DRAFT FINAL
ENGINEERING EVALUATION & COST ANALYSIS

Kennedy Creek Mining Complex
Missoula County, Montana

Prepared for:

Trout Unlimited
111 North Higgins Street, Suite 500
Missoula, Montana 59802

and

U.S. Department of Agriculture Forest Service
Lolo National Forest
Fort Missoula, Building #24
Missoula, Montana 59804

Prepared by:

AMEC Environment and Infrastructure, Inc.
1001 South Higgins Avenue, B-1
Missoula, Montana 59801
(406) 542-0129

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EXECUTIVE SUMMARY

AMEC Environment and Infrastructure, Inc. (AMEC) prepared this Engineering Evaluation and Cost Analysis (EE/CA) for the Kennedy Creek mining complex on behalf of Trout Unlimited (TU) and the U.S. Department of Agriculture Forest Service (USDA-FS). The mining complex is located in the Lolo National Forest near Huson in Missoula County, Montana. This report presents the results of an engineering evaluation and cost analysis of alternatives for response and reclamation work proposed to address mine waste and an adit discharge at the Nugget and Lost Cabin mines within the complex.

The Kennedy Creek mining complex includes three abandoned mine sites: the Hauttula prospect, Lost Cabin mine, and Nugget mine. The three lode claims in the mining complex reportedly operated intermittently from the 1930's until the 1970's and targeted lead-zinc ore in the Prichard Formation. By 1996, all mining claims in the complex had been abandoned. The USDA-FS is considering a "non-time critical removal action" to reduce or eliminate potential human health and environmental risks associated with waste rock at the Lost Cabin and Nugget mines and an adit discharge at the Nugget mine. The Hauttula prospect is not included in this EE/CA because the relatively small volume of waste rock at the mine (approximately 390 cubic yards) does not contain metals concentrations above cleanup goals and is largely covered by vegetation that naturally re-established following the cessation of mining activities.

Approximately 1,830 and 3,800 cubic yards of waste rock are present at the Lost Cabin and Nugget mines, respectively. Waste rock is in direct contact with Kennedy Creek at both mines, and mine waste was observed to be actively eroding into the creek at the Nugget mine. The waste rock is variable in color and has a silty gravel to coarse gravel texture. The maximum depth of the waste rock is approximately 5.5 and 7.0 feet at the Lost Cabin and Nugget mines, respectively.

Concentrations of metals in surface water, waste rock, and sediment at the mine sites were initially compared to screening levels to identify constituents of potential concern (COPCs) at the mining complex. The screening levels were selected for the complex during a Preliminary Assessment and Site Investigation (PA/SI) completed in 2010, and include risk-based guidelines for recreational users of abandoned mine sites (Tetra Tech 1996), Montana chronic aquatic life standards for surface water (MDEQ 2010a), and screening concentrations for sediment developed by the National Oceanic and Atmospheric Administration (NOAA 2008). Risk-based cleanup levels were then selected for the COPCs in surface water, waste rock, and sediment at the mining complex based on a review of applicable or relevant and appropriate requirements that include state and federal regulatory requirements. Finally, detected metals concentrations in surface water, sediment, and waste rock were compared to cleanup levels to define the nature and extent of impacts resulting from historic mining practices.

Waste rock at the Lost Cabin and Nugget mines exhibits concentrations of lead and arsenic above cleanup levels for the project. Copper and zinc are also present at concentrations more than 10 times background levels in the waste rock, but below cleanup levels. The average concentrations of arsenic and lead in the waste rock at the mines are 80.4 and 3,072 mg/kg, respectively.

Lead present in the waste rock is mobile in the environment, as indicated by the leachable concentrations of lead detected in waste rock samples analyzed using the synthetic precipitation leaching procedure (SPLP). In addition, concentrations of copper, lead, and zinc have been detected in Kennedy Creek above Montana's chronic aquatic life standards downstream of the Lost Cabin and Nugget mines. Concentrations of these metals detected downstream of the mines are substantially higher than concentrations detected in the creek upstream of the mines.

The highest concentrations of copper, lead, and zinc in surface water samples from the mining complex have been detected in an adit discharge and settling pond at the Nugget mine. The adit opening is largely blocked by a rubble pile that appears to be the result of colluvium sloughing from the adjacent hill slope. Water from the adit expresses approximately 30 feet down slope from the adit opening and flows into a settling pond constructed in mine waste. The settling pond discharges seasonally to Kennedy Creek. The pH of the adit discharge is circum neutral, potentially due to buffering provided by carbonate-rich bedrock and glacial deposits present in the area.

Copper and lead have also been detected in streambed sediment in Kennedy Creek downstream of the Lost Cabin mine at concentrations above cleanup goals. In addition, copper and zinc have been detected in streambed sediment downstream of Nugget mine above cleanup goals. Concentrations of these metals were notably lower in sediment samples collected from Kennedy Creek upstream of the two mines. These findings suggest that waste rock at the mines has eroded into Kennedy Creek resulting in elevated metals concentrations in streambed sediment.

A streamlined risk evaluation of the Lost Cabin and Nugget mines indicates that concentrations of metals in mine waste and surface water at the mines pose unacceptable risks to human and ecological receptors. COPCs at the mines include arsenic, copper, lead, and zinc. Exposure pathways for human and ecological receptors include direct contact, ingestion, and inhalation of COPCs. Human populations that may be exposed to mine waste and metals-impacted water are primarily recreational users of USDA-FS land, including hunters and hikers. Ecological populations that may be exposed to mine waste and metals-impacted water are primarily fish and other aquatic life.

The USDA-FS may initiate a response action under the non-time critical removal action process to prevent, minimize, stabilize, mitigate, or eliminate the release or threat of release of a hazardous substance if the agency determines there is a threat to public health, welfare, or the environment. Impacts to surface water in Kennedy Creek are occurring due to the mobilization of contaminants from waste rock at the Lost Cabin and Nugget mines and the adit discharge at the Nugget mine. In addition, metals are present in waste rock at the mines that exceed cleanup levels for the project.

Proposed removal action objectives (RAOs) for the mining complex include the following:

- Reduce or eliminate safety and health hazards to recreational users of Forest Service lands;
- Improve water quality, stream function, and aquatic life and fisheries habitat in Kennedy Creek and in an unnamed tributary immediately downstream of the Lost Cabin mine;
- Reduce or eliminate sources of metals impacts to surface water and sediment; and
- Maximize use of native vegetation and soils to the extent practical for revegetation and reclamation efforts.

Response action alternatives to address human health and environmental risks associated with waste rock at the Lost Cabin and Nugget mines and the adit discharge at the Nugget mine were developed for further evaluation. Two mine waste and four adit discharge response action alternatives were developed incorporating technologies retained from an initial screening of potentially applicable technologies. In addition, a no action alternative was evaluated to provide a baseline for comparative purposes. The alternatives were developed such that each alternative offered a distinct benefit over another alternative or relied on a different approach to meet RAOs. A brief description of each alternative follows.

- **No Action Alternative NA-1:** The Lost Cabin and Nugget mines would be left in their existing conditions under this alternative and no action would be taken to control contaminant migration, or reduce the toxicity and volumes of waste. Risks to human health and the environment would remain unchanged.
- **Mine Waste Alternative MW-1: On-site Disposal with Simple Soil Cover**. Waste rock at the Lost Cabin and Nugget mines containing metals concentrations above cleanup goals would be excavated and removed for disposal in an on-site repository constructed with a simple soil cover using materials salvaged from the repository site. Approximately 1,780-cubic yards of waste rock containing metals concentrations below cleanup levels would remain on-site at the Nugget mine. The excavation area would be backfilled and graded to match surrounding areas undisturbed by mining activities. Topsoil salvaged from the repository area would be spread over the backfilled excavations at the mine sites. Disturbed areas at the mines and repository site would be revegetated in accordance with USDA-FS guidelines. Portions of Kennedy Creek and an unnamed tributary downstream of the Lost Cabin mine affected by the removal action would be reconstructed.
- **Mine Waste Alternative MW-2: On-Site Disposal with Composite Cover**. This alternative includes all the components of Alternative MW-1, with one exception. The on-site repository would be constructed with a composite cover system that includes a low permeability geomembrane component to reduce infiltration of meteoric water into the waste rock in the repository instead of a simple soil cover. A drainage layer (gravel or geocomposite) would be installed over the geomembrane layer to direct water that infiltrates through the top layers of the cover system off the geomembrane and away from the repository.
- **Adit Discharge Alternative AD-1: Infiltration**. Under this alternative, a collection structure would be installed in the adit portal to capture the adit discharge and direct it to a subsurface infiltration gallery.
- **Adit Discharge Alternative AD-2**: **Bioreactors and Infiltration**. A series of on-site, passive sulfate reducing bioreactors would be used to reduce metals concentrations in the adit discharge. The bioreactor cells would be constructed below grade to protect them against freezing conditions and allow year-round operation. The treated effluent would be directed to a subsurface infiltration gallery.
- **Adit Discharge Alternative AD-3**: Chemical Adsorption/Ion Exchange and Infiltration. The adit discharge would be treated with the ion exchange media Apatite II in a series of subsurface reactors cells. The treated effluent would be directed to a subsurface infiltration gallery.
- **Adit Discharge Alternative AD-4**: Constructed Wetlands and Infiltration. Under this alternative, metals concentrations in the adit discharge would be reduced using free water surface constructed wetlands. The wetlands would consist of a deep pool forebay to diffuse flow from the adit discharge and attenuate storm water/adit discharge surges. A series of

shallow wetland areas would be constructed downstream of the forebay. Effluent from the constructed wetlands would be piped from an outlet structure to a subsurface infiltration gallery.

Alternative MW-1, excavation of mine waste and placement in an on-site repository constructed with a simple soil cover, is the preferred response action to address mine waste at the Lost Cabin and Nugget mines. This alternative was selected as the preferred response action because it provides a significant reduction in risks to human health and the environment at a lower associated cost than Alternative MW-2. The estimated cost for Alternative MW-1 is $394,000.

The simple soil cover would allow a greater volume of precipitation to infiltrate through the waste rock in the repository than the composite cover system evaluated in Alternative MW-2. However, leachate from the repository is unlikely to impact Kennedy Creek due to the distance of the repository from the creek (approximately 700 feet). In addition, future use of groundwater in the vicinity of the repository is unlikely because it is located on land administered by the USDA-FS. Therefore, the higher infiltration rates of the simple soil repository cover do not appear to present a significant increase in risks to human and ecological receptors. The simple soil cover is a practicable removal action to abate immediate known threats to multiple receptors on the mine sites and in Kennedy Creek. Removal actions, such as those under consideration in this EE/CA, must be protective of human health and the environment. However, removal actions are not expected or required to attain all applicable or relevant and appropriate requirements (such as Montana groundwater standards).

Alternative MW-1 would permanently remove the source of impacts to Kennedy Creek at the Lost Cabin mine and significantly reduce the contaminant load discharged to the creek at the Nugget mine. The response action does not address the adit discharge at the Nugget mine, which would continue to discharge to Kennedy Creek until addressed through implementation of an additional response action. No long-term monitoring or maintenance would be required once vegetation is fully established at the repository site and areas disturbed by excavation activities at the mine sites.

Infiltration (Alternative AD-1) is the preferred response action for the adit discharge at the Nugget mine. This alternative was selected as the preferred response action because it would result in a significant reduction of risks to human and ecological receptors. Alternative AD-1 would prevent direct contact and ingestion of the adit discharge by capturing the adit flows for infiltration into the subsurface. Although the other alternatives evaluated would provide additional treatment and reductions in contaminant concentrations, they would include long-term operation and maintenance requirements (Alternatives AD-2 and AD-3) or pose higher risks to potential receptors because the adit water would continue to be accessible at the surface (Alternative AD-4). The estimated cost of Alternative AD-1, $87,000, is also the lowest of all four response actions evaluated for the adit discharge at the Nugget mine.

1.0 INTRODUCTION

AMEC Environment and Infrastructure, Inc. (AMEC) prepared this draft Engineering Evaluation and Cost Analysis (EE/CA) for the Kennedy Creek mining complex located in the Lolo National Forest near Huson in Missoula County, Montana (**Figure 1**). This report presents an engineering evaluation and costs analysis of alternatives for response and reclamation work proposed to address mine waste at the Nugget and Lost Cabin Mines within the complex, and an adit discharge at the Nugget mine.

1.1 Background

The Kennedy Creek mining complex includes three abandoned mine sites: the Hauttula prospect, Lost Cabin mine, and Nugget mine. The mines targeted lead-zinc ore in the Prichard Formation. The ore is associated with quartz veins that also contain gold and copper. No milling operations were conducted in the mining complex. The three lode claims in the mining complex actively operated during various times from the 1930's until the 1970's. By 1996, all mining claims in the complex had been abandoned. Since 1996, parties have pursued formal mining rights to the area, but no earthwork or maintenance has occurred.

Pioneer Technical Services (Pioneer) completed hazardous materials inventories of the three mine sites in 1993 on behalf of the Montana Department of State Lands. This program is now administered by the Montana Department of Environmental Quality (MDEQ) Mine Waste Cleanup Bureau. The work included the collection of waste rock samples from the three mine sites (Pioneer 1993). Pioneer also collected streambed sediment and surface water samples from Kennedy Creek at the Lost Cabin and Nugget mines. In addition, a surface water sample was collected from an adit discharge at the Nugget mine. All samples were submitted to an off-site laboratory for analysis of metals. The inventories were completed to characterize environmental impacts at the mining complex and rank them relative to 273 other abandoned or inactive hard rock mine sites that were also inventoried. Nugget and Lost Cabin mines are ranked 75th and 57th, respectively, on the current MDEQ list of abandoned mines prioritized for potential cleanup actions (MDEQ 2010b).

AMEC completed a Preliminary Assessment and Site Investigation (PA/SI) of the three mines in 2010 on behalf of Trout Unlimited (TU) and the U.S. Department of Agriculture Forest Service (USDA-FS). The purpose of the PA/SI was to evaluate the nature and extent of impacts to land and surface water resulting from historic mining practices. AMEC estimated the volumes of waste rock present at each mine, determined the extent of mine-disturbed land, and evaluated the concentrations of metals in soil, surface water, and streambed sediment within the Kennedy Creek mining complex and immediate vicinity. The results of the investigation are presented in a Preliminary Assessment/Site Investigation Report (AMEC 2011a).

Screening levels were selected for metals concentrations in surface water, sediment, and waste rock at the mining complex during the PA/SI. Screening levels include risk-based guidelines for recreational users of abandoned mine sites (Tetra Tech 1996), Montana chronic aquatic life standards for surface water (MDEQ 2010a), and screening concentrations for sediment developed by the National Oceanic and Atmospheric Administration (NOAA 2008). Refer to **Section 4.2** for a detailed discussion of the screening levels for the mine complex.

The results of the 1993 and 2010 investigations completed by Pioneer and AMEC indicate that waste rock at the Lost Cabin and Nugget mines contains elevated concentrations of arsenic and lead (above screening levels). In addition, surface water and streambed sediment samples collected downstream of the Lost Cabin and Nugget mines exceeded screening levels for several metals, including copper, lead, and zinc. Waste rock is in direct contact with Kennedy Creek at both mine sites and is actively eroding into the creek at the Nugget mine. Metals concentrations in waste rock at the Hauttula prospect were below screening levels. Surface water and sediment samples collected from Kennedy Creek downstream of the Hauttula prospect did not contain metals above screening levels. Additional information about previous assessments completed at the mining complex is provided in **Section 3.0**.

The results of additional investigation activities conducted in 2011 to further define site conditions and provide additional data necessary for the completion of this EE/CA are also described in **Section 3.0**. These activities included:

- The removal of the adit portal structure to allow adit discharge flow measurements to be taken;
- An inspection of the adit interior (conducted from outside the adit opening) to assess conditions inside the adit; and
- An inspection of a potential repository site for the disposal of mine waste from the Lost Cabin and Nugget mines.

1.2 Purpose and Objectives

This EE/CA was developed following the "non-time critical removal action" process outlined in the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended, and the updated National Hazardous Substances Pollution Contingency Plan (NCP). A non-time critical removal action is implemented by the lead agency (the USDA-FS in this instance) to provide "the cleanup or removal of released hazardous substances from the environment… as may be necessary to prevent, minimize, or mitigate damage to the public health or welfare or to the environment…" (U.S. Environmental Protection Agency [EPA] 1993). Following EPA's Guidance on Conducting Non-Time Critical Removal Actions under CERCLA (EPA 1993), the EE/CA provides the logic, process, and cost estimate to develop and evaluate potential response action alternatives that may be used to address mining wastes.

The objective of this EE/CA is to develop and evaluate potential response action alternatives to reduce or eliminate potential human health and environmental risks associated with waste rock at the Nugget and Lost Cabin mine sites in the Kennedy Creek mining complex and an adit discharge at the Nugget mine. The EE/CA identifies the preferred alternative that best satisfies the criteria and removal action objectives used to evaluate the potential response action alternatives. A third mine in the complex, the Hauttula prospect, is not included in this EE/CA based on the results of the PA/SI (AMEC 2010). The relatively small volume of waste rock identified at the Hauttula prospect during the PA/SI (approximately 390 cubic yards) contained metals concentrations below cleanup levels, and was largely covered by natural vegetation.

1.3 Report Organization

Following this introduction, this EE/CA is organized into the following sections:

- **Section 2.0** provides a brief description of the mine sites.
- **Section 3.0** summarizes the key findings of previous assessments of the mining complex, including the 2010 PA/SI (AMEC 2010), as well as the results of field activities conducted in 2011.
- **Section 4.0** presents a streamlined evaluation of potential risks to human health and the environment resulting from historic mining activities.
- **Section 5.0** describes the scope, goals, and response action objectives for the mining complex.
- **Section 6.0** identifies potential remedial technologies, presents an initial screening of those technologies, and describes the potential response action alternatives developed for further evaluation for the mining complex.
- **Section 7.0** summarizes the criteria used to evaluate the alternatives and provides a detailed analysis of each alternative using those criteria.
- **Section 8.0** presents a comparative analysis of the anticipated performance and costs of the alternatives and identifies the preferred alternative for the mining complex based on that analysis.
- **Section 9.0** presents the references cited in the text.

Figures and tables follow the text of the report. Appendices containing supporting information follow **Section 9.0**.

2.0 SITE LOCATION AND DESCRIPTION

The Kennedy Creek mining complex is located in Missoula County, approximately 10 miles north-northwest of Huson, Montana. The mining complex is located in the Lolo National Forest in the Kennedy Creek drainage (**Figure 1**). Additional information about the mining complex, including the geology, hydrology, climate, and vegetation of the site and surrounding area is provided in the following subsections.

2.1 Site Location and Description

The Kennedy Creek watershed was reportedly one of the most heavily mined watersheds in the Ninemile valley (TU 2011). The Kennedy Creek mining complex is comprised of three lode claim mines, which reportedly operated from the 1930's the 1970's on or adjacent to upper Kennedy Creek. As previously discussed, the Hauttula prospect is not included in this EE/CA based on the results of the 2010 PA/SI. Descriptions of the Lost Cabin and Nugget Mines follow:

- The Lost Cabin mine is located on Kennedy Creek approximately 4-miles upstream of the confluence with Ninemile Creek. The mine includes six unpatented mining claims at which several adits of unknown length were developed.
- The Nugget mine is located approximately 500 feet downstream of the Lost Cabin mine. The mine includes 18 mining claims. When operational, it was the largest of the three mines. Two collapsed and one open adit are present at the mine. The open adit discharges water to a settling pond constructed in mine waste. The length of underground mine workings leading to

the Nugget mine portal have been estimated to be between 1,100 and 1,200 feet (Hargrave et al. 2003).

The Lost Cabin and Nugget mines are located in Township 16 North, Range 23 West, Section 13 (**Figure 2**). As shown in **Figure 2**, a roadway slump is present downstream of the mining complex. This slump prevents access by typical excavation equipment or highway vehicles. The abandoned roadway upstream of the slump is easily passable on foot until the upstream edge of the Lost Cabin mine. Upstream of the Lost Cabin mine, dense vegetation and small gullies eroded into the abandoned roadway make travel more difficult.

2.2 Geology

The historic lode claims in the Kennedy Creek drainage are located in the Proterozoic-aged Prichard Formation of the Belt Supergroup. Metasediments of the Prichard Formation consist of interlaminated siltite, laminated carbon-rich argillite, iron sulfides and minor quartzite. Bedrock in the Kennedy Creek drainage strikes northwest and dips from 45 to 50 degrees to the northeast (Lonn et al. 2007). Mineralization of metals is likely controlled by intersecting northwest- and northeast-trending faults associated with the Ninemile Fault to the southwest. The host rock is bluish to dark gray massive argillite that weathers to a reddish buff. The ore type was localized along northwest-striking quartz veins that included gold, copper, lead, and zinc. Gold-bearing placers lining the Kennedy Creek valley floor were likely sourced from these lode deposits, as suggested by the presence of pyrite, galena, and flat pieces of gold (Lonn et al. 2007).

Assays of the ore removed from the Lost Cabin Mine indicate that zinc concentrations increase to the southwest in the bedrock underlying the Kennedy Creek drainage (MDEQ 2009). No assays were reported from the Nugget Mine; however, ore removed from this claim was primarily zinc-lead. Downstream of the Nugget Mine, elevated concentrations of lead, copper and zinc suggest natural leaching of sulfide deposits. Additional hydrothermic alteration of bedrock is also suggested by the presence of sulfide minerals including chalcopyrite, sphalerite, galena and pyrite in local quartz-filled fractures in and around the Kennedy Creek mine adits. No milling operations were conducted in the Kennedy Creek mining complex (Pioneer 1993).

Fluvial outwash and glacial flood deposits make up the surficial geology in the Kennedy Creek drainage. Glacial deposits include carbonate-rich Belt Supergroup gravels in a semi-consolidated clay matrix (MDEQ 2009). The lower reaches of the drainage may contain lake deposits associated with the Pleistocene-aged Glacial Lake Missoula (Lonn et al. 2007).

2.3 Hydrology

The mining complex is located in the drainage of Kennedy Creek, which is a perennial tributary to Ninemile Creek (**Figure 2**). The confluence of an unnamed tributary and Kennedy Creek is located immediately south (downstream) of the Lost Cabin mine. An irrigation diversion is located on Kennedy Creek near the downstream edge of the Nugget mine. Lower sections of Kennedy Creek reportedly go dry in summer months due to the irrigation diversion and valley bottom disturbance from past mining activity (MDEQ 2005).

AMEC measured stream flow at five stations on Kennedy Creek, including an upstream background location, and the unnamed tributary in 2010, including an upstream background location (**Figure 3**). Flow measurements were taken in high-flow conditions during a period of continued snow melt in late June and again in late summer 2010 to capture low-flow conditions (AMEC 2010). Flows measured in Kennedy Creek ranged from 3.22 to 3.99 cubic feet per second (cfs) in June 2010, and were much lower in August 2010 (0.019 to 0.027 cfs). The measured flow rate in the unnamed tributary was 0.07 cfs in June 2010. The monitoring station was not flowing in August 2010 when only isolated pools of ponded water were observed at the station.

An adit discharge at the Nugget Mine flows through a settling pond constructed on mine waste before seasonally discharging to Kennedy Creek. Pioneer (1993) reported the adit discharges approximately 1.3 gallons per minute (gpm; 0.003 cfs) based on July 1993 field observations. Adit discharge measurements were not taken during the 2010 PA/SI due to obstructions in the channel, ponded water, and diffuse flow. AMEC removed the channel obstructions and the adit portal structure in June 2011 and installed steel wing walls to channelize the discharge for flow measurements. A discharge of 28 gpm (0.062 cfs) was measured on 9 June 2011 during spring runoff, and a discharge of 3.3 gpm (0.007 cfs) was measured on 11 August 2011(low-flow conditions).

Kennedy Creek is a 303(d) listed stream with impairments to cold-water fishery, aquatic life, recreation, and drinking water beneficial uses caused by metals, siltation, dewatering, flow alteration, and other habitat alteration (MDEQ 2005). Impairments to the stream are primarily the result of historic mining activities at the Kennedy Creek mining complex and irrigation diversions for agriculture.

2.4 Climate

The climate of the Kennedy Creek drainage varies with elevation, as is typical for mountainous regions of Montana (MDEQ 2005). Elevations within the watershed range from 3,215 feet above mean sea level (AMSL) at the confluence with Ninemile Creek to approximately 7,040 feet AMSL at the watershed divide. Average annual precipitation within the drainage is approximately 27 inches, depending upon the elevation (NRIS 2011a). The USDA-FS maintains a Remote Automatic Weather Station at the Ninemile Ranger Station, which is the closest weather station to the mining complex. Average annual precipitation at the Ninemile Ranger Station is approximately 15.7 inches, which is at an elevation of approximately 3,170 feet AMSL. April, May, and June are typically the wettest months of the year (MDEQ 2005). Precipitation falls partly as snow beginning in late October and lasting into early May. The average daily minimum and maximum temperatures at the mining complex are approximately 31 and 52° Fahrenheit, respectively (NRIS 2011b and 2011c).

2.5 Vegetation

Vegetative cover within the Kennedy Creek drainage is dominated by mixed mesic forest (36%) with lesser amounts of Douglas-fir (9%), Lodge-pole Pine (11%), and Western Larch (11%; MDEQ 2005). Smaller areas of mixed mesic shrubs, Ponderosa Pine, and mixed sub-alpine forest are also present. Vegetation at the mine sites primarily consist of grasses, forbs, and weeds in the areas that were disturbed by mining operations with significant portions of the areas covered by waste rock devoid of vegetation.

3.0 SOURCE, NATURE, AND EXTENT OF CONTAMINATION

Several investigations have been conducted at the mining complex to assess potential impacts to human health and the environment from mining wastes and to evaluate water quality in Kennedy Creek, including:

- Pioneer completed hazardous materials inventories of the Hauttula prospect, Lost Cabin mine, and Nugget mine in 1993 on behalf of the Montana Department of State Lands (now the MDEQ) that included the collection of surface water and waste rock samples for laboratory analysis.
- MDEQ collected surface water samples from Kennedy Creek in the vicinity of the mining complex in 2003 and 2004 as part of their efforts to develop Total Maximum Daily Loads (TMDLs) for the Ninemile Creek watershed. MDEQ also collected fine bed sediment samples from Kennedy Creek in 2003.
- AMEC conducted a PA/SI of the mining complex in 2010 to characterize the nature and extent of mining-related impacts.
- AMEC collected additional surface water samples and adit discharge measurements to characterize the adit discharge at the Nugget Mine in 2011. AMEC also conducted site reconnaissance of a potential mine waste repository location that included the completion of several shallow soil borings to assess subsurface conditions in the area.

A topographic survey of the Lost Cabin and Nugget mines was completed during the PA/SI by Eli and Associates, Inc. to allow the volumes of waste rock present at the mines to be estimated. A brief summary of the results from these investigations is presented below.

Screening levels were selected for the mining complex during the 2010 PA/SI to evaluate concentrations of metals detected in surface water, waste rock, and sediment at the mine sites. The screening levels include risk-based guidelines for recreational users of abandoned mine sites (Tetra Tech 1996), Montana chronic aquatic life standards for surface water (MDEQ 2010a), and screening concentrations for sediment developed by NOAA (NOAA 2008). The screening levels are provided in the summary tables of metals concentrations detected in surface water, waste rock, and sediment during previous investigations of the mining complex (see **Tables 2** through **5** and **Table 7**). Refer to **Section 4.2** for additional discussion of the screening levels for the mine complex.

3.1 Waste Characteristics

3.1.1 Lost Cabin Mine

Approximately 1,830 cubic yards of relatively fine-grained waste rock are present at the Lost Cabin mine along the stream channel. Waste rock impinges on and is in direct contact with Kennedy Creek along approximately 350 feet of the left bank of the creek (**Figure 4**). A total of 16 test pits were hand excavated during the PA/SI to depths of up to 5.5 feet below ground surface (bgs). Observations of physical waste rock characteristics (texture, color, moisture content, etc.) are summarized in **Table 1**. Depth of waste rock in the test pits ranged from 0.5 feet at the northern half of the mine area to more than 5.5 feet at test pit B5.

Composite samples of the waste rock were submitted for laboratory analysis from seven sampling areas and discrete depth intervals during the PA/SI based physical characteristics of the waste rock observed during excavation of the test pits (**Figure 4**). A background soil sample was also collected approximately 450 feet upstream of the Hauttula prospect. The samples were analyzed for total and leachable metals.

Total Metals

Total metals results for the waste rock samples collected during the PA/SI are summarized in **Table 2**. Analytical results for a four-point composite sample of the waste rock collected by Pioneer in 1993 are also provided in **Table 2**. Total arsenic and lead were detected at concentrations above their associated screening levels (70 and 1,100 milligrams per kilogram [mg/kg], respectively) in the majority of waste rock samples collected from the mine. Elevated copper concentrations (more than 10 times background levels) were also detected in all waste rock samples collected from the mine, although the concentrations did not exceed the screening level. Zinc was detected in one waste rock sample during the PA/SI at a concentration more than 10 times the background level but below the screening level.

Leachable Metals

The seven composite waste rock samples collected during the PA/SI were also analyzed by the laboratory using the synthetic precipitation leaching procedure (SPLP) method to evaluate the leachability of 13 metals in the waste rock. Metals that were detected above laboratory reporting limits following SPLP extraction are summarized in **Table 3**. Leachable lead was detected in all samples above the screening level of 0.015 mg/L. It should be noted, however, that the acidic leaching solution (pH of 4.2) used in the SPLP tests may over estimate the concentrations of lead that may be leached from the waste rock through infiltration/percolation of meteoric water In addition, precipitation of lead is very rapid in a carbonate-buffered environment. In the event that lead is leached from waste rock, it would likely travel a short distance prior precipitating out of solution.

Leachable mercury was also detected above the screening level in one sample (Lost Cabin Waste-4). However, the total mercury concentration for sample Lost Cabin Waste-4 was five orders of magnitude below the total mercury screening level. In addition, mercury was not detected at levels of concern in surface water and no ore processing or other mercury-generating activities are known to have occurred at the site. Therefore, mercury was not considered a contaminant of potential concern (COPC) for the mining complex.

3.1.2 Nugget Mine

Approximately 3,800 cubic yards of fine- to coarse-grained waste rock are present at the Nugget mine (**Figure 5**). Kennedy Creek is in contact with mine waste throughout the entire Nugget Mine area (approximately 550 lineal feet). Mine waste is actively eroding into the creek on the steep left bank of Kennedy Creek. A total of 16 test pits were hand excavated at the Nugget mine during the PA/SI to depths ranging from 0.8 to 7.0 feet bgs. Observations of physical waste rock characteristics (texture, color, moisture content, etc.) are summarized in **Table 1**. Depth of waste rock in the test pits ranged from 0.6 feet in test pit B12c in the portion of mine waste on the southeast side of Kennedy Creek (**Figure 5**) to more than 7.0 feet at test pit B7.

Composite samples of the waste rock were submitted for laboratory analysis from eight sampling areas and discrete depth intervals during the PA/SI based on physical characteristics of the waste rock observed during excavation of the test pits (**Figure 5**). The samples were analyzed for total and leachable metals.

