FINAL
RECLAMATION DESIGN REPORT
FOR THE
McLAREN TAILINGS ABANDONED MINE SITE
COOKE CITY, MONTANA

Prepared for:

Montana Department of Environmental Quality
Mine Waste Cleanup Bureau

Prepared by:

PIONEER TECHNICAL SERVICES, INC.

Butte, Montana

April 17, 2009

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Prepared for:

Montana Department of Environmental Quality
Mine Waste Cleanup Bureau
P. O. Box 200901
Helena, Montana 59620

Engineering Services Contract DEQ/MWCB Number 407038
Task Order Number 21

Prepared by:

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April 17, 2009

The registration seals affixed to this page convey approval for these sections by the Engineer responsible. The purpose of this page is to identify each section and define levels of responsibility. Note that all construction drawings are currently DRAFT and have not been approved for construction. Approved construction drawings will be provided in the Bid Documents.

SECTIONS COVERED

Project Engineer

Joseph McElroy, P.E. 12542 PE

Geotechnical Engineering
Sections 3.6, 7.4.3

Will Goldberg, P.E. 5888 PE

Hydrogeological Engineering
Sections 3.4, 7.2

Appendix E
(Groundwater Model)

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1.0 INTRODUCTION

The McLaren Tailings Abandoned Mine Site (Site) is an abandoned hardrock mine/mill site listed on the Montana Department of Environmental Quality/Mine Waste Cleanup Bureau (DEQ/MWCB) (formally the Department of State Lands/Abandoned Mine Reclamation Bureau [DSL/AMRB]) Priority Sites List. Based on the conclusions of the detailed analysis and comparative analysis of alternatives completed in the Draft Final Expanded Engineering Evaluation/Cost Analysis (EEE/CA) for the McLaren Tailings Site Cooke City, Montana (DEQ/MWCB-Pioneer, 2002), Alternative 5b: On-Site Disposal in an Un-Lined Repository with a Multi-Layered Cap was recommended as the preferred reclamation alternative for the McLaren Tailings Abandoned Mine Site. This alternative is the basis of the design and implementation of reclamation activities presented in this design report. In order to support the design efforts for the reclamation of the Site, it was necessary to collect additional data at the Site to confirm that the preferred reclamation alternative could be implemented. Therefore, in September 2008, additional field investigations were conducted at the Site to further support the design efforts for the reclamation of Site.

This document summarizes the results of the 2008 field investigations conducted at the Site and determines if the preferred reclamation Alternative 5b: On-Site Disposal in an Un-Lined Repository with a Multi-Layered Cap is implementable at the Site.

In addition, this document includes design drawings and engineering specifications of the following design elements: 90% excavation and grading design; 90% repository design; 60% groundwater dewatering design; and tailings stabilization methods. The document also includes volume of waste to be disposed in the repository (including expected swell as a result of amendment using lime products); specifications for placement of mining/milling wastes in the repository; lime quantities and processes for adding lime products to saturated tailings materials; layout and design for isolation/diversion of Soda Butte Creek; preliminary description and layout of construction best management practices (BMPs); and revegetation plans.

2.0 SITE BACKGROUND

2.1 SITE LOCATION

The Site is located in Park County in Section 25 of Township 9 South, Range 14 East of the Montana Principal Meridian (Figure 1). The Site is accessed by traveling approximately one quarter of a mile east of Cooke City, Montana, along Montana Highway 212 and turning south onto a dirt road that exits the highway. The Site is located less than 500 feet south of the highway and encompasses an area of roughly 20 acres (Figure 2).

2.2 CLIMATE

The Cooke City area has a continental climate modified by the high mountain setting. It is characterized by large daily and annual temperature ranges and marked differences in precipitation, temperature, and wind patterns over distances of only a few miles.

Precipitation and temperature data have been collected periodically at Cooke City, Montana, from 1967 through 1995. The eastern portion of Cooke City is located approximately one tenth of a mile from the Site. The Cooke City station is located at an elevation of 7,460 feet above mean sea level (amsl), which is similar to the Site elevation of 7,600 to 7,700 feet amsl. The average annual precipitation for the period of record is 25.38 inches. Temperatures are coldest in January with an average minimum temperature of -16.5 degrees Celsius (°C) (2.4 degrees Fahrenheit [°F]) and an average maximum temperature of -4.8 °C (23.3 °F). Temperatures are warmest in July with an average minimum temperature of 3.3 °C (37.9 °F) and an average maximum temperature of 22.8 °C (73.1 °F).

Precipitation and temperature vary with elevation, which ranges from 7,400 feet amsl at Cooke City to 10,500 feet amsl in the nearby higher elevations. Freezing conditions can occur any day of the year. Precipitation records from a Soil Conservation Service (SCS) SNOTEL station (SCS Station TX06) at an elevation of 9,100 feet amsl in the Fischer Creek drainage indicate that the average annual precipitation at this location is 60 inches. Fifty percent of the annual precipitation occurs between October and February, with January being the highest average precipitation month (14.4 percent) and August having the lowest average monthly precipitation (3.9 percent). Average annual snowfall at the higher elevations is about 500 inches.

A meteorological station was maintained in upper Fischer Creek near a proposed mill site for various periods during exploration activities by Crown Butte Mining, Inc. Data collected from this site for the period of May 1992 through August 1993, indicate an average wind speed of 5.4 miles per hour and a prevailing direction from the northwest.

2.3 LAND USE AND POPULATION

The communities of Cooke City and Silver Gate, Montana, are the only population centers near the McLaren Tailings Abandoned Mine Site. The neighboring communities of Mammoth, Wyoming, and Gardiner, Montana, are located approximately 50 miles to the west. Red Lodge, Montana, is approximately 65 miles to the northeast via the Beartooth Highway, and Cody, Wyoming, is located 60 miles to the southeast. The primary land uses in the immediate area are residential and recreational including hiking, biking, horseback riding, ATV/motorcycling, snowmobiling, and camping.

Only two routes of travel are open on a year-round basis: the Sunlight Basin Road, which provides access to within a few miles of the Site in the winter, and Highway 212 (west of Cooke City) between Mammoth and Cooke City, Montana. The Beartooth Highway 212 (east of Cooke City) between Cooke City and Red Lodge is closed during the winter.

2.4 SITE HISTORY

The Site was subject to an Emergency Response Action by the U.S. Environmental Protection Agency (EPA) Region VIII in 1988. At this time, the Kennecott Corporation (identified as a Potentially Responsible Party [PRP]) elected to perform the corrective actions at the Site itself, in lieu of having the U.S. Department of Interior/Bureau of Reclamation (BOR) perform the work. The proposed remediation plan included: 1) constructing an earthen berm to reinforce the existing tailings dam; 2) removing tailings from the toe of the existing tailings dam and replacing with clean fill material; 3) constructing an open interceptor drain along the southern perimeter of the Site; and 4) seeding all disturbed areas. Construction activities began on September 4, 1988 and were completed by September 24, 1990 (BOR, 1994).

In March 1991, the BOR evaluated the effectiveness of Kennecott's stability actions. The results of the analysis concluded the tailings dam was only "marginally stable". Kennecott was directed by the EPA to conduct additional construction activities at the Site, which included: 1) installing a perforated plastic drainpipe within the prism of the open interceptor drain along the southern perimeter of the Site; 2) installing a filter along the toe of the tailings dam and placing buttress fill; 3) dewatering the tailings dam toe to facilitate construction operations; 4) operating a bulldozer parallel to the slope of the dam to enhance reseeding operations; 5) filling in some of the exploration holes remaining in the tailings cover; and 6) leveling the slope over the toe drain in the area where a seep occurs to encourage water to flow into the drain. All activities were completed by August 22, 1991 (BOR, 1994).

On August 10, 1993, a site investigation was completed at the Site (PA# 34-004) by Pioneer Technical Services, Inc. (Pioneer) for the DSL/AMRB as part of a state-wide abandoned mine inventory project. During this investigation, samples of waste rock, tailings, groundwater, surface water, sediment, and background soils were collected. Upon scoring this Site using the DEQ/MWCB Abandoned and Inactive Mines Scoring System (AIMSS), the resulting rank was #130 of 278 on the DEQ/MWCB list.

A *Response Action Report for the McLaren Tailings Site, Cooke City, Montana* (BOR, 1994) was prepared by BOR in 1994. This report summarized response actions that were undertaken by the EPA, Region VIII, Emergency Response Branch at the McLaren Tailings Abandoned Mine Site. These actions were undertaken by the EPA in response to a request for technical assistance by the National Park Service, the U.S. Forest Service (USFS) (Gallatin National Forest), and the U.S. Fish and Wildlife Service.

The report concluded the following:

- *The toe drain below the tailings dam appears to have increased the stability of the embankment; however, random "quick" conditions can still be generated along the toe when the groundwater levels are high. The toe of the embankment appears much more stable than in the past. Surface erosion is scouring the face of the tailings dam because reseeding efforts have been only marginally successful.*

- *The subsurface drain pipe located along the southern boundary of the tailings area intercepts some surface water and diverts it away from the tailings; however, it is suspected that partial plugging of the geotextile is preventing the drain from performing at its optimum capacity.*

- *The emergency tailings dam located on the eastern edge of the Site continues to provide protection from flooding of Soda Butte Creek.*

- *The original creek channel of Soda Butte Creek (located beneath the tailings footprint) continues to contribute flow to the tailings.*

- *Miller Creek likely continues to contribute subsurface flow into the tailings.*

- *A significant portion of the Site is void of vegetative ground cover.*

- *The effluent from the drains below the McLaren Tailings Dam discharge directly into Soda Butte Creek.*

On September 20 and 21, 2000, under contract with DEQ/MWCB, Pioneer conducted a limited site investigation at the Site, which included collecting surface water, sediment, and tailings samples. Results of this investigation are included in the *Site Evaluation Report for the McLaren Tailings Site* (DEQ/MWCB-Pioneer, 2001). On September 17 through 20, 2001, Pioneer conducted a geotechnical investigation at the Site, which included installing and sampling multiple boreholes in the tailings area and multiple backhoe test pits in the waste rock dump, and potential borrow area. Results of this investigation are included in the *Draft Final Expanded Engineering Evaluation/Cost Analysis for the McLaren Tailings Site Cooke City Montana* (DEQ/MWCB-Pioneer, 2002).

2.5 MINING HISTORY

Placer gold was discovered on upper Soda Butte Creek in 1869 and the first lode claims were staked the following year. At the time of discovery, the New World Mining District was part of the Crow Indian Reservation and mining was conducted under trespass on Indian lands. Consequently, sponsors were reluctant to invest in the area until after 1882 when the reservation boundaries were reduced. Once legal title to mining property could be obtained, attraction to the New World Mining District was renewed and hundreds of claims were staked throughout the area. Development of mines and prospects was limited due to the high cost of mule-back freight. Interest in the District languished when attempts to build a railroad into Cooke City, Montana, failed (GCM, 1985).

Several smelters were constructed at the New World Mining District in an attempt to counteract high transportation expenses. In 1889, the Montana State Mine Inspector documented 3 smelting facilities in the New World Mining District (Swallow, 1989). One of these smelters was a portable furnace located north of Cooke City, Montana, along Miller Creek. Another was the Great Republic Smelter, the ruins of which can be found below Cooke City on Woody Creek. The exact location of the third smelter, the 20-ton per day plant of the Eastern Montana Mining and Smelting Company, is unknown. Though the exact location of this early smelter is not recorded, there is speculation that it was located on Soda Butte Creek in the vicinity of the Site.

In 1933, the McLaren Gold Mines Company discovered the McLaren deposit on Henderson Mountain. The McLaren mine ore consisted of limestone and shale replaced by auriferous pyrite with some copper mineralization. The ore was mined on a non-selective basis using open cut methods. In 1934, a flotation mill was constructed on the Copper Glance mill site near Cooke

City, Montana, and a tailings impoundment was constructed on the adjoining Horseshoe and Greeley placer (Hart, 1935). The McLaren Mill produced a gold and copper concentrate that was shipped to Anaconda, Montana, for smelting. Extensive exploration work at the mine in 1937 and 1938 resulted in the discovery of additional reserves and the mill was remodeled to increase capacity. During the operation of the mill, Soda Butte Creek's channel was filled with tailings and the stream was pushed into a ditch and culvert that ran along the south side of the impoundment (Johnson, 1949; GLO, 1946). The McLaren Mill operated until 1953 when excess stripping ratios at the mine made the operation unprofitable (Goddard, 1953).

During operation of the McLaren Mill, tailings disposal was problematic as overflow from the tailings impoundment flowed downstream into Yellowstone National Park. Inspections by Park Rangers documented a regular pattern of leaks and breaks in the earthen tailings dam surrounding the tailings impoundment. While the daily operation of the mill tended to give a milky appearance to Soda Butte Creek, the frequent breaks and washouts of the impoundment had more serious consequences (Johnson, 1949). A Park Ranger inspecting a breach in the impoundment tailings dam in June 1950 documented repairs made to the impoundment but noted that similar breaks in the dam occurred each spring and more breaks could be anticipated with continued operation of the mill (Johnson, 1950).

Closure of the mill in 1953 did not end the concern about downstream environmental impacts resulting from the McLaren tailings. By the late 1960s, Soda Butte Creek was considered the most polluted stream entering Yellowstone National Park. Investigations into the cause of the pollution showed that ferrous iron precipitates and heavy silt loads from the tailings were adversely affecting the fish producing capacity of Soda Butte Creek within the Park (DOI-BSFW, 1969). In 1969, Bear Creek Mining, the site owner and a Kennecott Corporation subsidiary, rehabilitated the Site by covering the eroding tailings with soil, demolished the buildings at the Site, and excavated a new channel for Soda Butte Creek along the north side of the tailings impoundment (DOI-BSFW, 1970). Since completion of the initial reclamation work at the Site by Bearcreek Mining, the Site has continued to be studied by state and federal agencies.

2.6 GEOLOGY, HYDROGEOLOGY, AND HYDROLOGY

The Site is located in the Beartooth Mountains, a mountainous region that has been subject to extensive uplift and thrust faulting, exposing Precambrian crystalline rocks (Foosse et al, 1961). The Site is located in a valley that is drained by Soda Butte Creek, an east to west flowing stream which runs through the Site and eventually through Yellowstone National Park, five miles downstream. The valley is steep-sided and has morphological and lithological characteristics typical of glaciated landscapes.

The Site is characterized by three general geologic units:

1. Precambrian and Tertiary age intrusive rocks that comprise the bedrock base.

2. Pleistocene age sediments consisting of alluvial sands and gravels, lacustrine silts and sands, fine to coarse textured glacial tills, and variable slope debris deposits.

3. Holocene age sediments and fill deposits resulting from the mining activity. These fills include mine tailings sediments, dam embankment or soil cap fills, and mine waste rock or stockpile ore deposits.

2.7 REGIONAL GEOLOGIC SETTING

Outcrops of bedrock are exposed on the valley walls adjacent to the Site; however, on the valley floor the bedrock is generally obscured by overlying Quaternary deposits. Borings and seismic records indicate the bedrock contact is 0 to 65 feet below the ground surface (bgs) at the Site. The bedrock at the Site consists of either light to dark greenish-gray granite, or dark to medium gray diorite (Elliot, 1979).

Pleistocene age deposits consist primarily of coarse-grained alluvial sediments that overlie the bedrock base. The alluvial sediments are mantled by a two- to four-foot surficial layer of glacial till. Lacustrine sediments occupy low gradient areas of the valley floor. These sediments range from 0 to 10 feet in thickness, and are deposited beneath the present tailings deposits (BOR, 1990). Slope debris of alluvial and glacial origin mantle the steeper sloping areas adjacent to the Site.

2.8 LOCAL GEOLOGIC SETTING

The geology of the Site is described in detail by Elliot (Elliot, 1973). The tailings area is underlain by moraine deposits of Pleistocene age covered with a thin veneer of recent unconsolidated stream deposits. Bedrock consists of coarse-grained granite occasionally intruded by fine-grained diorite tailings dams.

Areas adjacent to the Site are typically comprised of stratigraphic units of Cambrian age which have been intruded by small sills and tailings dams. Areas adjacent to the intrusions were the zones that were first inspected for potential mineral development due to alteration of the host rock by oxidation and hydrothermal activity.

2.9 HYDROGEOLOGIC SETTING

Groundwater conditions at the Site within the tailings dam and tailings deposit are highly variable throughout the year. Monitoring well data indicates a 6- to 15-foot variation in piezometric levels between the seasonal low in March and the seasonal high in May.

Groundwater input into the tailings appears to be from the four sources listed below:

- Overland and subsurface flow from sloping areas on the south and southeast perimeter of the Site;
- Seepage from precipitation that falls directly on the tailings pond surface;
- Possible recharge from fractured bedrock underlying the Holocene alluvium beneath the tailings deposit; and

- Inflow from Soda Butte Creek and Miller Creek which flows on the north and northeastern margin of the tailings pond including subsurface flow in the Holocene alluvium beneath the tailings deposit and tailings dam.

In borings completed by the BOR, artesian pressures were encountered. These heads represent confined flow at depth in highly stratified deposits, rather than excess pore pressures just below the tailings dam.

Groundwater in the area is probably limited to unconsolidated alluvial deposits along Soda Butte Creek and a regional system in adjacent bedrock which appears to be controlled by secondary or fracture permeability.

The quality of groundwater in the McLaren tailings is variable and depends on the location within the tailings deposit with respect to the recharge area, local permeability, and proximity to the old Soda Butte Creek channel. The tailings groundwater generally exhibits a low pH, high Specific Conductance (SC), high sulfate concentrations, and high dissolved and total recoverable iron concentrations. Other parameters which occasionally exhibit high concentrations include aluminum, lead, copper, silica, and zinc (David Stiller & Associates, 1983). Stiller identified a low pH cell near the center of the tailings. The cell is believed to represent an area where oxygen-bearing waters are introduced at a sufficient rate to more than offset weathering conditions (i.e., Soda Butte Creek alluvial gravels underlying the tailings).

Movement of water through the tailings is generally from east to west with some discharge occurring from seeps along the base of the tailings dam and one significant spring at the southwest corner of the tailings dam (David Stiller & Associates, 1983).

The Montana Bureau of Mines and Geology (MBMG, 1975) reports groundwater flow within the tailings toward and along the former Soda Butte Creek channel, near the southern perimeter of the tailings. Significant recharge to groundwater within the tailings is apparent at the eastern and northern contact with Soda Butte Creek.

During the 2001 investigation conducted for the Draft Final EEE/CA for the McLaren Tailings Site, Cooke City, Montana (DEQ/MWCB-Pioneer, 2002), groundwater was encountered in six of the nine borings drilled through the tailings impoundment. Groundwater was absent in the three borings in the northeast corner of the tailings. Groundwater was encountered below the tailings in the native sandy gravel. In the borings closest to the containment tailings dam, groundwater was encountered within the tailings.

2.10 SEISMOTECTONIC SETTING AND HISTORY

The study area is outside but near the eastern boundary of the Centennial Tectonic Belt and the Intermountain Seismic Belt, as defined and mapped by Smith and Sbar, 1974, Witkind, 1975, and Stickney and Bartholomew, 1987. These earthquake and micro-earthquake belts have generated historic, as well as Holocene and Pleistocene tectonic, activity that is documented by Stickney and Bartholomew, 1987. Seismic activity in the Yellowstone-Snake River plain which is nearer to the Site, but well within the two earthquake belts, is addressed by Smith and Sbar,

1974. The principal historical earthquake affecting the Site is the 1959 Hebgen Lake event (M_s about 7.5).

2.11 SURFACE WATER HYDROLOGY

Area streams are high energy, first and second order tributaries of the Yellowstone River system (B-1 classified, A-1 classified within Yellowstone National Park). These streams occupy glacially carved valleys and are fed largely by melting snow pack. Peak stream flow is characteristically reached by mid-June or early July and may be several orders of magnitude higher than base flow conditions, which typically occur in late winter or early spring.

The main surface water feature in the vicinity of the Site is Soda Butte Creek (B-1 classified), a perennial tributary to the Lamar River. Soda Butte Creek formerly occupied a channel beneath the present tailings site, but has been diverted around the northern perimeter of the Site. Significant tributaries to Soda Butte Creek include Miller Creek, Woody Creek. and Sheep Creek.

Miller Creek drains to the south side of Daisy Pass, the west flank of Henderson Mountain, and the east flank of Miller Mountain. Miller Creek flows southeast for approximately two miles to its confluence with Soda Butte Creek, which in turn flows west into Yellowstone National Park where it enters the Lamar River. Immediately above Miller Creek's confluence with Soda Butte Creek, a measured flow of 0.44 cubic feet per second (cfs) was recorded on September 25, 1997. The measured high flow at this location was 55.5 cfs on July 2, 1990. Although several minor historic mine disturbances are present in the Miller Creek drainage basin, Miller Creek water is largely unimpacted by acid rock drainage.

The drainage area of Soda Butte Creek above the Site is reported by George Maddox and Associates as 5.5 square miles (3,422 acres). This drainage area has a hydrologic soil group of C, a watershed condition as fair forest land, a curve number of 73, a hydraulic length of 15,300 feet, a watershed slope of 28.52 percent and exhibits the following precipitation events:

- 10-year, 24-hour = 2.4 inches;
- 25-year, 24-hour = 2.6 inches;
- 50-year, 24-hour = 3.0 inches; and
- 100-year, 24-hour = 3.4 inches.

Using these data and a Type II runoff chart indicates a maximum flow in Soda Butte Creek at the Site for each storm event as follows:

- 10-year, 24-hour = 670 cfs;
- 25-year, 24-hour = 835 cfs;
- 50-year, 24-hour = 1,226 cfs; and
  100-year, 24-hour = 1,660 cfs.

Continuous USGS flow gaging on Soda Butte Creek was conducted in Cooke City in the mid-70's and is currently conducted at Silver Gate. The Cooke City gaging station, USGS 06187900

(Soda Butte Creek at Cooke City, MT), recorded flow from September 1, 1974 to August 31, 1977, and the Silver Gate gaging station, USGS 06187915 (Soda Butte Creek at Park Boundary at Silver Gate), has recorded flow, temperature, and gage height from October 1, 1998 to present.

