10-721(1), MCA. Additionally, the Montana Department of Environmental Quality (MDEQ) "shall require cleanup consistent with applicable state or federal applicable or relevant and appropriate requirements" and "may consider substantive state or federal applicable or relevant and appropriate requirements that are relevant to the site conditions." Section 75-10-721(2)(a) and (b) (emphasis added).

A distinction exists between "applicable" requirements and those that are "relevant." "Applicable" requirements are those requirements that would legally apply at the site regardless of the action. "Relevant" requirements are those requirements that are not applicable, but address situations or problems sufficiently similar to those at the site and, therefore, are relevant for use at the site. Attainment of "applicable" requirements is mandatory under CERCLA and CECRA. "Relevant" requirements may be considered by MDEQ. Within this document, MDEQ has identified applicable or relevant state and federal environmental requirements for the proposed reclamation action plan at the Highland Mine Site. Additionally, pursuant to § 75-10-721(6), MDEQ may exempt any portion of a reclamation action that is conducted entirely on site from a state or local permit that would, in the absence of the reclamation action, be required if the reclamation action is carried out in accordance with the standards established under §§ 75-10-701 et seq.

Applicable or relevant and appropriate requirements are grouped into three categories: contaminant-specific, location-specific, and action-specific. Contaminant-specific requirements are those that establish an allowable level or concentration of a hazardous or deleterious substance in the environment or that prescribe a level or method of treatment for a hazardous or deleterious substance. Location-specific requirements are those that serve as restrictions on the concentration of a hazardous or deleterious substance or the conduct of activities solely because they are in specific locations. Action-specific requirements are those that are relevant to implementation of a particular remedy. Action-specific requirements do not in themselves determine the remedy, but rather indicate the manner in which a remedy must be implemented.

The ARARs contained in this document are tailored to the various reclamation alternatives proposed in the Reclamation Work Plan for the Highland Mine site. If a different plan or reclamation action were proposed, preferred, chosen or implemented for the Highland Mine Site, the ARARs contained herein might be substantially different. Therefore, the ARARs contained herein are intended to apply exclusively to the various reclamation alternatives proposed in the Reclamation Work Plan for the Highland Mine Site.

CERCLA and CECRA define as cleanup requirements only state and federal applicable or relevant and appropriate requirements. Reclamation design, implementation, operation and maintenance must, nevertheless, comply with all other applicable laws, both state and federal. Many such laws, while not strictly environmental, have environmental impacts.

Also contained in this list are policies, guidance and other sources of information which are "to be considered" in the implementation of the reclamation action plan at the Highland Mine Site. Although not enforceable requirements, these documents are important sources of information which the State of Montana Department of Environmental Quality (MDEQ) may consider or find appropriate during selection and implementation of the reclamation action plan.

Finally, this list contains a non-exhaustive list of other legal provisions or requirements which should be complied with during the implementation of the reclamation action plan.

Many requirements listed here are promulgated as identical or nearly identical requirements in both federal and state law, usually pursuant to delegated environmental programs administered by EPA and the states, such as the requirements of the federal Clean Water Act and the Montana Water Quality Act. The preamble to the new NCP states that such a situation results in citation to the state provision as the appropriate standard, but treatment of the provision as a federal requirement. ARARs and other laws which are unique to state law are identified separately by the State of Montana.

FEDERAL ARARs

I. FEDERAL CONTAMINANT SPECIFIC REQUIREMENTS

A. Groundwater Standards - Safe Drinking Water Act

The National Primary Drinking Water Standards (40 CFR Part 141), better known as maximum contaminant levels and maximum contaminant level goals (MCLs and MCLGs), are relevant to the Highland Mine Site area because the aquifer underlying the area is a current or potential source of drinking water. Groundwater use through private wells does occur in the area, and some of the groundwater in the area is a current source of drinking water.