<u>Total Metals</u>

Total metals results for the waste rock samples collected during the PA/SI are summarized in **Table 2**. Analytical results for a four-point composite sample of the waste rock collected by Pioneer in 1993 are also provided in **Table 2**. Lead was detected in four of the nine waste rock samples collected from the Nugget mine at concentrations that exceed the screening level (1,100 mg/kg). Lead was also detected at concentrations more than 10 times background levels, but less than the screening level, in four additional waste rock samples. Arsenic was detected in three samples at concentrations above the screening level (70 mg/kg). Copper concentrations in all samples collected from the mine were below the screening level (27,100 mg/kg) but were more than 10 times background levels. Elevated levels of zinc were also detected in three samples at concentrations more than 10 times background levels but below the associated screening level.

<u>Leachable Metals</u>

The eight composite waste rock samples collected during the PA/SI were also analyzed by the laboratory using the SPLP method to evaluate the leachability of metals in the waste rock. Leachable lead was detected in all but one of the samples at concentrations above the screening level of 0.015 mg/L (**Table 3**). It should be noted, however, that the acidic leaching solution (pH of 4.2) used in the SPLP tests may over estimate the concentrations of lead that may be leached from the waste rock through infiltration/percolation of meteoric water. In addition, precipitation of lead is very rapid in a carbonate-buffered environment. In the event that lead is leached from waste rock, it would likely travel a short distance prior precipitating out of solution. No other leachable metals were detected in the samples above their associated screening levels.

3.1.3 Waste Rock Volumes

The Lost Cabin and Nugget mines were surveyed during the PA/SI to develop topographic maps of the mine sites with two-foot elevation contours (**Figures 4** and **5**). Volumes of waste rock at each mine were estimated by extending the slope of undisturbed areas uphill of the mines to beneath the mine waste to determine the likely pre-disturbance ground surface. Differences in elevation between the existing ground surface in disturbed mine areas and the estimated pre-disturbance ground surface were then utilized to calculate cut and fill thicknesses. To calculate the estimated volume of mine waste, the estimated volume of surficial cut was subtracted from the estimated volume of fill to account for site grading (i.e. roadway construction) prior to the extension of mine adits. Based on this approach, there are approximately 1,830 and 3,800 cubic yards of waste rock at the Lost Cabin and Nugget mines, respectively. Additional details regarding waste rock volume estimates are provided in the PA/SI report (AMEC 2011a).

3.2 Surface Water Quality

Pioneer collected surface water samples from Kennedy Creek at upstream and downstream locations from the Lost Cabin and Nugget Mines in July 1993. The approximate sampling locations are shown on **Figures 4** and **5**, respectively. The downgradient sample for the Lost Cabin mine was collected below the confluence with the unnamed tributary. The samples were submitted for laboratory analysis of metals, total dissolved solids, chloride, and sulfate. Pioneer also measured flow and field parameters (pH, conductivity, temperature, etc.) at the sampling locations. Analytical results and flow measurements are summarized in **Table 4**.

MDEQ collected water quality samples from Kennedy Creek upstream and downstream of the mining complex and near the mouth of Kennedy Creek in 2003 and 2004 as part of their TMDL development efforts for the Ninemile watershed. Samples with concentrations that violated state water quality standards during the sampling effort are summarized in **Table 4**.

During the 2010 PA/SI, AMEC collected surface water samples from Kennedy Creek for laboratory analysis from locations upstream and downstream of the Lost Cabin and Nugget mines. AMEC also collected surface water samples from the unnamed tributary immediately downstream of the Lost Cabin mine, and the adit discharge and settling pond at the Nugget Mine. Sampling locations are shown on **Figures 4** and **5**. Flow and field parameters measurements were taken at each flowing sampling site, with the exception of the adit discharge. Flow was not measured at the adit discharge in 2010 due to obstructions in the channel, ponded water, and diffuse flow. The samples were submitted for laboratory analysis of total metals and hardness. Analytical results and flow measurements for the 2010 samples collected by AMEC are summarized in **Table 5**.

AMEC collected additional surface water samples in June 2011 to further characterize the adit discharge. Prior to sample collection, the adit portal structure was dismantled and removed. A surface water sample was collected at the first expression of water below the rubble pile at the mouth of the adit (station Adit K1 on **Figure 5**). Following sample collection, steel wing walls were installed to channelize the diffuse flow and allow discharge measurements to be collected. A surface water sample was also collected from the settling pond (station Pond K1 on **Figure 5**) and field parameters were measured. The surface water samples were submitted for laboratory analysis of metals and several additional parameters to allow potential treatment options for the adit discharge to be evaluated. The additional analyses included sulfur, sulfate, total Kjeldahl nitrogen, alkalinity, and total organic carbon. In addition, a flow measurement was taken at station Adit K1 and field parameters were taken at both sample locations in August 2011.

AMEC also collected surface water samples from inside the adit (sample Adit-Inside), the first surface expression of the adit discharge (station Adit K-1), and from Kennedy Creek east of the adit (station SWK East of Adit) in early September 2011 (AMEC 2011b). The samples were submitted for laboratory analysis of total zinc. Metals concentrations detected in the 2011 surface water samples are summarized in **Table 5** and common ions and nutrients concentrations are summarized in **Table 6**. The complete laboratory analytical reports are provided in **Appendix A**.

As shown in **Tables 4** and **5**, copper, lead, and zinc have been detected in surface water samples from the mining complex at concentrations above screening levels since the first sampling event was conducted in 1993. The highest concentrations of these analytes were detected in the adit discharge and settling pond at the Nugget mine. Zinc concentrations in the adit discharge are two orders of magnitude above the screening level (**Table 5**). Zinc concentrations increase markedly in Kennedy Creek as it passes the Nugget Mine (269 and 346% increases from station SWK4 to SWK5 in June and August 2010, respectively). These data indicate that the adit is a significant source of zinc impacts to surface water quality in Kennedy Creek.

Copper, lead, and zinc were detected in a surface water sample collected upstream of the Lost Cabin mine by Pioneer in July 1993 (sample 32-057-SW-1, see **Table 4)** at concentrations that exceed their associated screening levels. However, concentrations of these analytes were well below the screening levels in a surface water sample collected by AMEC in June 2010 from the approximate location of the Pioneer sample (surface water station SWK-2). In addition, these metals were not detected above laboratory reporting limits in the August 2010 (low-flow conditions) sample collected from station SWK-2.

The 2010 results indicate that metals concentrations in Kennedy Creek are not at levels of concern upstream of the Lost Cabin mine and were lower than those measured in 1993. This may be due to weathering and natural revegetation of mine waste at the Hauttula prospect, which currently contains only coarse-grained mine waste covered by small trees (AMEC 2010).

Copper and lead were detected in the surface water sample collected from the unnamed tributary immediately south of the Lost Cabin mine (surface water station SWK3) above screening levels during high-flow conditions in June 2010 (**Table 5**). Concentrations of copper and lead were below the screening levels in a subsequent sample collected by AMEC during low-flow conditions in August 2010 (**Table 5**). Conversely, zinc concentrations at surface water station SWK-3 were below the screening level during high flow conditions (June 2010), but above the screening level during low flow conditions (August 2010).

Physical parameters measurements taken by Pioneer in 1993 and AMEC in 2010/2011 indicate the pH of surface water in Kennedy Creek and the Nugget mine adit discharge are circum neutral (**Tables 4** and **5**, respectively). Country rock in the region contains several sulfide minerals, including chalcopyrite, sphalerite, galena, and pyrite (AMEC 2010). Sphalerite (zinc sulfide) and chalcopyrite (copper iron sulfide) will dissolve as adit drainage becomes increasingly oxic under neutral to acidic conditions. Weathering of these sulfide minerals is typically accompanied by sulfide oxidation and subsequent acid production. AMEC postulated in the PA/SI that carbonate-rich glacial deposits that have been reported in the region (MDEQ 2009) provide surficial buffering for the adit discharge (AMEC 2010). Surface water samples collected from the adit discharge and settling pond at the Nugget mine in June 2011 had total alkalinity concentrations of 21.4 and 24.4 mg/L as $CaCO_3$, respectively (**Table 6**). These alkalinity values suggest a moderate to high buffering capacity in the adit discharge and appear to support AMEC's theory.

3.3 Streambed Sediment

Pioneer collected streambed sediment samples from Kennedy Creek at upstream and downstream locations from the Lost Cabin and Nugget Mines in July 1993. AMEC also collected streambed sediment samples in August 2010 from five surface water stations on Kennedy Creek and the unnamed tributary. The 1993 and 2010 sediment sample locations coincided with surface water sample locations depicted on **Figures 4** and **5**. Select total metals results from the sampling events are summarized in **Table 7**.

Metals concentrations in sediment samples collected upstream of the Lost Cabin mine were notably lower than concentrations in samples collected downstream of the Lost Cabin and Nugget mines during both sampling events. The samples collected in 1993 exceeded the copper Severe Effect Level (SEL) for freshwater sediment (NOAA 2008) downstream of both mines and exceeded the SEL for lead downstream of the Lost Cabin mine. Lead did not exceed the SEL in the sediment sample collected by Pioneer downstream of the Nugget Mine. In 2010, the sample collected from the Nugget mine (station SWK-5) exceeded the SEL for copper and zinc. All other metals were below their associated SELs. These findings suggest that waste rock at the Lost Cabin and Nugget mines is contributing to metals concentrations in streambed sediment in Kennedy Creek. As discussed in **Section 3.1**, waste rock is in direct contact with Kennedy Creek at both mines, and is actively eroding into the creek at the Nugget Mine.

3.4 Adit Inspection

AMEC inspected the adit and surrounding area at the Nugget Mine on September 2, 2011 to provide additional data for development and evaluation of potential response actions to address water issuing from the adit. The objectives of the inspection were to determine the following:

- Relative elevations of water within the adit compared to nearby surface water;
- Zinc concentrations of water within the adit compared to nearby surface water; and
- Appearance and condition of the inside of the adit beyond the rubble pile at the mouth of the adit.

AMEC inspected the interior of the adit using reflected light to illuminate the interior of the adit entrance. AMEC also used an engineer's level and rod to measure relative elevations of adit features (ceiling, standing water, and adit floor), the first surface expression of adit water downstream of a rubble pile at the adit opening, and surface water in Kennedy Creek adjacent to the adit. Photographs of the adit interior and of the first exterior surface expression of adit water are included in **Appendix B**. Field notes showing measurements of water elevations in the vicinity of the adit are also included in **Appendix B**.

The adit opening is largely blocked by a rubble pile that appears to be the result of colluvium sloughing from the adjacent hill slope. As a result, the underground mine workings are currently inaccessible for thorough inspection and evaluation of adit stability. The limited portion of the adit visible from the opening appeared to be in good condition with no rock fall during AMEC's September 2011 visual inspection. The conditions of the mine workings beyond the adit entrance are unknown. However, the mine workings were reportedly maintained by the Nugget Mining Company as recently as 1988 (Hargrave et al. 2003).

The field inspection in September 2011 determined that the water inside the adit was approximately 4.3 feet lower in elevation than the water surface in Kennedy Creek immediately east of the adit. The first surface expression of water downhill of the rubble pile at the adit entrance was 1.6 feet lower in elevation than the water surface in Kennedy Creek directly east of the seep. These measurements confirm that it is possible for Kennedy Creek to recharge both the water inside the adit and the surface expression of water downhill of the adit through discharge to shallow groundwater and subsequent subsurface flow. Cross sections of the Nugget mine area depicting the elevation of water in the adit and the adit seep relative to Kennedy Creek are provided as **Figures 6** and **7**, respectively.

In June 2010 and 2011, water was observed to flow from the seep at the downhill edge of the adit rubble pile into the settling pond at the Nugget Mine. Water then flowed out of the south end of the pond to a channel directly connected to Kennedy Creek (see Photo 3 in **Appendix B**). In August and September 2011, the seep continued to flow to the settling pond, but no water flowed out of the pond.

3.5 Repository Site Evaluation

AMEC evaluated the Kennedy Creek drainage to identify potential locations for the construction of a repository for the disposal of mine waste from the Lost Cabin and Nugget mines (AMEC 2011c). Several criteria were used to identify and evaluate potential repository sites, including that the sites be located:

- On land administered by the USDA-FS.
- Outside the 100-year floodplain and wetlands. In addition, the repository site must be more than 500 feet from the nearest surface water body.
- More than 500 feet from mapped faults and preferably not in areas of alluvium.
- In areas with depths to groundwater greater than 20 feet.
- In areas with slopes of less than 20 percent and a southern to southwestern aspect.
- In close proximity to the Kennedy Creek mining complex.

AMEC performed Geographic Information System (GIS) analysis to identify potential repository sites utilizing metadata and shapefiles compiled in ArcGIS by Ms. Janine Lindley, a GIS analyst / Geologist with the USFS Northern Region Student Employee Program. The preferred repository site identified during the analysis is located approximately 3/4-miles west-southwest from the Nugget mine (**Figure 8**). Results of the analysis are summarized in an 18 May 2011 memorandum to TU and the USDA-FS (AMEC 2011c).

AMEC conducted site reconnaissance in June 2011 to further evaluate the suitability of the site for the construction of a mine waste repository. AMEC personnel advanced four hand-augured boreholes to depths ranging from approximately two to five feet bgs to assess subsurface conditions at the site, including thickness of salvageable topsoil. Observations of soil conditions (texture, color, moisture content, etc.) are summarized in **Table 8** and shown on field forms included in **Appendix C**. Hand auguring locations are shown on **Figure 8**.

Vegetative cover at the preferred repository site consists of a mixture of grasses, forbs, shrubs, and open stands of Douglass fir (see photographs in **Appendix C**). Access to the site is provided by existing two-track roads that would require little improvement to accommodate trucks hauling mine waste and construction equipment.

Depth to subsoil, which is relatively coarse-grained material with lighter (higher value) colors, ranged from 11 inches at location RB3 advanced at the foot of the adjacent slope to 26 inches at location RB2 on a slight knoll. Hand auguring advanced through subsoil to 3 feet or more bgs before encountering refusal at all locations except RB1, where refusal was encountered at 24 inches on cobble. Water saturated conditions observed near the surface in boreholes RB1 and RB2 appeared to be the result of recent precipitation and not shallow groundwater, because relative moisture content in borehole samples decreased with depth.

3.6 Conceptual Site Model

Investigations of the Lost Cabin and Nugget mines include hazardous materials inventories completed by Pioneer in 1993 (Pioneer 1995) and a PA/SI completed by AMEC in 2010 (AMEC 2011a). MDEQ collected surface water quality and streambed sediment data from Kennedy Creek upstream and downstream of the mining complex in 2003 and 2004. Additional water quality data was also collected by AMEC in 2011 to characterize the adit discharge at the Nugget mine. Analytical and field data resulting from these investigations and sampling events provide an understanding of the primary sources, pathways, and potential receptors of mining-related contaminants from the mines. A conceptual site model (**Figure 9**) was prepared for the mines based on this data to assist with the development of response action objectives (RAOs) and response action alternatives to mitigate impacts from the mines. The principal contaminants associated with the Lost Cabin and Nugget mines are arsenic, copper, lead, and zinc.

The primary sources of contaminants are waste rock at both mine sites and the adit discharge at the Nugget mine. Waste rock is in direct contact with Kennedy Creek at both mine sites and is actively eroding into the creek at the Nugget mine. Therefore, streambed sediments in Kennedy Creek are a secondary source of contaminants. Native soils and groundwater beneath the waste rock may have also been impacted from metals leaching from the waste rock. However, no data are available to evaluate these potential impacts.

Exposure pathways for humans and ecological receptors are primarily related to direct contact with or ingestion of contaminants. Current risks to humans are limited to recreational uses of the mine sites and the surrounding area. Vehicle access to the mines is prevented by the locked gate at the trailhead and by a roadway slump downstream of the mines. However, the Lost Cabin and Nugget mines are readily accessible by foot and available to users of National Forest land. Ecological receptors may include aquatic organisms and animals drinking from Kennedy Creek, as well as the adit discharge and settling pond at the Nugget mine.

4.0 RISK EVALUATION

In order to determine if corrective action is necessary to address chemical contaminants at the Kennedy Creek mining complex, AMEC performed a streamlined human health and ecological risk assessment. The risk assessment discusses potential exposure to chemical contaminants in the study area, identifies screening levels associated with accepted exposure models and risk thresholds, and compares detected concentrations of contaminants in the study area to screening levels. This assessment identifies metals in mine waste, water, and streambed sediment that present unacceptably high risks to humans and/or ecological receptors in the study area.

4.1 Potential Exposure to Contaminants in the Kennedy Creek Mining Complex

The exposure evaluation presented below includes discussion of the identified COPCs, the populations that may be exposed to COPCs, the routes of exposure, and the specific human health or ecological effects of each COPC.

4.1.1 Contaminants of Potential Concern

Abandoned mines in the Kennedy Creek drainage were identified as potential sources of contaminants to the environment in work performed by Pioneer, as contractor to the Montana Department of State Lands (now the MDEQ; Pioneer 1993). Metals were generally identified as the class of contaminants most likely to be present in the study area, based on review of historical information regarding mining operations, geologic information, and initial laboratory testing performed in 1993. In order to determine which metals were COPCs, mine waste samples were analyzed for total concentrations of the 13 metals on the EPA

Priority Pollutants list. The metals present at concentration above screening levels were arsenic, copper, lead, and zinc (AMEC 2010). These four metals were retained as COPCs.

4.1.2 Potentially Exposed Populations

Human populations that may potentially be exposed to mine waste or metals-impacted water in the Kennedy Creek mining complex include recreational users of USDA-FS land, such as hunters, hikers, gold panners, anglers, motorcyclists, or bicyclists. Anglers are at risk not only due to direct exposure to mine waste and elevated metals concentrations in the creek water, but also to consumption of accumulated metals in fish tissue. Patented mining claims are active on the Kennedy Creek valley floor, which is known to contain gold-bearing placers (Lonn et al. 2007). Future commercial placer miners are an additional potentially exposed population. Outside of the Kennedy Creek drainage, humans may be exposed to metals-laden waters routed from Kennedy Creek to pastures in the Ninemile Valley via an irrigation diversion immediately downstream of the Nugget mine.

Ecological populations that may be exposed to mine waste or metals-impacted water in the mining complex are primarily fish and other aquatic life. Exposed fish populations include a resident population of genetically pure Westslope cutthroat trout (*Oncorhynchus clarkii lewisi*), which is designated as a species-of-concern in Montana. Terrestrial animals may be exposed to high concentrations of metals in mine waste at the mine complex and may directly consume creek water containing elevated metals concentrations. Physical conditions in the mining complex, such as lack of organic matter and predominance of coarse-grained material, are adverse to plant growth.

4.1.3 Exposure Pathways

Humans may be exposed to elevated concentrations of arsenic, copper, lead, and zinc in the mining complex by ingestion or dermal exposure to mine waste, surface water, or sediment; and by inhalation of dust or mobilized sediment. For instance, recreational forest users could be exposed to mine waste if they rested or stopped to eat in the relatively open mine areas, and ingested mine waste that had accumulated on their hands and/or food. In addition, recreational users could obtain drinking water out of the stream, which may also contain entrained sediment.

Aquatic ecological receptors in the mining complex could be completely immersed in and continually ingesting surface water. In addition, aquatic receptors would have direct contact with streambed sediment at multiple life stages, including eggs and juvenile life forms.

4.1.4 Health Effects of the Contaminants of Concern

The health effects of arsenic, copper, lead, and zinc are discussed below. The discussion includes details regarding effects for human and ecological receptors.

4.1.4.1 Arsenic

The effects of arsenic on humans are summarized in a publication by the Centers for Disease Control (CDC; ATSDR 2007a) which is paraphrased as follows. Respiratory effects of arsenic include irritation of the mucous membranes in the nose and throat, which can lead to laryngitis, bronchitis, or rhinitis. Increased mortality due to respiratory diseases such as emphysema has been reported for workers exposed to arsenic, and arsenic has been demonstrated to cause lung cancer. Arsenic is also associated with neurological deficits in children. Exposure to arsenic has been shown to result in restricted blood flow to the extremities, resulting in Reynaud's phenomenon, which includes numbness and increased cold sensitivity. Gastrointestinal effects include nausea, vomiting, and diarrhea.

The effects of arsenic on aquatic life are summarized by EPA as follows (USEPA 2008):

> "Cancer-causing and genetic mutation-causing effects occur in aquatic organisms, with those effects including behavioral impairments, growth reduction, appetite loss, and metabolic failure. Aquatic bottom feeders are more susceptible to arsenic."

4.1.4.2 Copper

Small amounts of copper are essential for good health in humans. The CDC describes the negative health effects of high doses of copper as follows (ATSDR 2004):

> "Breathing high levels of copper can cause irritation of your nose and throat. Ingesting high levels of copper can cause nausea, vomiting, and diarrhea. Very-high doses of copper can cause damage to your liver and kidneys, and can even cause death."

Particular types of aquatic life are very sensitive to copper. In the comprehensive USEPA review of copper toxicity to aquatic life (USEPA 2007), the average concentration causing death in 50% of the exposed population (LC50), ranged as low as 2.37 micrograms per liter (µg/L) for the sensitive species *Daphnia pulicaria*. In general, invertebrates were more sensitive to copper than fish, but the most sensitive fish genus was *Oncorhynchus*, which includes Cutthroat trout and Rainbow trout. The average LC50 for *Oncorhynchus* species was 31.39 µg/L.

4.1.4.3 Lead

Human health effects of lead include decreased nervous system function, weakness in fingers, wrists, and ankles, anemia, and damage to the brain and kidneys, which can lead to death at high exposure levels. Children can suffer brain damage and developmental problems even at moderate levels of lead exposure, and are more likely than adults to ingest lead, and to absorb the lead they ingest. High levels of lead exposure can cause pregnant women to suffer miscarriage, and can cause damage to male reproductive organs (ATSDR 2007b).

Lead can negatively affect fish, aquatic invertebrates, and algae. Exposure to lead can cause fish to exhibit muscular degeneration, reduced growth, reproductive problems, paralysis, and death (Eisler 1988, USEPA 1976). Lead can impair reproduction of invertebrates, and can reduce algal growth (USEPA 2008).

4.1.4.4 Zinc

As with copper, zinc is an essential human nutrient. As reported by the Agency for Toxic Substances and Disease Registry (ATSDR 2005), high doses of zinc can cause stomach cramps, nausea, and vomiting. Chronic exposure can cause anemia. Preliminary animal studies showed development of infertility in rats exposed to high doses of zinc. Inhaling large amounts of zinc dust can cause a short-term condition called metal fume fever, which resembles the flu. Zinc is likely to cause skin irritation, as well.

Although zinc deficiency can negatively affect many species of animals and plants, high concentrations of zinc can have detrimental effects to aquatic biota (Eisler 1993), as quoted below:

> "The most sensitive aquatic species were adversely affected at nominal water concentrations between 10 and 25 μg/L, including representative species of plants, protozoans, sponges, molluscs, crustaceans, echinoderms, fish, and amphibians. Acute LC50 (96 h) values were between 32 and 40,930 μg/L for freshwater invertebrates, 66 and 40,900 μg/L for freshwater teleosts [e.g. bass]…" – Page 4

> "Zinc toxicosis affects freshwater fish by destruction of gill epithelium and consequent tissue hypoxia." – Page 12

4.2 Selected Screening Levels

Screening levels used to assess human and ecological exposure to metals are discussed below. The discussion includes description of the sources of references concentrations such as adopted regulatory criteria, evaluation of the exposure models of the screening levels to determine if the models correspond with exposure scenarios at the Lost Cabin and Nugget mines, and comparison of screening levels to detected concentrations of metals at the mine sites.

4.2.1 Sources of Screening Levels

4.2.1.1 Human Health

The primary source of human health screening levels used in this assessment is a document entitled *Risk-Based Cleanup Guidelines for Abandoned Mine Sites* (Tetra Tech 1996). The 1996 guidelines were produced for the Montana Department of Environmental Quality Abandoned Mine Reclamation Bureau, and they were designed to address potential exposure to metals at abandoned mine sites in Montana. Screening levels taken from the 1996 guidelines for the four COPCs were discussed in the PA/SI (AMEC 2011a) and are presented in **Table 9**. Additional screening levels used in this evaluation of potential human health risks include Montana groundwater standards (MDEQ 2010a), which were applied to mine waste leachate produced in the laboratory according to the SPLP analysis.

4.2.1.2 Ecological Risk

The criteria used for evaluation of ecological risk in surface water are the Montana Numeric Water Quality Standards (MDEQ 2010a). In the case of metals, the Montana surface water quality criteria are typically based on USEPA recommended water quality criteria for protection of aquatic life in a freshwater environment (USEPA 2011b). As shown in **Table 10**, Montana criteria for copper, lead, and zinc in surface water are hardness-dependent.

For streambed sediment, screening levels were used from the sediment section of the National Oceanic and Atmospheric Administration (NOAA) Screening Quick Reference Tables (SQuiRTs, NOAA 2008). Values for the four COPCs are presented in **Table 11**. The Lowest Effect Level (LEL) and the Severe Effect Level

(SEL) were selected as screening levels for sediment that represent the range of toxicity thresholds presented by NOAA (2008). These values are calculated using studies involving at least 20 species of aquatic life. The LEL represents a concentration at which only 5 percent of the studied species are anticipated to have adverse effects, and the SEL represents a concentration at which adverse effects are anticipated in 95 percent of the studied species.

The screening levels listed above apply to fish and aquatic life, such as the resident population of genetically pure Westslope cutthroat trout. As listed in the discussion of exposed populations, terrestrial animals may also be exposed to metals in the mining complex.

4.2.2 Exposure Models and Risk Thresholds for the Selected Screening Levels

Published exposure models and risk thresholds, where available, are described below for the screening levels, including details regarding the assumed routes of exposure.

4.2.2.1 Human Health

<u>1996 Guidelines</u>

In the document entitled *Risk-Based Cleanup Guidelines for Abandoned Mine Sites* (Tetra Tech 1996), the conceptual model for human exposure to metals from mine waste involves the following details. The report assumes that the potential receptors are engaged in recreational activities. The categories of recreational users evaluated in the report are anglers, hunters, gold panners, riders of motorcycles or All-Terrain Vehicles (ATVs), a well as a composite exposure category for a site visitor who participates in all four of the above activities. The potential and actual recreational use of abandoned mine sites is briefly established in the 1996 report, including description of the types of streams and access roads identified near abandoned mines in the State of Montana database, and a summary of actual recreational use intensities observed at abandoned mines in the database.

The routes of human exposure analyzed in the 1996 report are shown in **Appendix D**, including potential routes such as groundwater ingestion, that were deemed to be incomplete and not a source of risk. Complete exposure routes include ingestion or dermal exposure to mine waste, surface water, or sediment; and inhalation of dust or mobilized sediment. The 1996 analysis of exposure routes was prepared specifically for mine sites in Montana, and is applicable to the Kennedy Creek mining complex.

The 1996 report used the following risk thresholds to calculate screening levels. For non-carcinogenic metals, a Hazard Index (HI) of 0.5 for individual metals was used by TetraTech (1996) to develop screening levels. MDEQ typically uses a threshold HI of 0.1 for individual contaminants and a cumulative HI of 1.0 for all COPCs, which is more restrictive than the 1996 guidelines in instances where more than two non-carcinogens are present. For carcinogenic metals (arsenic and cadmium), one-in-500,000 was used as the risk target in development of the 1996 recreational screening levels. MDEQ uses one-in-100,000 as the overall excess cancer risk target level. Risk thresholds used in the 1996 guidelines differ from current MDEQ practices, but the overall approach of determining recreational user groups and use frequencies specific to Montana abandoned mine sites is applicable to the mining complex, and more appropriate than alternative approaches based on residential or industrial use.

Montana Groundwater Standards

The cancer risk threshold used to develop the Montana numeric water quality standards is typically an excess risk of one-in-100,000, consistent with general MDEQ practices. For non-carcinogens, the risk thresholds vary depending on the contaminant and are taken from the National Primary Drinking Water Regulations (40 CFR 141) and the National Recommended Water Quality Criteria (USEPA 2011b).

The exposure model used to develop Montana numeric groundwater standards is based on an assumed rate of drinking water consumption. The Montana calculations are for a 70 kilogram person consuming two liters per day of drinking water from the source in question, over a period of 70 years. The calculations assume that there is no other route of exposure to the target contaminant. The assumed rate of consumption and the assumption that no other route of exposure is present are not directly applicable to the Kennedy Creek mining complex. Groundwater in the mining complex is not used for drinking water, and there are no foreseeable drinking water developments in the vicinity of the complex. No groundwater data is currently available for the Kennedy Creek mining complex. The groundwater standards were used as screening levels to identify mine waste with low levels of metals leachability versus waste with high metals leachability, not to identify locations and scenarios where health risk thresholds are exceeded. The leachable metals results, and comparison to groundwater standards, will be used to inform cleanup, but not for making decisions regarding whether cleanup is needed.

4.2.2.2 Ecological Risk

Montana Numeric Water Quality Standards

National Aquatic Life Criteria were generally adopted by Montana as surface water quality standards, except that the Biotic Ligand Method for evaluating copper exposure (recommended in 2010) has not been adopted by Montana. National Aquatic Life Criteria were created using the 1985 derivation guidelines (USEPA 1985), which are intended to be applicable to all North American bodies of water, their resident species, and uses of these species; except for unusual bodies of water such as Great Salt Lake, and unusual species and uses such as harvest of brine shrimp. The 1985 derivation guidelines recommend a general approach that no more than 1-in-20 studied taxa should exhibit adverse effects at the critical concentration.

SQuiRTs

The two values selected as screening levels for evaluating sediment in the Kennedy Creek mining complex are the LEL and the SEL from the SQuiRTs developed by NOAA (2008). As recommended in the 1985 derivation guidelines for water (USEPA 1985), the LEL and SEL values are calculated using studies involving at least 20 species of aquatic life. The LEL represents a concentration at which only 5 percent of the studied species (or 1-in-20) are anticipated to have adverse effects, and the SEL represents a concentration at which adverse effects are anticipated in 95 percent of the studied species.

4.3 Comparison of Detected Concentrations to Screening Levels

Concentrations of arsenic, copper, lead, and zinc detected in waste rock, surface water, and streambed sediment have exceeded screening levels for protection of human health and ecological receptors during multiple sampling events dating back to 1993. Sample results indicate elevated human health risks from arsenic, lead, and zinc; and elevated ecological risks from copper, lead, and zinc at and downstream of the Lost Cabin and Nugget Mines, as described below.

4.3.1 Human Health

Arsenic, lead, and zinc have been detected in the Kennedy Creek mining complex at concentrations that indicate elevated risks to human health. Instances where these metals exceed human health screening levels presented in **Table 9** are summarized below. The risk thresholds associated with human health screening levels are summarized in **Section 4.2.2.1**. In waste rock, lead exceeds screening levels by the greatest magnitude. For surface water, zinc is the metal with the greatest exceedances of the associated human health screening level.

4.3.1.1 Arsenic

Waste rock samples from both the Lost Cabin and Nugget Mines contained arsenic at concentrations above the recreational human health standard of 70 mg/kg (see **Table 2**). Seven of eight waste rock samples collected from the Lost Cabin Mine, and three out of nine samples collected from the Nugget Mine exceeded the standard. The magnitude of exceedance was typically less than a factor of two. Arsenic concentrations in surface water did not exceed the human health screening level of 6.5 μg/L (see **Tables 4** and **5**).

4.3.1.2 Copper

Although copper is present in waste rock at more than 10 times the background concentration (see **Table 2**), copper in waste rock does not present an elevated risk to human health in the mining complex. Concentrations of copper in surface water did not exceed the human health screening level of 472 μg/L (see **Tables 4** and **5**).