The Cooke City gaging station (USGS 06187900) recorded flow for a drainage area of 5.88 square miles and recorded minimum and maximum flows of 0.11 to 94 cfs, respectively. No gage height data was collected at this site. While this flow information from this location is dated, it is the most representative of flow conditions at the Site.

In comparison, the Silver Gate gaging station (USGS 06187915) has a drainage area of 31.2 square miles and minimum and maximum recorded flows of 0.8 cfs to 735 cfs, respectively. Gage height at this location has been recorded from October 1, 2004 to present, the minimum and maximum measurements range from 0.73 to 2.98 feet, respectively.

3.0 2008 RECLAMATION DESIGN INVESTIGATION RESULTS

3.1 EXISTING COVER SOIL INVESTIGATION

Currently overlying the tailings impoundment is a soil cap comprised of primarily silty sands, and minor gravels, and cobbles. It is believed that the majority of this material was obtained from the sloped areas located immediately to the south of the tailings impoundment. During the 2001 investigation, it was confirmed that the cap varies significantly in thickness. A volume estimate of 54,100 cubic yards (cy) of cover soil was made from a topographic map and the boreholes from the 2001 investigation. A detailed topographic map and additional depth measurements were necessary to confirm the volume of cap materials that can be salvaged for use in the reclamation of the Site.

To confirm the volume of cap materials that could be salvaged for the reclamation project, a 100 foot by 100 foot grid system consisting of 35 boring locations was developed and staked across the tailings impoundment area (Figure 3). A Geoprobe unit equipped with a closed tip Macro-Core soil sampling system was utilized at each location to collect a soil boring core of cover soil and tailings. The soils were collected in 4 foot polyvinyl chloride (PVC) liners. The liners were cut to document the cover soil thickness and obtain samples for laboratory analyses. The field crew documented the cap thickness by measuring the thickness with a tape measure. The measurements were to the nearest inch. The stratigraphic profile was logged for each soil boring and the cover soil depth recorded in the logbook. In addition to the data collected from the soil borings, cap thicknesses were documented for each test pit excavated as part of the 2008 source area investigation as well as for boreholes utilized for piezometer installations. The existing cover soil measurements are summarized in Table 1. The field measurements and stratigraphic profiles can be found in Table 1. Photos of the stratigraphic profiles can be found in Appendix A.

Five composite samples of the cover soil materials were collected and submitted to the laboratory for analyses. The composite cover soil samples were composited from the cover soil investigation soil borings. Tables 2 through 5 summarize which soil borings were utilized for the cover soil composite samples. The composite samples of the existing cover soil were analyzed for the following parameters:

Target Analyte List (TAL) Metals
Aluminum, antimony, arsenic, barium, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, silver, and zinc.

Sulfur Fractions
Acid-Base Accounting (ABA) and Shoemaker, McLean, and Pratt (SMP) Buffering Capacity.

Physical Properties
Moisture Content; Rapid Hydrometer (% Coarse, % Sand, % Silt, % Clay); U.S. Department of Agriculture (USDA) Texture; wilting point; field capacity; and available moisture.

Agronomic Properties
Percent Organic Matter, pH, Electrical Conductance (EC), Sodium Absorption Ratio, Saturation Percentage, Cation Exchange Capacity, and Fertilizer Recommendation (Nitrogen, Phosphorus, and Potassium [N, P, K]).

Results for the existing cover soil composite samples are summarized in Tables 2 through 5. Laboratory data sheets can be found in Appendix B.

Analytical results summarized in Table 2 indicate that antimony, arsenic, cadmium, mercury, and silver were not present above the instrument detection limits. Aluminum concentrations ranged from 4,460 mg/kg to 5,480 mg/kg. Barium concentrations ranged from 71 mg/kg to 95 mg/kg. Chromium concentrations ranged from 16 mg/kg to 20 mg/kg. Copper concentrations ranged from 15 mg/kg to 44 mg/kg. Iron concentrations ranged from 10,800 mg/kg to 15,000 mg/kg. Lead concentrations ranged from 9 mg/kg to 16 mg/kg. Manganese concentrations ranged from 241 mg/kg to 314 mg/kg. Nickel concentrations ranged from 12 mg/kg to 16 mg/kg. Zinc concentrations ranged from 25 mg/kg to 38 mg/kg. The metal concentrations found in the existing covers soils are very comparable to those soils found in the proposed repository area (Table 2). The soils from the repository would represent background levels. Based on this comparison and the total metals concentrations observed, the selection of plant species should consider species tolerant of aluminum and iron.

Physical and agronomic analytical results are used primarily to assess the revegetation characteristics of the material for use as cover soil. The results indicate that the soils can generally be classified as sandy loam and contain a relatively low organic matter content (0.50 to 0.74 %); application of organic amendment will be required to increase the fertility of the soil. Fertilizer recommendation rates are 30 pounds per acre nitrogen, 50 pounds of phosphate per acre, and 60 pounds of potassium per acre. The pH of the existing cover soils range from 7.4 to 7.9, which is within acceptable levels, and electrical conductivity of the soils ranged from 0.61 to 2.51 millimohs per centimeter (mmhos/cm), which is within acceptable levels as well. The ABA analyses were positive, indicating that amendment with lime is not necessary (see Table 3). The sodium adsorption ratio of the soils range from 0.14 to 0.29 and is within the desired range. The saturation percentage ranges from 20.1 to 24.6 and is slightly lower than the desired range. The cation exchange capacity (CEC) ranged from 8.08 to 9.98 milequivelent (meq.)/100 grams (g), which is low, but within the expected range for sandy loam soils.

Based on the analytical results summarized in the Tables 2 through 5, the existing cover soils that can be salvaged from the tailings impoundment area and will be adequate for use as cover soil for the reclamation of the Site when appropriately amended with compost and fertilizer.

Utilizing the existing cover soil depths measured in the cover soil borings, test pits, and piezometers, the volume of available cover soil that could be salvaged from the tailings impoundment area was determined. The data were utilized to create the bottom surface of existing cover soil as shown on Sheets 8 to 12 of the Construction Drawings provided in Appendix G. Based on the excavation surface for the existing cover soil, it estimated that 32,500 bank cubic yards (bcy) of existing cover soil can be salvaged from the tailings impoundment area.

3.2 REPOSITORY INVESTIGATION

The repository investigation activities focused on the proposed repository location identified in Alternative 5b: On-Site Disposal in an Un-Lined Repository with a Multi-Layered Cap of the EEE/CA (DEQ/MWCB-Pioneer, 2002). A comprehensive investigation was required to confirm characteristics and suitability of the proposed repository site and borrow materials. The repository site is located immediately southwest of the tailings impoundment, on the timbered bench above the south bank of Soda Butte Creek (Figure 4).

In order to determine the subsurface conditions of the repository site (i.e., absence or presence of bedrock, presence of shallow or perched groundwater, available capacity to contain waste materials, and to determine the physical and agronomic characteristics of the soils), multiple test pits were installed using a tracked excavator with a maximum excavation depth of 25 feet. Nineteen (19) test pits were completed to assess the repository location (Figure 4). A stratigraphic profile of each test pit (test pit log) was sketched to correlate the various physical characteristics within each test pit. The profile described any color or texture changes, the presence or absence of groundwater, bedrock depth (if encountered), and a visual estimate of rock content (2-inch plus fraction) including changes in rock content with depth. During the excavation of the test pits, bedrock was not encounter in any of the nineteen test pits. However, moist and damp soils were encountered in Test Pit RA-19 at 8.5 feet below the ground surface. This test pit is located in the existing channel that traverses the proposed repository location (Figure 4). RA-19 is located at the lowest elevation of the proposed repository bottom. Therefore, the presence of these moist and damp soils may represent seasonal high groundwater levels in this area. The soil profiles for each test pit can be found in Table 1. Photos of the test pits can be found in Appendix A.

Three (3) composite soil samples were collected to determine suitability of the soil for cover soil (agronomic properties). Composite soil samples collected for agronomic properties did not include cobbles and coarse fractions. Additionally, geotechnical samples were collected to determine the general stability of the repository location. The composite soil samples collected from the repository area were analyzed for the following parameters:

Target Analyte List (TAL) Metals
Aluminum, antimony, arsenic, barium, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, silver, and zinc.

Sulfur Fractions
ABA and SMP Buffering Capacity.

Physical Properties
Moisture Content; Rapid Hydrometer (% Coarse, % Sand, % Silt, % Clay); USDA Texture; wilting point; field capacity; and available moisture.

Agronomic Properties
Percent Organic Matter, pH, Electrical Conductivity (EC) and, Sodium Absorption Ratio, Saturation Percentage, Cation Exchange Capacity, and Fertilizer Recommendation (N, P, K).

Geotechnical/Engineering Properties
Standard Proctor, Gradation, Atterberg Limits, and Moisture Content.

Results of the composite samples for agronomic properties can be found in Table 4. Results of the geotechnical samples can be found in Table 5 and Appendix C.

Analytical results summarized in Table 2 indicate that antimony, cadmium, mercury, and silver were not present above the instrument detection limits. Aluminum concentrations ranged from 5,760 mg/kg to 12,100 mg/kg. Arsenic ranged from below analytical detection to 8 mg/kg. Barium concentrations ranged from 82 mg/kg to 120 mg/kg. Chromium concentrations ranged from 21mg/kg to 31 mg/kg. Copper concentrations ranged from 13 mg/kg to 26 mg/kg. Iron concentrations ranged from 13,400 mg/kg to 20,500 mg/kg. Lead concentrations ranged from 16 mg/kg to 107 mg/kg. Manganese concentrations ranged from 348 mg/kg to 524 mg/kg. Nickel concentrations ranged from 12 mg/kg to 21 mg/kg. Zinc concentrations ranged from 40 mg/kg to 49 mg/kg. Based on the total metal concentrations, the selection of plant species should consider species tolerant of aluminum, and iron.

The physical and agronomic analytical results are used primarily to assess the revegetation characteristics of the material for use as cover soil. The results indicate that the soils can generally be classified as sandy loam. Two of the three samples contain relatively low organic matter content (0.31 and 0.66 %); application of organic amendment will be required to increase the fertility of the soil. Recommended fertilizer rates are as follows: 30 pounds per acre nitrogen, 50 pounds of phosphate per acre, and 60 pounds of potassium per acre. The pH of the repository soils ranged from 4.6 to 7.9. The soils with a pH of 4.6 (organic matter content of 27.5%) are located within the 0 to 4 inch depth interval, indicating that the heavy timber cover has created acidic conditions within the surface soils (organic acids). When these soils are mixed with the underlying subsoil, they are expected to result in an acceptable pH values for use as cover soil. The electrical conductivity of the soil ranged from 0.31 to 0.58 mmhos/cm, indicating favorable conditions. The ABA analyses were positive, indicating that amendment with lime is not necessary once the three soil horizons have been mixed together (see Table 3).

The sodium adsorption ratio of the soils range from 0.09 to 0.15 and is within the desired range. The saturation percentage ranges from 26.3 to 35.4 and is slightly lower than the desired range. The CEC ranged from 8.26 to 35.1 meq. /100 g, which is within the expected range for sandy loam materials.

Based on the analytical results summarized in the Tables 2 through 5, the soils in the repository area, when amended with compost and fertilizer, will be adequate for use as cover soil for reclamation of the Site.

3.3 SOURCE AREA INVESTIGATION

The mine waste sources located at the Site (one tailings impoundment and one waste rock dump) have previously been investigated to determine their chemical characteristics and estimated volume. Chemical concentrations (primarily metals and acid-production potential) and volume estimates applicable to the tailings and waste rock are reported in the *Draft Final Expanded Engineering Evaluation/Cost Analysis for the McLaren Tailings Site* (DEQ/MWCB-Pioneer, 2002). Consequently, no additional testing of the waste rock material was proposed for this investigation, all source sampling was focused on the physical and geotechnical/engineering characteristics of the tailings impoundment.

Under this investigation, multiple test pits were excavated through the tailings to determine the thickness of the tailings deposit, the topography of the contact between the tailings and the underlying alluvial sediments, and the extent of saturation within the tailings materials. Forty five (45) test pits were excavated through the entire depth of the tailings (where conditions allowed) to determine whether an obvious interface exists where relatively dry tailings (located nearest the ground surface) transform into wet/saturated tailings at depth, and the approximate rate at which groundwater infiltrates into the test pits (Figure 5).

A stratigraphic profile of each test pit (test pit log) was documented to correlate the various physical characteristics within the tailings. The stratigraphic profiles describe any color and/or texture changes, debris present in the test pit and presence or absence of groundwater. The stratigraphic profile for each of the test pits can be found in Table 1. Photos of each of the test pits can be found in Appendix A.

Discrete subsamples were collected from both relatively dry and wet sections of the profile within individual test pits. These subsamples were composited with similar subsamples from adjacent test pits for moisture analyses to document the variability of moisture content through the depth profile of the tailings as a single large unit and determine the quantity of lime required for stabilization/dehydration.

The discrete subsamples were composited into seven samples. The composite samples were submitted to Energy Laboratories, Inc., located in Billings, Montana and analyzed for the following parameters utilizing the Synthetic Precipitation Leach Procedure (SPLP):

Target Analyte List (TAL) Metals
Aluminum, antimony, arsenic, barium, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, silver, and zinc (pre and post lime addition).

Additionally, the composite tailings samples were submitted to the Pioneer Technical Services Laboratory for geotechnical testing and bench scale (lime dehydration) testing. The results of this testing is further discussed in Section 3.6.

Results of the tailings analyses are summarized on Table 6. Laboratory data sheets can be found in Appendix B.

Based on initial results of the SPLP analyses, iron and manganese exceeded the detection limits in samples TP-01A, TP-01B, TP-02A, TP-02B, and TP-03B. The iron concentrations ranged from 0.02 mg/L to 24.5 mg/L and the manganese concentrations ranged from 0.6 mg/L to 4.29 mg/L. The detected concentrations were lower than initially expected; consequently, sample TP-03B (the "worst case" sample with the highest detected concentrations) was re-analyzed using a lower detection limit to allow comparison with post-lime addition samples. Utilizing the lower detection limits, concentrations of aluminum, barium, cadmium, copper, iron, manganese, nickel, and zinc were detected. Based on the results summarized in Table 6, the concentrations of cadmium, iron, and manganese in the leachate from TP-03B exceeded DEQ-7 groundwater quality standards. However, none of the CoCs in lime-treated tailings leachate exceeded DEQ-7 groundwater quality standards.

In addition to the tailings samples, nine (9) samples of the alluvial sediments underlying the tailings were collected from selected test pits to determine the soil characteristics of the underlying alluvium. The alluvial sediment samples were submitted to Energy Laboratories located in Billings, Montana and analyzed for the following parameters.

Target Analyte List (TAL) Metals
Aluminum, antimony, arsenic, barium, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, silver, and zinc.

Physical Properties
pH

Results of the alluvial sediment analyses are summarized on Table 2. Laboratory data sheets can be found in Appendix B.

The alluvium samples were analyzed for total metals. Analytical results summarized in Table 2 indicate that concentrations of aluminum, arsenic, barium, cadmium, chromium, copper, iron, lead, manganese, nickel, and zinc are above the instrument detection limits. Aluminum concentrations range from 4,790 mg/kg to 11,700 mg/kg. Arsenic ranges from below analytical detection to 12 mg/kg. Barium concentrations range from 39 mg/kg to 106 mg/kg. Cadmium ranges from non-detect to 2 mg/kg. Chromium concentrations range from 15mg/kg to 33 mg/kg. Copper concentrations range from 121 mg/kg to 494 mg/kg. Iron concentrations range from 18,400 mg/kg to 54,900 mg/kg. Lead concentrations range from 28 mg/kg to 172 mg/kg.

Manganese concentrations range from 101 mg/kg to 169 mg/kg. Nickel concentrations range from 13 mg/kg to 27 mg/kg. Zinc concentrations range from 43 mg/kg to 151 mg/kg. The pH results range from 2.93 standard units (s.u.) to 7.55 s.u., with 6 of the samples being under 5.0 s.u. Given the alluvial sediment sample results, additional alluvial sediments should be removed concurrent with the tailings removal; alternatively, the pH of the alluvium should be neutralized to a pH value above 6.5 s.u.

3.4 GROUNDWATER INVESTIGATION

Although groundwater monitoring wells were installed and sampled during several previous investigations, many of the existing wells have been plugged and/or abandoned and only a few remain. To design an effective groundwater dewatering system it was necessary to confirm the following: groundwater elevations across the tailings impoundment; hydraulic gradient; hydraulic conductivity of the tailings materials and the under lying native materials; and, groundwater quality to be encountered during construction.

The design of a dewatering system required that a pumping test be performed at the Site. Performing a pumping test provided the hydraulic conductivity, flow rates, radius of influence and the groundwater quality data that could be expected during the construction dewatering activities. The objectives for the pumping test were to address the following questions:

- What flow rates will be necessary to dewater the tailings?
- What will the groundwater quality be during construction?
- Will a groundwater treatment system be required during construction, prior to discharge to Soda Butte Creek?
- What size sediment detention pond will be required during construction?

Conducting a pumping test provided the best data that would represent the construction dewatering activities. In order to collect the necessary data and conduct the pumping test, it was necessary to install 11 piezometers and 1 pumping well within the tailings impoundment footprint. Additionally, 3 staff gages were installed in Soda Butte Creek and the seeps along the tailings dam toe, and 1 temporary sediment detention basin was constructed southwest of the tailings impoundment in the native soils. The following sections discuss the installation of the piezometers, pumping well, groundwater sampling and analysis and the pumping test results.

3.4.1 Piezometer Installation

Numerous observation points for recording groundwater elevations were necessary to determine the direction of groundwater flow, the aquifer response during the pumping test, and the effectiveness of the dewatering efforts during construction. Four observation points existed within the tailings, in the form of four existing monitoring wells (W-2, W-3, W-4, W-5) (Figure 6). These existing monitoring wells were installed during previous investigations by the Environmental Protection Agency (EPA) to characterize the site. In addition to the EPA existing monitoring wells there were six additional monitoring wells (MBMG -1, MBMG-2, MBMG-3, MBMG-4, MBMG-5, MBMG-6) that were installed by the Montana Bureau of Mines and Geology (MBMG) in 1973. These MBMG monitoring wells were also available to record groundwater elevations. To supplement these existing observation points, 11 piezometers were installed in a pattern radiating away from the pumping well in 2 directions. The layout of the new piezometers consisted of 2 lines trending to the northeast and northwest, oriented at 90 degrees from each other and radiating out from the pumping well (Figure 6).

Prior to the installation of the piezometers, soil sampling was conducted in the seven boreholes using the Geoprobe® macro core soil sampler. The completions of the boreholes in the tailings ranged from 22 to 27.5 feet and boreholes in the alluvium ranged from 30 to 31.5 feet. The borings for piezometers PZ-2d, PZ-3d were sampled continuously to the total depth; the remaining piezometers, PZ-1d, PZ-4d, PZ-5d, PZ-6d, PZ-7d, were sampled from 0 to 4 feet bgs and across the tailings/alluvium interface. No soil samples were collected when installing the shallow piezometers because they were located directly adjacent to the deeper piezometers that had already been sampled.

The collection of soil samples from the piezometer borings was conducted utilizing a Geoprobe® equipped with a Macro-Core Closed Piston Sampler. The use of a Macro-Core Closed Piston Sampler allowed continuous soil sampling at 4 foot intervals or discrete sampling of targeted four foot intervals in soft materials. A PVC liner was inserted into the Macro-Core Sampler with the closed piston tip. When the leading end of the sampler reaches the top of the sampling interval, the piston tip was unlocked using extension rods inserted down the inside of the probe rods. Once the piston tip is unlocked, the sampler is driven 48 inches. Soil entering the sampler pushes the piston assembly to the top of the sample liner where it is retrieved upon removal of the soil core and liner. Each PVC liner sleeve was opened lengthwise and logged, photographed and if needed, sampled. The soil lithologic logs can be found on the soil boring and well completion logs in Appendix D. Photos of the soil boring samples are included in Appendix A.

Once sampling was completed, a one-inch piezometer was installed in each of the 11 boreholes. The piezometers were installed utilizing the Geoprobe equipped with 2.125 inch rods. The 2.125 inch rods equipped with an expendable tip were driven down the boring to the desired completion depth. The 1-inch Schedule 40 PVC casing and 0.010-inch slotted screen were placed in the annular space of the rods and the rods were retrieved. Once the rods had been retrieved, 10/20 silica sand was installed a minimum of 2 feet above the top of the screen. Bentonite crumbles were installed from the top of the filter pack to the ground surface. The piezometers were completed with above ground protective steel casings with lids that were locked. The screened interval was placed so that the entire screened interval was either located in the saturated tailings or in the underlying alluvium.

For the shallow piezometer installations, the same procedures were utilized but soil samples were not collected from the borings. The 2.125 inch rods were driven to the desired completion depth and the piezometer was installed, as described above. The piezometer construction data were recorded in the field logs and on the soil boring and well completion logs found in Appendix D.

Each of the piezometers had common construction elements including diameter, material, screen length and screen placement. Piezometer construction details are summarized in Appendix D. In order to accommodate a transducer with an outer diameter of 7/8 inch, the inner diameter of each piezometer was one inch. The screen was placed so that it was installed in the saturated tailings or the underlying alluvium. Four (4) piezometers were installed in the saturated tailings and seven (7) piezometers were installed in the underlying alluvium. Piezometers PZ-01s, PZ-02s, PZ-04s, and PZ-05s were completed in the saturated tailings. Piezometers PZ-01d, PZ-02d, PZ-03, PZ-04d, PZ-05d, PZ-06, and PZ-07 were completed in the alluvium. Piezometers installed in the tailings did not extend through the tailings and piezometers installed in the underlying alluvium extended 1 to 6 feet below the tailings, depending on soil conditions and available equipment.

Upon completion, the piezometers were developed utilizing a peristaltic pump utilizing Pioneer's Standard Operating Procedures (SOPs). The piezometers were developed until field parameters stabilized. Data regarding the piezometer development can be found in Appendix D.