Use of these standards for this action is fully supported by EPA regulations and guidance. The Preamble to the NCP clearly states that MCLs are relevant and appropriate for groundwater that is a current or potential source of drinking water (55 Fed. Reg. 8750, March 8, 1990), and this determination is further supported by requirements in the regulations governing conduct of RI/FS studies found at 40 CFR § 300.430(e)(2)(i)(B). EPA's guidance on Remedial Action for Contaminated Groundwater at Superfund Sites states that "MCLs developed under the Safe Drinking Water Act generally are ARARs for current or potential drinking water sources." MCLGs which are above zero are relevant and appropriate under the same conditions (55 Fed. Reg. 8750-8752, March 8, 1990). See also, State of Ohio v. EPA, 997 F.2d 1520 (D.C. Cir. 1993), which upholds EPA's application of MCLs and non-zero MCLGs as ARAR standards for groundwater which is a potential drinking water source.

As noted above, standards such as the MCL and MCLG standards are promulgated pursuant to both federal and state law. Under the Safe Drinking Water Act, EPA has granted the State of Montana primacy in implementation and enforcement of the Safe Drinking Water Act. Nevertheless, both federal and state promulgated standards are potential ARARs for the Highland Mine Site.

Chemical	MCLG	MCL
Arsenic	N.A.[1]	0.05 milligrams per liter (mg/l)[2]
Cadmium	0.005 mg/l[3]	0.005 mg/l[4]
Copper	1.3 mg/l[5]	1.3 mg/l[6]
Lead	N.A.[7]	0.015 mg/l[8]
Mercury	0.002 mg/l[9]	0.002 mg/l[10]

B. Air Standards - Clean Air Act (Applicable)

Limitations on air emissions resulting from cleanup activities or emissions resulting from wind erosion of exposed hazardous substances are set forth in the action specific requirements, below.

II. FEDERAL ACTION SPECIFIC REQUIREMENTS

A. Solid Waste (Relevant), Surface Mining Control and Reclamation (Relevant), and RCRA (Relevant) Requirements

The contamination at the Highland Mine Site is primarily mining waste and solid waste from various man-made sources. This waste may not be RCRA hazardous waste, although MDEQ reserves its rights to make a more formal determination in this regard at a later date. For any management (i.e., treatment, storage, or disposal) or removal or retention of that contamination, the following requirements are ARARs.

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1 The MCLG for arsenic is zero.

2 40 CFR § 141.11, 60 Fed. Reg. 33926 (June 29, 1995).

3 40 CFR § 141.51

4 40 CFR § 141.62.

5 40 CFR § 141.51

6 40 CFR § 141.80(c).

7 The MCLG for lead is zero.

8 40 CFR § 141.80(c).

9 40 CFR § 141.51.

10 40 CFR § 141.62.

1. Requirements described at 40 CFR §§ 257.3-1(a), 257.3-3, and 257.3-4, governing waste handling, storage, and disposal, including retention of the waste, are relevant in general[11].

2. For any discrete waste units which are addressed by the Highland Mine Site cleanup, reclamation and closure regulations found at 30 CFR Parts 816 and 784, governing coal and to a lesser extent, non-coal mining, are relevant requirements.[12]

3. RCRA regulations found at 40 CFR §§ 264.116 and .119 (governing notice and deed restrictions), 264.228(a)(2)(i) (addressing de-watering of wastes prior to disposal), and 264.228(a)(2)(iii)(B), (C), and (D) and .251(c), (d), and (f) (regarding run-on and run-off controls), are relevant requirements for the any waste management units created or retained at the Highland Mine Site.[13]

B. Air Standards - Clean Air Act (Applicable)

These standards, promulgated pursuant to section 109 of the Clean Air Act (Applicable),[14] are applicable to releases into the air from any Highland Mine Site cleanup activities.

1. Lead: No person shall cause or contribute to concentrations of lead in the ambient air which exceed 1.5 micrograms per cubic meter ($\mu g/m^3$) of air, measured over a 90-day average.

These standards are promulgated at ARM 16.8.815 (Applicable) as part of a federally approved State Implementation Plan (SIP), pursuant to the Clean Air Act of Montana, §§ 75-2-101 et seq., MCA (Applicable). Corresponding federal regulations are found at 40 CFR § 50.12 (Applicable).[15]

2. Particulate matter that is 10 microns in diameter or smaller (PM-10):

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11 Solid Waste regulations are promulgated pursuant to the federal Solid Waste Disposal Act, as amended by the Resource Conversation and Recovery Act, 42 U.S.C. 6901 et seq. They are relevant regulations, although the State of Montana has the lead role in regulating solid waste disposal in the State of Montana.