4.3.1.3 Lead

Waste rock at the Lost Cabin Mine contains lead at concentrations 16 times higher than the recreational human health screening level of 1,100 mg/kg, and Nugget Mine waste rock contains lead 5 times higher than the screening level (see **Table 2**). Lead in surface water did not exceed the human health screening level of 47.1 μg/L (see **Tables 4** and **5**).

4.3.1.4 Zinc

Zinc is present in waste rock at more than 10 times the background concentration (see **Table 2**), and has been detected above the human health screening level of 17.2 micrograms per liter (μg/L) in Kennedy Creek below the Lost Cabin and Nugget Mines (see **Tables 4** and **5**). Concentrations of zinc in adit discharge and water in the pond receiving adit discharge are typically more than 100 times the human health screening level.

4.3.2 Ecological Risk

Screening levels and thresholds for ecological risk in the Kennedy Creek mining complex apply to surface water and sediment, as described in **Section 4.1.2**. Arsenic, copper, lead, and zinc have been detected in surface water or sediment above ecological screening levels, as summarized below. The risk thresholds associated with ecological screening levels are summarized in **Section 4.2.2.2**. Arsenic does not exceed surface water standards and does not increase in concentration downstream of the Lost Cabin and Nugget Mines. In surface water, zinc exceeds ecological screening levels by the greatest magnitude. In addition, the zinc concentration of water within the adit is extremely high. For sediment, copper and zinc are the two metals that exceed the SEL for prediction of ecological impacts.

4.3.2.1 Arsenic

Arsenic concentrations in sediment in the mining complex exceed the LEL, however this was true for all sediment samples including the upstream background sample (see **Table 7**). Arsenic concentrations do not exceed the surface water screening level and did not increase downstream of the Lost Cabin and Nugget Mines.

4.3.2.2 Copper

All surface water samples collected downstream of the Lost Cabin and Nugget Mines exceeded the hardness-dependent screening levels for ecological risk from copper (see **Tables 4** and **5**), except the sample collected in August 2010 from downstream of the Nugget Mine. This sample had elevated hardness and a higher screening level than earlier samples. Copper concentrations in the adit discharge were typically 10 times higher than the surface water screening level (see **Tables 4** and **5**). Sediment samples collected from the bed of Kennedy Creek exceeded not only the LEL, but also the SEL, in samples collected immediately downstream of the Lost Cabin Mine (1993 only) and the Nugget Mine (1993 and 2010; see **Table 7**).

4.3.2.3 Lead

All surface water samples collected downstream of the Lost Cabin and Nugget Mines exceeded the hardness-dependent screening levels for ecological risk from lead (see **Tables 4** and **5**). The adit discharge and pond water at the Nugget Mine exceeded the ecological screening level during all sampling events except June 2010.

As with arsenic, lead in sediment samples from the mining complex exceeded the LEL, but did not exceed the SEL (see **Table 7**). Unlike arsenic, however, lead concentrations in sediment increase downstream of the Lost Cabin and Nugget Mines. The upstream background sample did not contain lead above the LEL. The lead concentrations downstream of the Lost Cabin and Nugget Mines are within 10% of the SEL, and lead in sediment is an ecological risk concern for the site.

4.3.2.4 Zinc

Zinc was not detected in samples from Kennedy Creek upstream of the Lost Cabin and Nugget Mines in 2010 and 2011 (see **Table 5**). Zinc was detected above the hardness-dependent surface water screening level in samples collected downstream of the Lost Cabin and Nugget Mines in July 1993 and August 2010 (see **Tables 4** and **5**), but not during high-water conditions of June 2010 (see **Table 5**). The zinc concentration within the adit is extremely high (sample Adit-Inside on **Table 5**), and decreases to approximately 100 times the screening level in the first surface expression of adit discharge at the toe of a rubble pile covering the former adit opening (see Adit K1 on **Table 5**).

Zinc concentrations in sediment exceeded the LEL downstream of the Lost Cabin and Nugget Mines, and also upstream of the Lost Cabin Mine in an unnamed tributary to Kennedy Creek (see **Table 7**). The zinc concentration in sediment exceeded the SEL in the sample collected August 2010 downstream of the Nugget Mine (see **Table 7**).

5.0 RESPONSE ACTION SCOPE, GOALS, AND OBJECTIVES

A response action may be conducted under the non-time-critical removal action process to prevent, minimize, stabilize, mitigate, or eliminate the release or threat of release of a hazardous substance if the lead agency (USDA-FS) determines there is a threat to public health, welfare, or the environment. Impacts to surface water in Kennedy Creek are occurring due to the mobilization of contaminants from waste rock at the Lost Cabin and Nugget mines and the adit discharge at the Nugget mine. Based on the results of the risk evaluation presented in **Section 4.0**, arsenic, lead, and zinc pose a risk to human health due to the potential for exposure through dermal contact, ingestion, and inhalation. In addition, arsenic, copper, lead, and zinc pose an ecological risk to aquatic life at the mining complex. The following subsections present the scope of the response action, response action objectives, and project goals.

5.1 Response Action Scope

Response actions are required to meet specified cleanup levels under the non-time-critical response action process while working within statutory limits and attaining applicable or relevant and appropriate requirements (ARARs; **Appendix E**) to the extent practical. Response actions must also consider the potential for future response actions that may be undertaken at the site and must not preclude these actions even if not currently planned. The response action under consideration for the Kennedy Creek mining complex is an initial response to the release of hazardous substances at the Lost Cabin and Nugget mine sites. This removal action may not be the sole response taken at the mining complex, however, no additional response actions are currently planned.

The scope of the response action under consideration for the Kennedy Creek mining complex is focused on the reduction or elimination of uncontrolled releases of metals to soil, surface water, and sediment from waste rock present at the Lost Cabin and Nugget mines and the adit discharge at the Nugget mine.

5.2 Response Action Objectives

The primary goal of the removal action presented in this EE/CA is to reduce or eliminate potential human health and environmental risks associated with waste rock at the Nugget and Lost Cabin mine sites and an adit discharge at the Nugget mine in the Kennedy Creek mining complex. Specific RAOs for the Lost Cabin and Nugget mines include the following:

- Reduce or eliminate safety and health hazards to recreational users of Forest Service lands;
- Improve water quality, stream function, and aquatic life and fisheries habitat in Kennedy Creek and the unnamed tributary;
- Reduce or eliminate sources of metals impacts to surface water and sediment; and
- Maximize use of native vegetation and soils to the extent practical for revegetation and reclamation efforts.

5.3 Response Action Schedule

The Forest Service has determined that a risk to human health and the environment exists in the Kennedy Creek mine complex, and therefore a removal action is appropriate to mitigate this risk. The removal action could commence within 6 to 12 months following approval of this EE/CA. However, the schedule for implementation of the preferred alternative (identified in **Section 8.3**) will be dependent upon the availability of funding. Based on the scope of the removal action alternatives under consideration in this EE/CA, it is anticipated that the removal action could be implemented within one field season.

5.4 ARAR-Based Goals

Section 300.415(i) of the NCP requires response actions to ARARs to the extent practicable, considering the exigencies of the situation at the site (EPA 1992). ARARs are either applicable, or relevant and appropriate. "Applicable" requirements are cleanup standards, standards of control, or other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that specifically address the COPCs, cleanup action, location or other circumstance at the site. "Relevant and appropriate" requirements are regulatory requirements or guidance that do not apply to the site under law but address problems or situations sufficiently similar to those at the site that their use is well suited to the site. Once the agency determines that a requirement is relevant and appropriate, the agency must comply with the requirement to the same extent as if it were applicable. Exception to the requirement for compliance with ARARs is provided in the case of removal actions, which are limited in scope compared to remedial actions. This difference is briefly summarized in the following excerpt from the NCP, which is also provided in **Appendix E**.

> *The purpose of removal actions generally is to respond to a release…so as to prevent, minimize, or mitigate harm to human health and the environment. Although all removals must be protective…removals are distinct from remedial actions in that they may mitigate or stabilize the threat rather than comprehensively address all the threats at a site. Consequently, removal actions cannot be expected to attain all ARARs. Remedial actions, in contrast, must comply with all ARARs or obtain a waiver.*

Alternatives presented in this EE/CA are removal actions to mitigate threats from uncontrolled mine waste and adit discharge. A preliminary list of ARARs for the removal action alternatives is provided in **Appendix E**. ARAR-based cleanup goals for the Kennedy Creek mining complex are limited to surface water because no contaminant specific ARARs exist for soils, mine waste, or sediment. Montana groundwater standards are applicable to the response action alternatives presented in this EE/CA, but compliance with groundwater ARARs may not be achievable, and therefore is not required under CERLCA for this removal action.

Surface water ARARs include established aquatic life and human health water quality standards. Montana aquatic life standards include both chronic and acute criteria. Chronic standards are applicable to long-term exposure scenarios and are lower than the acute aquatic life standards. Therefore, chronic aquatic life standards were used for this ARAR evaluation. The more stringent of the human health or chronic aquatic life water quality standard was selected as the ARAR-based cleanup goal for surface water for each COPC at the Kennedy Creek mining complex. The ARAR-based goals for surface water are summarized in **Table 12**. Surface water criteria that are hardness dependant were calculated based on a hardness value of 25 mg/L.

5.5 Risk-Based Goals

The results of the streamlined risk evaluation (**Section 4.0**) indicate that arsenic and lead in waste rock at the Lost Cabin and Nugget mines present risks to human health and the environment. Cleanup guidelines for project COPCs in sediment and soil are listed in **Table 13**. Reclamation goals for surface water are presented in **Table 12**.

5.6 Contaminants of Concern

Concentrations of COPCs detected in surface water, sediment, and waste rock were compared to the cleanup goals for the project (**Tables 12** and **13**) to identify constituents of concern (COC) for the mining complex. Arsenic and lead have been detected in waste rock at the Lost Cabin and Nugget mines at concentrations above cleanup goals (**Table 2**). Copper, lead, and zinc have also been detected in surface water and sediment at the mining complex above cleanup goals (**Tables 4**, **5**, and **7**). Therefore, arsenic, copper, lead, and zinc were retained as COCs for the mining complex.

6.0 DEVELOPMENT OF REMOVAL ALTERNATIVES

This section of the EE/CA identifies response action technologies that could be implemented to reduce or eliminate potential human health and environmental risks associated with waste rock and the adit discharge at the Nugget and Lost Cabin mine sites. The technologies were initially screened against their ability to meet the RAOs presented in **Section 5.2** and practical considerations of their implementation at the mining complex. The technologies retained from the initial screening process were then used to develop response action alternatives for detailed analysis based on their effectiveness, implementability, and cost. The detailed evaluation of alternatives is presented in **Section 7.0**.

6.1 Identification and Preliminary Screening of Removal Actions

Response action technologies that address elevated concentrations of metals in waste rock at the mining complex and the adit discharge at the Nugget mine were identified based on AMEC's experience at similar sites, engineering judgment, and a review of available literature. The technologies identified for preliminary screening can be classified into four general categories:

- Institutional Controls – measures that restrict or control access to or use of a site as a means to reduce exposure of the public to COCs.
- Engineering Controls – technologies that reduce contaminant mobility and eliminate exposure pathways through the use of physical barriers.
- Excavation and Disposal – excavation of waste rock for disposal at either an on-site repository or an of off-site permitted disposal facility. This category does not apply to the adit discharge.
- Treatment – destruction or immobilization of contaminants by treatment of the adit discharge and/or waste rock with elevated metals concentrations. Technologies considered for treatment of the waste rock included in-situ and ex-situ methods.

Response action technologies for mine waste are summarized in **Table 14** with the preliminary screening results and discussed below. Preliminary screening of response action technologies for the adit discharge are discussed in **Section 6.4** and summarized in **Table 15**.

6.2 Institutional Controls

Institutional controls include physical barriers, signs, and land use restrictions to control or restrict access to a site and are potentially applicable to both solid mine waste and the adit discharge. Institutional controls provide some measure of protection to human health by limiting exposure to contaminants. However, institutional controls do not prevent contaminant migration, reduce COC concentrations, or achieve cleanup goals. In addition, institutional controls would do little to address ecological impacts associated with the mining complex.

Land use restrictions would limit possible future uses of the mine sites through the local forest management plan. Physical barriers, such as fences, are readily implemented and could be installed around areas of waste rock and the adit discharge to prevent (reduce) access by the public. Posted signs notifying the public of potential hazards associated with the Lost Cabin and Nugget mines may also be potentially effective deterrents to use of the mining complex by the public.

Institutional controls would not be effective as stand-alone response actions. When combined with other actions, however, these options would increase the protectiveness of the alternative. Therefore, institutional controls have been retained for further consideration through inclusion with other response actions.

6.3 Mine Waste Response Action Technologies

6.3.1 Engineering Controls

Engineering controls use physical barriers to reduce contaminant mobility and eliminate exposure pathways. Engineering controls typically include containment, run-on/runoff controls, and revegetation. As discussed below and in **Table 14**, these response actions would not reduce contaminant concentrations or the volume of impacted media. This response action could be used in conjunction with another action, but by itself will not receive further consideration.

6.3.1.1 Containment

Containment (i.e., capping) of waste rock in place would prevent direct contact with contaminated media, eliminate fugitive emissions from windblown dust, and prevent continued erosion of waste rock into Kennedy Creek. Capping would also reduce contaminant mobility by decreasing the infiltration of precipitation into the waste rock. Cap designs range from simple monolithic soil covers to composite cover systems with compacted clay layers, geomembranes, and vegetative covers. The cap design is selected based on the hazards posed by the contaminated media and site characteristics (e.g., annual precipitation volumes, site slope, etc.).

Waste rock is in direct contact with Kennedy Creek at both the Lost Cabin and the Nugget mines and would need to be excavated back from the creek channel prior to capping. In addition, the adit discharge at the Nugget mine flows through a settling pond constructed over waste rock prior to discharging to the creek. The adit discharge would need to be rerouted away from the waste rock prior to capping. It would also be necessary to import cover materials to the Lost Cabin and Nugget mines because sufficient volumes of suitable cover materials are not present at the mines.

In-place containment of waste rock at the Lost Cabin and Nugget mines was not retained for further evaluation due to the availability of a suitable location for the construction of on-site repository for disposal of mine wastes approximately 3/4-miles downstream (west-southwest) of the Nugget mine (refer to **Section 6.3.2.1**).

6.3.1.2 Surface Controls

Surface controls include grading to reshape and reduce the slopes of waste areas, construction of diversion channels to control run-on/runoff, revegetation of waste areas, and erosion controls. Surface controls are implemented to control erosion of mine waste, reduce windblown dust, and decrease infiltration of surface water. These measures are not typically used as stand-alone response actions at sites where direct human contact is a concern, but may be integrated with other measures (such as containment) to provide additional protection.

Grading is used to reshape and reduce the slopes of mine waste to control storm water run-on/runoff, prevent erosion of mine wastes, and reduce infiltration of surface water. Periodic maintenance may be necessary to repair any erosion that occurs following closure.

At the Nugget and Lost Cabin mines, revegetation could be implemented to control water and wind erosion of mine wastes and reduce infiltration of precipitation through evapotranspiration. It would necessary to add soil amendments to the waste rock at both sites to establish vegetation due to the absence of organic materials in mine waste. Mulching and/or chemical stabilization, as well as fertilization, would also be necessary to promote revegetation. Periodic maintenance, including weed control, may be necessary following initial revegetation efforts until a self-sustaining plant community is established.

Erosion control measures include the use of run-on/runoff diversion channels and placement of erosion resistant materials on mine waste, such as mulch and natural or synthetic fiber mats. Run-on/runoff diversion channels are constructed to direct storm water runoff away from mine waste. Erosion control products are strategically placed in areas considered likely to be subject to water erosion.

Surface control measures, including grading, revegetation, and erosion control are retained for further evaluation through inclusion with other response action alternatives.

6.3.2 Excavation and Disposal

Excavation and disposal of impacted media in an on-site repository or at an off-site permitted landfill is a permanent source control measure. Approximately 1,830 and 2,020 cubic yards of waste would be removed from the Lost Cabin and Nugget mines, respectively, for disposal under these response actions. It would be necessary to repair the roadway slump south of the mining complex or construct a temporary access road around the slump to allow excavation equipment and haul trucks to access the site. Growth media would be placed at both sites following excavation and revegetated through seeding and/or planting to stabilize soil cover and control erosion.

6.3.2.1 On-Site Disposal

As discussed in **Section 3.4**, the USFS has identified a suitable location for an on-site repository approximately ¾-miles downstream (west-southwest) of the Nugget mine (**Figure 8**). The repository would include a cover system designed to limit infiltration of precipitation into the waste rock. Diversion channels would be constructed to direct storm water run-on/runoff away from the repository to prevent erosion of the soil component of the cover system and further limit infiltration. Top soil and suitable subsoils would be salvaged from the repository area for use in constructing the cover and reclaiming the excavation areas at the mines. Excavation and on-site disposal of mine wastes has been retained for further evaluation.

6.3.2.2 Off-Site Disposal

Under this scenario, excavated mine waste would be hauled to an off-site permitted landfill for disposal. Elevated concentrations of arsenic and lead detected in the waste rock during the 2010 PA/SI (AMEC 2011a) and samples collected by Pioneer in 1993 at the Lost Cabin and Nugget mines indicate that the waste rock may be considered a hazardous waste due to toxicity. The waste rock may require disposal at a landfill licensed to receive hazardous waste if transported off site for disposal. However, additional sampling and laboratory analysis would be necessary to confirm this.

Excavation and off-site disposal were not retained for further evaluation because landfill disposal fees and waste hauling costs make this option cost prohibitive, and a potential on-site repository site has been identified. Disposal fees at a Class D (municipal) licensed landfill are estimated to be more than $200,000. Disposal fees at the Grassy Mountain treatment storage and disposal facility in Utah would be approximately $289 per cubic yard of waste, or approximately $1,400,000, including transportation costs. Transportation to and disposal at the Arlington facility in Oregon or Mountain Home in Idaho would also be prohibitively expensive.

6.3.3 Ex-Situ Treatment

Ex-situ treatment of mine waste involves the physical removal of impacted media for treatment at either an on-site or off-site facility to reduce contaminant mobility and/or toxicity. The treated media may then either be placed back on site or disposed of at an off-site facility. Treatment processes may include chemical, physical, or thermal methods.

6.3.3.1 Reprocessing and Re-use

Reprocessing consists of subjecting mine waste to physical/chemical extraction processes for the beneficial recovery of metals, which reduces the mobility of contaminants in the mine waste. The resulting waste can potentially be disposed of on site or may be suitable for another beneficial use (e.g., road aggregate). Reprocessing was not retained for further consideration due to the likely low recoverable metals concentrations in the mine waste at the Lost Cabin and Nugget mines, distance from the mining complex to processing facilities, and liability issues associated with transporting the mine waste off-site.

Re-use of mine waste, either directly or following reprocessing or other treatment, into a beneficial product that is environmentally safe is another potential response action. Examples of re-use include:

- The use of mine waste as aggregate in asphalt or concrete mixes;
- The re-use of contaminated soil as a cover material for site remediation; and

- The use of waste rock as a construction material (either directly or following treatment/reprocessing).

Re-use of mine wastes was not retained for further consideration due to potential liability concerns associated with using contaminated materials at off-site locations and the lack of an indentified use for the materials.

6.3.3.2 Physical/Chemical Treatment

Physical treatment technologies rely on the physical properties of the contaminant and/or impacted media to separate the contaminants from soil, reducing the waste volumes for disposal or additional treatment. Chemical treatment technologies rely on chemical reagents to precipitate or immobilize contaminants. Potentially applicable technologies include soil washing and acid extraction.

Soil washing is a physical treatment technology that separates contaminants sorbed onto fine soil particles from bulk soil in a water-based system on the basis of particle size (EPA 2011). Contaminated media and wash water are mixed ex situ in a tank or treatment unit. A leaching agent, surfactant, or chelating agent may be added to the wash water or the pH of the wash water may be adjusted to enhance the removal of metals. The wash water and various soil fractions are usually separated by gravity settling.

Acid extraction is similar to soil washing, but an acidic solution is applied to the contaminated media in a mixing tank instead of water to extract metals from media. The extraction solution and treated media are separated using physical processes. Following separation, the treated media is rinsed with water to remove entrained acid and metals. Dissolved metals are subsequently removed from the extraction solution and rinse water using precipitants for additional treatment and/or disposal.

These processes were not retained for further evaluation due to their associated high costs, as well as the fact that these technologies would generate waste streams that would require additional treatment or disposal.

6.3.4 In-Situ Treatment

In-situ treatment consists of remediating impacted media in place to reduce contaminant mobility and toxicity. The only in-situ treatment method evaluated for the mining complex is chemical fixation/stabilization.

Chemical fixation/stabilization involves mixing a solidifying or chemical precipitating agent (or mixture of agents) to cause a physical or chemical change in the mobility and/or toxicity of contaminants. Potential fixation/stabilization agents include portland cement, other pozzolans, and phosphate. Tailings and waste rock have been successfully treated with phosphate amendments to reduce leachable concentrations of copper, lead, and zinc. Chemical fixation/stabilization was not retained for further evaluation due to its associated high implementation costs.

6.4 Adit Discharge Response Action Technologies

Treatment technologies that could potentially be implemented to address elevated metals concentrations in the adit discharge at the Nugget Mine can be classified into five general categories:

- Hydraulic controls to reduce, eliminate, or divert the adit discharge;
- Biochemical treatment, including bioreactors and constructed treatment wetlands;
- Passive chemical adsorption / ion exchange;
- Chemical precipitation; and
- Membrane separation.

A no action alternative will also be evaluated as a baseline to compare other response action alternatives against. Response action technologies and preliminary technology screening results are summarized in **Table 15** and discussed below.

6.4.1 Hydraulic Control

Hydraulic controls include measures to reduce (and potentially eliminate) the adit discharge, as well as measures to direct the discharge into the subsurface, which would eliminate the potential for direct contact of ecological and human receptors with the discharge.

6.4.1.1 Subsurface Hydraulic Barrier

Review of surface water elevations in Kennedy Creek and inside the adit at the Nugget mine suggest that the adit may receive some recharge from Kennedy Creek through subsurface flows. A subsurface hydraulic barrier constructed between Kennedy Creek and the adit could potentially reduce inflows to the underground mine workings, thereby reducing the discharge from the adit. The adit likely also receives recharge from infiltration of precipitation into the hill slope above the adit and inflow of groundwater west of the adit. A subsurface hydraulic barrier would not affect these flows.

Several construction methods for hydraulic barriers are available, including: installation of a cutoff wall with excavation equipment; driving sheet pile; and deep soil mixing with auger systems. Sheet pile cutoff walls are constructed by driving interlocking steel or high-density polyethylene (HDPE) sheets into the ground. Deep soil mixing methods rely on auger systems to inject and mix cement-bentonite grout with subsurface soil to create overlapping, low permeability columns that form a continuous vertical barrier to groundwater flow. Sheet pile and deep soil mixing methods would be cost prohibitive and are not considered further.

Slurry walls are constructed by backfilling an excavated trench with a mixture of the excavated soil, bentonite clay, and water to form a barrier to groundwater flow. Alternatively, an impermeable geomembrane could be installed on one face of the excavated trench to provide the flow barrier. The trench would then be backfilled with the excavated material. Although no information regarding depth to groundwater is available for the Nugget mining complex, it is likely to be relatively shallow (5 – 10 feet below ground surface) based on the presence of Kennedy Creek within the mine site (**Figure 5**). Shallow groundwater at the site would negatively affect the stability of the trench sidewalls. Dewatering or use of a stabilizing agent (i.e., guar gum) may be required for constructing of a cutoff wall with a geomembrane. The slurry used to construct slurry walls provides lateral support to the trench sidewalls during construction, eliminating the need for additional stabilization.

It would be necessary to key the cutoff wall into competent bedrock or a zone of low permeability soil (e.g., clay) to prevent groundwater from flowing underneath the wall. Limited information is available regarding subsurface conditions at the Nugget mine. Prior to design of a cutoff wall system, additional investigation would be required at the Nugget mine to confirm that Kennedy Creek is a significant source of recharge to the adit through groundwater flow. The investigation would also determine the depth to groundwater and competent bedrock (or other low permeability zone) prior to design of a cutoff wall.

Construction of a hydraulic barrier wall was not retained for further evaluation because its ability to significantly reduce adit flows is unknown.

6.4.1.2 Adit Seals

Cemented plugs installed in mine workings serve as watertight barriers to groundwater flow and eliminate adit discharge. Watertight plugs are typically constructed in pairs. The first plug stops the flow of water toward the portal and holds back the majority of the hydrostatic head. The second plug is constructed closer to the adit opening and serves as a barrier to any water that bypasses the first plug. A sufficient length of the adit must be open to install two effective plugs. In addition, installation of cemented plugs close to adit openings is typically avoided because the plugs would simply redirect flow into fractures in adjacent rock, which may in turn discharge to the surface. Therefore, this method of source control is not suitable for short or shallow adits.

Alternatively, cemented backfill may be installed in the adit to restrict water flow through the workings. Sections of cemented backfill may not be constructed to the same level of design / control as cemented plugs, and therefore, may reduce but not completely eliminate flow through the adit. Cemented backfill may be used in conjunction with watertight plugs to provide a foundation for the plugs.

As discussed in **Section 3.4**, AMEC inspected the immediate interior of the adit opening in September 2011. However, the opening is largely blocked by scree / rubble and the adit was not accessible for a detailed inspection. Available information on the Nugget Mine suggest that the adit is approximately 140 feet long with two drifts in sheared and tightly folded argillite host rock (Hargrave et al. 2003). The mine workings totaled 1,100 to 1,200 feet in length in 1978. It is unknown whether all mine workings remain open over their entire length. However, the underground workings were reportedly maintained as late as 1988 and may still be in good shape (with the exception of the blocked opening).

A thorough geotechnical inspection of the adit would be necessary to evaluate the stability and open length of the mine workings to determine whether it would be feasible to install watertight plugs or sections of cemented backfill. In addition, the inspection would be necessary to identify fractures in the surrounding rock and potential points of groundwater inflow into the workings to determine suitable locations for the plugs and/or backfill. It would be necessary to remove the rubble blocking the adit opening prior to the inspection.

If a geotechnical inspection determines the workings are amenable to sealing, this response action would be readily implementable using common underground mining practices and would provide a relatively permanent solution to the adit discharge. Associated costs for this response action may be relatively high, depending on the level of effort needed to prepare the workings for sealing (e.g., shoring, reconstructing / rehabilitating collapsed mine workings, etc.). Therefore, sealing of the adit, either through watertight plugs or cemented backfill, was not retained for further evaluation.

6.4.1.3 Infiltration Gallery

This response action consists of the construction of a collection system to capture surface flows from the adit and convey them to an infiltration gallery, which would distribute the flows into the subsurface at the mine. Infiltration would result in the dispersion and dilution of the adit flows in the subsurface, and would limit the potential for exposure of recreational users and ecological receptors to COCs. Treatment media, such as Apatite II, could be incorporated into the infiltration gallery to reduce COC concentrations in the water prior to discharge into the subsurface. Infiltration could also be used to dispose of water following treatment using other methods (e.g., bioreactors, chemical precipitation, etc.).

Shallow groundwater at the site may limit the ability of an infiltration gallery to accept adit flows, particularly seasonally high-flows during spring runoff. As previously discussed, no information is available regarding depth to groundwater and groundwater flow direction at the mining complex. If Kennedy Creek is seasonally recharged by groundwater, limited dispersion / dilution of the infiltrated adit water would occur in the subsurface prior to discharge to the creek. Infiltration is retained for further consideration.

6.4.2 Passive Chemical Adsorption / Ion Exchange

Passive chemical adsorption treats mine-impacted water through the adsorption of contaminants onto solid treatment media. Ion exchange relies on the interchange of ions between treatment media and the mine-impacted water to remove contaminants from the water. Available media for chemical adsorption or ion exchange include natural iron and aluminum oxyhydroxides, peat, zeolites, and Apatite II (a phosphatic material manufactured from fish bones). These technologies are readily implementable and could be combined with infiltration to treat the adit discharge and discharge it to the subsurface. Alternatively, a treatment cell could be installed within the adit to treat the water before it discharges at the surface. The treatment media would require periodic replacement.

Apatite II reduces metals concentrations in water through four general processes (Wright, et al. 2004):

- Provides a continuous supply of phosphate ions to solution for the formation of metal-phosphate precipitates.
- Induces precipitation of metals into other phases such as carbonates, oxides, and hydroxides.
- Adsorbs target metals onto its surface. Apatite II will adsorb up to 5% of its weight by this process.
- Stimulates biological reduction of target metals by supplying phosphorous and other readily-bioavailable organics to stimulate microbial activity.

Apatite II has been successfully used to reduce concentrations of metals, including copper, lead and zinc, in mine-impacted water at several sites (Conca, et al., 2006; Wright, et al., 2004; and PIMS 2011). Chemical adsorption using Apatite II has been retained for further consideration.

6.4.3 Biochemical Treatment

Biochemical treatment technologies rely on microbial processes to transform contaminants to less toxic and/or mobile species. Biochemical treatment technologies include bioreactors and constructed wetlands.

6.4.3.1 Bioreactors

Bioreactors have been effectively used to reduce concentrations of copper, lead, and zinc in mine-impacted water (ITRC 2011). Sulfate-reducing bioreactors (SRBs), which are operated anaerobically, are most commonly used to treat metals-impacted water at mine sites. The microbial process of sulfate reduction produces sulfides and bicarbonate within the reactor, allowing target metal species to precipitate as metal sulfides. The following general chemical equations illustrate the process of microbially-mediated sulfate reduction, oxidation of organic matter (represented by CH_2O), and metal (Me) precipitation.

$$2CH_2O(aq) + SO_4^{-} + H^{+} \rightarrow H_2S + 2HCO_3^{-}$$

$$H_2S + Me^{2+} \rightarrow MeS + 2H^{+}$$

Bioreactors can be designed to accommodate a wide range of flows and metals loading, and may be passive or actively operated (e.g., fluidized bed reactors). Passive SRBs typically rely on solid organic substrates (e.g., composted cow manure, wood chips, alfalfa hay, etc.) to support microbial processes. Low water temperatures slow down microbial activity, which significantly affects the performance of SRBs. Passive SRBs can be constructed below grade to insulate the bioreactor against freezing conditions. However, treatment performance would likely reduced during low temperature (winter) conditions.

SRBs utilizing solid organic substrates have also been successfully demonstrated both within mine adits (Nordick 2008; Sobolewski 2010) and external to mine workings (Doshi 2006). Solid substrate reactors may be supplemented with a liquid carbon substrate, such as methanol or ethylene glycol to provide higher levels of sustained sulfate reduction and increased treatment efficiency. The initial effluent from SRBs may contain elevated biochemical oxygen demand (BOD), nutrients, and color, and would be low in dissolved oxygen. Additional treatment, such as polishing ponds and flow over aeration structures, may be necessary.

The permeability of organic substrate bioreactors may be reduced over time due to the formation of precipitates, biological growth, and substrate settling. This may lead to short-circuiting or plugging within the reactor and reduced treatment efficiencies. Coarse wood chips, limestone gravel, and other support media may be incorporated into the treatment media to improve permeability and increase the lifespan of the reactor cell. Replacement of the treatment media in solid substrate systems would be required periodically. Estimates of long-term performance and substrate longevity vary and range from 10 – 30 years in the available literature (ITRC 2011a).