3.4.2 Pumping Well Installation

To effectively conduct an aquifer test of the saturated tailings and the underlying alluvium, a pumping well was installed in the southwest quadrant of the tailings pond in the area of greatest tailings thickness (Figure 6). The location was near Monitoring Well W-2, where the tailings are 26 feet thick and extend to a depth of 30 feet bgs. The pumping well was constructed such that the screen would straddle between the saturated tailings and the underlying alluvium (12 feet of screen was located within the saturated tailings and 8 feet of screen was located in the underlying alluvium).

To minimize the influx of tailings into the pumping well, the screen was constructed of two different screen sizes, one to be used in the saturated tailings and one to be used in the underlying alluvium. The upper screen consisted of 0.010 continuous slot molded PVC well screen with 10-20 silica sand as a filter pack. To maximize production in the alluvium and not pull in the silica sand from the upper completion, the lower screen in the alluvium consisted of 0.025 continuous slot molded PVC well screen with a washed rock filter pack completion (angular 1/4–inch minus gravel).

The borehole for the installation of the pumping well was drilled utilizing a hollow stem auger rig equipped with 10-inch inside diameter hollow stem augers. The borehole was drilled to a depth of 40.5 feet bgs. At a depth of 40.5 bgs the drill rig encountered bedrock. The tailings alluvium/interface was encountered at 32 feet bgs. Split spoon soil sampling was conducted during the drilling of the borehole but at the tailings/alluvium interface heaving sands were encountered and hindered the continuation of the split spoon sampling. The split spoon sample driven at the total depth of the borehole contained water-saturated sandy silts and rock fragments. .

Once the borehole was completed, the pumping well was installed. The pumping well consisted of 23 feet of 4-inch Schedule 40 PVC flush joint casing, 10 feet of 0.010 slotted screen, 10 feet of 0.025 slotted screen, and a 4-inch bottom cap. The 0.025 slotted screen was installed from 30.5 to 40 feet bgs with a ¼- inch minus gravel filter pack from 29 to 40.5 feet bgs. The 0.010 slotted screen was installed from 21 to 30.5 feet bgs with a 10/20 silica sand filter pack from 17.8 to 29 feet bgs. The four-inch well casing was installed 2 feet above the ground surface. The well was then completed with an above ground protective steel casing with a lockable lid. The well construction data is presented on the soil boring log and well completion form in Appendix D.

To properly complete the pumping well and remove fines from the well prior to the step drawdown and aquifer test, the well was developed via bailing for approximately 4 hours. The water removed from the well was discharged to the surrounding area

3.4.3 Groundwater Sampling and Analysis

Prior to groundwater sampling, depth-to-groundwater measurements were measured at each existing well (W-2, W-3, W-4, W-5), pumping well (PW-01), and piezometer locations (PZ-01s, PZ-01d, PZ-02s,PZ-02d, PZ-03, PZ-04s, PZ-04d, PZ-05s, PZ-05d, PZ-06, and PZ-07) in accordance with Pioneer's SOP (PTS-SOP-GW-03). After the water levels were recorded, the existing wells, pumping well, and piezometers were purged with a peristaltic pump or 12-volt submersible pump until a minimum of 3 well casing volumes had been removed or until the water quality parameters (pH, temperature, specific conductance, and dissolved oxygen [DO]) stabilized. Water quality measurements were recorded at intervals until the water quality parameters had stabilized. The key stabilization parameter was turbidity. Turbidity was considered stabilized when 3 consecutive readings were within 10% of each other. Water quality parameters were collected in accordance with Pioneer's SOPs. Once three well volumes were purged, the groundwater samples were collected directly from the sampling equipment into appropriate sample containers. The groundwater samples were analyzed for: alkalinity, pH, sulfate, total dissolved solids (TDS), total suspended solids (TSS), hardness, and dissolved metals (arsenic, aluminum cadmium, calcium, copper, iron, lead, magnesium, potassium, sodium, silica, and zinc). Results of the laboratory analyses can be found in Tables 7 and 8. The laboratory data sheets can be found in Appendix B.

The groundwater samples were analyzed for dissolved metals and wet chemistry. Analytical results for dissolved metals are summarized in Table 7 and indicate that dissolved concentrations of aluminum, barium, cadmium, copper, iron, magnesium, manganese, nickel, and zinc were above the instrument detection limits. Aluminum concentrations range from non-detect to 13.9 mg/L. Barium concentrations range from non-detect to 0.1mg/L. Cadmium range from non-detect to 0.006 mg/L. Copper concentrations range from 0.01 mg/L to 1.86 mg/L. Iron concentrations range from 0.13 mg/L to 1,490 mg/L. Magnesium concentrations ranged from 9 mg/L to 656 mg/L. Manganese concentrations range from 0.47 mg/L to 19.6 mg/L. Nickel concentrations range from 0.03 mg/L to 0.24 mg/L. Zinc concentrations range from 0.01 mg/L to 1.73 mg/L. In addition, the groundwater samples were analyzed for alkalinity, pH, sulfate, TDS, TSS, and hardness. Analytical results for the wet chemistry are summarized in Table 8 and indicated that alkalinity concentrations range from 1 mg/L $CaCO_3$ to 288 mg/L $CaCO_3$, bicarbonate concentrations range from 1 mg/L $CaCO_3$ to 351 mg/L $CaCO_3$, pH range from 3.24 s.u to 7.46 s.u., sulfate concentrations range from 9 mg/L to 4,870 mg/L, TDS concentrations range 355 mg/L to 7,760 mg/L, TSS concentrations range from 13 mg/L to 827 mg/L, and the hardness concentrations range 164 mg/L $CaCO_3$ to 3,850 mg/L $CaCO_3$.

As part of the groundwater investigation, a pumping test was conducted (see Section 3.4.4). During the pumping test, groundwater samples were collected from the pumping well at the start and at the end of the pumping test. The objective of the sampling was to determine the water quality parameters that would potentially be encountered while dewatering the tailings during construction. The groundwater samples were analyzed for alkalinity, pH, sulfate, TDS, TSS, hardness, and the following total and dissolved metals: arsenic, aluminum cadmium, calcium, copper, iron, lead, magnesium, potassium, sodium, silica, and zinc. Results of the laboratory analyses can be found in Tables 7, 8 and 9. The laboratory data sheets can be found in Appendix B.

Analytical results for dissolved metals are summarized in Table 7 and indicate that dissolved concentrations of barium, calcium, iron, magnesium, and manganese were above the instrument detection limits. Barium concentrations are 0.1mg/L. Calcium concentrations range from 110 mg/L to 112 mg/L. Iron concentrations range from 0.35 mg/L to 0.38 mg/L. Magnesium concentrations are 23 mg/L. Manganese concentrations range from 1.91 mg/L to 2 mg/L. Additionally, the groundwater samples were analyzed for alkalinity, pH, sulfate, TDS, TSS, and hardness. Analytical results for these wet chemistry parameters are summarized in Table 8 and indicate that the alkalinity concentrations range from 260 mg/L $CaCO_3$ to 270 mg/L $CaCO_3$, bicarbonate concentrations were are 320 mg/L $CaCO_3$, pH range from 7.5 s.u to 7.7 s.u., sulfate concentrations are120 mg/L, TDS concentrations range from 416 mg/L to 424 mg/L, TSS concentrations range from 10 mg/L to 19 mg/L, and hardness concentrations range from 368 mg/L $CaCO_3$ to 374 mg/L $CaCO_3$.

Analytical results for total metals are summarized in Table 9 and indicate that total concentrations of aluminum, barium, copper, iron, and manganese were above the instrument detection limits. Barium concentrations are 100 micrograms per liter (µg/L), Copper concentrations range from 40 µg/L to 50 µg/L. Iron concentrations range from 1,880 µg/L to 2,120 µg/L. Manganese concentrations range from 1,880 µg/L to 2,000 µg/L. Comparing the total metal concentrations to the Montana Numeric Water Quality Standards (WQB-7, Human Health Standards), the total copper concentration exceeds the copper standard of 48.5 µg/L and the iron and manganese concentration exceeds the secondary standards for iron (300 µg/L) and manganese (50 µg/L).

To obtain a "worst case" water quality scenario for dewatering, a groundwater sample was collected from Test Pit (TP)-24 (see Figure 5) during the Source Area Investigation. The sample was of standing groundwater within the test pit. The groundwater sample was collected and analyzed for pH; conductivity; TSS; TDS; alkalinity; chloride; sulfate; hardness; the following dissolved metals: calcium, magnesium, potassium, and sodium; and the following total metals: aluminum, arsenic, barium, cadmium, chromium, copper, iron, lead, manganese, mercury, selenium, silver, and zinc. The analytical results are summarized on Tables 7, 8, and 9.

Based on the groundwater sample results from the pumping well and TP-24, the design of the dewatering system should consider the following groundwater treatment to meet the discharge standards for Soda Butte Creek;

- Passive and/or active settling of sediments utilizing sediment basins and/or flocculants,
- Maintaining a neutral pH and elevated alkalinity by mixing pumped waters and/or addition of lime, and

- Treat groundwater for dissolved concentrations of iron and manganese.

The treatment of water from the dewatering system is discussed further in Section 7.2.

3.4.4 Execution and Evaluation of Pumping Test

On October 1, 2008, the newly installed pumping well and piezometers were utilized for a-24 hour pumping test and 24-hour recovery period (collectively referred to as "pumping test"). The pumping test is the first of three steps toward the 60 % construction dewatering design, and provides data to determine the most effective method for dewatering the McLaren Tailings prior to excavation. The second step of the design involves utilizing the pumping test evaluation to develop a groundwater model and to evaluate several construction dewatering scenarios. The final step in the design identifies effective construction dewatering methods, groundwater dewatering system component locations, and estimates the pumping duration required to effectively dewater the tailings. The second and third steps are summarized in Section 7.2.

The following sections outline the execution and evaluation of the 2008 McLaren Tailings pumping test. Throughout the following sections, groundwater within the tailings is referred to as the "tailings interval" and the groundwater within the underlying alluvium is referred to as the "alluvial aquifer".

3.4.4.1 Equipment Setup

This section describes how and why equipment for the pumping test was set up and utilized. The configuration of the pumping well and the piezometers is discussed in detail in Section 3.4.1 and 3.4.2.

Pumping Well:
The pumping well was specifically constructed to be screened within the tailings interval and the alluvial aquifer. By screening within both units, the well mimics the sidewall of a dewatering trench by intercepting the majority of the water from the alluvial aquifer and also taking advantage of any horizontal lenses within the tailings interval that might provide significant quantities of water.

For purposes of the pumping test, a 5 horsepower submersible pump capable of pumping 5 to 80 gallons per minute (gpm) was installed in the pumping well. A three phase diesel generator was utilized to power the submersible pump. The flow rate from the submersible pump was primarily monitored utilizing a Fuji electronic flow meter. Manual backup flow measurements were collected utilizing "bucket gauging" (estimating the flow rate by recording the time to fill a 5 gallon bucket with the pumped groundwater). The submersible pump was installed 0.75 feet from the bottom of the well, positioning the pump intake approximately 3.25 feet from the bottom of the well and 4 feet below the interface of the tailings and alluvium. Pumped water was conveyed via flat hose for approximately 200 feet to the downgradient settling pond that was excavated during the earlier site investigation activities.

To continually record water levels within the pumping well, a transducer was attached just above the check valve. In addition to the transducer, backup water level readings were manually collected with a static water level meter.

Piezometers:
To continually record water levels during the pumping test, transducers were placed in PZ-01s, -01d, -02s, -02d, -04s, -04d, -05d, and -07. Water levels in the remaining three piezometers (PZ-03, PZ-05s, and PZ-06) were manually recorded using a static water level meter.

Surface Water and Seeps:
Historical investigations at the McLaren tailings indicated that during certain times of the year Soda Butte Creek plays a major role in providing groundwater to the McLaren Tailings. To ensure that any fluctuations in surface water levels within Soda Butte Creek were accounted for, two staff gauges (SG-01 and -02) were installed at locations upgradient and cross-gradient to the pumping test, respectively (Figure 6). Water levels from these two locations were recorded manually throughout the pumping test.

Seeps:
Downgradient of the pumping test and along the toe of the tailings dam there are six existing seeps. During the pumping test, four seeps were monitored periodically for fluctuating water levels. At the largest seep, a staff gage (SG-03) was installed (Figure 6). At the three smaller seeps (Seep 1, 2, and 3) a wooden stake was installed and surveyed. Water levels from these four locations were recorded manually throughout the pumping test.

Other observation locations:
Additional observation locations were utilized for the pumping test, including the following: MBMG-1, -2 (Dry), -3, -4, -5 (Dry), and -6; and W-2, W-3, and W-4. Water levels from these locations were manually measured throughout the pumping test.

Settling Pond:
To accommodate pumped groundwater, a settling pond was constructed downgradient and to the southwest of the tailings impoundment (Figure 6). All water extracted from the pumping well was conveyed to the settling pond via two-inch flat hose where the water was allowed to infiltrate into the subsurface.

3.4.4.2 Field Observations

This section summarizes observations during the step-drawdown test and pumping test.

Step-Drawdown Test:
The purpose of the step-drawdown test is typically to determine the optimal pumping rate that will be utilized for the duration of the pumping test. During the step-drawdown test, it became apparent that the production rate of the pumping well was decreased by the production of the very fine tailings and alluvium materials. Although the projected flows for the pumping well were estimated at 20 to 80 gpm, the actual pumping rates during the step-drawdown test were varied from 7 to 19 gpm. At 19 gpm, the flow rate was such that very fine tailings and sands

surged into the filter pack and well screen area and effectively blocked most of the inlets into the well, reducing the flow to a nominal 7 gpm. This is significant because both the well construction and the results of the pumping test indicate that the pumping well should have been able to produce more groundwater. Pumping at too great of a rate apparently causes the very fine tailings and sand in the surrounding aquifer to enter into the filter pack and screened area, creating significantly lower flow rates. This low flow rate will have a direct impact on the efficiency of construction dewatering because it may take longer to effectively remove groundwater from the McLaren Tailings.

Pumping Test:

The 2008 pumping test was started twice. The first start occurred on September 30, 2008 at 1100 hours and was eventually abandoned due to decreased production rates. During this first start, the pumping rate was initially set to 15 gpm, producing a nominal drawdown in the pumping well of approximately 6 feet in three hours. At this point, with the interest of creating more "stress" in the aquifer and pumping at a greater rate, the pumping rate was increased to 20 gpm. Approximately one hour later, the water level in the well quickly dropped to the level of the pump inlet and decreased the pumping rate to approximately 8 gpm, which resulted in partial recovery of the water levels in the surrounding piezometers. As with the step drawdown test, the decreased pumping rate was attributed to the very fine tailings and sands within the tailings and alluvial aquifers. At 1750 hours, due to the water level being drawn down to the pump intake elevation, the test was stopped.

Before the pumping test was re-started, a strategy was formulated to begin pumping at a low rate and gradually increase the rate over a number of hours while specifically avoiding rapid changes in the pumping rate. With this strategy, it was hoped that the adverse effects of the very fine tailings and alluvium materials could be avoided. On October 1, 2008 at 0815 hours, the pumping test was re-started at an initial pumping rate of 5 gpm and increased gradually over 6 hours to 12 gpm. Once the pumping rate was established at 12 gpm, the flow rate was not modified for the rest of the test, and the difficulties with the very fine tailings and sands were not an issue.

Settling Pond:

Part of "determining the most effective method for construction dewatering" is how to collect, treat, and discharge the pumped groundwater. Central to this effort was the settling pond. During the 2008 McLaren pumping test, the groundwater discharged to the settling pond was to be evaluated for any improvements in water quality after 24-hours of residence time within the settling pond. Instead of improving the water quality, the very fine sediments in the banks of the settling pond significantly increased the water turbidity. Because the water quality directly from the well was apparently better than water in the settling pond, it was determined in the field to obtain groundwater samples directly from the pump.

While the turbidity in the pumped water was significantly increased within the settling pond, the permeable nature of the materials underneath the settling pond allowed the pumped water to infiltrate and emerge through the downgradient sidewall of the nearby drainage. The effects of the infiltration appeared to effectively filter out suspended sediment, and during construction dewatering could play a key role in reducing suspended sediment in the pumped groundwater.

3.4.4.3 Results

The results of the pumping test include how the tailings interval and underlying alluvial aquifer respond to sustained pumping. These observations and results from the pumping test will be utilized to design the construction dewatering system for the reclamation project. Important results from the pumping test evaluation that will be significant in the design of the construction dewatering system include the following:

- The horizontal conductivity through the tailings interval is low. An effort to dewater only the tailings interval would likely be more difficult than dewatering both the underlying alluvial aquifer and tailings interval;
- The alluvial aquifer is much more conductive and could be utilized as the main conduit for extracting groundwater; and
- Pumping the underlying alluvial aquifer could effectively dewater a portion, and perhaps all, of the tailings interval.

These confirmations are supported with the following summary of aquifer response and aquifer parameters.

Aquifer response:
An aquifer response is best defined by how the water table responds to pumping. During the pumping test, the aquifer response was recorded by obtaining static water level measurements. These measurements are instrumental in determining aquifer characteristics and designing the construction dewatering system.

While the flow rate from the pumping test was less than anticipated (12 gpm for 24 hours), the pumping test created a significant aquifer response and the water level in nearly every well or piezometer decreased in elevation. This response indicates that the alluvial aquifer is well connected and quite conductive. It is also significant to note that the water level in every piezometer completed within the tailings dropped from 0.25 to 0.45 feet in 24 hours, indicating that the water level in the tailings interval could be decreased by pumping the alluvial aquifer.

Impacts of the pumping test on nearby surface water seeps were less conclusive. During the course of the pumping test, the water level in the larger seep (SG-03) was not affected, and Seep 1 decreased in elevation nearly one-tenth of one foot and dried up while Seep 2 decreased in elevation by approximately six-hundredths of a foot. Once the pump was turned off, Seep 1 remained dry and the water elevation at Seep 2 increased four-hundredths of a foot.

Fluctuations of nearby Soda Butte Creek were very minimal over the duration of the pumping test. Because the creek level did not fluctuate significantly, it is likely that it had an minimal affect on the elevation of the water table during the pumping test.

Aquifer characteristics:
To determine specific aquifer characteristics, the aquifer response recorded during the pumping test was evaluated with the software package Aqtesolv®. These characteristics describe the

ability of each aquifer to conduct water and the ability of each aquifer to store excess water. Because these characteristics will be used to simulate multiple construction dewatering scenarios, they are central to the construction dewatering design. Aquifer characteristics for the pumping test have been summarized in terms of transmissivity (T), hydraulic conductivity (K), and storativity (S) within Table 11. The complete analysis of the pumping test data has been provided in Appendix E.

Important characteristics to note in Table 11 with respect to construction dewatering include the relatively high hydraulic conductivity of the alluvial aquifer (33 to 124 feet per day [ft/day]) and the very low conductivity of the tailings interval (0.001 to 0.029 ft/day). These numbers indicate that groundwater can be removed relatively quickly through the alluvial aquifer and very slowly through the tailings interval. Because the water in the tailings interval moves so slowly, it is important to minimize the distance this water must travel to be pumped. In the configuration of the McLaren tailings, the shortest distance the water could travel before being pumped is typically straight down or vertically into the underlying alluvial aquifer.

Because the shortest distance for water to leave the tailings interval is vertically into the alluvial aquifer, another important aquifer characteristic is the storativity of the alluvial aquifer. This value defines the communication, or ability for water to flow, between the tailings interval and the underlying alluvial aquifer. From Table 11, the storativity values within the alluvial aquifer range from 0.0061 in PZ-06 to 2.8E-06 in PZ-04d. These values are characteristic of a "leaky-confined" to "confined" aquifer. A confined aquifer is one that is overlain by a significantly less-permeable unit above it, and receives minor to no contributions of water from it. A leaky-confined aquifer is similar to a confined aquifer but receives significant contributions from the unit above it. The leaky-confined classification indicates that significant water from the tailings interval can migrate vertically into the alluvial aquifer.

Locations where the alluvial aquifer is leaky-confined (i.e., connected to the overlying tailings interval) are at PZ-03 and PZ-06. Because water from the tailings interval can more readily flow into the underlying alluvial aquifer, construction dewatering in these areas will likely be faster. Locations where the alluvial aquifer is confined (i.e., least connected to the overlying tailings interval) are near PW-01, PZ-01d, PZ-02d, PZ-04d, PZ-07. Because it is more difficult for water in the tailings interval to travel downward into the underlying alluvial aquifer, these locations will likely be the most difficult areas to dewater. These less connected locations appear to match up with other physical observations at the Site, specifically the area where willows are growing. This observation appears to be reasonable because if water in the tailings interval is less able to flow downward into the alluvial aquifer, the water table in the tailings interval could rise to the point where it is available to the willows.

Next Steps to the Completion of the Construction Dewatering Design

The evaluation of the pumping test is the first of three steps toward completing the 60% construction dewatering design. The information determined from the pumping test will be utilized in the second step to evaluate several design scenarios (including dewatering trenches, slurry walls, and pumping wells) with a groundwater model. The third step in the design identifies the effective construction dewatering methods, outlines the groundwater dewatering system component locations, and estimates the pumping duration required to effectively dewater the tailings. Both the second and third steps are summarized in Section 7.2, Tailings Dewatering Design.

3.5 SURFACE WATER INVESTIGATION

Two locations in Soda Butte Creek and one in Miller Creek were identified for measuring surface water flows in 2008. The locations for the flow measurements are presented on Figure 7. The surface water flows at these locations were measured using a Marsh-McBirney flow meter. Initially, existing surface water analytical data derived from previous investigations was to be utilized in the reclamation design (RD). Additional water quality samples were collected to confirm past results and provide pre-construction water quality data. The water quality samples consisted of grab samples at two locations on Soda Butte Creek and the one location on Miller Creek (Figure 7). The water quality samples were analyzed for alkalinity; pH; sulfate; TDS; TSS; hardness; and the following total recoverable metals and major ions: arsenic, cadmium, calcium, copper, iron, lead, magnesium, potassium, sodium, silica, and zinc. Results of the laboratory analyses can be found in Tables 7, 8, and 9. The laboratory data sheets can be found in Appendix B.