12 The Surface Mining Control and Reclamation Act is promulgated at 30 U.S.C. Sections 1201 - 1326.

13 As noted earlier, federal RCRA regulations are incorporated by reference into applicable State Hazardous Waste Management Act regulations. See ARM 16.44.702. Use of select RCRA regulations to mining waste is appropriate when discrete units are addressed by a cleanup and site conditions are distinguishable from EPA's generic determination of low toxicity/high volume status for mining waste. See Preamble to the Final NCP, 55 Fed. Reg. 8763 - 8764 (March 8, 1990), CERCLA Compliance with Other Laws Manual, Volume II (August 1989 OSWER Dir. 9234.1-02) p. 6-4, Preamble to Proposed NCP, 53 Fed. Reg. 51447 (Dec. 21, 1988), and guidance entitled "Consideration of RCRA Requirements in Performing CERCLA Responses at Mining Wastes Sites," August 19, 1986 (OSWER).

14 42 U.S.C. §§ 7401 et seq.

15 The ambient air standards established as part of Montana's approved State Implementation Plan in many cases provide more stringent or additional standards. The federal standards by themselves apply only to "major sources", while the State standards are fully applicable throughout the state and are not limited to "major sources". See ARM 16.8.808 and 16.8.811-.821. As part of an EPA-approved State Implementation Plan, the state standards are also federally enforceable. Thus, the state standards which are equivalent to the federal standards are identified in this section together. A more detailed list of State standards, which include standards which are not duplicated in federal regulations, is contained in the State ERCL identification section.

No person shall cause or contribute to concentrations of PM-10 in the ambient air which exceed:

- 150 μg/m^3 of air, 24 hour average, no more than one expected exceedence per calendar year;
- 50 μg/m^3 of air, annual average.

These regulations are promulgated at ARM 16.8.821 (Applicable) as part of a federally approved SIP, pursuant to the Clean Air Act of Montana, §§ 75-2-101 et seq., MCA. Corresponding federal regulations are found at 40 CFR § 50.6 (Applicable).

Ambient air standards under section 109 of the Clean Air Act are also promulgated for carbon monoxide, hydrogen sulfide, nitrogen dioxide, sulfur dioxide, and ozone. If emissions of these compounds were to occur at the site in connection with any cleanup action, these standards would also be applicable. See ARM 16.8.811 and 40 CFR Part 50.

C. Point Source Controls - Clean Water Act (Applicable)

If point sources of water contamination are retained or created by any Highland Mine Site voluntary cleanup plan activity, applicable Clean Water Act standards would apply to those discharges. The applicable regulations are discussed in the contaminant specific ARAR section, above, and in the State of Montana identification of ARARs. These applicable regulations would include storm water runoff regulations found at ARM 16.20.1301-1347, which sets out the Montana Pollutant Discharge Elimination System (MPDES) permit requirements, most specifically, a general permit scheme for various types of storm water discharges, see, ARM 16.20.1314 and 16.20.1317; and 40 CFR Parts 121, 122, and 125 (general conditions and industrial activity conditions). These would also include applicable requirements for best management practices and monitoring found at 40 CFR §§ 122.44(i) and 440.148, for point source discharges.

D. Transportation of Hazardous or Contaminated Waste (Relevant)

40 CFR Part 263 establishes regulations for the transportation of hazardous waste. These regulations would govern any on-site transportation of material. Any off-site transportation would be subject to applicable regulations.

STATE OF MONTANA ARARs

III. MONTANA CONTAMINANT SPECIFIC REQUIREMENTS

A. Water Quality

1. Groundwater Pollution Control System (Applicable)

In addition to the standards set forth below, relevant MCLs and MCLGs are included in the federal ARARs identified above.

ARM 16.20.1002 (Applicable) classifies groundwater into Classes I through IV based on the present and future most beneficial uses of the groundwater, and states that groundwater is to be classified according to actual quality or actual use, whichever places the groundwater in a higher class. Class I is the highest quality class; class IV the lowest. Based upon its specific conductance, the groundwater in the Highland Mine Site should be considered Class I groundwater. [16]

ARM 16.20.1003 (Applicable) establishes the groundwater quality standards applicable with respect to each groundwater classification. Concentrations of dissolved substances in Class I or II groundwater (or Class III groundwater which is used as a drinking water source) may not exceed the human health standards listed in department Circular WQB-7. For the primary contaminants of concern these levels are listed below.