Based on a review of the adit water chemistry (**Table 6**), sufficient sulfate is not present in the adit discharge to provide the level of sulfide production necessary to reduce all metals to concentrations below surface water quality criteria through precipitation as metal sulfides. However, significant reductions in metals concentrations would occur. Copper and lead would be preferentially removed from the adit discharge, followed by zinc. Sulfur prills or gypsum could be added to the treatment media to provide a supplemental source of sulfate.

SRBs, constructed either in the subsurface or the adit interior, have been retained for further consideration due to their proven effectiveness and relatively low costs compared to more active treatment alternatives.

6.4.3.2 Constructed Wetlands

Metals removal in wetlands generally results from processes that include reduction of aqueous species to insoluble forms and deposition into the sediments, uptake and accumulation into plant tissue, adsorption onto organic matter, and volatilization to the atmosphere (i.e. through biological volatilization of plants, plant/microbe associations, and microbial processes alone). Constructed wetlands have been used at several mine sites to reduce metals concentrations in water (ITRC 2011). However, cold conditions in the Kennedy Creek drainage would likely reduce the effectiveness of constructed wetlands during a significant portion of the year, including during spring runoff. Constructed wetlands were retained for further evaluation because they would be readily implementable at Nugget mine, would seasonally reduce COC concentrations, and would have lower implementation and long-term operation costs compared to more active treatment methods.

6.4.4 Chemical Precipitation

Chemical precipitation is a conventional treatment technology for metals-impacted water that consists of the addition of chemical reagents, followed by physical separation of precipitated solids from the treated water. Two different processes, hydroxide precipitation and sulfide precipitation, have potential applicability for the adit discharge. Hydroxide precipitation relies on the addition of alkaline reagents, such as sodium hydroxide (NaOH), quick lime (CaO), and magnesium hydroxide ($Mg(OH)_2$), to increase the pH of the impacted water and cause certain dissolved metals (including the COCs in the adit discharge) to precipitate as hydroxides. Sulfide precipitation consists of the addition of a sulfide to the impacted water to induce precipitation of select metals as metal sulfides. In both processes, the resulting solids are removed from the treated water and disposed of. Additional processing may take place to reduce the moisture content of the generated sludge. The sludge may also be reprocessed for beneficial metals recovery in some instances.

Chemical precipitation is a proven technology that provides effective and efficient treatment of metals in mine-impacted water. However, chemical precipitation has relatively high implementation costs, requires ongoing operation and maintenance, requires power at the treatment site, and generates a waste product that requires disposal. Therefore, chemical precipitation has not been retained for further evaluation.

6.4.5 Filtration/Membrane Separation

Pressure driven membrane separation (PDMS) technologies rely on semi-permeable membranes to selectively separate contaminants from the influent feed solution. PDMS technologies include reverse osmosis, nanofiltration, ultrafiltration, and microfiltration. PDMS has a proven implementation record and has been effectively used to treat mine-impacted water. These technologies require access to power and generate a concentrate that requires further treatment and/or disposal. Evaporative ponds are frequently used for concentrate disposal. Treatment of the relatively low flows from the Nugget adit using PDMS is unlikely to be cost-effective. Therefore, filtration/membrane separation has not been retained for further evaluation.

6.5 Response Alternative Development

The most promising technologies that were retained through the screening process to address mine waste and the Nugget Mine adit discharge are summarized in **Table 16**. These technologies are proven, effective, and readily implementable over a range of costs. EPA guidance for non-time critical removal actions (EPA

1993) recommends that only a limited number of response action alternatives be developed for detailed analysis. EPA guidance also recommends that only the most qualified technologies that apply to the media or source of contamination be included in the response action alternatives. Based on this guidance, a limited number of alternatives were developed for further evaluation using the technologies that were retained during the initial screening process summarized in **Sections 6.2** through **6.4** of this EE/CA. **Table 17** lists the response action alternatives that were developed for each media. **Section 7.0** presents the evaluation of the identified response action alternatives.

7.0 RESPONSE ACTION EVALUATION CRITERIA

Response action alternatives developed in **Section 6.5** incorporate technologies retained following a preliminary screening of their ability to meet RAOs and practical considerations of their implementation at the mining complex. These alternatives represent a range of potential actions or process options that will reduce or eliminate potential human health and ecological risks associated with waste rock and the adit discharge at the Nugget and Lost Cabin mines to varying degrees over a range of estimated costs. This section presents a detailed evaluation of the individual response action alternatives.

7.1 Evaluation Criteria

Response action alternatives are evaluated against short- and long-term aspects of three broad criteria: effectiveness, implementability, and cost. A general description of each criterion is provided below.

7.1.1 Effectiveness

In accordance with EPA guidance on non-time critical removal actions (EPA 1993), the effectiveness of an alternative is evaluated against the following criteria:

- Overall protection of human health and the environment;
- Compliance with ARARs;
- Long-term effectiveness and permanence;
- Reduction of toxicity, mobility, or volume through treatment; and
- Short-term effectiveness.

The ability of the alternative to meet RAOs is considered in the evaluation of the alternative against these criteria. The evaluation of the effectiveness of an adit discharge response alternative is dependent upon whether the alternative relies on treatment or hydraulic control to meet RAOs. Hydraulic control alternatives were evaluated based on their ability to reduce or eliminate adit discharge flows. Treatment alternatives were evaluated based on their ability to reduce COC concentrations below ARAR-based reclamation project goals for surface water (refer to **Table 12**).

As discussed in **Section 5.4**, a preliminary list of ARARs has been developed for the project and is presented in **Appendix E**; however, removal actions such as the alternatives presented in this EE/CA are limited in scope compared to remedial actions, and removal actions are not expected to attain all ARARs. The ARARs for this project are grouped into both federal and state ARARs in **Appendix E**, then subdivided into contaminant-specific, location-specific, and action-specific categories. The MDEQ identified State ARARs that apply to abandoned mine lands in Montana in a report titled *Applicable or Relevant and Appropriate Requirements (ARARs) for Reclamation Projects* (MDEQ 2009), which has been provided in **Appendix E**. The degree to which each response action alternative would comply with state and federal ARARs is discussed in the detailed evaluation of alternative presented below.

7.1.2 Implementability

Implementability addresses the technical and administrative feasibility of implementing an alternative, as well as the availability of the services, personnel, and materials necessary to implement it. Technical feasibility considerations include the applicability of the alternative to the contaminant source and overall reliability of the alternative. The evaluation of the technical feasibility of implementing the response action alternatives includes:

- Construction and operational considerations, including schedule and the availability of personnel, equipment, and materials;
- Infrastructure requirements (e.g., power);
- Reliability and simplicity/complexity of operation and any required maintenance;
- Remoteness of location, accessibility, and climatic conditions.

Evaluation of the administrative feasibility of implementing the alternative considers the need for off-site permits and waivers (e.g., building permits, easements, zoning variances, etc.), adherence to applicable non-environmental laws, and potential concerns of other regulatory agencies.

7.1.3 Cost

Costs of response action alternatives may include implementation costs, operation and maintenance costs (if necessary), monitoring costs, and reporting costs. Cost estimates were prepared for each alternative considered in this EE/CA. The costs estimates include future costs for each alternative over a life of 30 years using present worth analysis. Cost estimates were prepared in accordance with EPA guidance on preparing cost estimates for response actions under CERCLA (EPA 2000).

The costs for implementing a response action include additional investigations/studies (if necessary), engineering, permitting (if necessary), purchase of materials and equipment, waste transportation (if applicable), and site reclamation costs. Implementation costs typically occur during the planning and construction of the response action, but may include cots that occur later in the useful life of the action, such as costs for replacement of key system components. Details regarding costs estimates for each response action alternative are presented in **Appendix F**.

Costs for operation, maintenance, monitoring (OM&M), and reporting (if required) generally occur annually after construction has been completed. Reporting costs are incurred to document monitoring and maintenance activities. OM&M costs typically include labor, analytical costs, subcontractors, and replacement of consumed materials. Future recurring costs for OM&M are combined with initial implementation costs into a single net present value (NPV) cost for each response action alternative. The NPV calculations include an annual discount rate (assumed to be 4.2 percent) that addresses the time value of money. The discount rate is typically described as the interest rate that could be realized from a prudent investment. An escalation rate of 3.5 percent was used to estimate the annual increase in future costs due to inflation. The NPV cost, including initial implementation and future recurring costs, is used to assess the cost criterion and compare the cost of the response action alternatives. Details concerning OM&M and reporting costs are included in **Appendix F**.

For this EE/CA, a standard period of 30 years has been used to evaluate future recurring costs for all response action alternatives evaluated, unless the estimated cleanup timeframe is less than 30 years. In general practice, monitoring is conducted for several years after reclamation has been completed to ensure that cleanup standards have been reliably attained. For those alternatives where the time required to meet RAOs is expected to be 30 years or longer, the standard monitoring period of 30 years is used as a reasonable basis for the evaluation of response action alternatives and comparison of associated costs.

7.2 No Action – Alternative NA-1

The no action alternative consists of leaving the Lost Cabin and Nugget mines in their existing conditions. The waste rock at both mines would be left in place and no action would be taken to control contaminant migration from the mines, reduce toxicity, or reduce waste volumes. Waste rock would continue to be in direct contact with Kennedy Creek at both mines and actively erode into the creek at the Nugget mine. In addition, no attempt would be made to reduce, treat, or control the adit discharge at the Nugget mine.

7.2.1 Effectiveness (NA-1)

The effectiveness of the No Action alternative is low. The alternative would not address impacts to surface water and sediment resulting from the waste rock at the Lost Cabin and Nugget mines. In addition, the No Action alternative would not prevent or reduce exposure of human and ecological receptors to contaminants through direct contact with mine waste or ingestion of impacted water. Discharge of adit water into Kennedy Creek at the Nugget Mine would continue unabated under this alternative. ARAR-based cleanup goals for surface water and risk-based goals for soil would not be achieved. Contaminant concentrations detected in sediment at the Lost Cabin mine are below risk-based goals but would continue to be exceeded at one location at the Nugget Mine (station SWK-5).

7.2.2 Implementability (NA-1)

Implementation of the no action alternative is both technically and administratively feasible.

7.2.3 Cost (NA-1)

No capital costs would be incurred under this alternative. Site conditions are unlikely to change under this scenario, and therefore, long-term monitoring and associated reporting costs would be unnecessary and unlikely to be incurred. External costs were not considered for this alternative, but may include the loss of certain ecological functions of Kennedy Creek, including a healthy, viable fishery and aquatic community downstream of the Lost Cabin and Nugget mines.

7.3 Excavation and On-Site Disposal – Alternatives MW-1 and MW-2

These alternatives include the excavation and removal of most waste rock at the Lost Cabin mine and waste rock from the southern portion of the Nugget mine, as shown on **Figures 10** and **11**. Waste rock in the northern portion of the Nugget mine contained COCs at concentrations below risk-based cleanup goals and will remain in place.

As previously discussed, the east bank of Kennedy Creek is in direct contact with waste rock along the entire length of the Lost Cabin mine and would be reconstructed following removal of the waste. Approximately 95 feet of the north bank of the unnamed tributary is also in direct contact with waste rock and would be reconstructed following completion of excavation activities. Concentrations of COCs in a sediment sample collected from Kennedy Creek downstream of the Lost Cabin mine during the PA/SI were below risk-based screening goals, and therefore, the streambed would be left in place during excavation activities.

Kennedy Creek is also in direct contact with waste rock on both sides of the creek throughout the limits of the excavation area at the Nugget mine under this alternative. In addition, a sediment sample collected immediately downstream of the mine (Station SWK-5) contained copper and zinc at concentrations above cleanup goals (**Table 7**). Therefore, the streambed within the excavation area at the Nugget mine would be removed. The streambed and streambanks of Kennedy Creek would be reconstructed following the completion of excavation activities to pre-disturbance (pre-mine) conditions. The reconstructed stream channel at both mine sites would include riffles, runs, and pools and approximate the sinuosity of undisturbed sections of the creek above the mining complex.

Figure 8 shows the conceptual design of the proposed on-site repository. Typical cross-sections of two potential repository cover design options are shown on **Figure 12**. The existing access road would be used as the haul route between the mines and the repository. Some improvements would be required to the access road, including rerouting an approximately 300 foot section of the road around a roadway slump. In addition, limited tree and brush removal would be required to allow passage of equipment along the road. As previously discussed, existing two-track roads to the proposed repository area would require little, if any, improvements.

The excavation and on-site disposal alternative for waste rock at the Lost Cabin and Nugget mines includes the following additional elements:

- Repository Site Preparation - Clearing and grubbing the repository site; separating combustible and non-combustible debris; and debris disposal.
- Construct Repository - Items to be completed under this task include:
    - Strip and stockpile approximately one foot of topsoil within the footprint of the repository;
    - Excavate subsoil to a depth of approximately four feet within the footprint of the respository;
    - Compact the subgrade at the base of the repository to a specified density;
    - Place and compact the waste rock in the repository;
    - Grade and shape waste rock to suitable slopes for cover construction;
    - Install repository cover system (two potential options identified);

  - Construct run-on/runoff control ditches around the perimeter of the repository; and
  - Seed repository cover and disturbance area, including application of appropriate fertilizer and mulch.
  - The repository would cover an area of approximately 0.6-acres.

- Surface Water Diversion Systems - It would be necessary to divert Kennedy Creek around the excavation areas at both the Lost Cabin and Nugget mines. As shown on **Figures 10** and **11**, diversion systems would include temporary dams installed across Kennedy Creek upstream of the excavation areas. Water in Kennedy Creek would be piped from the temporary diversion dams around the excavation areas to temporary sediment basins prior to discharge back into Kennedy Creek. Excavation would be completed in late summer / early fall when Kennedy Creek flows are low and the unnamed tributary at the Lost Cabin mine is not flowing (**Figure 10**).

- Excavate, Load, and Haul Waste - Excavate waste rock at the Lost Cabin and Nugget mines to the approximate lateral limits shown on **Figures 10** and **11**. The excavations would extend to native soils beneath the waste rock. Approximately 1,830 and 2,020 cubic yards of waste rock would be removed from the Lost Cabin and Nugget mines, respectively. The waste rock would be loaded into haul trucks and transported to the on-site repository for disposal.

- Regrade Nugget Mine - Approximately 1,780-cubic yards of waste rock with COC concentrations below cleanup goals would remain on-site at the Nugget mine. Remaining waste rock adjacent to the excavation area would be utilized to partially backfill the excavation. Waste rock north of the excavation would be contoured to more closely match surrounding areas undisturbed by mining activities.

- Load, Haul, Place, Compact Backfill - Backfill (subsoil) from the repository would be hauled, placed, and compacted in the excavation areas at the mines. Backfill would be placed to within six inches of the designed final grade at the sites.

- Reconstruct Kennedy Creek: - Reconstruct the streambed and streambanks of Kennedy Creek affected by excavation activities. Approximately 390 and 300 linear feet of Kennedy Creek would require reconstruction at the Lost Cabin and Nugget mines, respectively. In addition, approximately 100 linear feet of the unnamed tributary at the Lost Cabin mine would require reconstruction following the completion of waste rock removal. Stream reconstruction would consist of placing stream gravel in the section of streambed removal at the Nugget mine. Fabric-wrapped streambanks may be constructed at both mine sites to replace the excavated streambanks. The new stream channel would include riffles, runs, and pools and would approximate its current sinuosity. Logs cut during waste rock excavation, road improvement, and clearing of the repository site and possibly available root wads would be strategically placed to anchor the constructed streambanks.

- Haul and Spread Topsoil - Topsoil salvaged from the repository site would be spread at the Lost Cabin and Nugget mines to a depth of approximately six inches. Approximately 420 and 680 cubic yards of topsoil would be spread at the Lost Cabin and Nugget mines, respectively.

- Revegetate Disturbed Areas - Disturbed areas at the mines would be revegetated as required by the USFS. Revegetation may include use of soil amendments, seeding, streambank plantings, and mulching.

- Vegetation Monitoring/Maintenance - Disturbed areas at the Lost Cabin and Nugget mines, as well as the repository, would be monitored and maintained (if necessary) until vegetation is fully established. Weed control measures would be employed as necessary.

7.3.1 Repository Cover Options

Two different conceptual cover system designs were evaluated and are described below. **Figure 12** shows cross-sections of the two different covers systems.

- Alternative MW-1: Simple Soil Cover – A simple soil cover constructed using salvaged topsoil and subsoil from the repository area would be constructed over the mine waste. The total depth of the soil cover would be three feet to provide adequate rooting depth for conifers that may establish on the cover.
- Alternative MW-2: Composite Cover – This cover system is similar to the simple soil cover (Alternative MW-1), but includes a low permeability geomembrane component (high density polyethylene [HDPE] or equivalent) at the base of the soil cover to further reduce infiltration of meteoric water to the waste. A drainage layer consisting of gravel or coarse sand would be installed over the geomembrane to direct water that infiltrates through the soil cover off the geomembrane and away from the repository. Alternatively, a geocomposite material could be used for the drainage layer. The drainage layer would also serve to protect the geomembrane cover during placement of the soil cover.

The Hydrologic Evaluation of Landfill Performance (HELP) model (version 3.07) was used to perform a comparative analysis of the performance of the two conceptual cover systems by estimating the amount of precipitation that would infiltrate through each cover system. The HELP model was developed by the U.S. Army Engineer Waterways Experiment Station under agreement with the U.S. EPA to estimate water balances for landfills to allow different landfill designs to be evaluated and compared (USACE 2011). The results of the HELP3 modeling effort are summarized below in **Table 18**. A detailed description of the modeling approach and the modeling results are provided in **Appendix G**.

7.3.2 Effectiveness

Excavation and on-site disposal of waste rock from the Lost Cabin and Nugget mines containing COCs at concentrations above cleanup goals would be an effective method for reducing the volume and mobility of contamination at the mine sites.

7.3.2.1 Overall Protection of Human Health and the Environment

Excavation of waste rock at the Lost Cabin and Nugget mines containing COCs at concentrations above cleanup goals for disposal at an on-site repository would significantly reduce risks to human health and the environment. This alternative would also substantially meet RAOs for the project (refer to **Section 5.2**). Exposure of human and ecological receptors to contaminants through direct contact with waste rock would be eliminated. In addition, the response action would eliminate a source of metals impacts to surface water and sediment in Kennedy Creek and the unnamed tributary. This would reduce the risk to human and ecological receptors associated with the ingestion of surface water containing elevated concentrations of COCs. This alternative would also reduce metals impacts to irrigated pasture land outside the Kennedy Creek drainage that currently receive metals-laden water from an irrigation diversion immediately downstream of the Nugget mine. The stream function and aquatic life and fisheries habitat in Kennedy Creek and the unnamed tributary would be also be improved through removal of waste rock in contact with the creek and reconstruction of the streams.

Precipitation that infiltrates through the cover systems and waste rock may impact groundwater in the vicinity of the repository. Information regarding the depth to groundwater and flow direction is not available for the repository site. However, the site is located more than 700 feet from Kennedy Creek. Any impacts to groundwater resulting from infiltration of meteoric water through the repository would likely attenuate prior to reaching the creek. The proposed repository is located on land administered by the USDA-FS and future use of groundwater on Forest Service land in proximity to the site is considered unlikely. Based on a review of groundwater records maintained by the Montana Groundwater Information Center (GWIC), the closest current beneficial use of groundwater to the repository site is located approximately 2,000 feet to the southeast on the opposite side of Kennedy Creek from the repository (GWIC 2011).

7.3.2.2 Compliance with ARARs

Compliance with surface water quality ARARs (**Appendix E**) would be achieved at the Lost Cabin mine because this response action would remove the source of impacts to Kennedy Creek. Although this response action would significantly reduce the load of contaminants discharged to surface water at the Nugget mine, it may not fully achieve surface water quality ARARs alone because it does not address the adit discharge.

No information is currently available regarding groundwater quality at the mine sites. However, removal of waste rock with elevated metals concentrations (above cleanup goals) will likely improve groundwater quality beneath the Nugget and Lost Cabin mines. Contaminant-specific ARARs for ambient air are expected to be met because the waste rock will be placed in a repository with an engineered cover system and disturbed areas will be revegetated. Dust control measures would be implemented during construction activities to control generation of fugitive dust.

Location-specific ARARs would be met to a substantial degree. There are no known cultural or historic resources at the Lost Cabin and Nugget mines or the proposed repository site. The response action would improve habitat for migratory birds, endangered species, and aquatic life. Work would be performed within the floodplain of Kennedy Creek. However, reconstruction of Kennedy Creek will be performed in a manner that does not result in lasting impacts to the floodplain. Potential wetlands at the Nugget mine (a wetland inventory has not been performed) would be removed by the response action. However, the total potential wetland area is less than 0.1-acres and mitigation would not be required under a Nationwide Permit for work in wetlands issued by the U.S. Army Corp of Engineers under Section 404 of the Clean Water Act.

Action-specific ARARs are expected to be met by this alternative. Best management practices (BMPs) would be employed during construction activities to prevent discharge of sediment to surface water. Dust suppression and control measures would be implemented to control fugitive dust generation during construction. Construction personnel would have current Hazardous Waste Operations and Emergency Response training as necessary under 29 Code of Federal Regulations (CFR) 1910.120.

7.3.2.3 Long-Term Effectiveness and Permanence

The long-term effectiveness and permanence of this response action is excellent because waste rock containing concentrations of metals above cleanup goals would be permanently removed from the Lost Cabin and Nugget mines. No long-term monitoring or maintenance would be required once vegetation is fully established in disturbed areas.

7.3.2.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Mobility of contaminants would be significantly reduced under this response action, depending on the cover system selected for the on-site repository, by removing waste rock with elevated metals concentrations from the mine sites. No reduction in the toxicity or volume of contaminants would be achieved by this alternative.

7.3.2.5 Short-Term Effectiveness

The alternative would not create significant short-term risks to human health or the environment. Some limited risks associated with construction activities would occur. However, these risk would be effectively managed through the implementation of appropriate engineering and administrative controls. Construction would be completed in a single construction season and is anticipated to take less than 90 days to complete.

7.3.3 Implementability

Removal of waste rock containing concentrations of metals above site cleanup goals at the Lost Cabin and Nugget mine is both technically and administratively feasible. All activities would be completed on site and no permits would be necessary. No power would be required at the mine sites or repository during or post-construction. The alternative uses proven technologies that are reliable, relatively simple, and would not require long-term maintenance following the establishment of vegetation in disturbed areas. The mine sites are remote but would be accessible following completion improvements to the mine access road (i.e., rerouting around the roadway slump). The area has a short construction season due to heavy winter snows. However, the construction activities proposed under this alternative could be easily implemented in single construction season through advanced planning.

7.3.4 Cost

As shown in **Table 19** below, Alternatives MW-1 and MW-2 could be implemented for estimated costs of $394,000 and $564,000, respectively. A detailed cost estimate for these alternatives is provided in **Appendix F**.

7.4 Adit Discharge Response Alternatives

Four potential response action alternatives to address the adit discharge at the Nugget mine were developed for further evaluation using the technologies retained during the initial screening process summarized in **Section 6.4**. The four alternatives are listed in **Table 17** and are subject to detailed evaluation in the following subsections.

7.4.1 Infiltration – Alternative AD-1

This alternative consists of the installation of a collection structure within the adit portal to capture the adit discharge and direct it to an infiltration gallery. It would be necessary to remove a portion of the rubble / scree pile currently blocking the entrance of adit to install the collection structure. The infiltration gallery would distribute the adit flow into the subsurface, resulting in the dilution, dispersion, and attenuation of COCs through natural biochemical reactions. The infiltration gallery would consist of a subsurface drainfield constructed using perforated pipe bedded in gravel. The infiltration gallery would be covered with a minimum of three feet of soil to protect it from freezing.

The response action alternatives developed for mine waste at the Nugget mine would result in the excavation and removal of approximately 2,000 cubic yards of mine waste containing COC concentrations above cleanup goals. Following this removal, the excavation would be backfilled and the remaining mine waste (approximately 1,800 cubic yards) would be regarded and contoured to more closely match surrounding areas undisturbed by mining activities. These actions would remove / fill the existing settling pond at the Nugget mine. Implementation of Alternative AD-1 would be staged to occur after the completion of excavation and grading activities. The infiltration gallery would be constructed in the former pond location. The system would be constructed to operate under gravity flow, so it would be necessary to ensure adequate slopes are provided during construction of the system.

7.4.1.1 Effectiveness (AD-1)

Infiltration would reduce the potential exposure of human and ecological receptors to COCs in the adit discharge. Dilution, dispersion, and natural attenuation processes would likely reduce COC concentrations in the discharge from the infiltration gallery. The depth to groundwater and flow direction at the mine will control the effectiveness of this response action. Shallow groundwater would limit the ability of an infiltration gallery to accept adit flows. In addition, if Kennedy Creek is seasonally recharged by groundwater, limited dispersion / dilution of the infiltrated adit water would occur in the subsurface prior to discharge to the creek. As previously discussed, no information is available regarding depth to groundwater and groundwater flow direction at the mining complex. It would be necessary to conduct a limited groundwater study to assess groundwater conditions at the mine prior to designing an infiltration system. The study would also provide data necessary to evaluate the probable fate of infiltrated water at the mine site. In addition, it would be necessary to perform infiltration tests to confirm subsurface soils would accept expected adit flows.

Overall Protection of Human Health and the Environment

Implementation of this alternative would partially meet RAOs for the project (refer to **Section 5.2**) because it would protect human health and wildlife from direct contact and ingestion risks associated with the adit discharge. The degree to which infiltration of the adit discharge would reduce impacts to surface water in Kennedy Creek is dependent upon the distance between the infiltration gallery and the point at which the discharge may reach the creek.

Compliance with ARARs

Compliance with surface water ARARs (**Appendix E**) may not be achieved by Alternative AD-1 because sufficient attenuation of COC concentrations may not occur before infiltrated water discharges to Kennedy Creek. Elevation measurements taken by AMEC in September 2011 indicate that Kennedy Creek immediately east of the adit discharge is a losing reach (i.e., not recharged by groundwater) during low flow conditions. However, some portion of the infiltrated adit discharge may reach the creek downstream of the infiltration gallery before attenuation of contaminants is complete.

No information is available regarding groundwater quality at the Nugget mine. This alternative is would likely result in some limited impacts to groundwater quality at the mine. However, it is anticipated that COC concentrations would attenuate downgradient of the infiltration gallery to existing background levels.

Location-specific ARARs would be met to a substantial degree. There are no known cultural or historic resources at the Nugget mine. Threatened and endangered species in the vicinity of the mine (if present) may be affected by activities associated with the implementation of this alternative in the short-term. However, it is unlikely that these species would be adversely affected because disturbance would be limited, there would be no permanent aboveground facilities, and implementation of the alternative would be completed over a brief construction period (one to two weeks).

Action-specific ARARs are expected to be met by this alternative. Best management practices (BMPs) would be employed during construction activities to prevent discharge of sediment to surface water. Dust suppression and control measures would be implemented to control fugitive dust generation during construction. Construction personnel would have current Hazardous Waste Operations and Emergency Response training as necessary under 29 Code of Federal Regulations (CFR) 1910.120.

Long-Term Effectiveness and Permanence

The long-term effectiveness and permanence of this response action is high. Replacement of the gravel infiltration basin may be required in the future due if entrained solids are present in the captured adit discharge and are deposited in the perforated pipe or gravel bedding. In addition, mineral deposition may occur due to biochemical processes that restricts flow through the gravel. No long-term monitoring or maintenance would be required.

Reduction of Toxicity, Mobility, or Volume through Treatment

The toxicity of contaminants in the adit discharge may be reduced through natural attenuation processes. Contaminant mobility would not be reduced, nor would there be any reduction in the volume of the adit discharge through treatment.

7.4.1.2 Short-Term Effectiveness (AD-1)

Alternative AD-1 would not create significant short-term risks to human health or the environment. Some limited risks associated with construction activities would occur. However, this risk would be effectively managed through the implementation of appropriate engineering and administrative controls. Construction would be completed in a single construction season and is anticipated to be completed within one to two weeks.

7.4.1.3 Implementability (AD-1)

Construction of an infiltration gallery for the adit discharge is administratively and technically feasible if sufficient soil depth above the water table or bedrock is available at the mine. As previously discussed, a limited groundwater study would be required to assess groundwater conditions at the mine prior to designing the infiltration system. The infiltration gallery would likely be constructed in the footprint of the filled settling pond, which should provide sufficient depth of soil for infiltration. If soil depths are insufficient, imported soil can be used. On site testing to determine infiltration rates would allow design optimization.

7.4.1.4 Cost (AD-1)

The estimated cost to implement Alternative AD-1 is $87,000. A summary of associated costs is provided in **Table 20** and a detailed cost estimate is provided in **Appendix F**.

7.4.2 Bioreactor and Infiltration – Alternative AD-2

A series (primary and backup) of passive sulfate-reducing bioreactors would be utilized under Alternative AD-2 to reduce metals concentrations in the adit discharge. The bioreactors would rely on a solid substrates (e.g., composted cow manure, wood chips, alfalfa hay, etc.) to develop anaerobic reducing conditions in the reactors and support microbial processes. Sulfur prills may be added to the bioreactor cells to provide a supplemental source of sulfate to support sulfide production. A flow collection structure would be installed inside the adit interior to direct the adit discharge to the bioreactor cells via gravity flow, which would be constructed below grade to protect them from freezing conditions. It would be necessary to remove a portion of the rubble / scree pile currently blocking the entrance of adit to install the inlet structure.

The discharge from the bioreactor cells would be piped via gravity flow to a subsurface infiltration gallery that would be constructed as described in Alternative AD-1. The entrance to the adit would be covered with a solid, insulated barrier to reduce the potential for vandalism and also protect the bioreactor inlet structure from freezing conditions. An emergency outlet/overflow would be installed in the barrier to route the adit water directly to the infiltration gallery (by-passing the reactor cells) in the event that flow through the reactor cells is blocked due to plugging or the formation of ice. The conceptual design of Alternative AD-2 is shown on **Figure 13**.

7.4.2.1 Effectiveness (AD-2)

The SRB would likely be effective in reducing metals concentrations in the adit discharge. Sufficient sulfate may not be present in the adit water to support the level of sulfide production necessary to reduce all metals concentrations below surface water quality criteria. However, it is anticipated that significant reductions in metals concentrations could be achieved. The addition of sulfur prills to the solid substrate in the bioreactor cells would provide a supplemental source of sulfate to the treatment process. Additional reduction in COC concentrations would occur through dilution, dispersion, and natural attenuation of the infiltrated discharge. In addition, infiltration of the treated water would reduce the potential exposure of human and ecological receptors to COCs remaining in the treated effluent.

Overall Protection of Human Health and the Environment

Implementation of this alternative would substantially meet RAOs for the project (refer to **Section 5.2**) because it would reduce sources of metals impacts to surface water and protect human health and wildlife from direct contact and ingestion risks associated with the adit discharge.

Compliance with ARARs

Compliance with surface water ARARs (**Appendix E**) would likely be achieved by implementation of Alternative AD-2. The bioreactor would substantially reduce metals concentrations in the adit discharge. Concentrations in the treated effluent would be further reduced through attenuation processes following subsurface infiltration prior to potential discharge to Kennedy Creek.

Location-specific ARARs would be met to a substantial degree. There are no known cultural or historic resources at the Nugget mine. Threatened and endangered species in the vicinity of the mine may be affected by activities associated with the implementation of this alternative in the short-term. However, it is unlikely that these species would be adversely affected because disturbance would be limited, there would be no permanent aboveground facilities, and implementation of the alternative would be completed over a brief construction period (one to two weeks).