Analytical results for total metals are summarized in Table 9 and indicated that total concentrations of iron and manganese were above the instrument detection limits. Iron concentrations range from non-detect to 1,630 μg/L and manganese concentrations range from non-detect to 60 μg/L. In addition, the surface water samples were analyzed for the following dissolved metals: aluminum, calcium, copper, iron, and magnesium. The samples were also analyzed for alkalinity, pH, sulfate, TDS, TSS, and hardness.

Analytical results for dissolved metals summarized in Table 7 indicate that dissolved concentrations of calcium, copper, iron, and magnesium were above the instrument detection limits. Calcium concentrations range from 35 mg/L to 50 mg/l. Copper concentrations range from non-detect to 0.05 mg/L. Iron concentrations range from non-detect to 0.13 mg/L. Magnesium concentrations range from 5 mg/L to 9 mg/L.

Analytical results for wet chemistry parameters are summarized in Table 8 and indicate that alkalinity concentrations range from 69 mg/L $CaCO_3$ to 128 mg/L $CaCO_3$. Bicarbonate concentrations range from 84 mg/L $CaCO_3$ to 156 mg/L $CaCO_3$ and the pH range from 7.6 s.u. to 8 s.u. Sulfate concentrations range from 7 mg/L to 35 mg/L. Total Dissolved Solids concentrations range 123 mg/L to 173 mg/L. Total Suspended Solids concentrations were non-detect, and the hardness concentrations range from 107 mg/L $CaCO_3$ to 160 mg/L $CaCO_3$.

The total metal analyses indicate the McLaren tailings impoundment is a source of iron and manganese loading to Soda Butte Creek. Iron and manganese concentrations downgradient of the McLaren tailings impoundment exceed the Montana Numeric Water Quality Standards (WQB-7) Secondary standards for iron (1,300 μg/L) and manganese (50 μg/L).

3.6 GEOTECHNICAL INVESTIGATION

In order to develop the reclamation design, it was necessary to identify the geotechnical characteristics of the cover soil, tailings, and repository soils. It was also necessary to collect adequate and representative samples of the tailings to conduct stabilization/dehydration bench scale testing. The following sections summarize the geotechnical characteristics of the cover soil, tailings, and repository soils and the results of the bench scale lime dehydration testing.

3.6.1 Field Investigation

During the cover soil investigation, source area investigation, and repository investigations conducted in the fall of 2008, composite soil samples were collected and sent to Pioneer Technical Services Soil Laboratory located in Helena, Montana for analysis. The samples were analyzed for moisture content, pH, sieve analysis, particle size analysis, Standard Proctor (AASHTO T-99), specific gravity, and Atterberg Limits.

Cover Soil

The characteristics applicable to the soil currently covering the tailings impoundment indicate the following: moisture content ranges from 3.6 % to 6.4%; pH ranges from7.4 s.u. to 7.9 s.u.; specific gravity ranges from 2.741 to 2.748; and the soil exhibits a USDA textural Classification of Sandy Loam. The results are summarized in Table 5. The Laboratory Data Reports can be found in Appendix C.

Repository Soils

The soil characteristics applicable to the repository soils indicate the following: moisture content ranges from 6.4% to 34.8%, pH ranges from 4.6 s.u. to 7.9 s.u.; specific gravity ranges from 2.707 to 2.740; and the soil exhibits a USDA textural Classification of Sandy Loam. Although the soil classification is a Sandy Loam, significant cobbles are present in some of the repository soils. The results are summarized in Table 5. The Laboratory Data Reports can be found in Appendix C.

Tailings Materials

The soil characteristics applicable to the tailings materials indicate the following: moisture content ranges from 21.1% to 49.3%; specific gravity ranges from 3.257 to 3.554, USDA textural Classification of Sandy Loam to Silty Clay Loam; liquid limit ranging from not present to 46; a plastic limit ranging from not present to 28; and, a plastic index from not present to 18. The results are summarized in Table 5. The Laboratory Data Reports can be found in Appendix C.

In addition, standard proctors were run on the tailings materials. The tailings materials had a wet density that ranged from 151.7 pounds per cubic foot to 161.7 pounds per cubic foot, and a maximum dry density that ranged from 104.8 pounds per cubic foot, with an optimum moisture content of 25.3 % to 131.4 pounds per cubic foot with an optimum moisture content of 14.9 %. The results are summarized in Table 5.The Laboratory Data Reports can be found in Appendix C.

3.6.2 Bench Scale Testing and Results

To place the tailings materials into the on-site repository it will be necessary to reduce the moisture content within the tailings in order to effectively compact the materials to provide an overall stable embankment. Two effective ways to reduce the moisture content within the tailings include: 1) construction dewatering; and 2) stabilization/dehydration utilizing lime amendment. To implement the reclamation project it will be necessary to utilize both methods. In order to develop a Tailings Stabilization Method it was necessary to investigate the following issues:

- Quantity of lime required to reduce the moisture content of the tailings so they are workable;
- Time frame required for the tailings/lime mixture to marble (cure or make more workable) before it can be placed in the repository;
- Performance differences between alternate lime amendments;
- Maximum dry density and optimum moisture content at different lime amendment rates and marble periods; and
- Shrink/swell of the tailings/lime amendment mixture.

To address these issues, bench scale testing on the tailings materials was conducted utilizing the following Lime Dehydration methods: ASTM D 3877 – Test Method for One-Dimensional Expansion, Shrinkage, and Uplift Pressure of Soil-Lime Mixtures; and, ASTM D 5102– Test Method for Unconfined Compressive Strength of Compacted Soil-Lime Mixtures.

Bench scale testing was conducted in both closed container and open air conditions. The open air condition will better represent the conditions at the Site. The bench scale testing was performed utilizing quicklime and Lime Kiln Dust (LKD) from Graymont located in Townsend, Montana, and crushed lime from Wyoming Lime Producers located in Frannie, Wyoming. Lime rates of 3, 5, 7, 9, and 12% (by weight) were utilized in the bench scale testing and testing was conducted over a seven day period. The results of the bench scale testing are summarized in the laboratory data reports in Appendix C.

In summary, the bench scale testing determined the following:

- Stabilization/dehydration of the tailing requires more LKD than quicklime. This was confirmed with laboratory analyses of the lime products. The quick lime has higher CaO content than that of the LKD. Therefore, lime amendment must have a CaO percentage of 85% or greater to minimize the volume of lime amendment required.
- Tailings with a moisture content of less 30% require the addition of 3% quicklime. With a higher percentage of quicklime, the tailings/lime mixture became too dry and would require the addition of water to adequate compact in the repository.

- Tailings with a moisture content greater than 30% would require the addition of 5% quicklime to produce adequate dehydration.
- The tailings/lime mixture would swell approximately 1%.
- Lime amendments from Graymont and Wyoming Lime Producers were comparable.
- The tailings/lime mixture must cure for 24 hours (minimum) before being placed in the repository.

3.7 STREAM CHANNEL INVESTIGATION

Soda Butte Creek formerly occupied a channel beneath the present tailings site, but in 1969, Soda Butte Creek was diverted to the north, to bypass the tailings impoundment. One goal of the reclamation project is to develop a stream design (within the original Soda Butte Creek alignment, which is currently covered with tailings) that will facilitate development of suitable habitat for fish, macro invertebrates, and other aquatic life via natural stream processes. The development of suitable habitat will depend in large part on the initial design and construction of the stream channel as well as subsequent natural processes of erosion, deposition, and vegetation establishment. No special measures will be taken to specifically create habitat in the newly constructed channel, rather the channel will be designed to allow creation of suitable habitat through subsequent natural processes.

To facilitate the stream reconstruction design, physical and biological data were collected from four reference reaches along Soda Butte Creek to help determine the stream channel physical and biological attributes. Three of the reference reaches (Stream Reach -1 [STR-1], STR-2, and STR-3) were established downgradient of the tailings embankment in relatively undisturbed channel areas that possess the types of natural habitat and aquatic life that would be expected in the reconstructed stream channels (see Figure 7). One reference reach (STR-4) was completed near the Soda Butte Campground, located approximately 0.5 miles east, and upgradient from, the project area. Because of the noticeably lower velocity and gradient of this reach, only minimal data from this area will be used for the design.

The information obtained at each of these reference reaches will be utilized to establish design criteria for the physical variables of the reconstructed stream design. This data will be used as a guide to help establish a stable and functioning stream.

Table 12 summarizes the data collected from each of the reference stream reaches in Soda Butte and Miller Creeks.

3.7.1 Soda Butte Creek Results

Soda Butte Creek has two distinct channels, a low flow (thalweg) and a high flow channel created from spring runoff. The low flow channel ranges in width from approximately 5 feet to approximately 10 feet, while the high flow channel ranges in width from approximately 15 feet to 23.5 feet. Stream gradients range from 1.6 percent at STR-1 to 8.1 percent at STR-3. The stream substrate size was visually estimated and generally consists of large cobbles and boulders 18 inches to 48 inches in diameter with the smallest rock observed being approximately 3 inches in diameter. There were no sands or gravels mixed within the channels except on the outer edges or within pools associated with the high flow channel.

Vegetation adjacent to Soda Butte Creek at STR-1 and STR-2 generally consists of dense willows with isolated patches of mountain alder. Mountain brome, rough fescue, and tufted hairgrass are the dominate grass species observed. No woody debris was observed within the stream channel at these locations.

At STR-3, only isolated patches of willows were present with small clumps of grasses. There was an abundance of woody debris within the channel consisting of large to medium sized pine trees. The lack of willows, grasses, and abundant large woody debris is likely due to unstable slopes that are continuing to be eroded during high flow events.

3.7.2 Miller Creek Results

Miller Creek has no clearly defined thalweg and is predominantly a boulder controlled stream ranging in width from approximately 8 feet to 34.4 feet. The stream substrate was visually estimated to consist primarily of 36 to 48 inch diameter boulders with some larger cobbles (6 to 8 inches in diameter). Very little sand or gravel sized material was observed. The gradient is approximately 13 percent, with small deep pools. No large woody debris was observed within the stream channel. Willows are present within the stream channel and along the upper banks. Scattered clumps of grasses were also noted.

4.0 PREFERRED RECLAMATION ALTERNATIVE 5B

Based on the conclusions of the detailed analysis and comparative analysis of alternatives completed in the EEE/CA, Alternative 5b: On-Site Disposal in an Un-Lined Repository with a Multi-Layered Cap was recommended as the preferred reclamation alternative for the Site. This alternative is described below to provide the basis of the reclamation design proposed for the Site.

Alternative 5b involves removing and permanently disposing of all on-site wastes (tailings, waste rock dump, and old stream channel wastes) in an un-lined repository with a multi-layered cap constructed on-site. The proposed repository site for Alternative 5b is located immediately southwest of the tailings impoundment, on the timbered bench above the south bank of Soda Butte Creek.

Due to heavy timber at the proposed repository site, coupled with private ownership, the area was not accessible with a backhoe when Pioneer conducted the initial field investigation at the site during the fall of 2001. However, three monitoring wells were installed in the repository area in August 2005 to determine the vertical separation between the bottom of the repository and groundwater levels, as well as associated static water level fluctuations.

Under Alternative 5b, the repository excavation would be sized appropriately to provide enough cover soil for reclamation of the entire Site. Based on analytical results from the 2001 field investigation (several shallow soil samples collected near the perimeter of the repository), the cover soil contains very little organic matter (averaging less than 1.0 percent), is nutrient-poor, and would require fertilizer application and amendment with organic matter to establish suitable plant growth.

Under Alternative 5b, the repository would be constructed to allow positive drainage with maximum side slopes of 4 horizontal to 1 vertical (4H: 1V). The multi-layered cap would consist of an impermeable liner, a drainage layer, and the vegetated cover component of the cap would be 2 feet thick (minimum).

Under Alternative 5b, a total of 267,200 cy of material would be disposed of in the repository (which includes 6 inches of potentially contaminated material underlying each of the waste sources caused by leaching and the formation of precipitates). This quantity includes the tailings impoundment, the waste rock dump, and other contaminated materials located throughout the Site. Based on the available data and the above considerations, the conceptual design for Alternative 5b included the following:

- Implementing Best Management Practices (BMPs) along Soda Butte Creek to protect the creek during site reclamation activities;
- Installing a temporary bridge across Soda Butte Creek near the northwestern edge of the tailings to allow access to the Site for the required equipment;
- Excavating and temporarily stockpiling approximately 30,000 cy of existing cap material currently overlying the tailings impoundment (this material would be salvaged for use as a portion of the final cover over the waste rock dump and tailings footprints);
- Establishing access and excavating the repository (development of the repository would involve clearing and grubbing of approximately five acres of timber in this area);
- Excavating, transporting, and disposing of the tailings, waste rock, and old stream channel wastes in the repository;
- Mixing lime with the waste materials to neutralize the acid generation potential of the wastes and to aid in dehydrating the tailings to improve handling and compaction characteristics;
- Constructing the repository multi-layered cap, including a two-foot thick layer of vegetated cover;
- Installing salvaged tailings cap materials over the excavated waste rock dump and the tailings footprints at a thickness of 12 inches;
- Installing a 12-inch thick cap of clean cover soil over the surface of the excavated waste rock dump and tailings footprints (this would result in a final cover thickness of 2 feet over the excavated waste rock dump and tailings footprints);

- Installing diversion ditches to facilitate run-on/runoff control around the perimeter of the reclaimed areas;

- Re-establishing vertical and horizontal alignment and reconstructing Soda Butte Creek and Miller Creek (approximately 2,050 lineal feet); and

- Revegetating and mulching all disturbed areas upon completion of the construction activities (including roads, staging areas, stockpile areas, etc.).

Under Alternative 5b, seeding would take place during the fall of the year. The seed mixture and fertilizer would be applied simultaneously to the prepared seedbeds via drill application. Mulch would be applied to promote temporary protection of the disturbed surfaces. Straw mulch (certified weed-free) would be applied over the reclaimed materials with a tow spreader or pneumatic spreader utilizing tucking/crimping as the anchoring mechanism.

Run-on/runoff controls would be achieved by construction of necessary diversion structures. Temporary surface water diversions (i.e., culvert, pipe, lined ditch, etc.) may need to be constructed and BMPs would be implemented to prevent runoff and sedimentation into Soda Butte Creek during the construction activities.

5.0 RECLAMATION DESIGN OBJECTIVES

The reclamation design objectives for the Site are as follows:

- Prevent the releases of contaminated tailings and waste rock to the extent that they will not result in an unacceptable metals loading and risk to aquatic life in Soda Butte Creek and Miller Creek.

- Prevent the releases of contaminated water from tailings and waste rock materials that would result in exceedances of the Montana State Water Quality Standards for surface water in Soda Butte Creek and Miller Creek.

- Prevent the releases of contaminated water from tailings and waste rock that would result in exceedances of the Montana State Water Quality Standards for groundwater.

- Isolate contaminated tailings and waste rock materials to the extent that they would not result in an unacceptable risk to human health and/or aquatic life and environmental receptors.

6.0 RECLAMATION DESIGN CRITERIA

The following is a list of the reclamation design criteria for the McLaren Tailings Reclamation Project:

- Implement the McLaren Tailings Reclamation Project within the State of Montana property boundaries.
- Obtain the required cover soil and fill materials from within the State of Montana property boundaries.
- Implement the McLaren Tailings Reclamation Project with minimal impacts (during construction) to Soda Butte Creek, Miller Creek, and the adjacent community of Cooke City, Montana.
- Implement the McLaren Tailings Reclamation Project over a three year construction period.
- Design a groundwater dewatering system that will meet the discharge standards for Soda Butte Creek.
- Design and construct a repository that is of adequate size, stable for the seismic activities of the area, and protective of the underlying groundwater.
- Design and implement the McLaren Tailings Reclamation Project so it results in no long term environmental impacts to Soda Butte Creek and the adjacent community of Cooke City, Montana.
- Reconstruct Soda Butte and Miller Creeks to their original channel alignments and configurations.
- Design and implement the McLaren Tailings Reclamation Project for short construction season periods (approximately June 15 to October 31).
- Design and implement temporary construction BMPs during winter shut down that are protective of the environment.
- Design long term BMPs for storm water run-on and runoff at the repository site.
- Revegetate the disturbed areas with grasses, forbes, shrubs, and trees that are native to the project area.

7.0 RECLAMATION DESIGN ELEMENTS

This section describes the individual reclamation design elements applicable to the Site:

1. Site Facilities and Layout (Section 7.1);
2. Tailings Dewatering System Design (Section 7.2);
3. Excavation and Grading Design (Section 7.3);
4. Repository Design (Section 7.4);
5. Tailings Stabilization Design (Section 7.5);
6. Soda Butte Creek/Miller Creek Diversion/Isolation (Section 7.6);
7. Soda Butte Creek/Miller Creek Reconstruction (Section 7.7);
8. Revegetation Design (Section 7.8);
9. Best Management Practices Design (Section 7.9); and
10. Post Construction Monitoring (Section 7.10);

7.1 SITE FACILITIES AND LAYOUT

The following section discusses the site facilities and layout that will be necessary to implement the McLaren Tailings Reclamation Project. The site facilities will consist of site access roads, temporary creek crossings, staging areas, lime storage areas, cover soil storage areas, compost storage areas, tailings stabilization areas and methods, and required utilities.

7.1.1 Site Access Roads

It will be necessary to improve the access at the project Site to mobilize the necessary equipment and materials. The Site access will be improved by raising overhead electric lines that are located at the Site entrance, widening the site entrance to 134 feet to accommodate the large turning radii of haul trucks, design and construction of entrance road and hauls roads to accommodate two way traffic, installation of two temporary crossings over Soda Butte Creek, and providing a turn-around location for haul trucks.

The primary haul roads, secondary haul roads, and turn-arounds will be constructed utilizing the waste rock materials located on the northeast side of the Site. The haul roads and turnaround will be 24 feet wide with 3:1 side slopes and will be constructed using a two foot thick layer of compacted waste rock. In the areas exhibiting soft subsoil, a Geonet (Tensar BX1200 or equivalent) material will be placed under the waste rock materials. The haul roads will be constructed in accordance with the typical details shown on SheetD1 of the Construction Drawings in Appendix G. The layout of the Site access and haul roads is shown on Sheet 4 of the Construction Drawings in Appendix G.

7.1.2 Soda Butte Creek Temporary Crossing

Two temporary crossings will be utilized to cross Soda Butte Creek on the east and west ends of the site as shown in Sheet 4 of the Construction Drawings in Appendix G. The temporary crossing at the west end of the Site will be 24 feet wide with a span of approximately 60 feet and will have a load rating of 70 tons. This temporary crossing will be utilized for primary haulage to and from the site. The temporary crossing located on the east end of the Site will be 12.5 feet wide with a span of 40 feet and will have a load rating of 50 tons. The temporary crossing on the east end of the site will be utilized to access the staging area located on the northeast end of the Site. Semi trucks with trailers will not be allowed to utilize this crossing. The temporary crossings will be designed to pass the 25 year, 24-hour Type II storm event for Soda Butte Creek (placed a minimum of 2 feet above the storm event flow elevation for the Soda Butte Creek).

7.1.3 Utilities

A three phase electrical service will be necessary to operate the dewatering system discussed in Section 7.2, blowers on the lime storage guppies, and lighting associated with the scale building and Site trailer/office. The electrical utilities will consist of overhead and underground electrical components. A complete design of the Site utilities will be provided in the forthcoming McLaren Tailings Reclamation Project Construction Bid Package.

7.1.4 Weight Scales

The truck scale will be utilized to weigh incoming deliveries and to weigh the required lime for tailings dehydration/stabilization. The scale location is shown on Sheet 4 of the Construction

Drawings in Appendix G. The scale will consist of a portable truck scale that is a minimum of 25 feet in length and capable of weighing up to 120,000 pounds during a single recording event. The scale will be a minimum of 11 feet wide and will be equipped with safety/guide rails that are capable of preventing a truck and trailer combination from unintentionally departing from either side of the upper scale platform. The scale will include its own steel frame and will have the ability to be operated on level, compacted soil. The scale will not require a separately constructed concrete foundation for fully functional operation.

The scale will be equipped with a digital indicator that has the capability of recording the individual axle weights of multiple axle truck and trailer combinations and summing those individual weights into a single load ticket (e.g., the digital indicator unit will be loaded with axle-summing software). The digital indicator will be able to weigh, record, and sum a minimum of 10 axles per truck and trailer combination. The digital scale indicator will also have the ability to produce daily summary reports displaying the total weight of materials moved across the scale during each operational period/day. The digital scale indicator will also have the ability to record and recall the tare weights of multiple truck and trailer combinations. The scale will also be equipped with a terminal ticket printer that can be interfaced with the digital indicator unit to produce the individual load tickets as wells as the daily summary reports. The terminal ticket printer will have the ability to produce time and date codes on all load tickets and summary reports that are printed during the course of the project. The entire scale unit will be calibrated by a certified technician prior to being placed in service for use on the project and annually for the duration of the project. The scale will remain on-site for the duration of the project.

7.1.5 Staging Area(s)

The primary staging area will be located on the northeast end of the Site as shown on Sheet 4 of the Construction Drawings in Appendix G. The staging area will be utilized to stage and store equipment and materials to implement the McLaren Tailings Reclamation Project. The area will also be utilized for a temporary office building/trailer and restroom facilities. In addition to the this primary staging area, the Contractor will be allowed to stage equipment on the current tailings impoundment area, the tailings stabilization area, and the repository area (Sheet 4 of the Construction Drawings in Appendix G) as needed and as approved by DEQ.

7.1.6 Lime Storage Area

The lime storage area will be located adjacent to the Tailings Stabilization Area discussed in Section 7.1.9. Lime materials for the project will be stored in concrete guppies with a capacity of 100 tons each, and will be equipped with an electric blower package with a cyclone blower. The guppies will have approximate dimensions of 11.5 feet wide by 13.5 feet tall by 60 feet long and will be placed on a pad with dimensions of 80 feet long by 100 feet wide by 2 feet thick (constructed of waste rock). After construction of the waste rock pad, three concrete guppies will be installed on the constructed pad per the manufacturer's recommendations. All required power for operation of the storage units will be placed underground per federal, state and local electrical codes. The guppies will remain on-site for the duration of the project. The proposed lime storage area is shown on Sheet 4 of the Construction Drawings in Appendix G.