Chemical	WQB-7 Human Health Standard
Arsenic	18 µg/l
Cadmium	5 µg/l
Copper	1000 µg/l
Lead	15 µg/l
Zinc	5000 µg/L

Concentrations of other dissolved or suspended substances must not exceed levels that render the waters harmful, detrimental or injurious to public health. Maximum allowable concentration of these substances also must not exceed acute or chronic problem levels that would adversely affect existing or designated beneficial uses of groundwater of that classification. ARM 16.20.1003 specifies certain references that may be used as a guide in determining problem levels unless local conditions make these values inappropriate.

An additional concern with respect to ARARs for groundwater is the impact of groundwater upon the surface water. If significant loadings of contaminants from groundwater sources to surface water contribute to the inability of the surface water to meet the I class standards, then alternatives to alleviate such groundwater loading must be evaluated and, if appropriate, implemented. Groundwater in certain areas may need to be cleaned up to levels more stringent than the groundwater classification standards for certain parameters in order to achieve the standards for affected surface water. See Compliance with Federal Water Quality Criteria, OSWER Publication

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16 ARM 16.20.1002 provides that Class I groundwaters have a specific conductance of less than 1000 micromhos per centimeter at 25° C, Class II groundwaters 1000 to 2500; Class III groundwaters: 2500 to 15,000; and Class IV groundwaters: over 15,000.

9234.2-09/FS (June 1990)("Where the ground water flows naturally into the surface water, the ground-water remediation should be designed so that the receiving surface-water body will be able to meet any ambient water-quality standards (such as State WQSs or FWQC) that may be ARARs for the surface water.")

B. Air Quality

In addition to the standards identified in the federal action specific ARARs above, the State of Montana has identified certain air quality standards in the action specific section of the State ARARs below.

IV. MONTANA LOCATION SPECIFIC REQUIREMENTS

A. Solid Waste Management Regulations (Applicable)

Regulations promulgated under the Solid Waste Management Act, §§ 75-10-201 et seq., MCA, specify requirements that apply to the location of any solid waste management facility.[17] Under ARM 16.14.505 (Applicable), a facility for the treatment, storage or disposal of solid wastes:

(a) must be located where a sufficient acreage of suitable land is available for solid waste management;

(b) may not be located in a 100-year floodplain;

(c) may be located only in areas which will prevent the pollution of ground and surface waters and public and private water supply systems;

(d) must be located to allow for reclamation and reuse of the land;

(e) drainage structures must be installed where necessary to prevent surface runoff from entering waste management areas; and

(f) where underlying geological formations contain rock fractures or fissures which may lead to pollution of the ground water or areas in which springs exist that are hydraulically connected to a proposed disposal facility, only Class III disposal facilities may be approved.[18]

Even Class III landfills (which can accept only materials which are essentially inert and do not contain hazardous waste constituents) may not be located on the banks of or in a live or intermittent stream or water saturated area, such as a marsh or deep gravel pit which contains

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17 These requirements apply, inter alia, to the treatment, storage, or disposal of solid waste. See ARM 16 14.502(17). While "solid waste" does not include "mining wastes regulated under the mining and reclamation laws administered by the Department of Environmental Quality," see § 75-10-203(11), MCA, as amended by Chapter 418, Laws of Montana 1995, the mining wastes found in the Joslyn Street Tailings Site are not regulated under the mining and reclamation laws administered by the Department of Environmental Quality Therefore, these requirements are applicable to the treatment, storage or disposal of mining wastes pursuant to the voluntary cleanup action plan.

18 Group III wastes consist of primarily inert wastes, including "industrial mineral wastes which are essentially inert and non-water soluble and do not contain hazardous waste constituents." ARM 16.14.503(1)(b).

exposed ground water. ARM 16.14.505(2)(j).