Action-specific ARARs are expected to be met by this alternative. Best management practices (BMPs) would be employed during construction activities to prevent discharge of sediment to surface water. ARARs for ambient air will be met under this alternative because short-term construction operations would not affect air quality. Dust suppression and control measures would be implemented to control fugitive dust generation during construction. Construction personnel would have current Hazardous Waste Operations and Emergency Response training as necessary under 29 Code of Federal Regulations (CFR) 1910.120.

Long-Term Effectiveness and Permanence

The long-term effectiveness and permanence of this response action is anticipated to be low to moderate. The system would be required to operate in perpetuity. The solid organic substrate in the bioreactor cells would require routine replacement on an ongoing, periodic basis. Long-term monitoring and maintenance would be required to ensure the system continues to operate effectively. Sources of funding for long-term system operation and maintenance have not been identified.

Reduction of Toxicity, Mobility, or Volume through Treatment

The toxicity and volume of contaminants in the adit discharge would be reduced through treatment in the bioreactor. The toxicity of contaminants in the treated effluent would be further reduced by natural attenuation processes during infiltration.

7.4.2.2 Short-Term Effectiveness (AD-2)

Alternative AD-2 would not create significant short-term risks to human health or the environment. Some limited risks associated with construction activities would occur. However, these risks would be effectively managed through the implementation of appropriate engineering and administrative controls. Construction would be completed in a single construction season and is anticipated to be completed within two to four weeks.

7.4.2.3 Implementability (AD-2)

Alternative AD-2 could be easily implemented. Installation of subsurface bioreactor cells and covering the adit opening with a solid, insulated barrier would protect the system from freezing and allow year-round operation. Similar to Alternative AD-1, the infiltration gallery would likely be constructed in the footprint of the filled settling pond. If soil depths in this location are insufficient, imported soil can be used. On site testing to determine infiltration rates would allow design optimization.

7.4.2.4 Cost (AD-2)

The estimated cost to implement Alternative AD-2 is $245,000. A summary of associated costs is provided in **Table 20** and a detailed cost estimate is provided in **Appendix F**.

7.4.3 Chemical Adsorption and Infiltration - Alternative AD-3

Alternative AD-3 would be identical to Alternative AD-2, with the exception that the SRBs would be replaced by a series (primary and backup) of subsurface reactor cells filled with Apatite II. The conceptual design of Alternative AD-3 is shown on **Figure 14**.

7.4.3.1 Effectiveness (AD-3)

Apatite II is expected to be effective in reducing concentrations of copper, lead, and zinc in the adit discharge. Infiltration of the treated water would reduce the potential exposure of human and ecological receptors to COCs remaining in the effluent. Additional reduction in COC concentrations would occur through dilution, dispersion, and natural attenuation of the infiltrated discharge. Bench-scale testing may be necessary to determine the volume of Apatite II necessary for effective treatment.

Overall Protection of Human Health and the Environment

Implementation of this alternative would substantially meet RAOs for the project (refer to **Section 5.2**) because it would reduce sources of metals impacts to surface water and protect human health and wildlife from direct contact and ingestion risks associated with the adit discharge.

Compliance with ARARs

It is anticipated that Alternative AD-3 would meet surface water ARARs (**Appendix E**). The Apatite II reactor is expected to significantly reduce metals concentrations in the adit discharge. Concentrations in the treated effluent would be further reduced through attenuation processes following subsurface infiltration before the infiltrated effluent reaches Kennedy Creek.

Location-specific ARARs would be met to a substantial degree. There are no known cultural or historic resources at the Nugget mine. Threatened and endangered species in the vicinity of the mine (if present) may be affected by activities associated with the implementation of this alternative in the short-term. However, it is unlikely that these species would be adversely affected because disturbance would be limited, there would be no permanent aboveground facilities, and implementation of the alternative would be completed over a brief construction period (two to four weeks).

Action-specific ARARs are expected to be met by this alternative. Best management practices (BMPs) would be employed during construction activities to prevent discharge of sediment to surface water in accordance with Montana Pollutant Discharge Elimination System (MPDES) permit requirements. ARARs for ambient air will be met under this alternative because construction operations would not affect air quality. Dust suppression and control measures would be implemented to control fugitive dust generation during construction. Construction personnel would have current Hazardous Waste Operations and Emergency Response training as necessary under 29 Code of Federal Regulations (CFR) 1910.120.

Long-Term Effectiveness and Permanence

The long-term effectiveness and permanence of this response action is anticipated to be low to moderate. The treatment media in the reactor cells would require routine replacement on an ongoing, periodic basis. Long-term monitoring and maintenance would be required to ensure the system continues to operate effectively. In addition, the system would be required to operate in perpetuity. Sources of funding for long-term system operation and maintenance have not been identified.

Reduction of Toxicity, Mobility, or Volume through Treatment

The toxicity and volume of contaminants in the adit discharge would be reduced through treatment in the Apatite II reactors. The toxicity of contaminants in the treated effluent would be further reduced by natural attenuation processes.

7.4.3.2 Short-Term Effectiveness (AD-3)

Alternative AD-3 would not create significant short-term risks to human health or the environment. Some limited risks associated with construction activities would occur. However, these risks would be effectively managed through the implementation of appropriate engineering and administrative controls. Construction would be completed in a single construction season and is anticipated to be completed within one to two weeks.

7.4.3.3 Implementability (AD-3)

Alternative AD-3 could be easily implemented. Installation of subsurface reactor cells and covering the adit opening with a solid, insulated barrier would protect the system from freezing and allow year-round operation. Similar to Alternative AD-1, the infiltration gallery would likely be constructed in the footprint of the filled settling pond. If soil depths in this location are insufficient, imported soil can be used. On site testing to determine infiltration rates would allow design optimization.

7.4.3.4 Cost (AD-3)

The estimated cost to implement Alternative AD-3 is $325,000. A summary of associated costs is provided in **Table 20** and a detailed cost estimate is provided in **Appendix F**.

7.4.4 Constructed Wetlands and Infiltration – Alternative AD-4

Alternative AD-4 would rely on constructed wetlands to reduce metals concentrations in the adit discharge. Two forms of treatment wetlands were considered for Alternative AD-4, horizontal subsurface flow (HSSF) wetlands and free water surface (FWS) wetlands. Water flows horizontally through of a gravel bed planted with wetland vegetation in HSSF wetlands and the water level remains below the surface of the bed. FWS wetlands consist of areas of open water and are similar in appearance to natural marshes. HSSF wetlands appear to remove zinc to a slightly greater degree than FWS wetlands (77% versus 68% median zinc removal rates) based on a review of available studies (Kaldec, et al. 2009). However, HSSF wetlands are subject to plugging and the gravel beds would require periodic replacement. Therefore, FWS wetlands would be utilized at the Nugget mine under Alternative AD-4. Copper and lead removal rates were similar in HSSF and FWS wetlands in the available literature.

The conceptual design of Alternative AD-4 is shown on **Figure 15**. The treatment wetland would consist of a deep pool forebay to diffuse flow from the adit discharge across the wetland and attenuate storm water/adit discharge surges. A series of shallow wetland areas would be constructed downstream of the forebay with typical flow depths of 6 to 18 inches under normal flow conditions (i.e., outside of spring runoff). The treatment wetland would end at a deeper terminal pool and outlet structure constructed to prevent the formation of dead (no flow) zones within the wetland. The effluent would be piped from the outlet structure to a subsurface infiltration gallery, which would be constructed as described in Alternative AD-1 (refer to **Section 7.4.1** for details).

7.4.4.1 Effectiveness (AD-4)

Treatment wetlands would be effective in reducing metals concentrations in the adit discharge during the growing season. However, spring runoff would likely overwhelm the capacity of the wetlands and result in reduced retention times and treatment effectiveness. In addition, the effectiveness of the wetlands would be significantly reduced by cold temperatures at the site during a significant portion of the year. Infiltration of the treated water would provide additional reductions in COC concentrations through dilution, dispersion, and natural attenuation of the infiltrated discharge.

Overall Protection of Human Health and the Environment

Treatment wetlands would effectively reduce metals concentrations in the adit discharge during the growing season, thereby reducing the potential exposure of recreational users of Forest Service lands or wildlife to elevated concentrations of metals. However, impacted surface water containing metals at concentrations above cleanup goals would still be accessible to potential human and ecological receptors in the initial influent sections of the wetlands.

Compliance with ARARs

Alternative AD-4 may not achieve compliance with surface water ARARs. Treatment wetlands would only be effective in reducing metals concentrations during a portion of the year. It is anticipated based on August 2011 adit discharge data, however, that there would be little adit flow during winter months and any adit discharge would likely freeze as it surfaces. Spring runoff from surrounding hill slopes would mix with the adit discharge and likely dilute metals concentrations in the discharge significantly. As previously discussed, elevation measurements taken by AMEC in September 2011 indicate that Kennedy Creek immediately east of the adit discharge is a losing reach (i.e., not recharged by groundwater) during low flow conditions. However, some portion of the infiltrated adit discharge may reach the creek downstream of the infiltration gallery before attenuation of contaminants is complete.

Alternative AD-4 would meet location-specific ARARs to a substantial degree. There are no known cultural or historic resources at the Nugget mine. Threatened and endangered species in the vicinity of the mine (if present) may be affected by activities associated with the implementation of this alternative in the short-term. However, it is unlikely that these species would be adversely affected because disturbance would be limited and implementation of the alternative would be completed over a brief construction period (one to two weeks). This alternative would result in the construction of additional wetland areas at the site.

Action-specific ARARs are expected to be met by this alternative. Best management practices (BMPs) would be employed during construction activities to prevent discharge of sediment to surface water. ARARs for ambient air would be met under this alternative because construction operations would not affect air quality. Dust suppression and control measures would be implemented to control fugitive dust generation during construction. Construction personnel would have current Hazardous Waste Operations and Emergency Response training as necessary under 29 Code of Federal Regulations (CFR) 1910.120.

Long-Term Effectiveness and Permanence

The long-term effectiveness and permanence of this response action is expected to be high. The treatment wetlands would be constructed to be self-sustaining and would not require ongoing maintenance once wetland vegetation is fully established. Replacement of the gravel infiltration basin may be required in the future if suspended solids are present in the treatment wetland effluent. However, the wetlands would be designed with relative slow flows that would allow suspended solids to settle out. Mineral deposition may occur in the gravel infiltration basin due to biochemical processes that would require replacement of the gravel.

Reduction of Toxicity, Mobility, or Volume through Treatment

The toxicity of contaminants in the adit discharge would be seasonally reduced by biochemical processes in the treatment wetlands. Further reduction in contaminant toxicity may occur through natural attenuation processes following infiltration. Contaminant mobility would be reduced through the sequestration of metals in wetland sediments and vegetation. There would be no reduction in the volume of the adit discharge through treatment.

7.4.4.2 Short-Term Effectiveness (AD-4)

Alternative AD-4 would not create significant short-term risks to human health or the environment. Some limited risks associated with construction activities would occur. However, these risks would be effectively managed through the implementation of appropriate engineering and administrative controls. Construction would be completed in a single construction season.

7.4.4.3 Implementability (AD-4)

Construction of treatment wetlands and an infiltration gallery for the adit discharge at the Nugget mine is administratively and technically feasible. Construction activities would take place in late summer or early fall during low flow and low groundwater conditions. It would be necessary to temporarily reroute the adit discharge during construction activities. Similar to Alternative AD-1, the infiltration gallery would likely be constructed in the footprint of the filled settling pond. If soil depths in this location are insufficient, imported soil can be used. On site testing to determine infiltration rates would allow design optimization.

7.4.4.4 Cost (AD-2)

The estimated cost to implement Alternative AD-4 is $180,000. A summary of associated costs is provided in **Table 20** and a detailed cost estimate is provided in **Appendix F**.

8.0 COMPARATIVE ANALYSIS OF ALTERNATIVES

This section compares the response action alternatives developed in **Section 6.0** and evaluated in detail in **Section 7.0**. Comparative analyses were performed for the waste rock and adit discharge alternatives using three primary criteria: effectiveness, implementability, and cost. Costs for each response action alternative were estimated for comparative purposes only since many design details that would affect costs are preliminary. Actual costs for selected alternatives may range from 30 percent lower to 50 percent higher than the comparative costs estimated in this EE/CA. Summaries of the alternative comparisons are provided in **Table 21**.

8.1 Mine Waste Alternatives

Both Alternatives MW-1 and MW-2 would significantly reduce overall risks to human health and the environment through the removal of mine waste containing COCs at concentrations above cleanup goals for placement in an on-site repository. SPLP results for the waste rock (discussed in **Section 3.1**) indicate that lead may leach from the waste rock due to infiltration of precipitation through the repository at concentrations that would exceed the groundwater standard. Therefore, the overall effectiveness of Alternative MW-2 is considered to be higher than Alternative MW-1 because the composite cover system would result in significantly lower volumes of precipitation infiltrating through the waste rock in the repository. The no action alternative (NA-1) is not effective in comparison to Alternatives MW-1 and MW-2 because it would not reduce exposure to human or ecological receptors to contaminants. In addition, Alternative NA-1 would not address impacts to surface water or sediment in Kennedy Creek resulting from mine waste at the Lost Cabin and Nugget mines.

The long-term effectiveness of all three alternatives rank relatively equally. No long term monitoring or maintenance would be required for Alternatives MW-1 and MW-2 once vegetation is established at the repository site and areas disturbed by excavation activities at the mine sites. Long term monitoring and maintenance would not be required under the no action alternative (NA-1).

As shown on **Table 21**, Alternatives MW-1 and MW-2 rank equally with respect to implementability. Both alternatives are readily implementable using conventional construction equipment and materials. The implementability of NA-1 is higher than the other mine waste alternatives because no action is required.

The estimated costs to implement Alternatives MW-1 and MW-2 are $394,000 and $564,000, respectively (**Table 21**). Construction and materials costs associated with Alternative MW-2 would be slightly higher than Alternative MW-1 due to the installation of a geomembrane in the cover system. There would be no cost to implement Alternative NA-1. Detailed cost estimates for these alternatives are provided in **Appendix F**.

8.2 Adit Discharge Alternatives

The comparative evaluation of the response action alternatives for the adit discharge at the Nugget mine is summarized on **Table 21**. Alternatives AD-1 (Infiltration), AD-2 (Bioreactor and Infiltration), and AD-3 (Chemical Adsorption) would result in the greatest reduction of risks to recreational users of Forest Service lands and wildlife. All three alternatives would prevent direct contact and ingestion of the adit discharge by capturing the adit flows for infiltration into the subsurface. Alternatives AD-2 and AD-3 provide slightly greater protection of human health and the environment than AD-1 because these two alternatives would reduce COC concentrations in the adit discharge through treatment prior to infiltration. Although Alternative AD-4 (Constructed Wetlands and Infiltration) would also reduce COC concentrations in the adit discharge prior to infiltration, it would not be as effective in reducing the potential for exposure of human receptors and wildlife to COCs as the other alternatives. Impacted surface water containing metals at concentrations above cleanup goals would still be accessible to potential receptors in the initial influent sections of the wetlands. The No Action Alternative (NA-1) would not reduce COC concentrations in the adit discharge or reduce potential risks to human health or the environment.

Alternatives AD-1 and AD-4 would provide the greatest degree of permanence and long-term effectiveness. Treatment wetlands utilized in Alternative AD-4 would be constructed to be self-sustaining with little on-going maintenance requirements once wetland vegetation is fully established. Replacement of the gravel infiltration basin may be required at some point in the future for all four alternatives. The long-term effectiveness of Alternatives AD-2 and AD-3 is anticipated to be low because the alternatives have ongoing monitoring and maintenance requirements. The treatment media in the bioreactors (Alternative AD-2) and in the Apatite II reactors (Alternative AD-3) would require periodic replacement to ensure the treatment systems continue to function effectively.

The No Action Alternative (NA-1) is the most easily implementable alternative since it would not require any actions at the mine sites. The implementability of the remaining four adit discharge alternatives is roughly equal. All four alternatives could be implemented using conventional construction methods and equipment. In addition, all four alternatives would require the adit discharge to be temporarily rerouted while the treatment systems and infiltration galleries are constructed. All of the alternatives rely on passive technologies that do not require access to power. Limited bench-scale testing of Alternatives AD-2 and AD-3 may be required to determine the volume of treatment media required in the bioreactors and Apatite II reactors, respectively.

As shown on **Table 20**, Alternative AD-1 is expected to have the lowest implementation and operating cost ($87,000), excluding the No Action Alternative. The costs of implementation costs of Alternatives AD-2 through AD-4 are roughly equivalent. However, ongoing monitoring and maintenance requirements for Alternatives AD-2 and AD-3 increase their overall costs to $245,000 and $325,000, respectively. As previously discussed, the treatment wetlands employed in Alternative AD-4 would be designed to be self-sustaining and would not require maintenance or monitoring once established. The estimated cost for Alternative AD-4 is $180,000.

8.3 Preferred Alternatives

Alternative MW-1 is the preferred alternative to address mine waste at the Lost Cabin and Nugget mines. As discussed in **Section 7.3**, this alternative includes the excavation of approximately 3,850 cubic yards of waste rock containing concentrations of metals above cleanup goals. The waste rock would be placed in an on-site repository with a simple soil cover constructed using materials salvaged from the repository site. Portions of Kennedy Creek and the unnamed tributary at the Lost Cabin mine would be reconstructed following completion of excavation activities.

Alternative MW-1 is preferred because it provides a significant reduction in risks to human health and the environment at a lower associated cost than the other response action alternative evaluated. As discussed above, the simple soil cover of Alternative MW-1 would allow a greater volume of precipitation to infiltrate through the repository cover. Information regarding the depth to groundwater and flow direction is not available for the repository site. However, the site is located more than 700 feet from Kennedy Creek. Any impacts to groundwater resulting from infiltration of meteoric water through the repository would likely attenuate prior to reaching the creek. The proposed repository is located on land administered by the USDA-FS and future use of groundwater on Forest Service land in proximity to the site is considered unlikely. As discussed in Sections 5.4 and 7.1.1, removal actions such Alternative MW-1 are limited in scope, and mitigate threats to human health and the environment to the extent practicable. As previously discussed, removal actions are not expected or required to attain all ARARs.

The preferred response action alternative for the adit discharge at the Nugget mine is Alternative AD-1. This alternative includes the installation of a collection structure within the adit portal to capture the discharge and direct it to a subsurface infiltration gallery. Implementation of Alternative AD-1 would reduce risks to human and ecological receptors. Although Alternatives AD-2 and AD-3 provide the added benefit of reducing the toxicity and volume of contaminants in the adit discharge through treatment, the overall long-term effectiveness of these alternatives is considered poor due to ongoing operation and maintenance requirements. Therefore, these alternatives were not selected. Alternative AD-4 would also reduce metals concentrations in the adit discharge through the use of treatment wetlands. However, the effectiveness of treatment wetlands would be reduced during a significant portion of the year due to cold conditions. In addition, Alternative AD-4 poses higher risks to human and ecological receptors than Alternative AD-1 because water containing elevated metals concentrations would be accessible in the influent areas of the treatment wetlands.

The combined cost to implement Alternatives MW-1 and AD-1 is estimated to be approximately $481,000.

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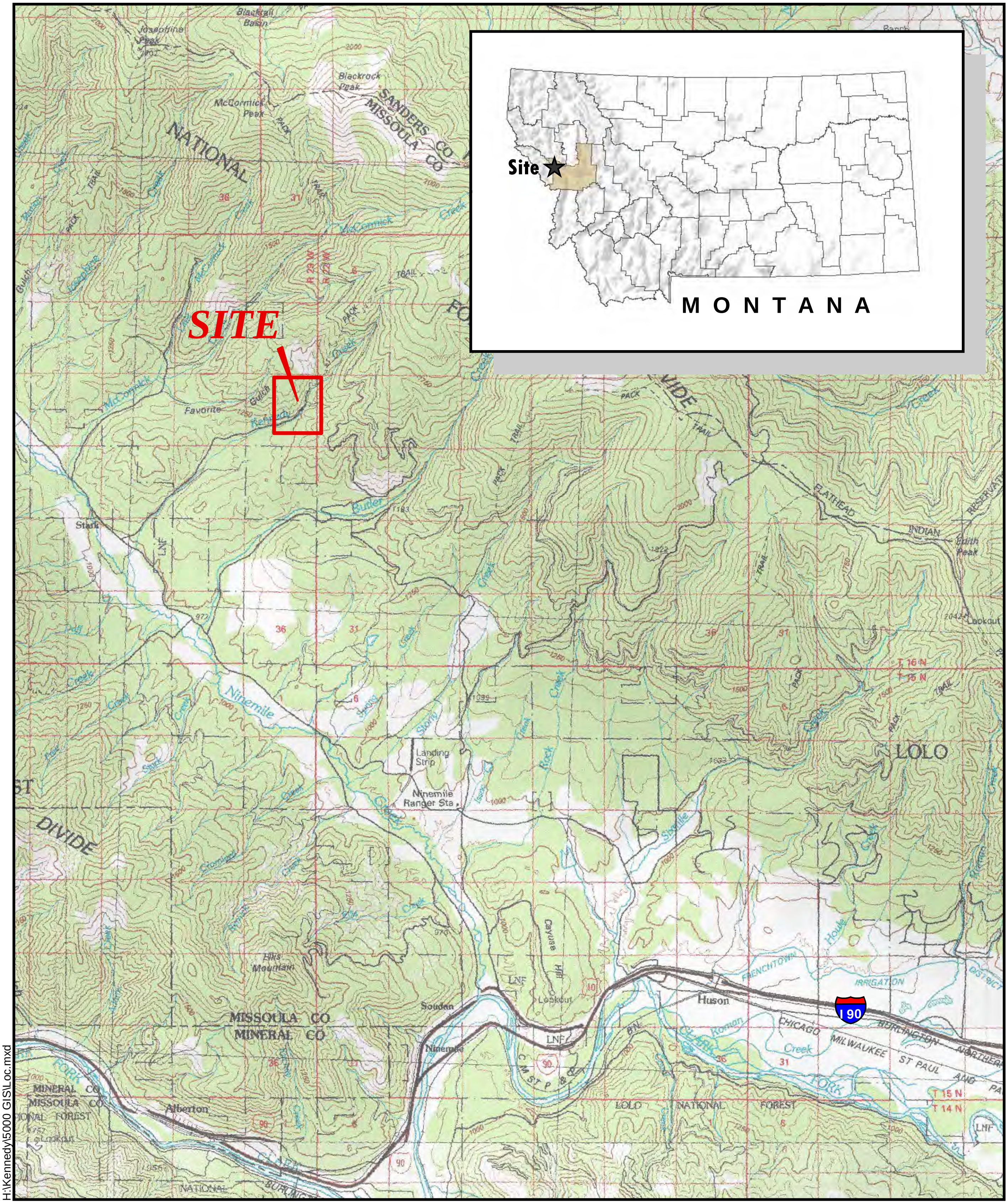
FIGURES



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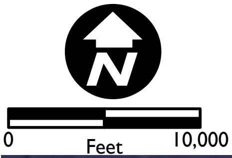
Source: USGS 250K Montana Quadrangle



AMEC Geomatrix

Site Location Map
Kennedy Creek Mining Complex
Missoula County, Montana
FIGURE 1

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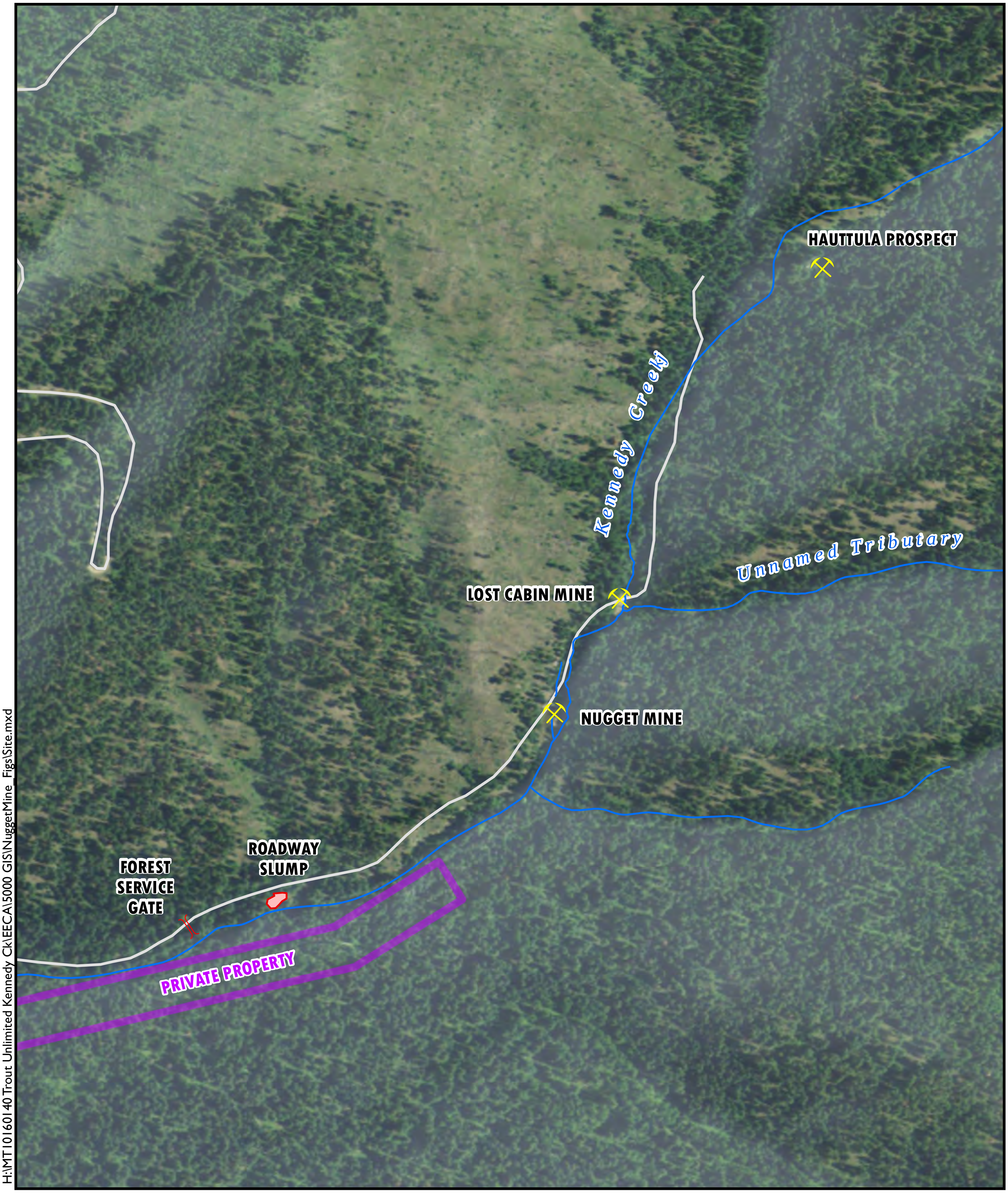

Source: NAIP, 2009

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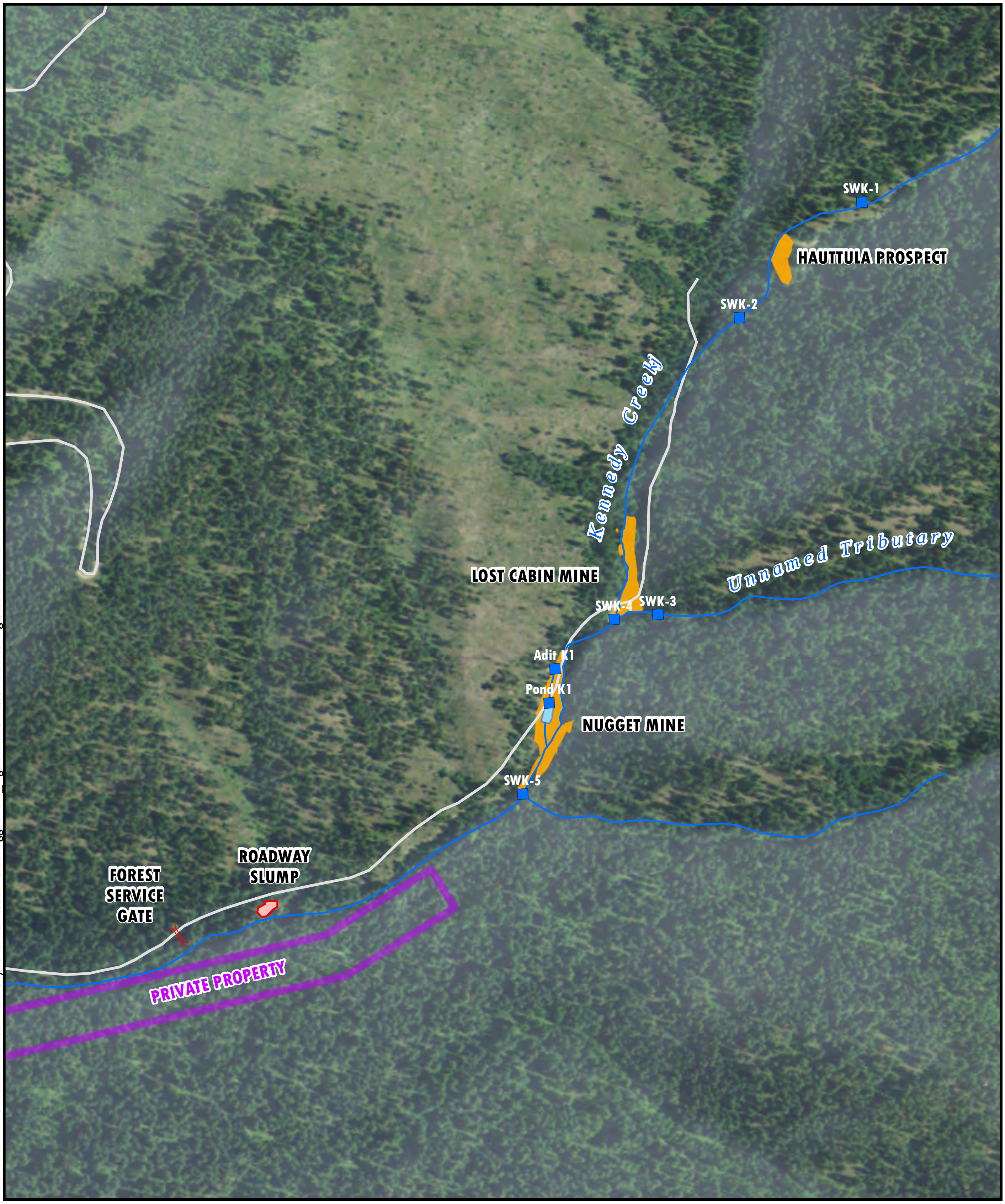
AMEC Geomatrix