7.1.7 Cover Soil Storage Area

The cover soil generated from excavation of the repository will be placed in the location identified in Sheet 4 of the Construction Drawings in Appendix G. After the cover soil has been stockpiled in the storage area, the stockpile will be fertilized, seeded and mulched as a BMP until needed for reclamation.

As outlined in Section 3.1 "Existing Cover Soil Investigation" there is approximately 32,500 cy of existing soil that will be salvaged prior to excavation of the tailings materials. The salvaged cover soil will be temporarily stockpiled on the undisturbed tailings impoundment surface. These soil stockpiles will be amended with compost and placed in a minimum 12-inch layer over the excavated tailings footprint prior to completion of each construction season. After the cover soil has been placed in the storage area, it will be fertilized, seeded, and mulched as a BMP until needed for reclamation. Salvaged cover soil will be stored temporarily and utilized at the end of each construction season for interim or final reclamation. No salvaged cover soil stockpiles will be left over the winter shutdown period. As the project progresses, it will be necessary to temporarily store salvaged cover soil in areas that have been excavated and capped.

7.1.8 Compost Storage Areas

Compost will be stockpiled on an as needed basis for each construction season. Compost will be temporarily stockpiled adjacent to the salvaged cover soil stockpiles so it can easily be utilized to amend the cover soil. Compost will not be stockpiled over the winter shutdown period. As discussed in Sections 7.1.5 and 7.8, the excavated tailings footprint will be capped, fertilized, seeded, and mulched prior to winter shutdown. As the project progresses, it will be necessary to temporarily store compost in areas that have been excavated and capped.

7.1.9 Tailings Stabilization Area

Implementation of the reclamation project will require that the tailings and alluvial sediments be stabilized with lime products prior to being placed in the on-site repository or hauled to an off-site facility for product recovery. A dedicated stabilization area will be required to implement the tailings stabilization design, as outlined in Section 7.5. The stabilization area will be located on the south side of Soda Butte Creek in an area of known waste rock (Sheet 4 of the Construction Drawings provided in Appendix G). The waste and impacted soils in this area will be the last of the waste to be removed (refer to Section 7.3.6: Excavation Sequence). The stabilization area will be utilized to stabilize and cure the tailings, store tailings prior to placement in the repository or off-site transport, load haul trucks, temporarily store lime, etc. The materials requiring stabilization will be managed as windrows and stabilized materials stockpiles. The construction BMPs, as outlined on Sheet 31 of the Construction Drawings provided in Appendix G will be installed to protect Soda Butte Creek.

7.2 CONSTRUCTION DEWATERING DESIGN

The objective of the Construction Dewatering Design is to dewater the McLaren Tailings to a sufficient level for the tailings to be safely and efficiently excavated, as well as dewatering the alluvium underneath to facilitate the removal of one foot of alluvium and provide a stable footing on which to operate construction equipment. The development process of the Construction Dewatering Design included the development of a groundwater model that would be utilized to emulate groundwater conditions at the Site and subsequently evaluate the effectiveness of the Construction Dewatering Design. To ensure the Construction Dewatering Design considers site-specific limitations, a list of site-specific conditions was developed and utilized in the evaluation. In addition, to evaluate the design for efficiency and feasibility, a series of 14 criteria were developed (See Section 7.2.2.2).

The resultant Construction Dewatering Design utilizes a combination of pumping wells, a cutoff wall, and a dewatering trench with a sump.

The Construction Dewatering Design for the Site proposes a three-phase approach to divide the dewatering effort into defined stages of sequential tailings dewatering and removal. In Phase 1, the majority of the Site will be dewatered and tailings located within the southern half of the McLaren Tailings will be excavated. Once the tailings material behind the tailings dam has been suitably dewatered and a significant portion removed, Phase 2 will initiate dewatering and enable the removal of the southern portion of tailings located downstream (west) of the tailings dam. With Phase 2 tailings removed, construction of the Soda Butte Creek channel will be completed, followed by the diversion of Soda Butte Creek back into its original channel alignment. In Phase 3, the northern portion of the McLaren Tailings will be excavated and the old Soda Butte Creek channel will be backfilled.

To accommodate the phased approach, almost all of the dewatering infrastructure will be constructed under Phase 1 (construction of dewatering wells, the cutoff wall and the treatment and sediment detention ponds) and be operational in the fall of 2009, before any significant excavation takes place. These components represent the majority of the dewatering infrastructure and will perform the majority of the tailings dewatering. The only other components constructed for the dewatering system will be a dewatering trench and sump located below the tailings dam to be installed during Phase 2.

In the following sections, the modeling and evaluation of the Construction Dewatering Design is described, followed by the proposed layout of the pumping system, design of each pumping well, and suggested sequence of the tailings excavation. Additional details for the modeling effort are provided in Appendix E.

7.2.1 Modeling of the Construction Dewatering Design

As part of the evaluation of the Construction Dewatering Design, a groundwater model was constructed. This model was utilized to emulate groundwater conditions at the Site and evaluate and optimize the effectiveness of the Construction Dewatering Design.

This groundwater model is the second step in the overall effort to produce an effective Construction Dewatering Design. This effort consists of three steps, including:

- 24-hour pumping test (evaluated in Section 3.4.4);
- Groundwater modeling; and
- Development of a Construction Dewatering Design.

As demonstrated in the pumping test (Section 3.4.4), the general strategy of the Construction Dewatering Design is to remove groundwater from the alluvium underneath the tailings and drain water from the saturated tailings into the underlying dewatered alluvium. This strategy is favored over dewatering of only the tailings, largely because groundwater moves so slowly through the tailings that the shortest path for this water to travel in order to be effectively pumped is straight down into the alluvium. Dewatering the alluvium serves a dual purpose because, in addition to indirectly dewatering the overlying tailings, the alluvium must be dewatered to facilitate the removal of the top one foot of alluvium and also provide a stable footing on which construction traffic may travel as the excavation nears completion.

Because the Construction Dewatering Design was determined through the aid of a groundwater model, a brief summary is provided on how the groundwater model was set up, the evaluation of various dewatering scenarios, considerations for materials stability, and a recommended construction dewatering configuration. A more detailed evaluation of the groundwater model is provided in Appendix E.

7.2.1.1 Model Setup

As stated previously, the primary objective of the groundwater model is to aid in the evaluation and optimization of the Construction Dewatering Design. In order for the groundwater model to be effective in this evaluation, it must reasonably simulate the groundwater conditions at the Site. The steps that have been completed in constructing the groundwater model and the subsequent calibration to ensure that the model provides a reasonable approximation of the groundwater conditions at the Site are summarized in this section and in Appendix E.

To construct the groundwater model, the software combination of MODFLOW® 2000 and Groundwater Modeling System (GMS®) was utilized. During the setup of the computer model, consideration was given to the model extent, material layers, streams and drains, recharge, and evapotranspiration. The extent of the groundwater model includes the entire site and was made large enough to include Soda Butte Creek, Miller Creek, and a significant portion of the Soda Butte Creek drainage. Within the model, different materials (i.e., tailings, alluvium, and bedrock) were separated into three layers, each having distinct hydrogeologic properties. Specific model setup details are summarized in Appendix E.

The McLaren Tailings Abandoned Mine Site has been the subject of numerous investigations, including the following: the 2008 McLaren Tailings pumping test (Section 3.4.4), groundwater elevations from the Bureau of Reclamation (BOR) provided in the *Response Action Report for the McLaren Tailings Site, Cooke City, Montana* (BOR, 1994), monthly climate summary from the Western Regional Climate Center (WRCC), borehole logs and stream flow measurements from the Montana Bureau of Mines (MBMG) report *MBMG-23 Final Report, Acid Mine Drainage Control – Feasibility Study, Cooke City, Montana* (*MBMG-23 McLaren Feasibility Study*) (MBMG, 1975), boreholes from the Bureau of Reclamation Investigation (BOR, 1990), the hydrogeologic investigation of the Upper Soda Butte Creek Basin (MBMG, 1999). Where possible, data from these investigations were utilized in the estimation of aquifer parameters, precipitation, quantity and seasonal variation of stream flow and precipitation, seasonal fluctuation of groundwater, thicknesses of tailings and alluvium, and location of bedrock.

To estimate the time required for the Construction Dewatering Design to be fully effective and also evaluate the effect of changing seasons, the model has been set up to simulate a period of three years. This period is equivalent to the anticipated length of construction to remove the tailings. Details of the transient simulation have been provided in Appendix E.

7.2.1.2 Model Calibration

Because the Construction Dewatering Design will be evaluated using the groundwater model it is important to ensure that the model is approximating true groundwater conditions. For this reason, several calibration methods were utilized, which include the following:

- Groundwater head calibration;
- Hydraulic gradient calibration;
- Pumping test calibration; and
- Transient calibration with seasonal response.

The application of each of the four calibration methods to the groundwater model is discussed in Appendix E.

7.2.1.3 Groundwater Quantities

In order to determine the quantity of groundwater that must be removed from underneath the tailings to prepare the Site for construction, the quantities of groundwater passing through the Soda Butte Creek drainage and flowing underneath the tailings have been estimated with the aid of the groundwater model. Of the total groundwater flow through the Soda Butte Creek Valley, an average of approximately 70 percent passes through the alluvium underneath the Site. From this comparison, it is evident that in order to effectively dewater the Site, a significant portion of the groundwater within the Soda Butte Creek drainage must be controlled.

Total Groundwater Flow

The total quantity of groundwater flow entering and leaving the model is referred to as the groundwater budget, which is summarized in Table E-3 in Appendix E. In the three year model simulation time, it is estimated that approximately 200 million cubic feet (cf), or approximately 1,000 gpm of groundwater flows through the Soda Butte Creek drainage. As shown in Table E-3 in Appendix E, the majority of the water entering the model is from precipitation (recharge) and the majority of the water leaving the model is through stream flows.

Typical Groundwater Quantities Underneath McLaren Tailings

The typical groundwater quantity flowing underneath the Site has been estimated by the groundwater model to be approximately 700 gpm (Table E-4 in Appendix E). This quantity is important because it provides a general estimate of the water that will need to be continuously removed from the alluvium underneath the construction site in order to maintain an effectively dewatered construction site.

To further guide the Construction Dewatering Design and better define the locations where the dewatering effort would be most effective, the 700 gpm flowing in the alluvium underneath the tailings has been divided into six separate zones, as shown on Figure E-1 (Appendix E) and the flux across each zone is provided in Table E-4 in Appendix E. By subdividing the Site into six zones, discrete regions of groundwater flow are defined and can be utilized to tailor the Construction Dewatering Design to accommodate differences in conditions across the Site.

7.2.2 Evaluation of Dewatering System Design Utilizing the Groundwater Model

Once the groundwater model was setup and shown to reasonably simulate groundwater conditions at the Site, the groundwater model was utilized to evaluate and optimize the Construction Dewatering Design. To assist in the evaluation, a list of site-specific conditions was compiled and a set of 14 criteria (See Section 7.2.2.2) were developed to assess the efficiency and feasibility of each design.

To evaluate the Construction Dewatering Design, the components of the design were configured within the model, including the location, depth, and pumping rate of each groundwater dewatering well, and the location, efficiency, and length of the cutoff wall. With all of the components represented within the model, a three-year simulation was run and the ability of the design to effectively dewater the tailings was assessed. In addition to tailings dewatering, the evaluation utilized the 14 criteria to assess efficiency and feasibility. The results of this evaluation are provided in Table E-6 in Appendix E.

Optimization of the design was achieved by first considering site-specific conditions and then modifying a portion of the design to more effectively dewater the tailings to meet the 14 criteria for efficiency and feasibility, or both.

The following sections provide the list of considerations for site-specific conditions, the set of 14 criteria to assess the efficiency and feasibility, and a summary of four iterations conducted to evaluate and optimize the Construction Dewatering Design.

7.2.2.1 Considerations for Construction Dewatering System

To support the evaluation of the Construction Dewatering Design, a list of considerations for site-specific conditions was assembled, including:

- Seasonal groundwater fluctuations;
- Inadequate materials stability;
- Effectiveness of a cutoff wall (sheet piling);

- Efficiency of dewatering wells;
- Number and location of dewatering wells;
- Removal of groundwater storage;
- Winter operations;
- Quantity of water requiring treatment;
- Quantity of water requiring sediment removal; and
- Sequence of tailings excavation.

In particular, during the groundwater model setup and evaluation of the dewatering system, it was observed that two of these conditions within the Site increase the difficulty of the construction dewatering effort. These conditions are the seasonal groundwater fluctuations and inadequate materials stability. Seasonal groundwater fluctuations provide significant changes in groundwater flow rate during different portions of the year. This provides a challenge in adjusting the design to accommodate the fluctuating rate. Inadequate materials stability at certain locations within the Site limits the use of open excavation for dewatering purposes, most specifically in the form of dewatering trenches, which is a disadvantage. Dewatering trenches are very effective at dewatering and are also cost-effective in comparison with "closed" dewatering techniques such as dewatering wells and cutoff walls. Additional details on these conditions and the considerations provided are included in Appendix E.

7.2.2.2 Evaluation Process for the Construction Dewatering Design

Once the groundwater model was developed to the point where it provided a reasonable approximation of the groundwater conditions at the Site, the Construction Dewatering Design was simulated using the groundwater model and evaluated for a period of three years. Following the completion of each model run, the design was evaluated for efficiency and feasibility.

Dewatering Methods with Limited Applicability

This evaluation was performed in accordance with considerations for site-specific conditions (Section 7.2.2.1), so that even though certain construction dewatering methods might be more effective at removing groundwater, these would not necessarily be appropriate for the Site based on either poor construction conditions, operational requirements, or both. Based on these considerations, a dewatering trench was deemed effective at only one location during Phase 2 of tailings dewatering and removal.

Another dewatering method that was reduced in effectiveness included the use of a cutoff wall at the northeast end of the Site. In addition, site-specific considerations limit the feasibility of a cutoff wall in the southwest portion of the Site. Because site-specific conditions have limited the applicability of these two construction dewatering methods, the primary dewatering method utilized in the design is dewatering wells.

The exception to the above limitations is in the area located downstream of the tailings dam, which is currently too saturated to allow the installation of pumping wells. In this location, the only constructible method for dewatering the area appears to be a dewatering trench and sump (Appendix E).

Criteria for Efficiency, Cost Effectiveness, and Feasibility
Before the evaluation and optimization of the Construction Dewatering Design, a set of criteria were developed to rate the relative efficiency, cost effectiveness, and feasibility of each design, as follows:

1. What is the quantity of groundwater pumped during winter and summer operations?
2. Does groundwater need to be treated during winter operations?
3. How much groundwater needs to be treated during summer operations?
4. Does the design violate any of the considerations for site-specific conditions (Section 7.2.2.1)?
5. What is the possibility of a portion of the tailings not being effectively dewatered?
6. How much reserve capacity is available for groundwater treatment and sediment settling?
7. Does the design contain expectations for conditions that have not been confirmed by Site investigations?
8. What is the potential for the system freezing during winter operations and what are the consequences?
9. How easily can the system be adapted to the growing size of the tailings excavation and the shrinking size of the groundwater dewatering system?
10. Can portions of the system be shut down without shutting down the entire dewatering system?
11. Does the system account for localized dewatering of deeper pockets of saturated tailings?
12. How well does the system account for heterogeneous conditions, including localized seeps and upwelling groundwater?
13. Can a cost-effective substitution be made for any of the physical components?
14. Does the system rely too heavily on any one component that if it fails, will shut down the entire dewatering system?

Using the above set of criteria, the Construction Dewatering Design was evaluated and optimized within the groundwater model.

7.2.2.3 Evaluation and Optimization of the Construction Dewatering Design

The general Construction Dewatering Design for the Site utilizes a series of dewatering wells, one cutoff wall, and a dewatering trench and sump. As mentioned previously, a phased dewatering and construction design divides the dewatering effort into three phases of sequential tailings dewatering and removal. The primary phases evaluated within the groundwater model are Phase 1 and 3, where the majority of the tailings are dewatered. Design changes for Phase 2 dewatering in the area located downstream of the tailings dam have been omitted from the evaluation largely because of the lack of constructible alternatives for a dewatering trench and sump.

The following four simulated designs represent the optimization of the Construction Dewatering Design and utilize common design elements, including larger dewatering wells near the center of the Site, smaller wells around the edges, and a cutoff wall located along the southwestern boundary. In addition, each of the four designs utilize a dewatering trench and sump for Phase 2 dewatering. Because the designs are similar, the text outlines the primary differences while a more complete summary of the design elements is presented in Table E-6 in Appendix E.

Design Simulation 1

The first design simulated within the Site focused on one set of four large dewatering wells located in the middle of the tailings impoundment and one set of five small dewatering wells paired with a cutoff wall located along the southeastern edge of the tailings impoundment. The total winter and summer pumping rate of Design Simulation 1 is 550 gpm, with 400 gpm of groundwater requiring treatment. Advantages of this design are simplicity (small number of wells) and a low pumping rate. Limitations of Design Simulation 1 are the requirements for treatment during the winter, incomplete dewatering of the tailings, and poor ability to adapt to undocumented point water and to dewater localized tailings pockets. For these reasons, the design was further optimized in Design Simulation 2.

Design Simulation 2

Design Simulation 2 modifies Design Simulation 1 with two of the four larger wells taken offline in the winter and a cluster of five smaller wells added in the northeast quadrant of the tailings. The total summer pumping rate of Design Simulation 2 is 700 gpm, with 400 gpm requiring treatment. This rate is reduced in the wintertime to 500 gpm with 200 gpm requiring treatment. Advantages of this design include: lower winter treatment rate; decreased reliance on the set of four large dewatering wells located in the middle; and, better ability to adapt to undocumented point water sources and to dewater localized tailings pockets. Because this design still requires treatment of 200 gpm of groundwater in the winter, the design was further optimized in Design Simulation 3.

Design Simulation 3

Design Simulation 3 modified Design Simulation 2 with three of the four larger wells taken offline in the winter with one in operation and a cluster of five smaller wells added in the north central quadrant of the tailings. The total summer pumping rate of Design Simulation 3 is 850 gpm, with 400 gpm requiring treatment, and reduced to in winter to 400 gpm, with 100 gpm requiring treatment. Advantages of this design include: lower winter treatment rate; decreased reliance on the set of four large dewatering wells located in the middle; and, better ability to adapt to undocumented point water sources and to dewater localized tailings pockets. Because this design still requires treatment of 100 gpm of groundwater in the winter, the design was further optimized in Design Simulation 4.

Design Simulation 4

Design Simulation 4 modified Design Simulation 3 with all larger central wells taken offline in the winter, one of the smaller wells in the northeast quadrant converted to a larger capacity well (150 gpm), and one larger sized well (60 gpm) added in the east quadrant of the tailings impoundment. The total summer pumping rate of Design Simulation 4 has been increased to 930 gpm, while the volume requiring treatment is approximately 300 gpm. Pumping volumes in the winter have been increased by 50 gpm to 450 gpm with no water requiring treatment. Advantages of this design are no winter treatment requirement, a significant decrease in the reliance on the set of the large dewatering wells located in the middle (one large central well was removed from the design), and improved ability to adapt to undocumented point water sources and to localized tailings pockets. This design fulfills the requirement of eliminating treatment of water in the wintertime, however has added many additional dewatering wells and an additional quantity of clean groundwater must be pumped. Design Simulation 4 appears to be a reasonable balance between no wintertime treatment and increased number of pumping wells.

7.2.2.4 Recommended Construction Dewatering Design

Based on the above four design simulations, the primary consideration of acceptability includes the feasibility of operating the dewatering system during the winter without pumping the water from within the tailings. Because three of the four simulated designs rely on pumping water from within the tailings and treatment during the winter, the recommended Construction Dewatering Design is Design Simulation 4. Because this design pumps water from the Site perimeter, it is assumed that there would be no need for treatment of groundwater during the winter. This appears more feasible than the other three design simulations. Additional advantages of this design include the high degree of adaptability to dewatering localized pockets of tailings and its ability to more likely accommodate any unknown point water sources. Because this design utilizes additional pumping wells (19) and one cutoff wall, these unknown point sources are more likely to be effectively accommodated, especially along the southwestern boundary of the Site. Disadvantages of this design include the cost effectiveness of not treating groundwater in the wintertime is most likely offset by the increased number of pumping wells and total required pumping volume.

7.2.3 Construction Dewatering Design

As shown on Sheet 14 of the Construction Drawings in Appendix G, the layout of the Construction Dewatering Design consists of a total of 19 wells, 1 cutoff wall, and 1 dewatering trench and sump. To take advantage of site-specific conditions, a series of larger wells have been designed to pump from 60 to 200 gpm and a series of smaller wells have been designed to pump approximately 30 gpm. The anticipated flow rate for each of the 19 wells has been provided on Sheets 15 and 16 of the Construction Drawings in Appendix G.

To convey pumped groundwater from the dewatering wells to the dewatering control building, piping will be extended from each well. Because the Construction Dewatering Design requires wintertime operation, all piping will be constructed to withstand the cold weather typical of Cooke City, including the use of pitless adapters, installation of pipe below the frost line (anticipated to be six feet), and installation of blue board insulation underneath primary and secondary tailings haul roads, and other appropriate measures for cold-weather conditions.

The layout and design of the pumping wells will accommodate the expanding size of the tailings excavation without interrupting pumping operations. This has been achieved by separating the pumping wells into three main well clusters that are independently piped to the dewatering control building. In addition, each cluster will be constructed with a number of isolation and check valves for the purpose of decommissioning or repairing a well without shutting down the rest of the well cluster. In this manner, one well or one well cluster could be taken offline while the remaining wells or well clusters continue pumping.

7.2.3.1 Pumping Well Design

As mentioned previously, the general strategy of the Construction Dewatering Design is to remove groundwater from the alluvium underneath the tailings and drain water from the saturated tailings into the underlying dewatered alluvium. To accomplish this task, the primary infrastructure that will be utilized includes multiple pumping wells. Located underneath the tailings is a highly conductive and thick alluvial zone surrounded by less conductive and thinner alluvium. The highly conductive zone is the original Soda Butte Creek channel and will be targeted with larger pumping wells with higher production rates. The surrounding thinner and less conductive alluvium will be dewatered with clusters of smaller wells with lower production rates.