In addition, § 75-10-212 (Applicable) prohibits dumping or leaving any debris or refuse upon or within 200 yards of any highway, road, street, or alley of the State or other public property, or on privately owned property where hunting, fishing, or other recreation is permitted. However, the restriction relating to privately owned property does not apply to the owner, his agents, or those disposing of debris or refuse with the owner's consent.

B. Montana State Antiquities Act (Relevant)

This Act, contained in section 22-3-435, MCA, requires that any person who conducts activities, including survey, excavation or construction, and who finds that an operation licensed or otherwise entitled by the state may damage heritage properties or paleontological remains on any state lands shall promptly report to the historic preservation officer the discovery and take all reasonable steps to ensure preservation of the heritage property or paleontological remains.

V. MONTANA ACTION SPECIFIC REQUIREMENTS

A. Water Quality

1. <u>Groundwater Act (Applicable)</u>

Section 85-2-505, MCA, (Applicable) precludes the wasting of groundwater. Any well producing waters that contaminate other waters must be plugged or capped, and wells must be constructed and maintained so as to prevent waste, contamination, or pollution of groundwater.

2. <u>Public Water Supply Regulations (Applicable)</u>

If reclamation action at the site requires any reconstruction or modification of any public water supply line or sewer line, the construction standards specified in ARM 16.20.401(3) (Applicable) must be observed.

B. Air Quality

1. <u>Air Quality Regulations</u>

Dust suppression and control of certain substances likely to be released into the air as a result of earth moving, transportation and similar actions may be necessary to meet air quality requirements. Certain ambient air standards for specific contaminants and particulates are set forth in the federal action specific section above. Additional air quality regulations under the state Clean Air Act, §§ 75-2-101 et seq., MCA, (Applicable) are discussed below.

ARM 16.8.815 (Applicable) specifies that no person shall cause or contribute to concentrations of lead in the ambient air which exceed the following: 90-day average--1.5 micrograms per cubic meter of air, 90-day average not to be exceeded.

ARM 16.8.817 (Applicable) specifies that no person shall cause or contribute to concentrations of ozone in the ambient air which exceed the following: 90-day average--1.5 micrograms per cubic meter of air, 90-day average not to be exceeded.

ARM 16.8.1401(1) and (2) (Applicable) provides that no person shall cause or authorize the production, handling, transportation or storage of any material; or cause or authorize the use of any street, road, or parking lot; or operate a construction site or demolition project, unless reasonable precautions to control emissions of airborne particulate matter are taken. Emissions of airborne particulate matter must be controlled so that they do not "exhibit an opacity of twenty percent (20%) or greater averaged over six consecutive minutes." ARM 16.8.1401(1) and (2) (Applicable) and ARM 16.8.1404 (Applicable).

ARM 16.8.1424 (Applicable) provides emission standards for hazardous air pollutants.

In addition, state law provides an ambient air quality standard for settled particulate matter. Particulate matter concentrations in the ambient air shall not exceed the following 30-day average: 10 grams per square meter. ARM § 16.8.818 (Applicable).

ARM 16.8.1427 (Applicable). Odors. If a business or other activity will create odors, those odors must be controlled, and no business or activity may cause a public nuisance.

ARM 26.4.761 (Relevant) specifies a range of measures for controlling fugitive dust emissions during mining and reclamation activities. Some of these measures could be considered relevant to control fugitive dust emissions in connection with excavation, earth moving and transportation activities conducted as part of the remedy at the site. Such measures include, for example, paving, watering, chemically stabilizing, or frequently compacting and scraping roads, promptly removing rock, soil or other dust-forming debris from roads, restricting vehicle speeds, revegetating, mulching, or otherwise stabilizing the surface of areas adjoining roads, restricting unauthorized vehicle travel, minimizing the area of disturbed land, and promptly revegetating regraded lands.

C. Solid Waste Regulations

As noted above, the Solid Waste Management Regulations are applicable to the management of the tailings and similar wastes within the reclamation plan. Certain of these regulations are identified in the state Location Specific ARARs above. Other applicable requirements are discussed here.

ARM 16.14.505(2) (Applicable) specifies standards for solid waste management facilities, including the requirements that:

1. if there is the potential for leachate migration, it must be demonstrated that leachate will only migrate to underlying formations which have no hydraulic continuity with any state waters;

2. adequate separation of such wastes from underlying or adjacent water must be provided, considering terrain, type of underlying soil formations, and facility design; and

3. no new disposal units or lateral expansions may be located in wetlands.