Site Map
Kennedy Creek Mining Complex
Missoula County, Montana
FIGURE 2



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Source: NAIP, 2009

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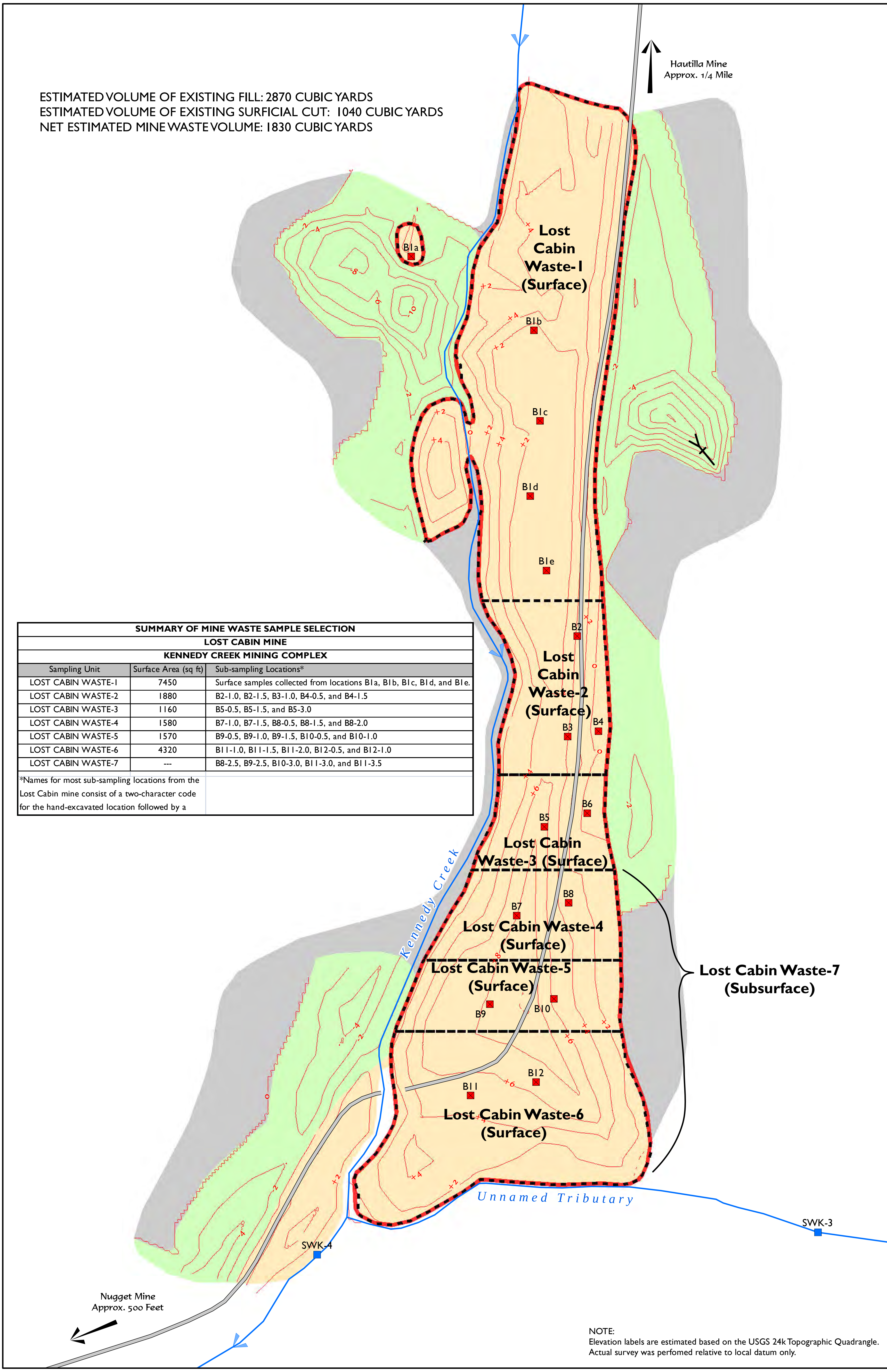
AMEC Geomatrix

Surface Water and Sediment Sample Location

Area of Mine Waste

Surface Water Monitoring Stations
Kennedy Creek Mining Complex
Missoula County, Montana
FIGURE 3

ESTIMATED VOLUME OF EXISTING FILL: 2870 CUBIC YARDS
ESTIMATED VOLUME OF EXISTING SURFICIAL CUT: 1040 CUBIC YARDS
NET ESTIMATED MINE WASTE VOLUME: 1830 CUBIC YARDS



SUMMARY OF MINE WASTE SAMPLE SELECTION		
LOST CABIN MINE		
KENNEDY CREEK MINING COMPLEX		
Sampling Unit	Surface Area (sq ft)	Sub-sampling Locations*
LOST CABIN WASTE-1	7450	Surface samples collected from locations B1a, B1b, B1c, B1d, and B1e.
LOST CABIN WASTE-2	1880	B2-1.0, B2-1.5, B3-1.0, B4-0.5, and B4-1.5
LOST CABIN WASTE-3	1160	B5-0.5, B5-1.5, and B5-3.0
LOST CABIN WASTE-4	1580	B7-1.0, B7-1.5, B8-0.5, B8-1.5, and B8-2.0
LOST CABIN WASTE-5	1570	B9-0.5, B9-1.0, B9-1.5, B10-0.5, and B10-1.0
LOST CABIN WASTE-6	4320	B11-1.0, B11-1.5, B11-2.0, B12-0.5, and B12-1.0
LOST CABIN WASTE-7	---	B8-2.5, B9-2.5, B10-3.0, B11-3.0, and B11-3.5

*Names for most sub-sampling locations from the Lost Cabin mine consist of a two-character code for the hand-excavated location followed by a

NOTE:
Elevation labels are estimated based on the USGS 24k Topographic Quadrangle.
Actual survey was perfomed relative to local datum only.

Hand-Augered Borehole Location
Surface Water and Sediment Sample Location
Area with Lead Concentrations Greater than Screeing Level
Area of Cut
Area of Fill
Undisturbed Pre-Mine Surface
Estimated Cut or Fill Thicknesses - Negative #s show cut (ft), Positive #s show fill (ft)
Former Road
Mine Waste Sampling Unit
Collapsed Adit

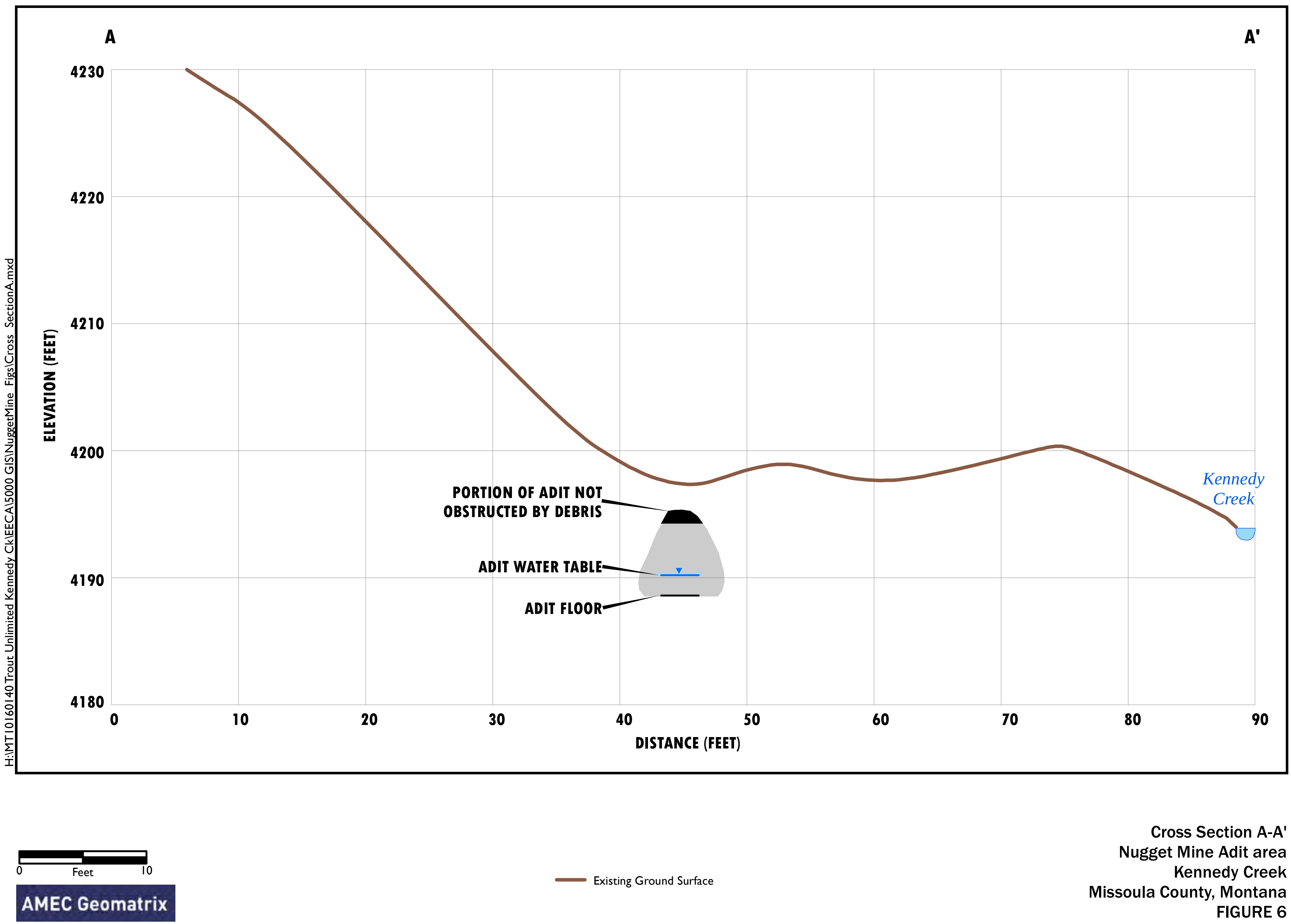
AMEC Geomatrix

Existing Conditions -
Lost Cabin Mine Site
Kennedy Creek
Missoula County, Montana
FIGURE 4

SUMMARY OF MINE WASTE SAMPLE SELECTION		
NUGGET MINE		
KENNEDY CREEK MINING COMPLEX		
Sampling Unit	Surface Area (sq ft)	Sub-sampling Locations*
NUGGET WASTE-1	6070	B1-0.5, B1-2.0, B2-0.5, B2-1.0, and B2-2.0
NUGGET WASTE-2	1700	B4-0.5, B4-1.0, B4-1.5, B6-0.5, and B6-1.5
NUGGET WASTE-3	3080	B5-1.0, B5-2.0, B7-1.5, B7-3.0, and B7-4.0
NUGGET WASTE-4	3520	B8-1.5, B8-2.0, B8-2.5, B9-0.5, and B9-1.0
NUGGET WASTE-5	7630	B10-0.5, B10-1.0, B11-0.5, B11-1.0, and B11-2.0
NUGGET WASTE-6	7650	Surface samples collected from locations B12a, B12b, B12c, B12d, and B12e.
NUGGET WASTE-7	---	B5-3.0, B5-3.5, B5-4.0, B7-6.5, and B7-7.0
NUGGET WASTE-8	---	B8-4.0, B8-4.5, B9-3.0, B9-3.3, and B9-3.7

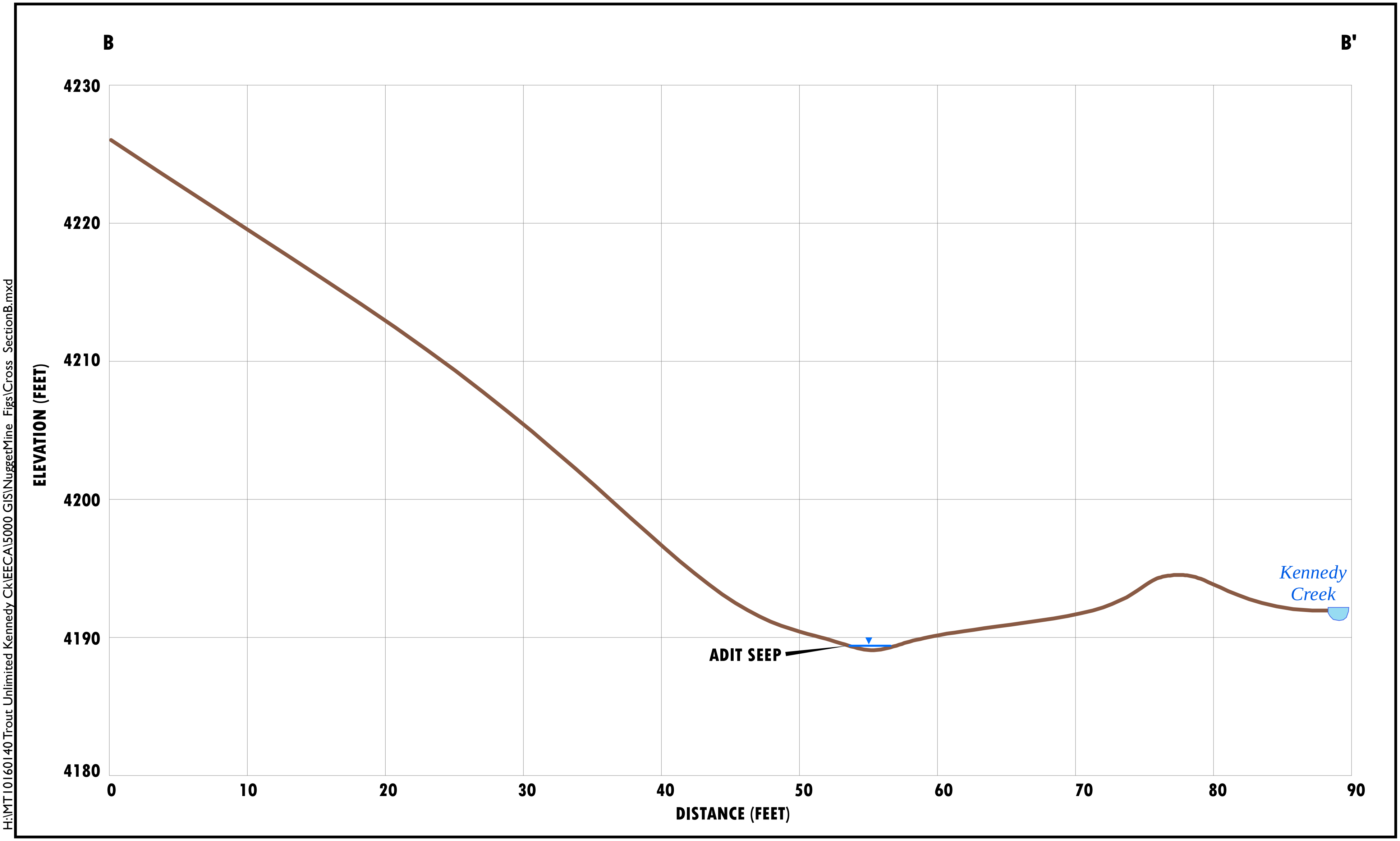
*Names for most sub-sampling locations from the Lost Cabin and Nugget mines consist of a two-character code for the hand-excavated location

Exiting Conditions
Nugget Mine Site
Kennedy Creek
Missoula County, Montana
FIGURE 5



AMEC Geomatrix

Cross Section A-A'
Nugget Mine Adit area
Kennedy Creek
Missoula County, Montana
FIGURE 6



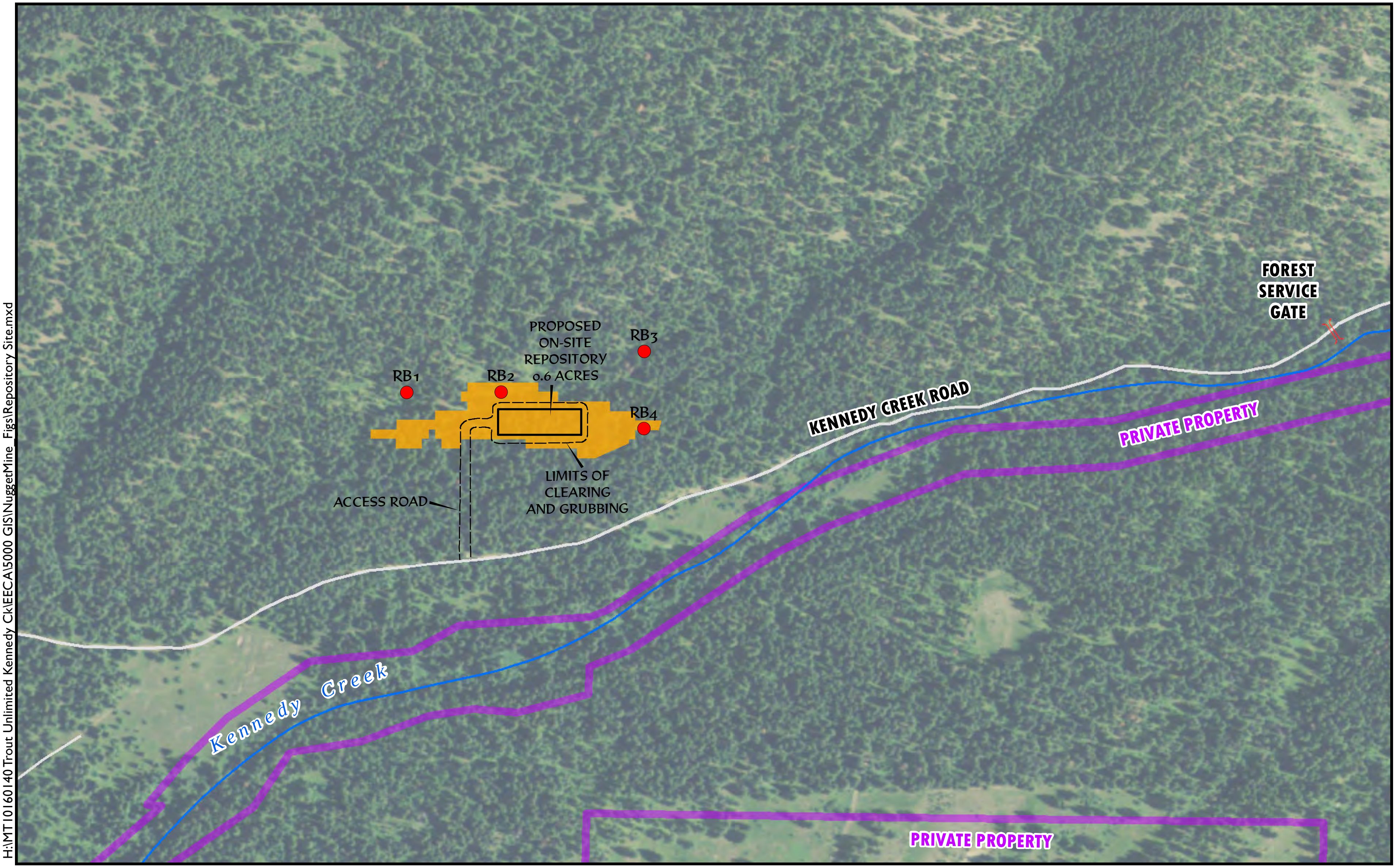
Cross Section B-B'
Nugget Mine Adit area
Kennedy Creek
Missoula County, Montana
FIGURE 7

0 Feet 10

Existing Ground Surface

AMEC Geomatrix

H:\MT10\60140 Trout Unlimited Kennedy Ck\EECA\5000 GIS\NuggetMine_Figs\Cross_SectionB.mxd



H:\MT10160140 Trout Unlimited Kennedy Ck\EECA\5000 GIS\NuggetMine Figs\Repository Site.mxd

Source: NAIP, 2009

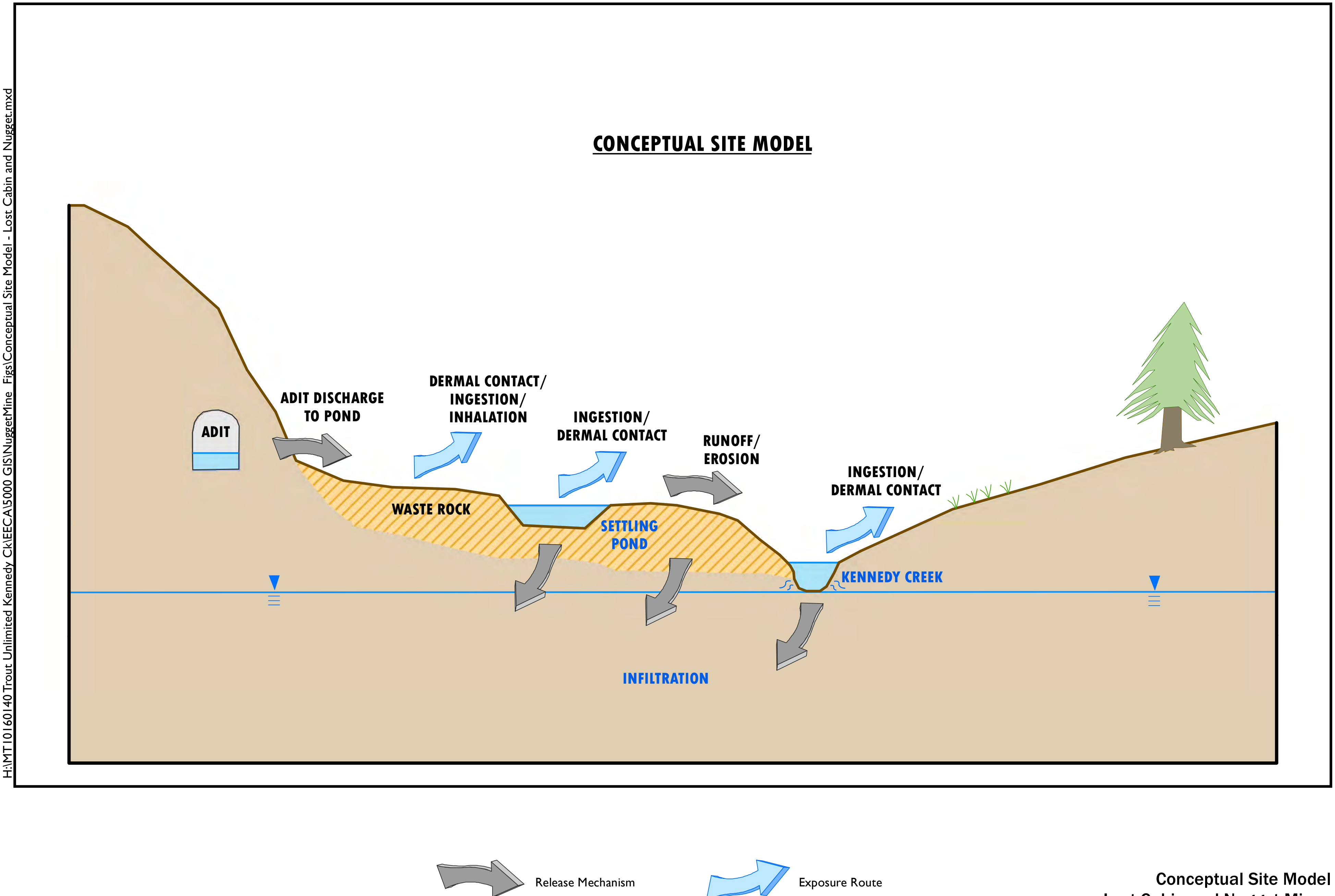
Hand Auger Borehole Location

Extent of Suitable Repository Area

AMEC Geomatrix

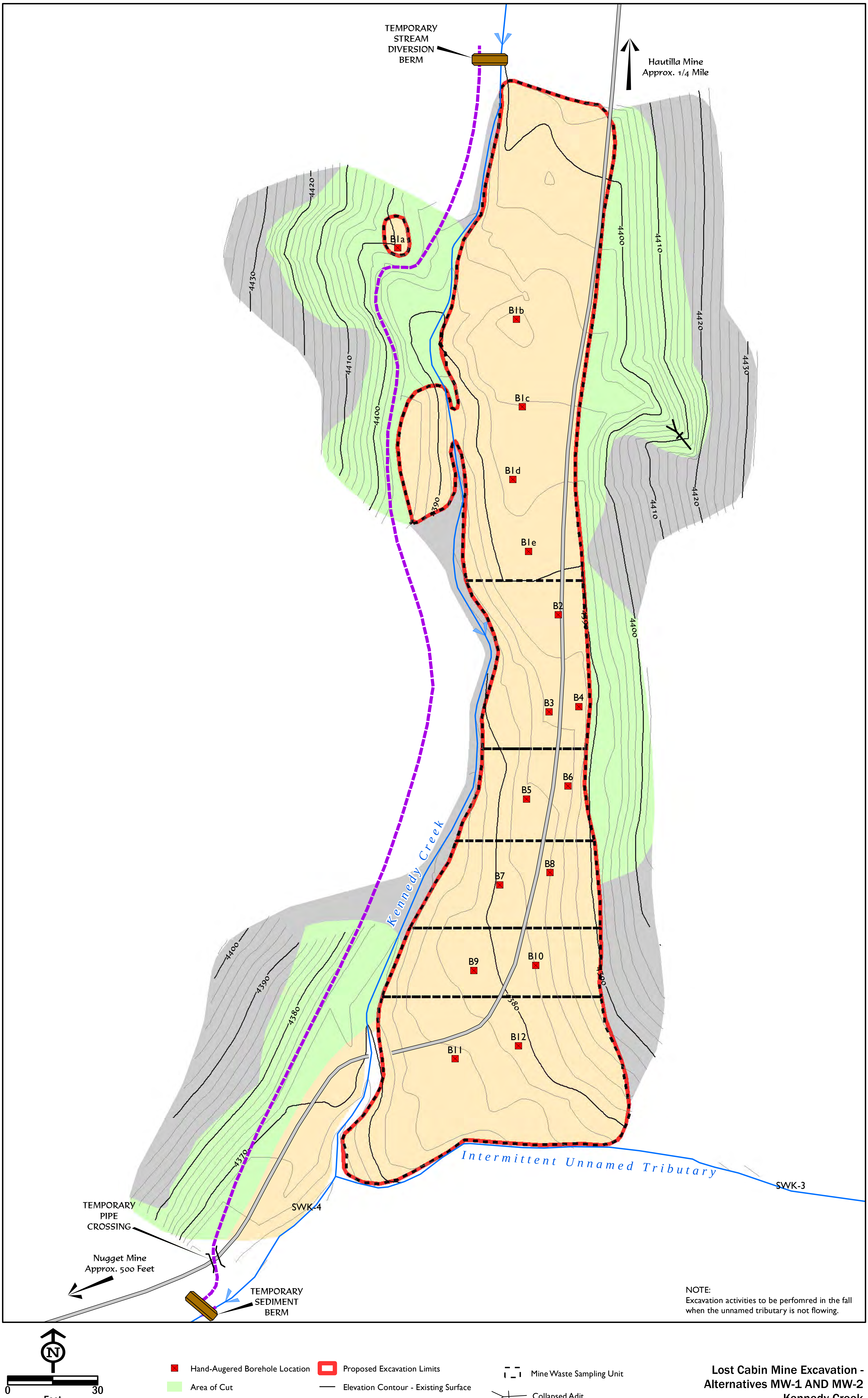
Repository Site
Kennedy Creek Mining Complex
Missoula County, Montana
FIGURE 8

H:\MT10160140 Trout Unlimited Kennedy Ck\EECA\5000 GIS\NuggetMine_Figs\Conceptual Site Model - Lost Cabin and Nugget.mxd



AMEC Geomatrix

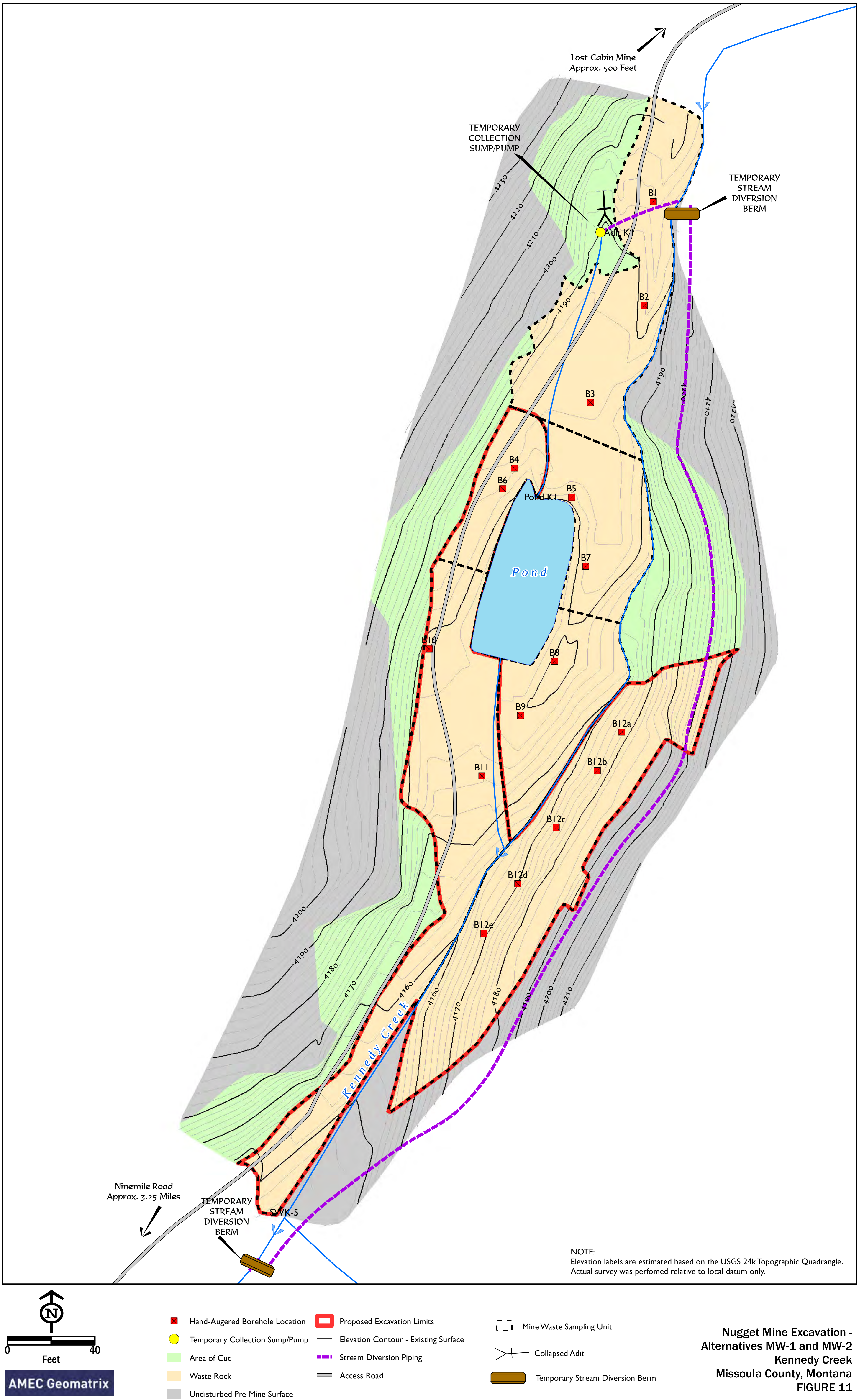
Conceptual Site Model
Lost Cabin and Nugget Mines
Missoula County, Montana
FIGURE 9