Larger Pumping Wells

Larger pumping wells will be located near the center of the tailings impoundment, with three large wells completed in the alluvial sediments underlying the tailings and two larger wells completed along the northeastern boundary of the tailings (Sheet D3 of the Construction Drawings in Appendix G). The purpose of the three large wells completed under the tailings is to remove groundwater from the alluvium underneath the tailings and from the tailings themselves, while the purpose of the two larger wells located along the northeastern boundary is to intercept large quantities of groundwater before it flows underneath the tailings.

To design the larger wells, the hydraulic conductivity of the aquifer (as determined from the 24-hour pumping test) and the reported thickness of the alluvium were utilized. Based on the hydraulic conductivity of the aquifer (approximately 120 feet per day), it was determined that a well with 40 feet of alluvium could produce approximately 200 gpm with 8 feet of drawdown (Driscoll, 1995). Using this information, the well diameter and screen were sized for maximum efficiency. With a 10-inch well, a screen with a slot size of thirty thousands of an inch (0.030) would allow an acceptable intake velocity that would also be lower than that utilized during the 24-hour pumping test (Driscoll, 1995). In addition, the inside of each larger well was designed to be very efficient with a 10-inch inside diameter (I.D.) well and a 7.4 inch outside diameter (O.D.) pump that would produce an acceptable flow velocity inside the well of less than 5 feet per second (Driscoll, 1995).

During the completion of the larger wells, it is important to complete the screen not within the tailings and within at least 40 feet of saturated alluvium. To avoid contamination and contribution of fines, the well seal for each large well should extend from the ground surface to two feet below the contact between the tailings and the underlying alluvium. In addition, if less than 40 feet of saturated alluvium is encountered during the installation of a large well, the production of the well should be maximized through the installation of a sump. The sump should be constructed and cased with PVC to a depth of approximately 10 feet into the bedrock. If the bedrock is suitably competent, the PVC casing may be omitted.

Smaller Pumping Wells

Fourteen smaller pumping wells with lower production rates will be located along the boundaries of the tailings impoundment with the purpose of intercepting groundwater from the perimeter of the impoundment before it flows underneath the tailings. In this manner, the quantity of pumped groundwater that requires treatment will be significantly reduced.

The design of the smaller wells is also based on the hydraulic conductivity of the aquifer (as determined from the 24-hour pumping test) and the reported thickness of the alluvium. Based on the hydraulic conductivity of the thinner alluvium (approximately 30 feet per day), it was determined that a well completed in 20 feet of alluvium could produce approximately 30 gallons per minute with 11 feet of drawdown (Driscoll, 1995). Using this information, the diameter and well screen were sized for maximum efficiency. With a 6-inch well, a screen with a slot size of thirty thousands of an inch (0.030) would allow an acceptable intake velocity that would also be lower than that utilized during the pumping test (Driscoll, 1995). In addition, the inside of the well was designed to be very efficient with a 6-inch I.D. well and a 4 inch O.D. pump that would produce a combined flow velocity inside the well of less than 5 feet per second (Driscoll, 1995).

During the completion of the smaller wells, it is important to complete the screen not within the tailings and within at least 20 feet of saturated alluvium. To avoid contamination and contribution of fines, the well seal for each smaller well should extend from the ground surface to two feet below the contact between any encountered tailings and the underlying alluvium. To ensure an adequate production rate, if less than 20 feet of saturated alluvium is encountered during the installation of a smaller well, the production of the well should be maximized through the installation of a sump. The sump should be constructed and cased with PVC to a depth of approximately 10 feet into the bedrock. If the bedrock is suitably competent, the PVC may be omitted.

Development of Installed Wells

Following the completion of each well, the productivity of the well will be optimized through effective well development. The purpose of the well development is threefold, as follows:

1. Repair the formation from any damage created during the drilling process;
2. Remove any naturally occurring fines located near the borehole that may inhibit the efficiency and productivity of the well; and
3. Minimize the turbidity of the pumped groundwater.

Typically, the most effective means of well development include a process of flow reversal through the screened area that will agitate the sediment, remove the finer fraction, break down any sediment bridging, and rearrange the remaining formation particles into an effective conduit for pumped groundwater. Therefore, each well will be developed with a procedure that includes flow reversal, and the well development will continue for a minimum of four hours, or until the turbidity of the groundwater falls below 5 nephelometric units (NTUs). Results from the well development will be documented and submitted to oversight personnel.

Verification of Productivity

Once each well is completed and developed, the productivity of the well will be verified with a short-duration (three hour) step-drawdown test. The purpose of this test is to ensure that the pump specified for the well is suitably sized and also to confirm that the pumping system will intercept the appropriate quantity of groundwater. Unless determined otherwise in the field, the larger wells will be pumped for an hour each at 50, 100, and 200 gpm and the smaller wells will be pumped for an hour each at 15, 30, and 60 gpm. Testing results for each well will be documented and submitted to oversight personnel.

7.2.3.2 Suggested Sequence of Dewatering and Tailings Excavation

Based on the results of the groundwater model, the Construction Dewatering Design for the Site would be most effective with a three-phase approach to divide the dewatering effort into defined stages of sequential tailings dewatering and removal. This sequence allows for lengthy dewatering of some of the more difficult areas, and diverts the focus of the initial tailings excavation effort to removing unsaturated tailings or tailings that are readily dewatered.

In Phase 1, the majority of the tailing are dewatered and tailings located within the southern half of the tailing impoundment will be excavated. Tailings located downgradient of the tailings dam toe will not be removed or even dewatered during Phase 1. Once the material behind the tailings dam has been suitably dewatered and a significant portion of tailings removed, Phase 2 will initiate dewatering and enable the removal of the southern portion of tailings located downstream of the tailings dam. It appears to be advantageous to delay Phase 2 because the area below the tailings dam is typically very saturated and difficult to work in. By allowing Phase 1 dewatering to operate, this area may become drier and subsequently more workable.

After the completion of Phase 2, Soda Butte Creek will be relocated. With the creek moved downgradient of these tailings, the losses from the existing Soda Butte Creek channel will not contribute water to the remaining tailings located along the northern boundary of the Site (just to the south of the existing Soda Butte Creek diversion). By waiting until Soda Butte Creek is relocated, these tailings should be easier to dewater and the excavation efficiency of these tailings should improve.

The proposed sequence of tailings excavation is outlined on Sheet 13 of the Construction Drawings in Appendix G. As outlined, the excavation sequence will provide the saturated tailings the maximum amount of time to dewater prior to excavation.

7.2.4 Water Treatment System (Sediment Detention Ponds)

As outlined in Section 7.2.2 and 7.2.3, the dewatering system will require the use of two sediment detention ponds to remove the sediment from the pumped groundwater during the implementation of the project. The design of the sediment ponds was based on the expected particle size and the flow rate of the system. The groundwater dewatering design assumes that 700 gpm will be intercepted prior to migrating through the Site and 350 gpm will be pumped from within the tailings impoundment. A total estimate of 1,050 gpm will be required to dewater the Site.

In designing the sediment detention ponds for the project, it was assumed that a total flow rate of 1,050 gpm would be pumped from the dewatering wells and an additional 450 gpm would be added for miscellaneous dewatering activities that may require the contractor to pump water from specific areas. Therefore, the sediment detention ponds were designed for a total flow rate of 1,500 gpm.

Based on the results of the sieve analysis conducted on the tailings, it was determined that 51.7% to 98.8 % of the tailings has a particle size less than 0.075 millimeter (mm) or 75 micrometers (µm). Base on the sieve analysis and observations during the pumping well development, it was assumed that a particle size of 8 µm would be utilized to size the sediment detention ponds. The typical size range for silts is 2 µm to 50 µm, therefore the use of a design particle size of 8 µm was considered conservative. Also, the 8 µm particle size would pass through the proposed Gunderboom system and require the need for additional retention time. The use of a flocculant will increase the settling velocity associated with the particles less than 8 µm.

During the design process, it was determined that the water from within tailings impoundment would be processed through its own sediment detention pond (Sediment Detention Pond #1) and then discharged to a second sediment detention pond (Sediment Detention Pond #2), which would be utilized to treat the water being intercepted from the perimeter of the Site. Therefore, Sediment Detention Pond # 1 was designed for a flow rate of 800 gpm and particle size of 8 µm and Sediment Detention Pond #2 was designed for a flow rate of 1,500 gpm and particle size of 8 µm. Utilizing a water depth of 6 feet, a settling velocity of 0.00019 feet per second (ft/sec) for an 8 µm particle size the detention time was calculated at 8.0 hours.

Given the size of the Site, the cross-sectional area of the sediment detention ponds was optimized. The cross sectional area of the sediment detention ponds would consist of a pond seven feet deep with a 25 feet wide bottom with interior side slopes of 3:1. The sediment pond, given these dimensions, is 67 feet wide at the top (see typical cross section on Sheet D4 of the Construction Drawings in Appendix G). Given the detention time of 8.0 hours and a flow rate of 800 gpm for Sediment Detention Pond #1 and 1,500 gpm for Sediment Detention Pond #2, Sediment Detention Pond #1 requires a length of 200 feet and Sediment Detention Pond #2 requires a length of 375 feet.

Based on the aforementioned calculations, Sediment Detention Ponds #1 and #2 were designed as shown on Sheet 14 of the Construction Drawings provided in Appendix G. Because the sediment detention ponds were placed downgradient of the isolation wall and dewatering system on the south boundary of the Site, the sediment detention ponds were designed with an HDPE liner system as outlined on Detail 7 on Sheet D4 of the Construction Drawings in Appendix G. The installation of a liner will halt the infiltration of water and the unnecessary recycling of water through the dewatering system. In addition, the sediment detention ponds were designed with a Gunderboom that will be placed in each sediment detention pond as shown on Sheet 16 of the Construction Drawings provided in Appendix G. The Gunderbooms are floating curtains that will be installed across the sediment detention ponds downgradient of the pond inlet. The Gunderbooms are capable of detaining particle sizes down to 10 microns.

Each sediment detention pond will be equipped with an outflow structure. The outflow structure will primarily consist of a 2 inch by 6 inch by 4 foot stop log (see Details 8 and 9 on Sheet D5 of the Construction Drawings provided in Appendix G). The use of a stop log system will provide the flexibility to control the elevation of the sediment detention pond, if necessary and provide aeration to the waters.

As a precaution, the dewatering control building will be designed so that pumped water can be treated with a flocculant to assist with sediment removal. The system for flocculant addition is discussed in further detail in Section 7.2.5. The use of a flocculant will increase the settling velocities of the particles ensuring sediment reduction prior to discharge.

To ensure the removal of the small particle size, the two sediment detention ponds will be operated in series. During the summer months or during construction (April through December) water pumped from within the tailings impoundment will be pumped to the dewatering control building, treated, and discharged to Sediment Detention Pond #1. It will then be discharged to Sediment Detention Pond #2, and then finally discharge to Soda Butte Creek. In addition, during the summer months or during construction (April through December), the water being intercepted from the perimeter of the Site will be pumped to the dewatering control building, treated (if necessary), and discharged to Sediment Detention Pond #2 and then to Soda Butte Creek. During winter operation (December though April) the pumps within the tailings impoundment will be turned off and only water being pumped from the perimeter of the Site will pumped to the dewatering control building, treated (if necessary), and discharged through Sediment Detention Ponds #1 and #2 and then to Soda Butte Creek. The water will be processed through Sediment Detention Ponds #1 and #2 to keep the detention ponds from freezing solid.

The amount of sludge that would accumulate in the sediment detention pond was estimated assuming a Total Suspended Solids (TSS) concentration of 25 mg/L, a dry density of the tailings of 120 pounds per cubic foot, and a flow rate of 1,500 gpm. The TSS concentration determined based on the TSS concentrations observed during the pumping test (Table 8). It was determined that a TSS concentration of 25 mg/L would best represent the waters processed from the pumping wells within the dewatering system. It was also assumed that the majority of the sludge would accumulate in the area upgradient of the Gunderboom. Based on a surface area of 2,500 square feet, it was estimated that approximately 7 inches of sludge/sediment would accumulate annually on the bottom of the sediment detention ponds upgradient of the Gunderbooms. Therefore, just prior to winter shut down, the dewatering system will be shutdown temporary and the ponds will be drained (utilizing stop logs) to remove the accumulate sediments from the sediment detention ponds. The sediment will be removed and placed in the tailings stabilization area for lime addition and placement in the repository. The contractor will utilize a vacuum truck with a dump box to remove the sludge/sediment from the lined ponds.

As a safety precaution, an eight foot security fence will be installed around the perimeter of Sediment Detention Ponds #1 and #2. The fence will keep wildlife (moose, deer, bears, etc.) from entering the lined sediment detention ponds and damaging the liner. The fence will also provide security against the public that may enter the Site after working hours or during the winter shutdown period. Snow poles will be attached to the fence posts to warn potential snowmobilers that the fence is present during the winter months.

7.2.5 Chemical Water Treatment System

The chemical treatment system will consist of natural aeration, which will be augmented by flocculation addition as needed to assist with settling the precipitates; and, pH adjustment, if necessary. The chemical treatment will occur in the dewatering control building. Flocculant will be added prior to the inlet of the first pond, the second pond, or both ponds depending on the water quality and seasonal fluctuations. In addition, pH will be monitored and adjusted (if necessary) using sodium hydroxide (NaOH). The NaOH will be added (if necessary) prior to the inlet of Sediment Detention Pond #1, Sediment Detention Pond #2, or both ponds, again depending on water quality and seasonal fluctuations.

7.2.5.1 Aeration

The water will be aerated naturally as it enters each pond. This will be achieved by free falling the water into each sediment detention pond via a stop log structure and/or pipe outlet.

7.2.5.2 pH Control

The pH meters will be located, as appropriate, within the system so that pH readings can be transmitted to the on-site control building. Depending on the pH readings, a pump controlling addition of the NaOH solution will either start or stop.

The water will be transported through a slipstream PVC pipe and the pH electrode will be installed in the pipe using in-line mounting. The design will include by-pass lines for ease of electrode removal for calibration, cleaning, and/or replacement. The transmitter will be housed in the on-site control building. The discharge line will return to the discharge stream.

If necessary, the pH will be increased for either influent stream using a 25% solution of NaOH. The first pH electrode will measure the pH of the incoming water from the tailings area. If the reading is 5.5 s.u. or lower, the NaOH pump will activate and the pH will be adjusted until the incoming waters from the tailings area have a reading of 7.0 s.u.. Once the incoming tailings water has a reading of 7.0 s.u., the pump will stop. The pH of the incoming water from the perimeter area will also be measured. If the reading is 5.5 s.u. or lower, pH adjustment will occur, similar to that described above. The pH readings will be monitored at the outlets of Sediment Detention Ponds #1 and #2. The actual trigger levels for pH adjustments may be modified in the field as necessary to achieve the discharge objectives. The final pH reading will be monitored at the effluent.

The recommended pH electrode for the Site is a Sensorex, in-line mounted, combination pH electrode with ceramic junction. The design of the electrode provides an extra barrier against reference side contamination. It has been used in applications where lime, sulfides, mercaptans, heavy metal ions, and similar materials are present. A transmitter will be selected to assist with chemical addition control.

Using the data collected in 2008, preliminary calculations were conducted using two flow rates of tailings water and one flow rate for perimeter water to estimate a pH of the blended water.

Using a 350 gpm flow of tailings water at a pH of 5.4 s.u. and blending it with 700 gpm of perimeter water at a pH of 6.93 s.u., which was an average of the piezometer readings, the pH of the total 1,050 gpm water would be approximately 5.85s.u. This assumes no other components and no buffering effects. The pH of the water from the tailings area will be increased to 7.0 s.u. using NaOH (25%). If this system operated continuously for the year, approximately 84 gallons of 25% NaOH would be required to raise the pH to 7.0 s.u. over a full year.

Using an 800 gpm flow of tailings water at a pH of 5.4 s.u. and blending it with 700 gpm of perimeter water at a pH of 6.93 s.u., the pH of the total 1,500 gpm water would be approximately 5.65s.u. This assumes no other components and no buffering effects. The pH of this stream will be increased to 7.0 s.u. using NaOH (25%). If this system operated continuously for the year, approximately 191 gallons of 25% NaOH would be required to raise the pH to 7.0 s.u. over a full year.

Given the above calculations, a pH adjustment system will be included as part of the Dewatering System Design and will be operational year round.

7.2.5.3 Flocculant

Flocculants are being considered to enhance the flow by making the suspended particles heavier and more stable. Two main groups of flocculants exist: mineral (which includes activated silica, clays, and, metal hydroxides), and synthetic (which include anionic, cationic, and nonionic compounds).

The liquid flocculant will be added to Sediment Detention Pond #1, Sediment Detention Pond #2, or both ponds depending on the water quality and seasonal fluctuations. Flocculants are being evaluated to enhance dissolved metal removal and increase the settling of very small suspended particles within the sediment detention ponds. Various vendors have been contacted and additional testing will be conducted on-site.

7.2.6 Discharge Monitoring

The water discharge from the dewatering system will be monitored continuously for pH as discussed in Section 7.2.5. The monitoring will occur at the discharge from Sediment Detention Pond # 2 prior to entering the nearby storm water control channel. During summer dewatering activities, pH, specific conductance, field iron, field manganese, and turbidity will be documented daily and weekly water quality samples will be collected and sent to the laboratory for analysis. The water quality samples will be analyzed for the following: alkalinity; pH; sulfate; TDS; TSS; hardness; and the following total metals: arsenic, cadmium, calcium, copper, iron, lead, manganese, potassium, sodium, silica, and zinc.

7.3 WASTE EXCAVATION DESIGN

The excavation design for the Site has been based on previous investigations and the Source Area Investigation and Existing Cover Soil Investigation conducted in the fall of 2008. The results of these investigations are summarized in Sections 3.1 and 3.3. The waste excavation design consists of salvaging existing cover soils, excavating waste rock materials, tailings materials, alluvial sediments, and embankment materials for a total excavation volume of 283,385 cy of materials. The total excavation volume includes lime required for stabilization and swell factors. Table 13 summarizes the total volume of waste rock, tailings, alluvial sediments, and embankment materials that will require excavation and placement in the on-site repository or haulage to an off-site disposal or reprocessing facility. The following sections discuss the excavation design in detail.

7.3.1 Salvage of Existing Cover Soils

Based on the results of the existing cover soil investigation, it has been determined that the cover soil currently installed over the tailings impoundment could be salvaged and amended with compost to provide a product adequate for the reclamation of the Site. Results of the Existing Cover Investigation are discussed in Section 3.1. In addition, the use of the existing (salvaged) cover soil minimizes the volume of soil required to be excavated from the on-site repository (discussed in Section 7.4).

By utilizing the existing cover soil depths measured in the cover soil borings, test pits, and piezometers, the volume of available existing cover soil that could be salvaged from the tailings impoundment area for the reclamation of the Site was determined. The data was utilized to create the bottom surface of the existing cover soil, as shown on Sheets 8 to12 of the Construction Drawings provided in Appendix G. Based on the final excavation surface for the existing cover soil, it is estimated that 32,500 bcy of existing cover soil can be salvaged from the tailings impoundment area. The salvage of this cover soil has been incorporated into the reclamation design.

7.3.2 Waste Rock Excavation

Based on investigations conducted for the Draft Final Expanded Engineering Evaluation/Cost Analysis (EEE/CA) for the McLaren Tailings Site Cooke City, Montana (DEQ/MWCB-Pioneer, 2002) and the source area investigation conducted in the fall of 2008, depth of waste rock measurements from test pits were utilized to determine the waste rock excavation design. Based on the investigation results, there were two areas that were identified to be waste rock. The first area is located on the northeast corner of the Site (refer to Sheet 5 and 6 of the Construction Drawings provided in Appendix G). The second area is located on the south side of Soda Butte Creek just west of the existing low water crossing. The depth of waste rock measurements were utilized to construct the waste rock excavation surface for the materials located in the northeast corner of the Site as shown on Sheets 8 to 12 of the Construction Drawings provided in Appendix G. The boundaries of the excavation were held to the DEQ property boundary and avoided areas around overhead electric poles. Based on the waste rock excavation design, an estimated 23,500 bcy of materials will be removed and utilized to construct temporary haul roads, lime storage pads, tailings stabilization pads, etc. However, the waste rock materials will ultimately be placed in the on-site repository. The removal of the second location containing waste rock materials was incorporated into the tailings impoundment excavation shown on Sheets 8 to 12 of the Construction Drawings provided in Appendix G. It estimated that there is an additional 10,650 bcy of waste rock materials to be removed from this area. A summary of the excavation volume for the waste rock materials (including swell) is outlined in Table 13.

7.3.3 Tailings Excavation

Based on the results of the Source Area Investigation discussed in Section 3.3 and the depth of tailings measured in the test pits and piezometers, a bottom of tailings surface was determined. The bottom of tailings surface is shown on Sheets 9 through 12 of the Construction Drawings provided in Appendix G. Based on the final excavation surface for the tailings, it is estimated that 160,177 bcy of tailings will need to be removed from the tailings impoundment. Based on the required lime addition for stabilization, as well as swell, it is estimated that 176,875 cy of tailings will need to be placed in the on-site repository or hauled to an off-site disposal site or reprocessing facility. A summary of the excavation volume for the tailings materials, including lime addition and swell, is outlined in Table 13.

7.3.4 Alluvial Sediment Excavation

Based on the soil analytical results of the alluvial sediments collected during the Source Area Investigation as discussed in Section 3.3, it was determined that a minimum of 12 inches of impacted alluvial sediments should be removed from directly beneath the tailings excavation surface. Based on the final excavation surface for the alluvial sediments, it is estimated that 15,000 bcy (approximately 17,250 cy, including swell) of alluvial sediments will need to be removed from the tailings impoundment footprint and placed in the on-site repository. A summary of the excavation volume for the alluvial sediments, including the swell, is outlined in Table 13.