ARM 16.14.523 (Relevant) requires that such waste must be transported in such a manner as to prevent its discharge, dumping, spilling, or leaking from the transport vehicle.

Section 75-10-206, MCA, (Relevant) allows variances to be granted from solid waste regulations if failure to comply with the rules does not result in a danger to public health or safety or compliance with specific rules would produce hardship without producing benefits to the health and safety of the public that outweigh the hardship. In light of the nature of the wastes at issue and the likelihood that any repository would contain only a single type of waste, i.e. tailings and related materials, and considering available Superfund procedures for the maintenance of remedies and the ability of the agencies, within the Superfund process, to consider the characteristics of the particular wastes at issue in appropriately determining and designing repositories, many of the following applicable Solid Waste Regulations may appropriately be subject to variance in selecting and implementing a remedy at this site: design of landfills, ARM 16.14.506, operational and maintenance requirements, ARM 16.14.520-521, and landfill closure requirements and post-closure care, ARM 16.14.530-531.

D. Reclamation Requirements

1. <u>Reclamation Activities - Hydrology Regulations (Relevant)</u>

The hydrology regulations promulgated under the Strip and Underground Mine Reclamation Act, §§ 82-4-201 et seq., MCA, provide detailed guidelines for addressing the hydrologic impacts of mine reclamation activities and earth moving projects and are relevant for addressing these impacts at the Highland Mine Site.

ARM 26.4.631 (Relevant) provides that long-term adverse changes in the hydrologic balance from mining and reclamation activities, such as changes in water quality and quantity, and location of surface water drainage channels shall be minimized. Water pollution must be minimized and, where necessary, treatment methods utilized. Diversions of drainages to avoid contamination must be used in preference to the use of water treatment facilities. Other pollution minimization devices must be used if appropriate, including stabilizing disturbed areas through land shaping, diverting runoff, planting quickly germinating and growing stands of temporary vegetation, regulating channel velocity of water, lining drainage channels with rock or vegetation, mulching, and control of acid-forming, and toxic-forming waste materials.

ARM 26.4.633 (Relevant) states that all surface drainage from a disturbed area must be treated by the best technology currently available (BTCA). Treatment must continue until the area is stabilized.

ARM 26.4.634 (Relevant) provides that, in reclamation of drainages, drainage design must emphasize channel and floodplain dimensions that approximate the premining configuration and that will blend with the undisturbed drainage above and below the area to be reclaimed. The average stream gradient must be maintained with a concave longitudinal profile. This regulation provides specific requirements for designing the reclaimed drainage to:

1. meander naturally;

2. remain in dynamic equilibrium with the system;

3. improve unstable premining conditions;

4. provide for floods; and

5. establish a premining diversity of aquatic habitats and riparian vegetation.

2. Reclamation and Revegetation Requirements

ARM 26.4.501 and 501A (Relevant) give general backfilling and final grading requirements.

ARM 26.4.504 (Relevant) provides that permanent impoundments that meet the requirements of ARM 26.4.642 may be retained in mined and reclaimed sites, provided that all highwalls are eliminated by grading to appropriate contours and the postmining land use and protection of hydrologic balance provisions are satisfied. No impoundments may be constructed on top of areas in which excess materials are deposited.

ARM 26.4.514 (Relevant) sets out contouring requirements.

ARM 26.4.519 (Relevant) provides that an operator may be required to monitor settling of regraded areas.

ARM 26.4.520 (Relevant) provides that spoil material may be placed in a controlled (engineered) manner in a disposal area other than the mine workings or excavations. Also provides various other relevant requirements, including, but not limited to, those for water protection, i.e., that leachate and surface runoff from the fill must not degrade surface or ground waters or exceed effluent limitations.

ARM 26.4.641 (Relevant) provides that drainage from acid- and toxic-forming spoil into ground and surface water must be avoided by several enumerated means, all of which are relevant.

ARM 26.4.642 (Relevant) prohibits permanent impoundments except under certain circumstances. Also provides other construction requirements for embankments, dams and diversion ditches.