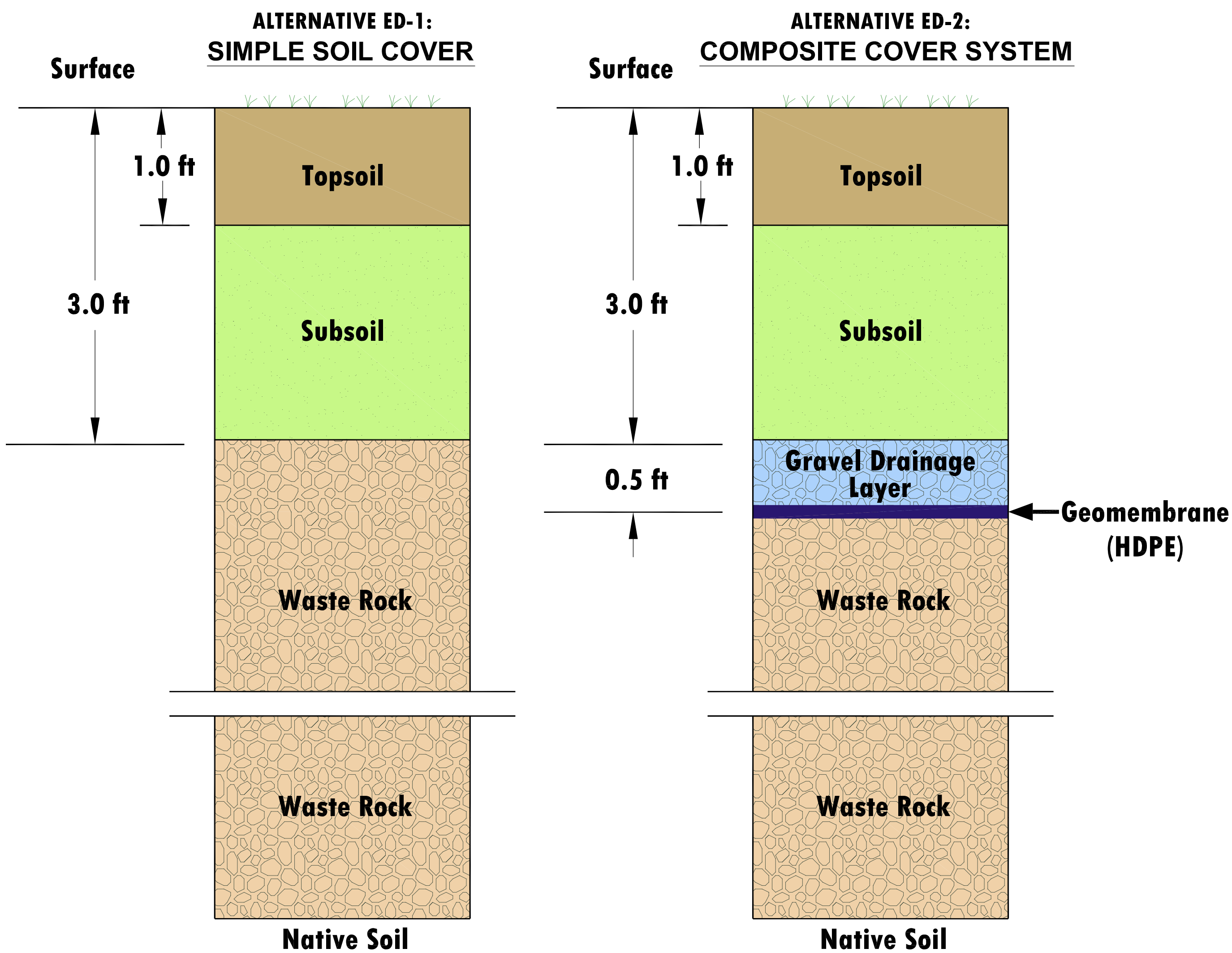
Hand-Augered Borehole Location
Area of Cut
Waste Rock
Undisturbed Pre-Mine Surface
Proposed Excavation Limits
Elevation Contour - Existing Surface
Access Road
Mine Waste Sampling Unit
Collapsed Adit
Temporary Stream Diversion Berm/ Sediment Basin Berm

AMEC Geomatrix

Lost Cabin Mine Excavation - Alternatives MW-1 AND MW-2
Kennedy Creek
Missoula County, Montana
FIGURE 10



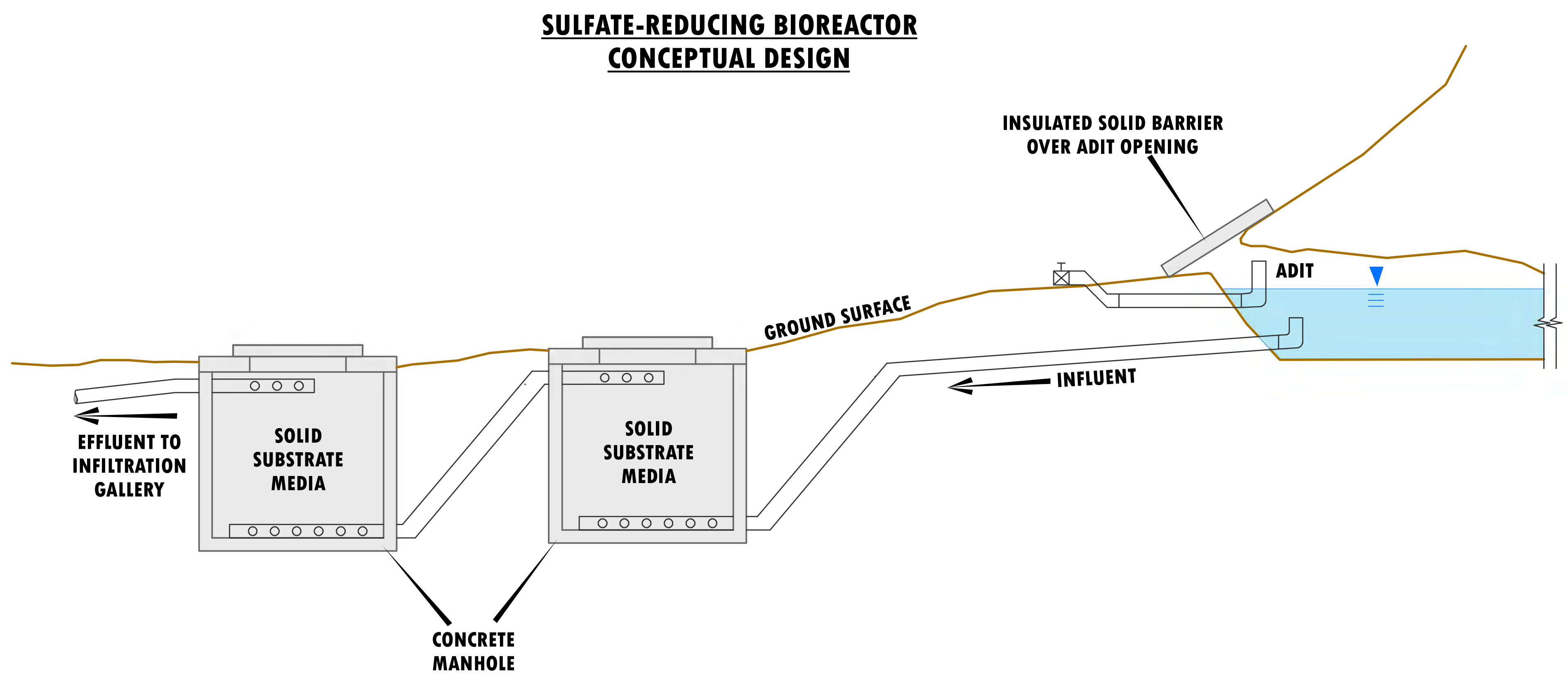
Nugget Mine Excavation -
Alternatives MW-1 and MW-2
Kennedy Creek
Missoula County, Montana
FIGURE 11



H:\MT10160140 Trout Unlimited Kennedy Ck\EECA\5000 GIS\CAD\Cover System Designs.dwg

Conceptual Repository Design - Cross-Sections
Kennedy Creek Mine Complex
Engineering Evaluation/Cost Analysis
FIGURE 12

AMEC Geomatrix

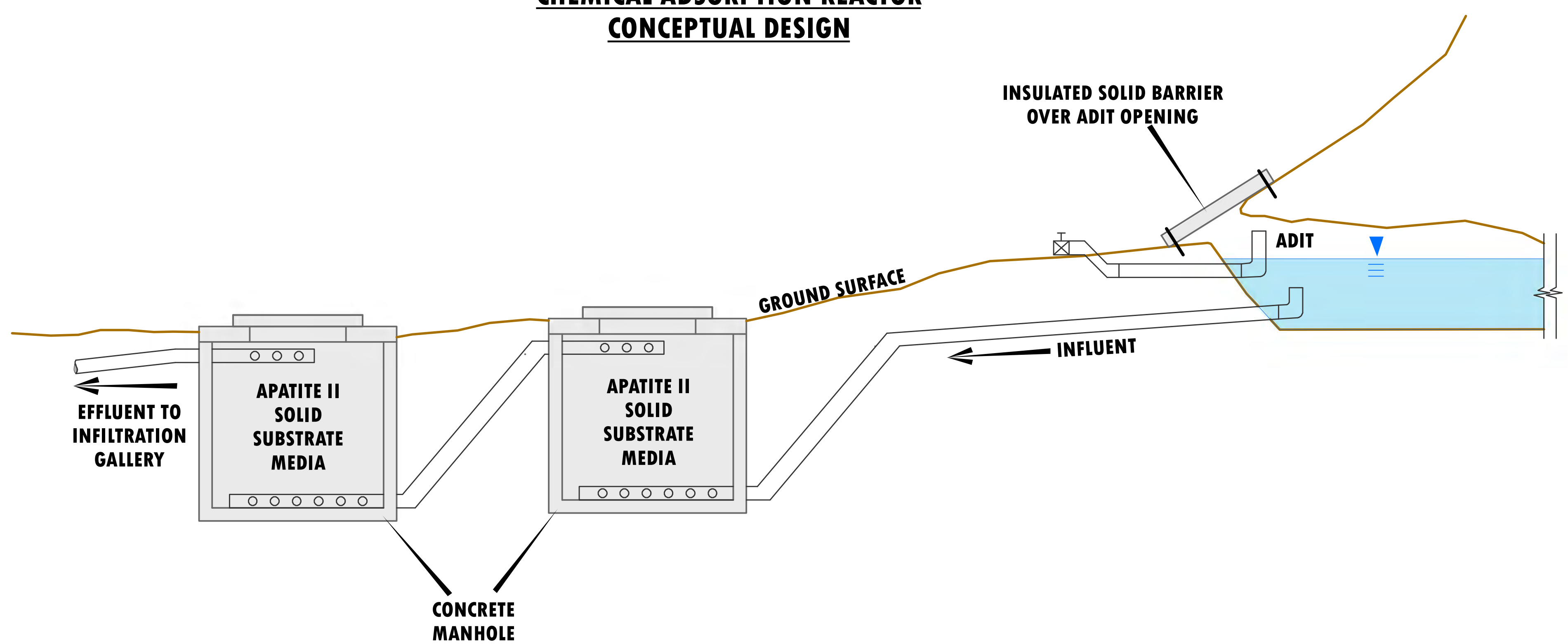


H:\MT10160140 Trout Unlimited Kennedy Ck\EECA\5000 GIS\NuggetMine_Figs\Sulfate Reducing Bioreactor.mxd

AMEC Geomatrix

Conceptual Design - Sulfate-Reducing Bioreactor
Nugget Mine
Missoula County, Montana
FIGURE 13

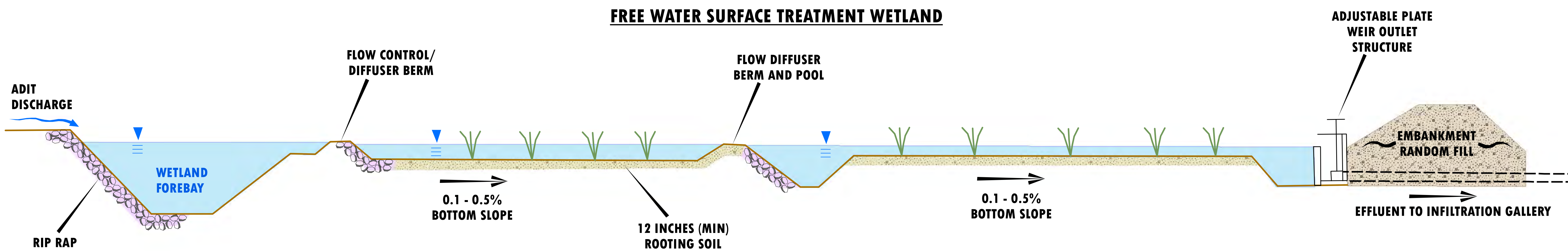
CHEMICAL ADSORPTION REACTOR CONCEPTUAL DESIGN



H:\MT10160140 Trout Unlimited Kennedy Ck\EECA\5000 GIS\NuggetMine_Figs\Chemical Absorbtion Ion Exchange.mxd

AMEC Geomatrix

Conceptual Design - Chemical Adsorption
Nugget Mine
Missoula County, Montana
FIGURE 14



H:\MT10160140 Trout Unlimited Kennedy Ck\EECA\5000 GIS\NuggetMine_Figs\Treatment Wetlands.mxd

AMEC Geomatrix

Conceptual Design - Treatment Wetlands
Nugget Mine
Missoula County, Montana
FIGURE 15

TABLES

TABLE 1 2010 MINE WASTE SAMPLE SUMMARY KENNEDY CREEK MINING COMPLEX				
Location	**Mine Site**	**Depth**	**Lithology**	**Setting**
B1a	Lost Cabin	0 – 0.5	Fine angular gravel	Isolated fill area on western side of Kennedy Creek near upstream edge of the site.
B1b – B1e	Lost Cabin	0 – 0.5	Silty gravel (GM): grayish brown (10YR5/2 and similar colors), no mottling. Color similar to surface of excavated area to the east. Gravel is fine and subrounded.	Isolated fill area on eastern side of Kennedy Creek near upstream edge of site. Sampled area has trees up to 4-in diameter.
B2	Lost Cabin	0 – 0.3 0.3 – 1.8 1.8 – 2.0	Poorly-graded gravel (GP) with cobbles: strong brown (7.5YR5/8), angular, dry. Wood cribbing present. Silty gravel (GM): very pale brown (10YR8/4), subangular, slightly moist. Poorly-graded gravel (GP): light yellowish brown (10YR6/4), subangular, slightly moist. Coarse gravel and small cobbles up to 5 inches max. dimension dominate (80%).	Area slightly vegetated. Flat.
B3	Lost Cabin	0 – 0.8 0.3 – 1.8 1.8 – 2.0	Poorly graded gravel (GP) with cobbles: strong brown, angular, dry. Wood cribbing present. Silty gravel (GM): very pale brown, subangular, slightly moist. Poorly graded gravel (GP): light yellowish brown, subangular, slightly moist. Coarse gravel and small cobbles up to 5 inches max. dimension dominate (80%)	No vegetation at boring location. Flat. Downhill shoulder of abandoned road grade.
B4	Lost Cabin	0-0.9 0.9-1.5 (uphill) or 2.8 (downhill side of excavation)	70% Silty gravel (GM): very pale brown (10YR7/3), angular, dry to slightly moist. 30% Highly weathered rock or low-plasticity silt (ML): white (5Y8/1), massive, slightly moist. Poorly-graded gravel (GP): olive yellow (10YR6/6), angular, slightly moist. Increasingly cobbly with depth.	No vegetation. Flat. Uphill edge of abandoned road grade.

TABLE 1
2010 MINE WASTE SAMPLE SUMMARY
KENNEDY CREEK MINING COMPLEX

Location	Mine Site	Depth	Lithology	Setting
B4 (cont.)	Lost Cabin	1.5 (uphill) or 2.8(down-hill)-3.0	Poorly-graded gravel (GP): dark gray(10YR4/1). Prevalent roots.	
B5	Lost Cabin	0-1.7	Silty gravel (GM): pale yellow (2.5Y7/4), angular, slightly moist.	Downhill shoulder of abandoned road grade.
		1.7-3.5	Low plasticity silt (ML) with gravel: brownish yellow (10YR6/8), subangular, slightly moist. 50% wood cribbing.	
		3.5-5.5	Well-graded gravel (GW): strong brown (7.5YR5/8), subangular, slightly moist.	
		5.5	Refusal encountered on gray rock (7.5YR5/1).	
B6	Lost Cabin	0-0.7	Highly weathered rock or low-plasticity silt (ML): white (5Y8/1), massive, slightly moist.	No vegetation. Flat. Uphill edge of abandoned road grade.
		0.7-1.8	Poorly-graded gravel (GP): yellow (2.5Y7/8), angular, slightly moist.	
		1.8 to 2.0	Poorly-graded gravel (GP): very pale brown (10YR7/3), less than 5% fines, slight roots.	
B7	Lost Cabin	0-2.0	Low plasticity silt (ML) with gravel: light yellowish brown (10YR6/4), angular, dry to slightly moist.	No vegetation. Downhill shoulder of abandoned road grade.
		2.0-2.6	Silty gravel (GM): brownish yellow (10YR/6/8), subangular, slightly moist.	
		2.6	Refusal encountered on wood cribbing.	
B8	Lost Cabin	0-2.0	Poorly-graded gravel (GP): brownish yellow (10YR6/6), angular, dry.	No vegetation. Approximate uphill edge of abandoned road grade across surface of mine waste pile.

TABLE 1
2010 MINE WASTE SAMPLE SUMMARY
KENNEDY CREEK MINING COMPLEX

Location	Mine Site	Depth	Lithology	Setting
B8 (cont.)	Lost Cabin	2.0-3.1 3.1-3.3	Silty gravel (GM): brownish yellow (10YR6/8), subangular, slightly moist. Silty gravel (GM): prevalent roots.	
B9	Lost Cabin	0-1.8 1.8-3.3 3.3	Low plasticity silt (ML) with gravel: brownish yellow (10YR6/6), subangular, slightly moist. Poorly-graded gravel (GP): brown (7.5YR5/4), angular, slightly moist. Refusal encountered on coarse gravel and cobbles.	No vegetation. Approximate downhill edge of abandoned road grade across surface of mine waste pile.
B10	Lost Cabin	0-0.5 0.5-2.6 2.6-3.8 3.8-4.0	Low plasticity silt (ML): yellow (10YR7/6), angular, dry. Silty gravel (GM): yellowish brown (10YR5/6), subangular, slightly moist. Poorly-graded gravel (GP): reddish brown (2.5YR4/3), angular, slightly moist. Low plasticity silt (ML): very dark gray (10YR3/1).	No vegetation. Approximate uphill edge of abandoned road grade across surface of mine waste pile.
B11	Lost Cabin	0-2.3 2.3-3.9 3.9-4.1	Silty gravel (GM): yellowish brown (10YR5/4), angular, dry. Low plasticity silt (ML) with gravel: brown (10YR4/3), subangular, slightly moist. Low plasticity silt (ML): dark gray (10YR4/1), angular, slightly moist.	No vegetation. Near southern end of mine waste.
B12	Lost Cabin	0-1.1	Low plasticity silt (ML) with fine gravel: brownish yellow (10YR6/8).	No vegetation. Near southern end of mine waste.

TABLE 1 2010 MINE WASTE SAMPLE SUMMARY KENNEDY CREEK MINING COMPLEX				
Location	**Mine Site**	**Depth**	**Lithology**	**Setting**
B12 (cont.)	Lost Cabin	1.2-1.3	Silty gravel (GM): grayish brown (10YR5/2). Stump to small tree encountered (1.5 in. diameter).	
B1	Nugget	0 – 2.7 2.7-2.9	Poorly graded gravel (GP): grayish brown, angular, slightly moist. Poorly graded gravel (GP): very dark grayish brown, angular, wet. Bottom of excavation is at elevation of adjacent creek.	North end of fill. Northwest of adit. Prevalent trees up to 1.5 in. diameter and moss present.
B2	Nugget	0-1.8 1.8-3.2 3.2-3.4	Poorly-graded gravel (GP): light gray (10YR7/2), angular, dry. Prevalent tree roots. Poorly-graded gravel (GP) with silt: grayish brown(10YR5/2), subangular, slightly moist. Slight fine roots. Poorly-graded gravel (GP) with silt: very dark brown (10YR2/2), wet to saturated. Bottom of excavation is at elevation of adjacent creek and adit discharge.	West of adit. Prevalent trees up to 5 in. diameter and moss present.
B3	Nugget	0-1.5	Poorly-graded gravel (GP): very dark grayish brown (10YR3/2), subangular, dry to slightly moist. Bottom of excavation is at elevation of creek side flat area.	Southwest of adit. Grass and moss present.
B4	Nugget	0-1.8 1.8-2.2	Silty gravel (GM): dark yellowish brown (10YR4/6), angular, slightly moist. Poorly-graded gravel (GP) with silt: brown (10YR5/3), subrounded, slightly moist.	Slope above northwest corner of pond. No vegetation present.
B5	Nugget	0-2.7 2.7-4.4 4.4	Well-graded gravel (GW): light gray (10YR7/1), sharp angular, dry. Poorly-graded gravel (GP): dark gray (10YR4/1), angular, moist to wet. Refusal on large rock.	Slope above northeast corner of pond. No vegetation present at excavation. Small trees (approx. 5 in. diameter) located at top of slope.

TABLE 1
2010 MINE WASTE SAMPLE SUMMARY
KENNEDY CREEK MINING COMPLEX

Location	Mine Site	Depth	Lithology	Setting
B6	Nugget	0-2.2 2.2-2.4	Silty gravel (GM): light yellowish brown (10YR6/4), angular, slightly moist. Well-graded gravel (GW): brown (10YR5/3), subrounded, slightly moist to dry.	Slope above northwest corner of pond. No vegetation present.
B7	Nugget	0-1.1 1.2-2 2.0-5.4 5.4-6.3 6.3-7.0 7.0	Silty gravel (GM): very pale brown (10YR7/3), angular, dry. Poorly-graded gravel (GP): brown (10YR5/3), subrounded, slightly moist. Metal plate encountered. Poorly-graded gravel (GP) with silt: light yellowish brown (10YR6/4) with orange mottling, subangular, slightly moist. Silty gravel (GM): strong brown (7.5YR5/6), angular, very moist. Low plasticity silt (ML) with gravel: dark gray (10YR4/1), subangular, very moist. Wood and charcoal encountered in small pieces less than ¼ in. max. dimension. Refusal on large rock	Slope above eastern side of pond. No vegetation present.
B8	Nugget	0-1.0 1.0-2.2 2.2-3.7 3.7-4.9 4.9	Poorly-graded gravel (GP) with silt: light brownish gray (10YR6/2), subangular, dry. Roots present. Poorly-graded gravel (GP): yellowish brown (10YR5/4), subangular, moist. No roots present. Poorly-graded gravel (GP): brownish yellow (10YR6/8), angular, moist. Silty gravel (GM): very dark gray (10YR3/1), subangular, wet. Refusal on large rock.	Slope above eastern side of pond. Prevalent trees up to ¾ in. diameter.

TABLE 1
2010 MINE WASTE SAMPLE SUMMARY
KENNEDY CREEK MINING COMPLEX

Location	Mine Site	Depth	Lithology	Setting
B9	Nugget	0-1.2 1.2-2.7 2.7-3.9	Poorly-graded gravel (GP): light brownish gray (10YR6/2), subangular, dry. Poorly-graded gravel (GP): brown (10YR4/3), angular, slightly moist. Silty gravel (GM): very dark gray (10YR3/1) with orange mottling, subangular, wet. Water-saturated conditions encountered at 3.9 ft. Material below 3.9 ft. not recoverable.	Slope at southeastern corner of pond. Prevalent trees up to ¾ in. diameter.
B10	Nugget	0-1.2 1.2-1.4	Poorly-graded gravel (GP): pale brown (10YR6/3), angular, dry. Low plasticity silt (ML) with angular gravel: brown (10YR5/3), dry. Prevalent tree roots up to 1 in. diameter.	Southwest of pond. Grass and trees up to 2 in. diameter present.
B11	Nugget	0-0.8 0.8-1.9 1.9	Poorly-graded gravel (GP) with silt: grayish brown (10YR5/2), angular, dry. Poorly-graded gravel (GP) with silt: brown (10YR4/3), subrounded, slightly moist. Timber (4 in. diameter) present horizontally in excavation. Refusal on woody material.	South of pond. Moss and trees up to 3/4 in. diameter present.
B12c	Nugget	0-0.6 0.6-0.8	Low plasticity silt (ML) with fine gravel: pale yellow (2.5Y8/4), angular gravel, dry. Poorly-graded gravel (GP): dark yellowish brown (10YR4/4), angular, slightly moist.	Steep slope east of Kennedy Creek. No vegetation in majority of surroundings, except one shrub (approx. 1.4 in. diameter).

TABLE 2
MINE WASTE SAMPLE RESULTS - METALS
KENNEDY CREEK MINING COMPLEX

Sample ID	Sample Date	Antimony (mg/kg)	Arsenic (mg/kg)	Beryllium (mg/kg)	Cadmium (mg/kg)	Chromium (mg/kg)	Copper (mg/kg)	Lead (mg/kg)	Mercury (mg/kg)	Nickel (mg/kg)	Selenium (mg/kg)	Silver (mg/kg)	Thallium (mg/kg)	Zinc (mg/kg)
Screening Level		293 [a]	70 [a]	160 [b]	1,950 [a]	735,000 [a]	27100 [a]	1,100 [a]	220 [a]	14,650 [a]	390 [b]	390 [b]	NA [c]	220,000 [a]
BACKGROUND														
SOIL K1	27-Aug-10	<0.53	16.1	0.38	0.091	8.7	20.1	21.9	0.00045	16.8	3	<0.53	<0.11	87.1
LOST CABIN MINE														
WR-1A (Lost Cabin)	2-Jul-93	8	98 J	---	1.2	4.3	1150 J	3370	0.318 J	11	---	---	---	478 J
LOST CABIN WASTE-1	25-Aug-10	2.8	101	0.44	1.2	6.9	436	2060	0.00088	14.2	1.5	2	0.12	460
LOST CABIN WASTE-2	25-Aug-10	3.3	50.5	<0.19	0.1	2.4	332	1110	0.005	1.7	0.83	1.7	<0.095	194
LOST CABIN WASTE-3	25-Aug-10	11.6	99.6	<0.21	<0.084	3.9	481	7970	0.007	3.3	0.97	11.9	0.11	418
LOST CABIN WASTE-4	25-Aug-10	6.8	138	<0.20	<0.078	1.4	343	4480	0.0038 M%	1	0.49U	7.6	<0.098	225
LOST CABIN WASTE-5	25-Aug-10	8.4	107	<0.19	<0.076	0.77	463	4110	0.0026	0.75	0.53	8.2	<0.095	234
LOST CABIN WASTE-6	25-Aug-10	26.3	108	<0.17	1	0.83	5630	17300	0.005	3.7	0.88	36.1	<0.083	3080
LOST CABIN WASTE-7	25-Aug-10	2	79.5	<0.16	0.73	0.61	324	1000	0.0029	4.1	0.42	1.5	<0.079	646
NUGGET MINE														
WR-1A (Nugget)	2-Jul-93	11	150 J	---	<0.5	<1.3	378	2340	0.196 J	9	---	---	---	330 J
NUGGET WASTE-1	26-Aug-10	1	44.5	0.26	0.8	5.8	187	398	0.0019	18.7	1.4	1.1	<0.095	321
NUGGET WASTE-2	26-Aug-10	1.9	44.2	<0.16	0.074	2.1	219	1690	0.0015	2	0.62	1.8	<0.079	271
NUGGET WASTE-3	26-Aug-10	8.9	41.3	0.24	2.7	6.1	1150	667	0.00099	18.1	1.3	2.1	<0.082	1360
NUGGET WASTE-4	26-Aug-10	1.1	55.9	<0.16	0.33	4.3	193	673	0.0022	8.2	1	0.87	<0.081	302
NUGGET WASTE-5	26-Aug-10	2.5	49.5	0.3	2.5	9.6	249	1510	0.0013	27	2.3	5.6	<0.075	2910
NUGGET WASTE-6	25-Aug-10	6.9	104	<0.19	<0.077	1.2	330	5550	0.0022	1.1	0.55	11.3	<0.097	189
NUGGET WASTE-7	26-Aug-10	1.7	108	0.29	5.5	5.1	448	62.6	0.0033	24	0.67	0.35U	<0.071	518
NUGGET WASTE-8	26-Aug-10	0.95	30.8	0.28	1.4	7.5	160	316	0.00077	20.4	1.8	0.86	<0.10	1950

Notes:

[a] Risk-Based Cleanup Guidelines for Abandoned Mine Sites (TetraTech 1996).
[b] U.S. Environmental Protection Agency Regional Screening Level.
[c] Thallium does not have an EPA Regional Screening Level (RSL). EPA has published 0.14 mg/kg as a thallium concentration in soil that screens for potential to impact underlying drinking water with soluble thallium salts. Groundwater use for drinking water is not permitted in the Kennedy Creek mining complex portion of the National Forest, therefore the drinking water-based screening level does not apply.
ND = Not detected. Reporting limit shown.
M% = Laboratory matrix spike recoveries exceed acceptable limits.
J = estimated value.
< = less than; analyte not detected above corresponding laboratory reporting limit.
(yellow) = Result is greater than 10 times the background concentration, but less than the Screening Level.
(orange) = Result is greater than the Screening Level.

References:

TetraTech, 1996. Risk-Based Cleanup Guidelines for Abandoned Mine Sites. Prepared for Montana Department of Environmental Quality, Abandoned Mine Reclamation Bureau. February.

TABLE 3
MINE WASTE SAMPLE RESULTS - DETECTED LEACHABLE METALS
KENNEDY CREEK MINING COMPLEX

Sample ID	Sample Date	Copper, SPLP (mg/L)	Lead, SPLP (mg/L)	Mercury, SPLP (mg/L)	Zinc, SPLP (mg/L)
Screening Level*		1.3	0.015	0.002	2.0
BACKGROUND					
SOIL K1	27-Aug-10	<0.12	0.27	<0.00080	<1.2
LOST CABIN MINE					
LOST CABIN WASTE-1	25-Aug-10	0.12	0.51	<0.00080	<1.2
LOST CABIN WASTE-2	25-Aug-10	<0.12	0.079	<0.00080	<1.2
LOST CABIN WASTE-3	25-Aug-10	<0.12	9.5	<0.00080	<1.2
LOST CABIN WASTE-4	25-Aug-10	0.23	8.4	0.0037	<1.2
LOST CABIN WASTE-5	25-Aug-10	0.21	5.9	<0.00080	<1.2
LOST CABIN WASTE-6	25-Aug-10	0.14	4.8	<0.00080	1.8
LOST CABIN WASTE-7	25-Aug-10	<0.12	1.3	<0.00080	<1.2
NUGGET MINE					
NUGGET WASTE-1	26-Aug-10	<0.12	0.091	<0.00080	<1.2
NUGGET WASTE-2	26-Aug-10	<0.12	8.1	<0.00080	<1.2
NUGGET WASTE-3	26-Aug-10	<0.12	0.2 F	<0.00080	<1.2
NUGGET WASTE-4	26-Aug-10	<0.12	<0.025	<0.00080	<1.2
NUGGET WASTE-5	26-Aug-10	<0.12	0.16	<0.00080	<1.2
NUGGET WASTE-6	25-Aug-10	0.26	6.4	<0.00080	<1.2
NUGGET WASTE-7	26-Aug-10	<0.12	0.033	<0.00080	<1.2
NUGGET WASTE-8	26-Aug-10	<0.12	0.31	<0.00080	<1.2

Notes:

All soil samples were analyzed for the 13 metals in the EPA Priority Pollutants list. Only metals with concentrations detected above laboratory reporting limits are included in the table above. Nine other metals (including arsenic) were not detected following SPLP extraction. The complete laboratory analytical reports are included in Appendix C of the Preliminary Assessment / Site Investigation (PA/SI) report dated February 2011.