7.3.5 Embankment and Stream Side Materials Removal

Based on previous investigations, and the source area investigation conducted in the fall of 2008 at the Site, it was determined that the existing tailings dam and materials located immediately downgradient from the existing embankment consist of impacted soils that require removal and placement in the repository. In addition, it was determined that the materials within 25 feet of the south side of Soda Butte Creek consist of impacted soils and would require removal and placement in the repository. Based on the excavation grades shown on Sheets 9 to 12 of the Construction Drawings provided in Appendix G, it is estimated that removal of the existing embankment and the downgradient materials will require excavation of 37,000 bcy of materials and the removal of the stream side soils will require excavation of 3,500 bcy of materials. Based on the lime addition and swell, it is estimated that 43,467 cy of materials from the existing embankment and stream side sediments removal will need to be placed in the on-site repository. A summary of the excavation volume for the existing embankment and stream side sediments, including lime addition and swell, is outlined in Table 13.

7.3.6 Excavation Sequence

As part of the excavation design, an excavation sequence has been developed for the project. The primary objectives for the development of the excavation sequence were as follows:

excavate tailings in conjunction with the dewatering activities at the Site and minimize the impacts to Soda Butte and Miller Creeks as the excavation is being implemented. The excavation sequence consists of excavating the materials from the south to the north in an east to west direction as shown on Sheet 13 of the Construction Drawings provided in Appendix G. The excavation sequence in conjunction with timing reconstruction of the new Soda Butte and Miller Creek channels provides isolation between the current Soda Butte Creek and Miller Creek Channels during excavation activities. Based on the excavation sequence, in conjunction with estimated daily production rates, it is estimated that the reclamation project will take 5 construction seasons to implement.

7.4 REPOSITORY DESIGN

7.4.1 Background

As indicated in the *Draft Final Expanded Engineering Evaluation/Cost Analysis for the McLaren Tailings Site, Cooke City, Montana* (MDEQ/Pioneer, 2002), the preferred reclamation alternative involves removing and permanently disposing of all on-site wastes (tailings, waste rock, impacted soils, etc.) in an engineered repository constructed on-site. The repository does not include a bottom liner system, but includes an impermeable, multi-layered cap to limit infiltration. The proposed repository would be located immediately southwest of the tailings impoundment, on the timbered bench above the south bank of Soda Butte Creek (refer to Figures 2 and 4).

7.4.2 McLaren Repository Site General Characteristics

Groundwater beneath the proposed repository location has been monitored since 2005, when three monitoring wells were drilled within the repository footprint to determine the depth to groundwater in the area. The wells were drilled to a total depth of approximately 40 feet bgs to determine the vertical separation between the floor of the repository and the underlying groundwater. Static water levels (SWL) within these three wells were measured from 2005 through 2007 by the DEQ. Although small quantities of water have been measured at the bottom of each of the wells, the data indicate that the water contained within the casings of two of the wells may consist of condensation (or weeping moisture) that has collected within the well points. However, the monitoring well located within the southeastern portion of the repository footprint (MW-1) experienced a spike in the SWL during the spring/summer of 2006, indicating that a zone of actual groundwater in that area may rise temporarily during high groundwater conditions. In any event, the data indicate that the floor of the repository would be vertically separated from groundwater (during high groundwater conditions) by a minimum distance of approximately 14 feet near the location of MW-1, and likely greater than 20 feet near the location of the other wells (MW-2 and MW-3), based on the data collected between 2005 and 2007.

The repository location was further evaluated by Pioneer in 2008 to determine its suitability as a repository site from an engineering perspective. Key features evaluated to determine its suitability as a repository site included overall static and pseudo-static (seismic) stability, depth to bedrock, ability of the area to produce quality cover soil for revegetation purposes, rock content of the soil and overall capacity available to dispose of mine wastes.

In 2008, 19 test pits were excavated within the repository footprint to total depths ranging from 11 to 21 feet bgs. The subsoil within the repository area consists of glacial till that is classified as sandy loam. The soil exhibits low metals values, low electrical conductivity, neutral pH, low organic matter content, and rock content generally increases with depth (refer to Tables 1 through 5). Overall, the repository area subsoil is considered suitable as cover soil (in compliance with DEQ Standard Specifications) for the repository cap and general reclamation of the Site. Deeper soils within the repository area contain a fairly high percentage of rock; however, the repository excavation can be limited in depth to avoid the majority of the high rock content soils. Additionally, the soil can be amended with organic amendment to overcome the low organic matter content.

7.4.3 Stability Analysis

7.4.3.1 Background

The stability of steep slopes and the potential for slope failures are important considerations for any construction project where movements of existing natural slopes or designed slopes would have an adverse effect on people, structures or the environment. Currently stable natural slopes can be impacted by both human actions (new construction) and natural changing conditions. Some typical human induced changes include adding an additional load to the top of a slope, such as a building or, in the case of the reclamation project, a large soil mass in the form of stabilized tailings deposited within the repository. Natural changes include such things as earthquakes and erosion, either of which could impact the repository.

The proposed location of the repository is on a bench approximately 50-feet in elevation above, and on the south side of Soda Butte Creek. This location raises concern for both the potential effect of the additional weight imposed on the bench by the repository fill, as well as the effect of continued erosion of the base of the slope by Soda Butte Creek. Additionally, the impact of an earthquake(s) must be evaluated for any engineered structure located in a seismic impact zone such as southwestern Montana. Stability analyses have been performed to evaluate the stability of the repository site in its current condition under both static and seismic conditions, and also following placement of over 250,000 tons of stabilized tailings, waste rock and cover soil within the repository area. The methods used to evaluate overall stability are described below.

7.4.3.2 Methods Used to Evaluate Stability

To evaluate the stability of a soil or rock slope, the strength of the soil materials must be measured via: 1) laboratory tests; 2) estimated based on published data for similar materials; or 3) derived from field observations. In the case of the proposed McLaren Repository, no laboratory strength tests pertaining to the natural soils within the repository area or the lime-stabilized tailings materials have been conducted. However, the materials have been sufficiently characterized to allow estimates of their strength properties to be derived from published data pertaining to similar materials. Perhaps the most reliable method of determining the strength or stability of a landform is from observation and measurement of past behavior. The existing natural slope extending from the repository area down to Soda Butte Creek shows signs of minor instability and recent movement as evidenced by the lack of vegetation in a number of localized places. This slope exhibits an angle of up to 41° from horizontal, which is slightly steeper than a commonly accepted maximum value of 38° for coarse sand and gravel. For the purpose of analyzing the stability of the natural slope near the repository area, a friction angle of 38° has been assigned. A more conservative value of 30° has been assigned for the lime-stabilized tailings.

A simplified way to envision the meaning of *friction angle* is the analogy of a block on an inclined plane. At some angle, depending upon the friction characteristics of the block and the plane materials, the block will reach limiting equilibrium where the force of gravity trying to move the block down the plane is balanced by the friction resistance between the two materials. The angle at which this occurs is known as the *friction angle*. Similarly, for cohesionless soils such as sand and gravel (typical of the natural soils within the proposed repository area) there is a maximum angle at which the soil's internal particle-to-particle friction can resist the force of gravity.

When no forces other than gravity are acting on a slope this condition is considered *static*. However, when an earthquake occurs, a seismic force is added to the force of gravity. The seismic force that an earthquake exerts at the Earth's surface is expressed as a percentage of the force produced by gravity (g). The United States Geological Survey (USGS) has compiled probabilistic earthquake ground motion maps of the United States that indicate the estimated probability and magnitude of earthquake-generated seismic forces. For the Cooke City area, these maps estimate a 10% probability that an earthquake producing 0.25g horizontal acceleration will occur during any 250 year interval. Another way of stating this is that an earthquake of 0.25g magnitude will have a return period of once every 2,500 years.

Stability analyses were performed under both static and pseudo static (seismic) conditions using presumptive soil strength parameters for the McLaren Repository. The computer program SLIDE (developed by Rocscience of Toronto, Canada) was utilized to perform stability analyses of the existing repository location (in its natural condition), as well as the condition of the Site after the stabilized tailings and the repository cap have been placed. This program performs two dimensional limit equilibrium analyses for soil and rock slopes by a number of established methods including Bishop, Janbu and Spencer.

The program divides the cross-section into slices and then generates several thousand possible circular failure paths through the slope and computes the sum of forces resisting movement as well as those producing movement (gravity and seismic forces). The ratio of resisting forces to driving forces is defined as the factor of safety (FS). Any FS value less than 1.0 indicates movement (i.e., failure). SLIDE computes the FS for each circular failure path and searches for the surface with the minimum FS.

Results can be displayed showing all the surfaces analyzed, or filtered to display only those surfaces within a specified range of FS, such as all surfaces with a FS less than 1.5, as shown on Figure 8, which depicts the existing, natural repository area configuration. Figure 8 shows that a failure path with a minimum FS of 1.004 as a very shallow surface on the slope above Soda Butte Creek under static conditions. All of the failure paths with a FS less than 1.5 are also depicted on Figure 8.

The two-dimensional model used for the stability analysis utilized a typical cross section through the repository and underlying soils. The cross-section at Station 2+00 depicts an area where the existing natural slope from the repository area extending down toward Soda Butte Creek exceeds 40° from horizontal and is at or near limiting equilibrium as evidenced by the limited vegetation on the slope and signs of erosion (in areas). Since no site-specific strength data is available for the soils from the repository area, a presumptive value of 38° was selected based on existing slope angles and the commonly accepted maximum value of 38° for coarse sand and gravel. Similarly, shear strength of the lime-stabilized tailings was based on typical values for dry silty sands and gravels. Material densities were obtained from laboratory testing of soils collected from the repository area and from the tailings.

7.4.3.3 Repository and Surrounding Area Stability Analysis

Figures 8 through 10 present the results of the stability analyses of four scenarios evaluated: existing, natural slope - static conditions; existing, natural slope - seismic conditions; static conditions with constructed repository included; and, seismic conditions with constructed repository included. The analyses indicate that the existing, natural slope situated between the repository and Soda Butte Creek would be unstable under the design seismic event. Failure of the existing slope above would break back to the south (toward the proposed repository location) an estimated 30 feet (measured horizontally) at the top of the bench. The wastes disposed in the repository (repository embankment) are estimated to be stable under the design seismic event due to the gentle design slope of 5H:1V. Construction of the repository in the proposed location would produce only a slightly increased probability of failure of the natural slope, as indicated by the slightly lower minimum FS associated with the slope when the repository is included compared to the slope in its existing, natural condition.

The predicted magnitude of the soil slope failure under seismic conditions destroys much of the 50-foot buffer between the edge of the repository and the edge of the bank above Soda Butte Creek. If this were to happen, it would be necessary to reinforce the bank of Soda Butte Creek to prevent future slope failures and/or prevent Soda Butte Creek from migrating south, toward the repository. Alternatively, if the predicted failure of the natural slope occurs in the future, some or all of the disposed wastes could be relocated.

It is important to note that a seismic event that would produce a horizontal ground acceleration of 0.25g would likely cause significant damage to all infrastructure in the Cooke City area, including buildings, highways, power lines, etc. Additionally, other steep slopes in the area may experience major land slides

7.4.3.4 Repository Cap Stability Analysis

The repository design includes an engineered cap to prevent infiltration of precipitation. In addition to the stability of the entire repository embankment, it is necessary to evaluate the stability of the cap under both static and seismic conditions. The most common type of failure on composite cap systems is between the interfaces of the various materials comprising the cap. Each of the interfaces associated with the McLaren repository cap design was analyzed individually to assess interface stability. This analysis was done manually and utilized the simplified concept of the block on the inclined plane. For an infinite slope consisting of cohesionless interfaces, the FS against sliding is defined as:

$$FS = \tan\delta / \tan\beta$$

Where: δ = friction angle; and
β = slope angle (Koerner p 82).

The cap consists of four interfaces beginning with the 3-feet of cover soil/geocomposite drainage layer, followed by the geocomposite/ texture HDPE liner, then the HDPE/geotextile cushion and lastly the geotextile/repository fill (See Sheet D8 of the Construction Drawings provided in Appendix G). Since there are no material-specific shear strength data available for the four interfaces involved, published data for similar material interfaces have been utilized in the analysis. While a large body of available data of interface shear strengths exists from both vendors and in text books such as Robert M Koerner's *Designing with Geosynthetics* (Koerner, 1990), the results vary substantially and material specific tests are preferable.

Both static and pseudo static stability of the proposed repository cap were evaluated. As shown on the table below, all of the interfaces are stable under both static and seismic conditions. The FS is computed as the ratio of the tangents of the friction angles of the interface to the slope angle.

Stability Analysis of Proposed Repository Cap

Interface	Data Source	Friction Angle	FS Static Conditions	FS Seismic Conditions
Cover Soil / Geocomposite	Koerner pg. 83	26°	2.44	1.07
Geocomposite / Textured HDPE	CETCO Avg. of 6 tests	28°	2.66	1.17
Textured HDPE / Geotextile	CETCO Avg. of 6 tests	28°	2.66	1.17
Geotextile / Subgrade	Koerner pg. 83	30°	2.89	1.27

7.4.3.5 Repository Design Recommendations

Based on the marginal stability of the natural slope situated between Soda Butte Creek and the McLaren Repository, Pioneer recommends that the northern boundary of the repository be offset from the crest of the slope a minimum of 50 feet (measured horizontally) to account for the predicted failure of the slope under the design seismic event. Additionally, the toe of the slope should be protected from further stream erosion by armoring the bank with large rock. This armoring must be designed to prevent any additional erosion or stream migration toward the south, resulting in a subsequent slope failure. Alternatively, provisions should be made to relocate some or all of the stabilized tailings subsequent to any significant slope failure that reduces the buffer zone distance between the repository and Soda Butte Creek.

The presumptive data utilized in analyzing the interface shear strengths of the cap predict that the cap is stable (marginally) under the design seismic event. Laboratory testing using the specified cap materials may yield results that would validate steeper repository slopes.

7.4.4 Repository Configuration and Capacity

Design constraints applicable to determining the configuration (and ultimately the capacity) of the McLaren Repository, include the following:

- The repository shall be completely contained within the property currently owned by the State of Montana;
- The northern boundary of the repository shall be offset from the crest of the slope situated directly to the north by a minimum distance of 50 feet (measured horizontally);
- Excavation of the repository footprint (to provide cover soil for reclamation purposes) shall be as shallow as possible to avoid deeper soils with higher rock content;
- For seismic stability reasons, side slopes of the repository embankment shall be limited to a maximum steepness of 5H:1V;
- The repository should not encroach on the existing rock outcrop located near the eastern boundary of the repository area; and
- The repository should not encroach on designated areas needed for on-site facilities during construction (soil stockpile areas, retention ponds, etc.).

Given the design constraints identified above, the maximum area that can be occupied by the repository is approximately 5 acres, as shown on Sheet 18 of the Construction Drawings provided in Appendix G. The first step involved with developing the repository includes harvesting the existing timber in the area. Although the repository footprint will be limited to a maximum surface area of approximately 5 acres, a larger area of timber should be harvested (8 to 10 acres, which includes extending up the steep slope located along the southern boundary of the repository) to allow sufficient area for stockpiling excavated soil, establishment of haul roads, construction of anchor trenches for cap materials, construction of storm water controls, and to allow adequate space for maneuvering heavy equipment during construction. A buffer zone of trees will remain along the north boundary of the proposed repository.

7.4.4.1 Repository Excavation Design

Excavation of the repository (to produce an adequate quantity of cover soil for the project) will be limited to a maximum average depth of approximately 13.5 feet to avoid deeper soils containing a higher percentage of rock. The coarser soils that are excavated from the repository area will be utilized to construct containment berms within the existing dry channel that traverses the repository area in an east-west direction. The containment berms will be constructed on the extreme eastern and western boundaries of the repository (as shown on Sheets 19 and 26 of the Construction Drawings provided in Appendix G). These containment berms (dams) are necessary to allow construction of anchor trenches (for cap materials) along uniformly sloping ground, and to contain runoff water (that contacts the wastes disposed in the repository) within the repository footprint during the initial phases of development of the repository.

During the excavation of the repository, materials containing a higher percentage of rock will be utilized to backfill the existing channel that traverses the repository area. The existing channel will be backfilled to the grades and lines outlined on Sheets 19 through 26 of the Construction Drawings in Appendix G. The existing channel is being backfilled to provide a greater separation from the repository bottom and the estimated high groundwater elevations. Backfilling the channel with an additional ten feet of materials in the location of Test Pit RA-19 (Figure 4) results in a separation of 18 feet between the repository bottom (wastes) and the estimated high groundwater elevations. This separation is outlined in the typical repository cross section (Station 3+60) shown on Sheet D8 of the Construction Drawings in Appendix G.

The repository excavation design is depicted on Sheet 17 of the Construction Drawings in Appendix G. The configuration shown results in a total excavation volume of 50,500 cy, which results in an adequate volume of cover soil (plus contingency) to perform all planned reclamation activities at the Site. Approximately 8,000 cy of the coarser repository soils will be utilized to construct the containment berms within the existing dry channel and fill the existing channel.

7.4.4.2 Repository Embankment Design

All waste materials placed in the repository will be subject to compaction specifications. Compaction shall be achieved by using appropriate compaction equipment to attain 95 percent of Standard Proctor Maximum Dry Density, at ±3 percent of optimum moisture content. Development of the repository embankment will include continuous grading to provide positive drainage, and side slopes will be limited to a maximum steepness of 5H:1V.

The repository embankment design/configuration is presented on Sheet 18 of the Construction Drawings provided in Appendix G. The cross-sections of the repository are shown on Sheets 19 to 26 of the Construction Drawings provided in Appendix G. This configuration results in a maximum capacity of 196,000 cy of waste materials that can be disposed within the repository.

7.4.5 Interim Cap Design

During the winter shutdown period(s) associated with the project, the wastes contained within the repository will be covered with a 8-mil reinforced BB (black on black colored) liner to minimize contact of snow melt and storm water with the wastes contained in the repository and to minimize erosion. This may not be necessary for the first winter shutdown period, since the existing dry channel (and downstream containment berm) within the repository footprint will serve to contain all runoff water within the repository footprint (which can then be pumped to the dewatering system, if necessary). However, as construction of the repository embankment progresses, the dry channel will eventually be filled and it will be necessary to cover the repository wastes during the winter shutdown period(s).

The interim cap will be installed prior to winter shutdown. The 8-Mil reinforced BB liner will be placed over the repository footprint. The liners seams will be sewed per the manufacturer's recommendations and the liner held down with a sand bag grid system. At the start of construction the following year the liner materials will be removed from the repository footprint and salvaged and/or disposed of off-site. The following are the 8-Mil Reinforced BB Liner specifications.

8-Mil Reinforced BB Liner Properties

Material Properties	Test Method	Specified Values
Thickness, mils	ASTM D1593	8
Tensile-Minimum Properties	ASTM D 751	52 lbf.
Grab Tensile`	ASTM D 751	70 lbf.
Elongation at Break %	ASTM D 751	600
Tear Resistance, lbs. min	ASTM D 4533	55 lbf
Low Temperature Degrees C	ASTM D1790	-57
Mullen Burst	ASTM D 751	100 psi
Hydrostatic Resistance, psi, min	ASTM D751	70
Perm Rating	ASTM E96	0.066 US Perms

7.4.6 Final Cap Design

The repository cap design includes the following components (see Sheet D8 of the Construction Drawings provided in Appendix G):

- Compaction and finish grading of the disposed waste materials to provide positive drainage (no ponding areas);

- Installation of a heavy (16 ounce [oz]/square yard [s.y.]) geotextile cushion placed directly over the prepared subgrade (uppermost lift of mine waste in the repository) to provide puncture and shear protection for the overlying synthetic cap materials;

- 60-mil textured High Density Polyethylene (HDPE) liner placed directly over the geotextile cushion to provide an infiltration barrier for precipitation/runoff (HDPE is chemically compatible with the lime used to stabilize/dehydrate the wastes disposed in the repository);

- Geocomposite drainage material, consisting of synthetic geonet drainage material with non-woven geotextile filter fabric thermally bonded on both sides of the geonet, placed directly over the GCL to allow infiltrating precipitation to drain laterally across the repository; and

- Placement of a 3-feet thick layer of cover soil to function as the vegetated component of the cap.

7.4.6.1 Repository Cap Materials Specifications

Product specifications applicable to the materials installed as part of the McLaren Repository cap construction shall be as follows:

GEOCUSHION

Material Property	Test Method	Units	MARV[1]
Weight	ASTM D5261	oz/s.y.	16
Grab Tensile	ASTM D4632	lbs	380
Grab Elongation	ASTM D4632	%	50
Puncture Strength	ASTM D4833	lbs	240
Trapezoidal Tear	ASTM D4533	lbs	145
Mullen Burst	ASTM D3786	psi	800

[1]MARV = Minimum Average Roll Value

TEXTURED HDPE LINER

Material Property	Test Method	Units	Value
Thickness (nominal)		mils	60
Thickness (min. average)	ASTM D5994	mils	57
Yield Strength		lbs/inch	126
Break Strength	ASTM D4833	lbs/inch	90
Break Elongation		%	12
Yield Elongation		%	100
Tear Resistance (min. average)	ASTM D1004	lbs	42
Puncture Resistance (min. average)	ASTM D4833	lbs	90
Carbon Black Content	ASTM D1603/D4218	%	2.0 – 3.0
Density (min. average)	ASTM D1505/D792	g/cc	0.940
Stress Crack Resistance	ASTM D5397	hr	200
Dimensional Stability (max. average)	ASTM D1204	%	± 2
Seam Properties 1. Shear Strength 2. Peel Strength	ASTM D4437	lbs/inch	120 88 & FTB

In addition to the materials properties specified above for textured HDPE liner, the installer of the HDPE liner material shall be properly qualified, as follows:

1. The Installer shall have installed a minimum of 10,000,000 square feet of HDPE geomembrane during the last 5 years. The installer shall have been in business under the same name for at least the last 5 continuous years.
2. The Installer shall have worked in a similar capacity on at least 10 projects similar in size and complexity to the McLaren Repository project.
3. The Master Welder shall have completed a minimum of 1,000,000 square feet of geomembrane seaming work using the type of seaming apparatus proposed for use on the McLaren Repository project.