ARM 26.4.643-646 (Relevant) provides for protection of groundwater and groundwater recharge, and provides requirements for monitoring surface and groundwater.

ARM 26.4.650 (Relevant) provides for postmining rehabilitation of sedimentation ponds, diversion, impoundments and treatment facilities before abandonment of the permit area.

ARM 26.4.638 (Relevant) specifies sediment control measures to be implemented during operations.

ARM 26.4.702 (Relevant) requires that during the redistributing and stockpiling of soil (for reclamation):

1. regraded areas must be deep-tilled, subsoiled, or otherwise treated to eliminate any possible slippage potential, to relieve compaction, and to promote root penetration and permeability of the underlying layer; this preparation must be done on the contour whenever possible and to a minimum depth of 12 inches;

2. redistribution must be done in a manner that achieves approximate uniform thicknesses consistent with soil resource availability and appropriate for the postmining vegetation, land uses, contours, and surface water drainage systems; and

3. redistributed soil must be reconditioned by subsoiling or other appropriate methods

ARM 26.4.703 (Relevant) When using materials other than, or along with, soil for final surfacing in reclamation, the operator must demonstrate that the material (1) is at least as capable as the soil of supporting the approved vegetation and subsequent land use, and (2) the medium must be the best available in the area to support vegetation. Such substitutes must be used in a manner consistent with the requirements for redistribution of soil in ARM 26.4.701 and 702.

ARM 26.4.711 (Relevant) requires that a diverse, effective, and permanent vegetative cover of the same seasonal variety native to the area of land to be affected shall be established except on road surfaces and below the low-water line of permanent impoundments. Vegetative cover is considered of the same seasonal variety if it consists of a mixture of species of equal or superior utility when compared with the natural (or pre-existing) vegetation during each season of the year. (See also ARM 26.4.716 below regarding substitution of introduced species for native species.)

ARM 26.4.713 (Relevant) provides that seeding and planting of disturbed areas must be conducted during the first appropriate period for favorable planting after final seedbed preparation but may not be more than 90 days after soil has been replaced.

ARM 26.4.714 (Relevant) requires use of a mulch or cover crop or both until an adequate permanent cover can be established. Use of mulching and temporary cover may be suspended under certain conditions.

ARM 26.4.716 (Relevant) establishes the required method of revegetation, and provides that introduced species may be substituted for native species as part of an approved plan.

ARM 26.4.718 (Relevant) requires the use of soil amendments and other means such as irrigation, management, fencing, or other measures, if necessary to establish a diverse and permanent vegetative cover.

ARM 26.4.720 (Relevant) requires annual state inspection of seeded areas.

ARM 26.4.721 (Relevant) requires rills and gullies forming in areas that have been regraded or resoiled must be filled, graded or otherwise stabilized and the area reseeded or replanted under certain circumstances.

ARM 26.4.723 (Relevant) requires periodic monitoring and data review of vegetation, soils, wildlife and other items at the site by the operator as prescribed or approved by the state.

ARM 26.4.724 (Relevant) provides revegetation comparison standards.

ARM 26.4.725 (Relevant) establishes commencement of the minimum period of responsibility for reestablishing vegetation.

ARM 26.4.726 (Relevant) establishes vegetation production, cover, diversity, density and utility requirements for revegetation and reclamation success.

ARM 26.4.728 (Relevant) sets forth requirements for the composition of vegetation on reclaimed areas.

ARM 26.4.730-731 (Relevant) requires season of use standards and analysis of toxicity if such toxicity is suspected due to the effects of disturbance caused by the reclamation technique.

VI. OTHER LAWS (NON-EXCLUSIVE LIST)

The following "other laws" are included here to provide a reminder of other legally applicable requirements for actions being conducted at the Highland Mine Site. They do not purport to be an exhaustive list of such legal requirements, but are included because they set out related concerns that must be addressed and, in some cases, may require some advance planning. They are not included as ARARs because they are not "environmental or facility siting laws." As applicable laws other than ARARs, they are not subject to ARAR waiver provisions.

A. Other Federal Laws

1. Occupational Safety and Health Regulations

The federal Occupational Safety and Health Act regulations found at 29 CFR § 1910 are applicable to worker protection during conduct of the reclamation plan.