GEOCOMPOSITE

Material Property	Test Method	Units	Value
Geocomposite			
Transmissivity[1] (15,000 psf)	ASTM D4716	Gal/min/ft	0.48
Ply Adhesion	ASTM D413 or F904	lbs/inch	1.0
Geonet			
Density	ASTM D1505	g/cm^3	0.94
Carbon Black Content	ASTM D4218	%	2.0
Thickness	ASTM D5199	Inches	0.200
Mass per unit area	ASTM D5261	lbs/sf	0.162
Transmissivity[1] (15,000 psf)	ASTM D4716	m^2/sec	90
Tensile Strength	ASTM D5035	lbs/inch	45
Geotextile			
Weight	ASTM D5261	oz/s.y.	6
Mullen Burst	ASTM D3786	$lbs/inch^2$	$\pm$ 2
Grab Strength	ASTM D4632	lbs	160
Puncture	ASTM D4833	lbs	90
Water Flow Rate	ASTM D4491	$Gal/min/ft^2$	110
AOS	ASTM D4751	Sieve size	70

[1] Measured using water @ 20° C with a gradient of one, between two steel plates, after one hour.

The installer of the liner system shall follow the materials installation procedures provided in the Technical Specifications in Appendix F.

7.4.7 Repository Storm Water Run-on/Run-off Controls

The existing dry channel that traverses the repository footprint will be maintained during the initial phases of development of the repository to contain storm water. The downstream (west) soil containment berm constructed within the existing dry channel will prohibit collected snow melt and storm water within the repository from flowing downstream and off-site (which can then be pumped to the dewatering system retention ponds, if necessary).

The repository run-on control ditch located on the southern boundary of the repository has been designed to prevent run-on to the repository cap and to prevent infiltration into the compacted repository embankment. The cross-section of the repository run-on control ditch (V-ditch) will be formed by proper grading of the south side slope of the repository embankment (5H:1V) in conjunction with the slope of the natural ground (typically 2H:1V), which the repository embankment ties into along the southern perimeter. The southern perimeter run-on control ditch will be lined with geotextile cushion and HDPE liner (extended from the repository cap), and covered with a 12-inch thick layer of riprap bedding material and a 24-inch layer of riprap. The repository run-on control ditch has been designed to contain the 25-year, 24-hour storm event (standard design event for sizing storm water conveyance systems for land disposal facilities as determined by the EPA [40 CFR 264]).

7.4.7.1 Run-on Control Ditch Materials Specifications

Specifications applicable to the materials installed as part of the McLaren Repository run-on control ditch construction shall be as follows:

Riprap Bedding Material

Used directly beneath areas specified to receive riprap. Apply at 12-inch minimum thickness under riprap. Riprap bedding material shall meet the gradation requirements listed below:

TABLE OF GRADATION
Riprap Filter Bedding Material

Sieve Size	Percentage (by weight) Passing Square Mesh Sieves
4"	100
1½"	65 – 95
No. 4	5 – 35
No. 200	0 – 5

Riprap

Riprap shall consist of solid, durable, and nonfriable rock that is free of thin, slab-type rock, with a minimum specific gravity of 2.65. Riprap material shall meet the gradation requirements listed below:

TABLE OF GRADATION
Riprap

Equivalent Spherical Diameter (inches)	Percent Passing
7 - 8	100
4 - 5	50
2 - 3	15
1 - 2	0

7.5 TAILINGS STABILIZATION DESIGN

In order to place the excavated tailings in the on-site repository and/or transport the tailings materials off-site, it will be necessary to initially stabilize/dehydrate the tailings materials. Based on the geotechnical investigation conducted during the fall of 2008, it was determined that the tailings materials exhibit moisture content ranging from 21.1% to 49.3% (see Section 3.6). In addition to the geotechnical testing of the tailings materials, bench scale testing was conducted to identify the quantity of lime required to stabilize/dehydrate the tailings materials and how long it would need to marble (cure) before the stabilized materials could be placed and compacted in the repository. Based on the results of the bench scale tests, it was determined that tailings materials with a moisture content of less than 30 percent would require a lime addition of 3% by weight and tailings materials with a moisture content greater than 30% would require a lime addition of 5% by weight. It was also determined that the stabilized materials would be required to cure for 24 hours (minimum) before being placed and compacted in the repository.

Given the results of the bench scale testing, the design objectives for the Tailing Stabilization Design are as follows:

- Design a system capable of mixing 3% to 5% lime materials (by weight) to tailings;
- Minimize the dust associated with working with lime products;
- Design a system that is flexible;
- Design a system that is capable of stabilizing/dehydrating the tailings so they can be transported off-site and/or placed and compacted in the repository;
- Design a system with the necessary quality controls; and
- Design a system with the productivity required to complete the project in a timely manner.

7.5.1 Tailings Stabilization Method

The tailings stabilization method for the reclamation project will utilize a stabilization system developed by ALLU Finland Ltd. At the turn of the 21st century, ALLU Finland Ltd. was involved in several equipment engineering projects for mass stabilization. In cooperation with the largest construction companies and research institutions, they have developed reliable and effective equipment for processing soft, non-bearing soils. As a result of this research and development effort, ALLU Finland Ltd. has launched several products for mass stabilization, such as a complete mass stabilization system.

The tailings stabilization method will utilize ALLU's PF-Pressure Feeder, PM-Power Mixer, and DAC control system coupled with a hydrated lime and/or quick lime amendment products to stabilize/dehydrate the tailings, existing embankment, and stream side materials associated with the project. The ALLU pressure feeder, power mixer, and DAC controls can be operated with 200, 300, and 500 series trackhoes. Given the stability of the tailings materials and the contractor's availability to 300 series trackhoes, the PM 300 power mixer will be utilized for stabilization of the tailings. The contractor will be required to have two complete systems at the Site for stabilization and an extra power mixer on hand.

The ALLU equipment has the capability of mixing the tailing in-situ or in a windrow scenario. In areas were the tailings are less than 10 feet in thickness, the contractor will stabilize the tailings in place. In areas where the tailings materials are thicker than 10 feet, the contractor will be allowed to excavate the materials and haul them to the stabilization area for mixing in a windrow/stockpile scenario. Stabilized tailings, whether mixed in place or in windrows at the stabilization area, will be placed in windrows at the tailings stabilization area and allowed to marble for a minimum of 24 hours before placing and compacting the materials in the repository, or before transporting them off-site.

The ALLU equipment will require the use of hydrated lime and/or quick lime powder to stabilize the tailings. The actual mixing takes place within the soils and minimizes lime dust generation.

7.5.2 Lime Amendment Estimated Quantities and Specifications

Based on the bench scale results, it was initially determined that the preferred lime amendment would be quicklime and/or 3/8-inch crushed lime because it would require a lesser quantity of product to meet the stabilization/dehydration objectives and would minimize the amount of dust that is generated. However, the ALLU equipment will require the use of a fine grained lime amendment such as hydrated lime, quick lime powder or Lime Kiln Dust (LKD). The use of hydrated lime or quicklime powder would be similar to that of the quicklime pellets utilized in the bench scale tests. Hydrated lime and quick lime in a powder form would be the preferred lime amendment because the bench scale test indicated that a significantly greater quantity of LKD would be required to achieve adequate stabilization/dehydration. This was confirmed by the analytical results applicable to the tested lime products. Analytical results indicate that the percent Calcium Oxide (CaO) of the LKD was about 60% of the quicklime and crushed lime (see Table 10). Therefore, the lime amendment utilized for the stabilization/dehydration of the tailings must have a CaO content of 85% or greater and be in a powdered form to achieve results similar to the bench scale testing.

Based on the excavation volume summarized in Table 13, it has been estimated that approximately 11,700 tons of lime amendment will be required to stabilize the tailings materials and the impacted soils associated with existing embankment and stream side soils.

7.5.3 Lime Amendment Sources

There are three lime sources that could be utilized for the reclamation project. The lime amendment sources are as follows:

- Graymont - located in Townsend, Montana (403 miles from Cooke City);
- Wyoming Lime Producers - located in Frannie, Wyoming(125 miles from Cooke City); and
- Pete Lien & Sons, Inc. - located in Rapid City, South Dakota (469 miles from Cooke City).

Due to the distance involved with utilizing the Graymont and Pete Lien & Sons sources, it is assumed the Wyoming Lime Producers facility would be utilized to supply lime amendments for the reclamation project. However, given the lime amendment availability it may be necessary to utilize the Graymont and Pete Lien & Sons, Inc. suppliers.

7.5.4 Conceptual Lime Amendment Facilities Layout

The lime amendments will be delivered to the Site in pneumatic trucks and off loaded into the on-site lime storage guppies discussed in Section 7.1.6. It is estimated that stabilization activities will consume approximately 60 to 80 tons of lime per day. This production rate will require three loads of lime amendment to be delivered each day. The ALLU PF Pressure Feeder will be pneumatically loaded from the storage guppies to the pressure feeder tanks. The lime storage area and storage guppy configuration can be seen on Sheet 4 of the Construction Drawings provided in Appendix G.

7.6 SODA BUTTE CREEK/ MILLER CREEK ISOLATION/DIVERSION

As detailed in Section 7.3.6, the proposed waste excavation sequence provides for isolation of Soda Butte and Miller Creeks during the excavation activities. The area south of Soda Butte Creek and Miller Creek will be utilized as the tailings stabilization area as shown on Sheet 4 of the Construction Drawings provided in Appendix G. To ensure that stabilized tailings do not enter Soda Butte Creek during construction, silt fence will be placed along the crest of the bank as a BMP. During winter shutdown periods, all stabilized tailings will be removed from the tailings stabilization area and placed and compacted in the repository. Once the tailings and embankment materials have been removed, and the newly constructed Soda Butte and Miller Creek channels have been completed, work long the existing Soda Butte Creek by-pass channel will commence.

It will be necessary to divert the Soda Butte Creek to conduct work on the west end of the Site. During the initial reconstruction of Soda Butte Creek, at Station 13 +50 and the adjacent waste removals, Soda Butte Creek will be diverted to the north of the existing Soda Butte Creek by-pass channel as shown on Sheet 31 of the Construction Drawings provided in Appendix G. The current alignment is conceptual and would be refined during the final design process. Soda Butte Creek will either be diverted into a closed pipe or lined channel sized for a 5 year, 24 hour Type II storm event. The diversion will operate only for a short period of time. When the work has been completed, Soda Butte Creek will be diverted back into its original channel, and the diversion structure will be removed and revegetated.

In addition to the diversion, stream bank protection will be installed along the south side of the Soda Butte Creek channel (see Sheet D10 of the Construction Drawings provided in Appendix G).

7.7 SODA BUTTE CREEK AND MILLER CREEK RECONSTRUCTION DESIGN

Soda Butte Creek formerly occupied a channel beneath the present tailings site, but in 1969 it was diverted to the north to bypass the tailings impoundment. One goal of the project will be to develop a stream design that will facilitate development of suitable habitat for fish, macro invertebrates, and other aquatic life via natural stream processes. The development of suitable habitat will depend in large part on the initial design and construction of the stream channel as well as subsequent natural processes of erosion, deposition, and vegetation establishment. No special measures will be taken to specifically create habitat in the newly constructed channel, rather the channel will be designed to allow creation of suitable habitat through subsequent natural processes.

The following sections discuss the design criteria, objectives, and the initial Soda Butte and Miller Creek alignments and reconstruction.

7.7.1 Design Objectives

The design objectives for reconstruction of Soda Butte Creek and Miller Creek are as follows:

- Design/develop a stable functioning land form.
- Develop a stream design that will facilitate development of suitable habitat for fish, macro invertebrates, and other aquatic life via natural stream processes.
- Use reference reaches to help guide the design components.
- Complete hydrology modeling using HEC-RAS and RiverCAD to determine stability, scour, sinuosity, etc., applicable to the re-constructed channels.
- Utilize the final tailings excavation configuration to identify the location, alignment and profile/grade of the stream channels.
- Incorporate bio-engineering methods using coir fabric, willows fascines and stakes, woody debris, and riparian vegetation.

7.7.2 Design Criteria

Channel design elements will be based on the measurements of the existing stream channels at the reference stream reaches. The channels will be designed to function as a natural channel wherever feasible. Stream construction materials and plant materials will be chosen to match native materials and species as closely as feasible. Streambank construction and stabilization techniques will utilize only natural and/or bio-degradable materials. Hard or armored banks will only be used where protection of infrastructure or reclaimed areas are required. Hard or armored reaches will be designed such that they provide as much cover and resting spaces as possible for aquatic life, as well as blending into natural surroundings to the extent that is feasible.

The Soda Butte Creek and Miller Creek channels will be designed to provide initial stability prior to grow-in and to function as naturally as feasible during the long term. Engineering calculations to assess channel stability and standard hydrologic calculations will be utilized to assess stability of the channels and determine appropriate construction materials and design elements.

7.7.3 Soda Butte Creek Alignment and Channel Configuration

The proposed location of Soda Butte Creek is based on the post excavation contours of the tailings area, generally following the natural valley bottom. However, the actual stream location will be determined during actual tailings removal and may differ somewhat from the lines and grades shown on Sheets 27 and 28 of the Construction Drawings provided in Appendix G. A typical cross section of the re-constructed Soda Butte Creek channel is shown on Sheet D9 of the Construction Drawings provided in Appendix G.

7.7.4 Miller Creek Alignment and Channel Configuration

The proposed location of Miller Creek is based on the post excavation contours of the tailings area, generally following the natural valley bottom. However, the actual stream location will be determined during actual tailings removal and may differ somewhat from the lines and grades shown on Sheet 29 of the Construction Drawings provided in Appendix G. A typical cross section of the re-constructed Miller Creek channel is shown on Sheet D9 of the Construction Drawings provided in Appendix G.

7.8 REVEGETATION DESIGN

Revegetation of the reclaimed Site will consist of placement of organically amended cover soil over all disturbed areas, as well as the repository cap. Soil will be obtained from salvaging the existing soil cap overlying the tailings and from the repository excavation. Prior to placement, the soil will be amended with approximately 3% (by weight) of organic matter (compost) to promote and maintain long-term vegetation growth at the Site. Reclamation of this Site is expected to take several years to complete; therefore, at the conclusion of each construction season, and prior to winter shutdown, all tailings excavation areas will be backfilled with amended soil and seeded, fertilized, and mulched to reduce erosion. All soil stockpiles will be fertilized, seeded, and mulched.

The seed mix designs are based on establishing cool season, native plants that are capable of thriving at high elevations with short growing seasons and vigorous root systems. Plant species observed growing on the tailings impoundment during the 2008 Site investigation included: slender wheatgrass, mountain brome, rough fescue, tufted hairgrass, alpine timothy, and rushes (ssp.). These species appear to have been planted from the previous reclamation effort and not to have naturally colonized on the Site.

All seeding will take place in the fall (October) of the year using approved grass seed drills followed by the application of mulch in the form of weed free straw. The straw mulch will be mechanically anchored (crimped) into the soil to prevent wind and storm water runoff erosion. The seeding rates are based on pounds (lbs) Pure Live Seed (PLS) per acre (ac) for drill seeding. The seeding rates will be doubled for areas that are inaccessible to the seeding equipment and will require broadcast seeding or hydroseeding.

7.8.1 Upland Revegetation

The upland seed mix will be applied to all disturbed areas greater than six feet from surface water. The table below lists the upland seed mix species and seeding rate. A sterile wheat will be included in the upland seed mix to quickly stabilize the revegetated areas and as a nurse crop.

Upland Seed Mix

Species	Common Name	lbs PLS/ acre[1,2]
Grasses:		
Elymus lanceolatus	Streambank Wheatgrass	5.0
Pseudoroegneria spicata (ssp)	Bluebunch Wheatgrass	5.0
Poa alpinum	Alpine Bluegrass	7.0
Bromus marginatus	Mountain Brome	7.0
Phleum alpinum	Alpine Timothy	7.0
Festuca ovine	Sheep Fescue	5.0
	Grasses Total	**36.0**
Forbs:		
Aquilegia flavescens	Yellow Columbine	0.5
Linum lewisii	Lewis Blue Flax	0.5
	Forb Total	**1.0**
Non-native annuals:[3]		
Regreen	Sterile wheat	15
	Annual Total	**15**
Seed Mix Total		**52.0 lbs PLS**

Notes:

1 PLS = Pure Live Seed

2 Reported rates are for drill seeding; rates shall be doubled for broadcast seeding.

3 Regreen used for temporary stabilization and nurse crop.

7.8.2 Riparian Revegetation

The riparian seed mix will be applied within an eight feet wide corridor from surface water, consisting of the area overlain by the Type B geotextile (coir mat) along the reconstructed water channels. The table below lists the riparian seed mix species and seeding rate.

Riparian Seed Mix

Species	Common Name	lbs PLS/ acre [1]
Grasses		
Deschampsia caespitosa	Tufted hairgrass	6.0
Phleum alpinum	Alpine Timothy	6.0
Calamagrostis Canadensis	Bluejoint Reedgrass	5.0
Poa Alpina	Alpine Bluegrass	5.0
	Grass Total	**22.0**
Grass-like		
Carex nebrascensis	Nebraska Sedge	1.0
Juncus arcticus (ssp.) littoralis	Baltic Rush	1.0
	Grass-like Total	**2.0**
Forbs		
Erigeron speciosus	Aspen Daisy	3.0
	Forbs Total	**3.0**
	Seed Mix Total	**25.0 lbs. PLS**

Notes:
1 PLS = Pure Live Seed
2 Reported rates are for drill seeding; rates shall he doubled for broadcast seeding.

As part of the stream reconstruction, willow facines and live stakes will be used within the floodplain and riparian zone. The willows will be obtained from local donor plants currently growing adjacent to the Soda Butte by-pass channel.

7.9 BEST MANAGEMENT PRACTICES (BMPs)

7.9.1 Construction BMPs

Construction BMPs that will be implemented during the construction phase of the project include the following items:

- Install silt fence adjacent to Soda Butte and Miller Creek;
- Install temporary crossings at two locations along Soda Butte Creek:
- Construct a storm water run-on control channel along the south boundary of the Site;
- Install Stream Bank Protection along south side of Soda Butte Creek on the west end of the Site;
- Construct a storm water run-on control channel on the east end of the Site;
- Mulch, fertilize, and seed cover soil storage areas;
- Cap, mulch, fertilize, and seed the excavated foot print prior to winter shutdown;
- Provide dust control during construction activities;

- All water pumped during construction will be processed through the water treatment system;
- Construct new Soda Butte Creek and Miller Creek channels before working adjacent to the existing channels;
- For the first year, split flows during spring runoff between the existing Soda Butte Creek channel and the newly constructed Soda Butte Creek channel;
- Divert Soda Butte Creek into a pipe or lined channel to construct new channel for Soda Butte Creek on the east end of the Site;
- Water accumulated in the repository during spring runoff will be processed through the water treatment system; and
- A vegetation buffer will be left between the repository and Soda Butte Creek.

The construction BMP locations are shown on Sheet 31 of the Construction Drawings provided in Appendix G.

7.9.2 Long Term BMPs

Long Term BMPs that will be completed during implementation of the project include the following:

- Grade all surfaces to promote positive drainage;
- Installation of a vegetative cap over the excavation footprint;
- Installation of an impermeable, multi-layered cap to limit infiltration through the repository;
- Planting of willows along the newly constructed Soda Butte and Miller Creek channels; and
- Install a lined storm water control channel along the south side of the repository.

The long term BMP locations are shown on Sheet 32 of the Construction Drawings provided in Appendix G.

7.10 TECHNICAL SPECIFICATIONS

All work conducted in conjunction with the project will be in accordance with the Technical Specifications in Appendix F.

7.11 POST-CONSTRUCTION MONITORING

Post Construction monitoring will consist of conducting a visual inspection of the Site to identify and document areas of high erosion, poor vegetation growth, and failure of the work performed during the reclamation project. The post-construction monitoring will be conducted on an annual basis for the first five years. Areas of concern will be repaired as needed.

8.0 PROJECT SCHEDULE

The reclamation project is estimated to be completed in five consecutive construction seasons. The majority of the tailings materials will be removed during the 2010 and 2011 construction seasons. To remove the estimated 176,000 cy of tailings, the production rate for tailings removal, stabilization and placement into the repository or transportation off--site would need to range between 1,000 to 1,500 cy a day for approximately 90 days per construction season. The remaining days in the construction season would be needed for capping the excavated footprints and preparing for winter shutdown. The following is a list of the tasks that will be completed during the individual construction seasons.

2009 Construction Season:

- Construct highway access into Site;
- Install construction BMPs;
- Construct interior roads;
- Install/Construct Dewatering System;
- Construct Sediment Detention Ponds;
- Clear and grub repository; and
- Cover and revegetate excavated areas.

2010 and 2011 Construction Seasons:

- Complete Construction of interior roads;
- Excavate, stabilize and dispose of tailings;
- Excavate, stockpile cover soil from repository; and
- Cover and revegetate excavated areas.

2012 Construction Season:

- Excavate, stabilize and dispose remaining waste materials;
- Reconstruct Soda Butte and Miller Creek;
    - Partially divert Soda Butte Creek flow into new channel
- Cover and revegetate excavated areas.

2013 Construction Season:

- Excavate, stabilize and dispose remaining waste materials;
- Complete tie-in to Miller Creek;
- Divert full flow of Soda Butte Creek into new channel;
- Backfill existing Soda Butte Creek channel;
- Cap repository;
- Remove remaining dewatering system and cutoff wall;
- Cover and revegetate excavated areas and repository;
- Demobilize all equipment and materials from the Site.

9.0 CONCLUSION

Reclamation of the Site, in accordance with the preferred alternative recommended in the EEE/CA, is implementable. However, the following limitations and contingencies must be accounted for:

- The reclamation project requires removal of 283,385 cy of materials (including lime);
- Maximum capacity of the on-site repository is 196,000 cy;
- Reclamation of the Site will require transport of 87,385 cy of tailings to an off-site disposal or reprocessing facility;
- The existing, natural slope located immediately north of the repository area is unstable under the design seismic event, and is expected to fail. Provisions for the repository design must account for this eventuality;
- A sufficient quantity of cover soil can be obtained on-site;
- Dewatering of the Site is necessary and will require continuous operation for the first three years of the project; and
- Reclamation of the Site will take five construction seasons to complete.

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