B. Other Montana Laws

1. Groundwater Act

Section 85-2-516, MCA, states that within 60 days after any well is completed a well log report must be filed by the driller with the DNRC and the appropriate county clerk and recorder.

2. Occupational Health Act, §§ 50-70-101 et seq., MCA.

ARM § 16.42.101 addresses occupational noise. In accordance with this section, no worker shall be exposed to noise levels in excess of the levels specified in this regulation. This regulation is applicable only to limited categories of workers and for most workers the similar federal standard in 29 CFR § 1910.95 applies.

ARM § 16.42.102 addresses occupational air contaminants. The purpose of this rule is to establish maximum threshold limit values for air contaminants under which it is believed that nearly all workers may be repeatedly exposed day after day without adverse health effects. In accordance with this rule, no worker shall be exposed to air contaminant levels in excess of the threshold limit values listed in the regulation. This regulation is applicable only to limited categories of workers and for most workers the similar federal standard in 29 CFR § 1910.1000 applies.

3. Montana Safety Act

Sections 50-71-201, 202 and 203, MCA, state that every employer must provide and maintain a safe place of employment, provide and require use of safety devices and safeguards, and ensure that operations and processes are reasonably adequate to render the place of employment safe. The employer must also do every other thing reasonably necessary to protect the life and safety of its employees. Employees are prohibited from refusing to use or interfering with the use of safety devices.

APPENDIX E

GROUNDWATER MODEL

Standard groundwater models could not be used for the Highland site since no groundwater data have been collected. Data regarding direction and rate of groundwater flow, background and downgradient water quality, and contaminant flux rates are all unknown and were not collected during the RI. Since there were no data to input into these conventional models, a simple mathematical model was developed for use at this site. Two components were needed for this simple model: an estimate of leachate concentrations for precipitation water that flows through the waste sources and ultimately into groundwater; and an estimate of the rate that this water flows through the wastes (flux). Both these components were also derived for the entire groundwatershed above the Highland site.

The first component, leachate concentrations were directly obtained from the TCLP analyses performed on the source samples. TCLP analyses were done for the following sources: WR1 (TCLP samples WR1-C2 and -C3); and, tailings (TCLP samples TP1-C and TP2-C).

The following list of analytes were run for the TCLP samples: As, Ag, Ba, Cd, Cr, Hg, Pb, and Se. This list covers only 2 of the 4 CoCs; Cu and Fe were not included.

Background groundwater concentrations were estimated using the detection limit for water samples collected at the Highland mine, and were used as the "leachate" concentrations for the groundwater basin.

The second component, water flux through the sources, was estimated using the HELP model. This model uses a variety of site meteorological data (temperature, precipitation, humidity, wind speed, and latitude) and physical data (area, slope, slope length, soil texture, and permeability) to estimate the volume of water flux through the bottom of an impoundment. The various sources were evaluated as impoundments as was the background groundwatershed. Meteorological data were gathered from the Butte weather station; physical data were collected for several sources and the repository site (background) during the RI. The results of the HELP model are as follows, with the As example for groundwater loading:

Source Name	HELP Model Water Flux in gallons/year	As in mg/L	As Loading to Groundwater lb/yr
WR1	4,400	0.0467	0.0017
Tailings	915	0.0438	0.0003
Groundwater Basin (non-sources)	189,975	0.0003	0.0005
Totals	195,290 (sum)	0.0016 (calc.)	0.0025 (sum)

Combination of the flux data and the concentration data (adjusted by unit constants) yields groundwater loadings (in lb/yr) for each source at the site and the background groundwatershed. Summing the loads, dividing by the sum of the water fluxes and adjusting for units, yields an estimated downgradient groundwater concentration.

Several assumptions are implicit in the development and use of this simple model. First, the contaminant loadings flowing through the bottom of the sources are assumed to be directly added to the groundwater basin with no attenuation by precipitation, adsorption, or dispersion (three significant natural contaminant concentration reduction processes); this overestimates the downgradient concentrations. Secondly, the contaminant loads are assumed to be completely mixed with and diluted by background groundwater prior to the downgradient exposure point: this has the effect of underestimating the downgradient concentrations and probably offsets the previous overestimate.