SPLP = Synthetic Precipitation Leaching Procedure

* Montana Groundwater Quality Standard - Circular DEQ-7.

ND = Not detected. Reporting limit shown.

F = Field duplicate analysis exceeds acceptable limits (Practical Quantitation Limit comparison)

[orange shading] = Result is greater than the Screening Level.

[purple shading] = The laboratory detection limit is greater than the SPLP Screening Level.

TABLE 4
HISTORIC SURFACE WATER QUALITY SAMPLE RESULTS - METALS
KENNEDY CREEK MINING COMPLEX

Sample ID	Description of Sample Location	Date	pH (s.u.)	Flow (cfs)	Arsenic (µg/L)	Copper (µg/L)	Hardness-Dependent Screening Level, Copper (µg/L)	Lead (µg/L)	Hardness-Dependent Screening Level, Lead (µg/L)	Mercury (µg/L)	Zinc (µg/L)	Total Hardness (mg/L as $CaCO_3$)
Screening Level			---	---	6.5 [a]	(sample-specific, see below [b])		(sample-specific, see below [b])		0.15 [a]	17.2 [a]	---
32-042-SW-1 [c]	Downstream of Nugget mine	2-Jul-93	7.39	0.869	< 1.49	6.7 J	2.68	1.67 J	0.50	0.071 J	60.1 J	23.2
32-042-GW-1 [c]	Adit discharge	2-Jul-93	7.09	0.003	2.63	38.6 J	3.62	6.1 J	0.78	0.096 J	1370 J	33
32-011-SW-1 [c]	20 feet downstream of Lost Cabin Mine	2-Jul-93	6.06	1.313	<1.49	7.73 J	2.66	2.24 J	0.49	0.056 J	37.7 J	23
32-057-SW-1 [c]	Upstream of Lost Cabin mine (downstream of Hauttula Prospect)	2-Jul-93	6.64	0.42	1.81	2.63 J	2.39	1.29 J	0.42	0.097 J	19.9 J	20.3
Near Mouth [d]	Near confluence with Ninemile Creek	Sep. 2003	NR	NR	NR	NR	6.12	2.0	1.70	<0.0002	NR	61.1
		June 2004	NR	NR	NR	3.0	2.66	NR	0.49	<0.0002	140	23
Below Mining Complex [d]	Downstream of Nugget mine	June 2004	NR	NR	NR	3.0	2.46	NR	0.44	<0.0002	40	21

Notes:

[a] Recreational exposure guideline (TetraTech 1996).

[b] Montana chronic aquatic life standard. Hardness dependent value.

[c] Sample collected by Pioneer Technical Services, Inc. 1993.

[d] Sample collected by Montana Department of Environmental Quality (MDEQ).

--- = Not applicable.

< = less than; analyte not detected above laboratory reporting limit.

J = estimated value.

NR = not reported by MDEQ because concentration was below Montana chronic and acute aquatic life standards.

= Result is greater than the Screening Level.

References:

Pioneer Technical Services, Inc. 1995. Abandoned Hardrock Mine Priority Sites, 1995 Summary Report. Prepared for Montana Department of State Lands, Abandoned Mine Reclamation Bureau. April.

TetraTech, 1996. Risk-Based Cleanup Guidelines for Abandoned Mine Sites. Prepared for Montana Department of Environmental Quality, Abandoned Mine Reclamation Bureau. February.

MDEQ 2005. Water Quality Restoration Plan and Total Maximum Daily Loads for the Ninemile Planning Area. January.

TABLE 5
2010/2011 SURFACE WATER QUALITY SAMPLE RESULTS - METALS
KENNEDY CREEK MINING COMPLEX

Sample ID	Location	Sample Date	Calculated Discharge [a] (cfs)	pH	Conductivity (mS/cm)	Temperature (°C)	Arsenic (µg/L)	Copper (µg/L)	Hardness-Dependent Screening Level, Copper (µg/L)	Lead (µg/L)	Hardness-Dependent Screening Level, Lead (µg/L)	Mercury (µg/L)	Zinc (µg/L)	Total Hardness (mg/L)
Screening Level				---	---	---	6.5 [b]	(sample-specific, see below [c])		(sample-specific, see below [c])		0.15 [b]	17.2 [b]	--
SWK1	Upstream of Hauttula Prospect	24-Jun-10	3.22	5.74	0.028	6.76	0.70	0.75	1.25	0.048 J	0.16	0.031 J	<1.3	9.5
		27-Aug-10	0.019	6.51	0.081	9.27	0.95	<0.50	3.24	<0.10	0.66	0.000762	<5.0	29.0
SWK2	Upstream Lost Cabin mine, downstream of Hauttula Prospect	24-Jun-10	3.99	6.57	0.034	6.89	0.73	0.73	1.43	0.042 J	0.19	0.00331	<1.3	11.1
		27-Aug-10	0.023	4.51	0.085	9.63	0.61	0.75	3.44	<0.10	0.72	0.000628	<5.0	31.1
SWK3	Unnamed tributary, upstream of Lost Cabin mine	24-Jun-10	0.07	6.97	0.052	7.87	0.77	2.5	2.21	0.99	0.37	0.00390	10.1	18.5
		27-Aug-10	---	7.03	0.137	9.90	0.50U	1.6	5.66	0.97	1.51	0.00121	40.4	55.7
SWK4	Downstream of Lost Cabin mine, below confluence with unnamed tributary	24-Jun-10	3.55	6.78	0.038	7.10	0.83	3.1	1.64	0.56	0.24	0.00756	8.1	13.1
		27-Aug-10	0.027	6.75	0.062	10.26	1.0	9.4	3.64	1.3	0.78	0.000776	59.3	33.2
SWK5	Downstream of Nugget mine	24-Jun-10	3.96	6.86	0.040	7.24	0.79	3.5	1.61	0.83	0.23	0.00350	21.8	12.8
		27-Aug-10	0.020	7.29	0.097	10.23	1.0	3.5	3.86	1.3	0.85	0.000898	205	35.6
SWK East of Adit	East of adit at Nugget Mine	02-Sep-11	---	---	---	---	---	---	---	---	---	---	40.1	---
ADIT K1	Adit discharge at Nugget mine	24-Jun-10	NM	6.70	0.177	6.78	1.4	24.1	5.95	1.1	1.63	0.00363	6990	59.1
		27-Aug-10	NM	7.13	0.367	8.78	2.2	41.4	8.95	9.9	2.99	0.00291	13,700	95.3
		09-Jun-11	0.068	6.48	0.075	5.35	3.6	49.6	3.15	4.1	0.63	---	3220	28.1
		11-Aug-11	0.007	6.91	0.245	11.65	---	---	---	---	---	---	---	---
		02-Sep-11	---	---	---	---	---	---	---	---	---	---	2,260	---
ADIT-INSIDE	Sample from adit interior.	02-Sep-11	---	---	---	---	---	---	---	---	---	---	25,00	---
POND K1	Settling pond at Nugget mine, downstream of adit discharge	24-Jun-10	---	6.99	0.120	15.35	0.84	12.5	4.14	1.1	0.95	0.00279	3010	38.6
		27-Aug-10	---	7.56	0.167	14.22	0.89	9.3	6.23	7.6	1.74	0.00135	4,610	62.3
		09-Jun-11	---	6.55	0.082	7.65	2.4	29	3.06	10.5	0.60	---	3380	27.1
		11-Aug-11	---	6.98	0.174	17.83	---	---	---	---	---	---	---	---

Notes:

--- = Not applicable.

NM = Not measured, due to submerged flow conditions and lack of a definable channel.

[a] Discharge calculated by AMEC based on field monitoring data.

[b] Recreational exposure guideline (TetraTech 1996).

[c] Montana chronic aquatic life standard. Hardness dependent value.

< = less than; analyte not detected above corresponding laboratory reporting limit.

J = Estimated concentration.

(shaded) = Result is greater than the Screening Level.

TABLE 6 ADIT WATER QUALITY SAMPLE RESULTS KENNEDY CREEK MINING COMPLEX		
Parameter	ADIT K1	POND K1
	09-Jun-11	09-Jun-11
Field Parameters		
Calculated Discharge* (cfs)	0.068	---
pH	6.48	6.55
Conductivity (mS/cm)	0.075	0.082
Temperature (^{o}C)	5.35	7.65
General Parameters, Major Ions, & Nutrients		
Calcium, mg/L	6.27	6.10
Magnesium, mg/L	3.02	2.87
Potassium, mg/L	<2.50	<2.50
Sodium, mg/L	2.76	2.61
Sulfur, mg/L	4.80	4.56
Chloride, mg/L	<3.0	<3.0
Sulfate, mg/L	12.5	14.1
Total Kjeldahl Nitrogen, mg/L	0.12	0.12
Nitrate+Nitrite, mg/L	0.11	0.02
Total Phosphorus, mg/L	0.028	0.024
Total Alkalinity (as $CaCO_3$), mg/L	21.6	24.4
Total Hardness, mg/L	28.1	27.1
Total Suspend Solids, mg/L	1.2	1.4
Total Dissolved Solids, mg/L	84.0	53.0
Total Organic Carbon, mg/L	6.0	7.0
Dissolved Organic Carbon, mg/L	6.3	7.0

Notes:

--- = Not applicable, not measured.

* Discharge calculated by AMEC based on field monitoring data.

< = less than; analyte not detected above corresponding laboratory reporting limit.

TABLE 7 STREAMBED SEDIMENT SAMPLE RESULTS KENNEDY CREEK MINING COMPLEX							
Sample ID	Description of Sample Location	Date	Arsenic (mg/kg)	Copper (mg/kg)	Lead (mg/kg)	Mercury (mg/kg)	Zinc (mg/kg)
Lowest Effect Level*			6.0	16	31	0.20	120
Severe Effect Level*			33	110	250	2.0	820
32-057-SE-1 [a]	Upstream of Lost Cabin mine (downstream of Hauttula Prospect)	2-Jul-93	11 J	37.1 JX	17	0.025 J	56 J
32-011-SE-1 [a]	Downstream of Lost Cabin mine, below confluence with unnamed tributary	2-Jul-93	26 J	177 JX	346	0.199 J	293 J
32-042-SE-1 [a]	Downstream of Nugget mine	2-Jul-93	32 J	642 JX	227	0.015 J	301 J
SWK1-SED	Upstream of Hauttula Prospect	27-Aug-10	11.3	17.5 M%	14.7 M%	ND<0.020	55.6 M%
SWK2-SED	Upstream Lost Cabin mine, downstream of Hauttula Prospect	27-Aug-10	27.3	24.6 M%	36.1 M%	ND<0.020	86.6 M%
SWK3-SED	Unnamed tributary, upstream of Lost Cabin mine	27-Aug-10	17	37.1 M%	112 M%	ND<0.018	198 M%
SWK4-SED	Downstream of Lost Cabin mine, below confluence with unnamed tributary	27-Aug-10	24	116 M%	227 M%	ND<0.019	290 M%
SWK5-SED	Downstream of Nugget mine	27-Aug-10	19.7	120 F%M%	236 F%M%	ND<0.018	964 F%M%

Notes:

* Lowest Effect Level (LEL) and Severe Effect Level (SEL) are from the National Oceanic and Atmospheric Administration (NOAA) Screening Quick Reference Tables (SQuiRTs, NOAA 2008). LEL and SEL are the concentrations at which 5 and 95% of the studies species are estimated to suffer adverse effects, respectively.

[a] Sample collected by Pioneer Technical Services, Inc.

J = Flagged by laboratory as estimated value.

X = Flagged by laboratory as outlier for accuracy or precision.

M% = Laboratory matrix spike recoveries exceed acceptable limits.

F% = Field duplicate analysis exceeds acceptable limits (Relative Percent Difference comparison).

(light shading) = Result is greater than the Lowest Effects Level.

(dark shading) = Result is greater than the Severe Effects Level.

References:

Pioneer Technical Services, Inc. 1995. Abandoned Hardrock Mine Priority Sites, 1995 Summary Report. Prepared for Montana Department of State Lands, Abandoned Mine Reclamation Bureau. April.

TABLE 8 SOIL OBSERVATIONS IN POTENTIAL REPOSITORY LOCATION KENNEDY CREEK MINING COMPLEX			
Location	**Slope, Aspect**	**Depth Interval (inches)**	**Soil Observations**
RB1	10%, South-Southwest (200°)	0 – 3.5	Sandy loam with fine angular gravel: brown (10YR4/3), water saturated, prevalent fine roots.
		3.5 – 22	Sandy loam with coarse angular gravel: brown (10YR5/3), very moist, slight medium roots.
		22 – 24	Sandy loam with angular cobbles: light yellowish brown (10YR6/3). Refusal at 24 inches.
RB2	10%, South-Southeast (160°)	0 – 5.5	Sandy loam with fine angular gravel: grayish brown (10YR5/2), water saturated, prevalent fine roots.
		5.5 – 26	Loam with fine angular gravel: brown (10YR5/3), water saturated, slight medium roots.
		26 – 40	Sandy coarse angular gravel: light yellowish brown (10YR6/4), very moist, slight medium roots.
		40 - 49	Sand with fine angular gravel: yellowish brown (10YR5/4), moist, no roots. Refusal at 49 inches.
RB3	15%, Southwest (220°)	0 – 33	Silt loam: black, moist, prevalent fine roots.
		3 – 11	Sand with fine angular gravel: brown (7.5YR4/3), very moist, prevalent fine roots.
		11 – 28	Sand: yellowish brown (10YR5/4), moist, slight fine roots.
		28 – 36	Sand with coarse angular gravel: light yellowish brown (10YR6/4), moist, no roots. Refusal at 36 inches.
RB4	10%, South-Southwest (210°)	0 – 3	Silt loam: black, moist, prevalent fine roots.
		3 – 13	Silt loam: brown (10YR5/3), moist, slight fine roots.
		13 – 23	Sand: yellowish brown (10YR5/4), moist, slight fine roots.
		23 – 55	Sand with fine angular gravel: yellowish brown (10YR5/4), very moist, no roots.
		55 - 60	Sandy coarse gravel: dark yellowish brown (10YR4/6), slightly moist, no roots.

TABLE 9 HUMAN HEALTH REFERENCE CONCENTRATIONS KENNEDY CREEK MINING COMPLEX		
Constituent	Reference Concentration	
	Mine Waste / Soil (mg/kg)	Surface Water (µg/L)
Arsenic	70	6.5
Copper	27,100	472
Lead	1,100	47.1
Zinc	220,000	17.2

Reference:

TetraTech, 1996. Risk-Based Cleanup Guidelines for Abandoned Mine Sites. Prepared for Montana Department of Environmental Quality, Abandoned Mine Reclamation Bureau. February.

TABLE 10 REFERENCE CONCENTRATIONS FOR PROTECTION OF AQUATIC LIFE KENNEDY CREEK MINING COMPLEX	
Constituent	Surface Water Reference Concentration [a] (µg/L)
Arsenic	150
Copper [b]	2.85
Lead [b]	0.545
Zinc [b]	37

Notes:

[a] Montana numeric surface water quality standard for the protection of aquatic life - chronic exposure criteria.

[b] Hardness dependent numeric surface water standard. Value shown is based on a hardness of 25 mg/L.

TABLE 11 SEDIMENT REFERENCE CONCENTRATIONS KENNEDY CREEK MINING COMPLEX		
Constituent	Reference	
	Lowest Effect Level (LEL)	Severe Effect Level (SEL)
Arsenic	6	33
Copper	16	110
Lead	31	250
Zinc	120	820

Reference:

National Oceanic and Atmospheric Administration (NOAA), 2008. Buchman, M.F. Screening Quick Reference Tables (SQuiRTs), NOAA OR&R Report 08-01. Seattle WA, Office of Response and Restoration Division.

TABLE 12 ARAR-BASED RECLAMATION GOALS FOR SURFACE WATER KENNEDY CREEK MINING COMPLEX				
	Total Recoverable Metals (µg/L)			
	Arsenic(1)	Copper(2)	Lead(2)	Zinc(2)
Reclamation Goal	10	2.85	0.54	37

Notes:

(1) Human health standard for surface water.

(2) Chronic aquatic life water quality standard. Hardness dependent. Criteria listed are based on a hardness of 25 mg/L.

TABLE 13 RISK-BASED CLEANUP GUIDELINES FOR SOIL AND SEDIMENT KENNEDY CREEK MINING COMPLEX				
Cleanup Guideline	Total Metals (mg/kg)			
	Arsenic	Copper	Lead	Zinc
Human Health Guideline(1)	70	27,100	1,100	220,000
Sediment Guideline(2)	33	110	250	820

Notes:

(1) Risk-Based Guidelines for Abandoned Mine Sites, TetraTech (1996).

(2) Severe Effects Level for freshwater sediment, NOAA Screening Quick Reference Lookup Tables (2008).

References:

TetraTech, 1996. Risk-Based Cleanup Guidelines for Abandoned Mine Sites. Prepared for Montana Department of Environmental Quality, Abandoned Mine Reclamation Bureau. February.

National Oceanic and Atmospheric Administration (NOAA), 2008. Buchman, M.F. Screening Quick Reference Tables (SQuiRTs), NOAA OR&R Report 08-01. Seattle WA, Office of Response and Restoration Division.

TABLE 14
MINE WASTE RESPONSE TECHNOLOGY SCREENING SUMMARY
KENNEDY CREEK MINING COMPLEX

General Response Action	Response Technology	Process Option	Description	Initial Screening Result
No Action	None	Not Applicable	No action taken to address site conditions.	Retained as a baseline for comparison to other response actions.
Institutional Controls	Access Restrictions	Physical barriers / signs	Install fences around contaminated areas and install warning signs to reduce access. Do not repair site access road.	Not effective as a stand-alone response. Retained for consideration as a potential component of overall response action.
		Land use restrictions	Legal restrictions to control current and future land use.	Not effective as a stand-alone response. Retained for consideration as a potential component of overall response action.
Engineering Controls	Containment	Simple Soil Cover	Mine waste covered by monolithic layer of growth media or a layer of coarse-grained material (as a capillary break) and then growth media; growth media revegetated to reduce infiltration and continued erosion of exposed mine waste.	Prevents direct contact with waste materials. Would require mine waste in direct contact with Kennedy Creek to be excavated and replaced on site. Would require maintenance and weed control until vegetation is established. Vegetated cover would not reduce infiltration during spring runoff when plants are dormant. Not retained due to the presence of a suitable repository location in close proximity to the Nugget and Lost Cabin Mines.
		Composite Cover	Compacted clay layer or geomembrane liner covered by a layer of growth media. Revegetate growth media to promote evapotranspiration and reduce infiltration.	Prevents direct contact with waste materials and effectively controls infiltration. Would require mine waste in direct contact with Kennedy Creek to be excavated and replaced on site. Not retained due to the presence of a suitable repository location in close proximity to the Nugget and Lost Cabin Mines.
	Surface Controls	Grading	Reshape and reduce slopes of mine waste to control storm water run-on/runoff, prevent erosion, and reduce infiltration.	Readily implementable. Periodic maintenance may be necessary to repair erosion that occurs following remedial action. Retained for further evaluation through inclusion with other response action alternatives.
		Revegetation	Seeding of mine waste to reduce infiltration and control erosion.	Addition of soil amendments would be necessary to establish vegetation due to the absence of organic materials. Mulching, chemical stabilization, weed control and fertilization will likely be necessary. Periodic maintenance may be necessary until a self-sustaining plant community is established. Readily implementable. Effectively controls erosion of mine waste. Retained for further evaluation since revegetation would be required with other response actions.
		Erosion Controls	Construction of run-on/runoff diversion channels to direct storm water runoff away from mine waste. Placement of erosion resistant materials (e.g., mulch or fiber mats) to reduce erosion of mine waste.	Readily implementable. Effective at reducing infiltration and controlling erosion of mine waste. Retained for further evaluation since other response action alternatives would require erosion control.
Excavation and Disposal	On-Site Disposal	Repository with Simple Soil Cover	Excavate mine waste and dispose in onsite repository with simple soil cover. Revegetate cover to reduce infiltration. Regrade and revegetate excavation areas to control erosion. Reconstruct portions of Kennedy Creek affected by excavation.	Readily implementable. Prevents direct contact with mine waste and removes source of impacts to Kennedy Creek. Onsite repository location available. Vegetative cover reduces infiltration into waste during growing season, but not effective during spring runoff when plants are dormant. Retained for further evaluation.
		Repository with Composite Cover	Excavate mine waste and dispose in onsite repository with composite cover. Revegetate cover to reduce infiltration. Regrade and revegetate excavation areas to control erosion. Reconstruct portions of Kennedy Creek affected by excavation.	Readily implementable. Onsite repository location available. Prevents direct contact with mine waste and eliminates source of impacts to Kennedy Creek. Composite cover would significantly reduce infiltration of precipitation into repository as compared to a simple soil cover. Retained for further evaluation.
	Off-Site Disposal	Class D Landfill	Excavate mine waste and dispose in a hazardous waste landfill. Regrade and revegetate excavation areas to control erosion. Reconstruct portions of Kennedy Creek affected by excavation.	Readily implementable. Prevents direct contact with mine waste and removes source of impacts to Kennedy Creek. Disposal fees and transportation costs would be cost prohibitive compared to on-site disposal. Not retained for further evaluation.
Ex-Situ Treatment	Reprocessing and Re-use	Milling and Smelting	Excavate and transport mine waste to operating mill and/or smelter for minerals extraction. Regrade/revegetate excavation areas. Reconstruct affected sections of Kennedy Creek affected by excavation.	Not readily implementable due to lack of nearby processing facility, likely low concentrations of recoverable metals, and high costs relative to other response actions. Not retained for further evaluation.
		Re-use	Excavate and use mine waste as aggregate in asphalt or concrete pavement. . Regrade and revegetate excavation areas to control erosion. Reconstruct portions of Kennedy Creek affected by excavation.	Not retained for further consideration due to potential liability concerns associated with using contaminated materials at off-site locations.
	Physical/Chemical Treatment	Soil Washing	Separate hazardous constituents from excavated mine waste through dissolution, physical separation, and precipitation. Regrade/revegetate excavation areas. Reconstruct affected sections of Kennedy Creek affected by excavation.	Testing required to verify effectiveness. Wastes generated would require additional treatment and/or disposal. Not retained for further evaluation due to high associated cost relative to other response actions.

TABLE 14
MINE WASTE RESPONSE TECHNOLOGY SCREENING SUMMARY
KENNEDY CREEK MINING COMPLEX

General Response Action	Response Technology	Process Option	Description	Initial Screening Result
Ex-Situ Treatment	Physical/Chemical Treatment	Acid Extraction	Application of acidic solution to excavated mine waste in mixing tank to extract metals from media. Regrade/revegetate excavation areas. Reconstruct affected sections of Kennedy Creek affected by excavation.	Testing required to verify effectiveness. Wastes generated would require additional treatment and/or disposal. Not retained for further evaluation due to high associated cost relative to other response actions.
In-Situ Treatment	Fixation/Stabilization	Portland Cement / Pozzolans	Mine waste would be mixed in-situ with Portland cement or other pozzolan(s) to solidify the waste and prevent or reduce leaching of contaminants to surface water. Revegetate treated mine waste to control erosion.	Extensive treatability and leaching tests required. Potentially implementable but cost prohibitive. Not retained for further evaluation.
		Phosphate	In-situ mixing of mine waste with phosphate to reduce leachable concentrations of metals. Revegetate treated mine waste to control erosion.	Demonstrated technology at similar mine sites, although limited data is available regarding long-term effectiveness. Extensive treatability and leaching tests required. Reapplication and maintenance may be required. Not retained for further evaluation.

Note: Shaded technologies retained for further evaluation.
Response technologies screened based on effectiveness and practical considerations of their implementation (e.g., cost, infrastructure requirements, ongoing operation and maintenance requirements).

TABLE 15
ADIT DISCHARGE RESPONSE TECHNOLOGY SCREENING SUMMARY
KENNEDY CREEK MINING COMPLEX

General Response Action	Response Technology	Process Option	Description	Initial Screening Results
Engineering Controls	Hydraulic Control	Recharge Control	Construct subsurface barrier, such as a slurry wall or vertical geomembrane installation, between Kennedy Creek and adit to prevent recharge of water in adit from Kennedy Creek.	May potentially reduce, but not eliminate, adit flows by isolating creek and adit discharge. Implementable. Not retained for further evaluation due to limited effectiveness in controlling adit flows.
		Seal Adit	Install cemented plugs or cemented backfill to reduce and potentially prevent discharge of adit water to the surface.	Would require excavation and removal of scree/debris from adit entrance to provide access. Stability and condition of adit is unknown. Geotechnical evaluation of adit stability required. Potentially implementable, but may not completely prevent surface expression of adit discharge at some location. Not retained for further evaluation due to associated high costs and uncertainty regarding the geotechnical stability of the adit.
		Infiltration	Construct infiltration gallery to capture and direct adit discharge into the subsurface. Treatment media could be included in the infiltration gallery to reduce contaminant concentrations prior to discharge to the subsurface.	Would prevent direct contact with adit discharge. May not prevent eventual discharge of adit water to Kennedy Creek, since groundwater may discharge to the creek. Likely presence of shallow groundwater may present construction challenges. Groundwater evaluation would be required prior to design. Retained for further evaluation.
Passive Treatment	Biochemical Treatment	Constructed Wetlands	Construction of treatment wetland in location of the current settling pond or along west side of valley at the Nugget mine to treat the adit discharge. Wetlands can be horizontal subsurface flow or free water surface.	Proven technology. Seasonal conditions would limit the effectiveness of this treatment method during large portions of the year. High flows during spring runoff would reduce residence time and treatment effectiveness. Low cost relative to active treatment options. Retained for further evaluation.
		Bioreactor	Installation of a passive sulfate-reducing bioreactor (SRB) to treat the adit discharge. The SRB could potentially be installed within the adit or constructed below grade to insulate it from freezing winter conditions.	Proven technology. Would effectively reduce contaminant concentrations. Periodic replacement of treatment media would be required. Additional treatment may be required to address BOD, nutrients, and low dissolved oxygen levels in treated water. Low cost relative to active treatment options. Retained for further evaluation.
	Chemical Adsorption / Ion Exchange	Appatite II Reactor	Treats mine-impacted water through the adsorption of contaminants onto solid treatment media or interchange of ions between treatment media and influent water. As discussed above, treatment media could be used in an infiltration gallery to provide treatment prior to discharge to the subsurface.	Proven technology. Low cost relative to active treatment options. Would effectively reduce contaminant concentrations in adit water. Treatment media would require replacement at periodic intervals. Retained for further consideration.
Active Treatment	Chemical Precipitation	Hydroxide Precipitation	Conventional treatment method that consists of the addition of chemical reagents, such as quick lime or limestone, followed by physical separation of precipitated solids from treated water.	Proven technology. High implementation costs relative to passive treatment technologies. Ongoing operation and maintenance requirements. Requires power at treatment site and generates waste sludge that requires disposal. Not retained for further evaluation.
	Filtration/membrane separation	Nanofiltration	Use of semi-permeable membranes to selectively separate contaminants from influent water.	Proven water treatment technology. Requires power and generates concentrated waste stream that requires additional treatment and/or disposal. Not considered cost effective for the relatively low flows from the Nugget mine adit. Not retained for additional consideration.

Note: Shaded technologies retained for further evaluation.
Response technologies screened based on effectiveness and practical considerations of their implementation (e.g., cost, infrastructure requirements, ongoing operation and maintenance requirements).

TABLE 16
PROCESS OPTIONS RETAINED FROM TECHNOLOGY SCREENING
KENNEDY CREEK MINING COMPLEX

General Response Action	Response Technology	Process Option
General Response Technologies		
No Action	None	Not applicable.
Institutional Controls	Access Restrictions	Fencing / Signs
		Land Use Controls
Mine Waste Response Technologies		
Engineering Controls	Surface Controls	Grading
		Revegetation
		Erosion Controls
Excavation and Disposal	On-site Disposal	Repository with Simple Soil Cover
		Repository with Composite Cover
Adit Discharge Response Technologies		
Engineering Controls	Hydraulic Control	Infiltration
Biochemical treatment	Constructed Wetlands	Free Water Surface Wetlands
	Bioreactor	Sulfate-Reducing Bioreactor Inside Adit
Chemical Adsorption / Ion Exchange	Appatite II Reactor	Reactor Installed Inside Adit

TABLE 17
RESPONSE ACTION ALTERNATIVES
KENNEDY CREEK MINING COMPLEX

Alternative		Process Option Description
NA-1	No Action	No action taken to contaminant sources at the Lost Cabin and Nugget mines.
Mine Waste Alternatives		
MW-1	Excavation, On-site Disposal, Simple Soil Cover	Excavate and remove waste rock from Lost Cabin and Nugget mines. Dispose of waste rock in on-site repository with simple soil cover. Import top soil and regrade/revegetate mine sites. Construct run-on/runoff controls around repository. Land use restrictions and signs at repository.
MW-2	Excavation, On-Site Disposal, Composite Cover	Excavate and remove waste rock from Lost Cabin and Nugget mines. Dispose of waste rock in on-site repository with composite cover system. Import top soil and regrade/revegetate mine sites. Construct run-on/runoff controls around repository. Land use restrictions and signs at repository.
Adit Discharge Alternatives		
AD-1	Infiltration	Direct adit discharge to subsurface infiltration gallery. Install barrier over adit opening.
AD-2	Bioreactor (SRB) and Infiltration	Treat adit flows with solid substrate SRBs installed below grade. Direct treated discharge to subsurface infiltration gallery. Install insulated barrier over adit opening.
AD-3	Adsorption / Ion Exchange and Infiltration	Install Apatite II reactors below grade to treat adit flows. Direct treated discharge to subsurface infiltration gallery. Install insulated barrier over adit opening.
AD-4	Constructed Wetlands and Infiltration	Construct wetlands downstream of adit to treat adit flows. Direct treated flows to subsurface infiltration gallery. Install barrier over adit opening.

TABLE 18
MODELED REPOSITORY COVER SYSTEM PERFORMANCE
KENNEDY CREEK MINING COMPLEX

Item	Volume (inches/year)	Percent of Total Annual Precipitation (%)
Simple Soil Cover		
Annual Precipitation	27.44	100
Runoff	5.32	19.4
Evapotranspiration	16.37	59.6
Infiltration of Precipitation to Base of Mine Waste	5.75	20.95
Composite Cover System		
Annual Precipitation	27.44	100
Runoff	5.32	19.4
Evapotranspiration	16.37	59.6
Lateral Drainage through Gravel Drainage Layer (Layer 3)	2.51	9.16
Percolation through HDPE Liner (Layer 4)	0.045	0.16
Infiltration of Precipitation to Base of Mine Waste	0.034	0.12

TABLE 19
MINE WASTE ALTERNATIVE COST COMPARISON
KENNEDY CREEK MINING COMPLEX

Item	MW-1: Simple Soil Cover	MW-2: Composite Cover
Road Re-Alignment / Improvement	$ 4,370	$ 4,370
Creek Diversion	$ 25,206	$ 25,206
Mine Waste Removal	$ 108,397	$ 108,397
Repository Construction	$ 103,477	$ 208,503
Subtotal	**$ 241,450**	**$ 346,476**
Mobilization and Site Prep	$ 38,718	$ 54,471
Design / Project Management (12%)	$ 28,974	$ 41,577
Construction Oversight (10%)	$ 24,145	$ 34,648
Contingency (25%)	$ 60,363	$ 86,619
TOTAL	**$ 394,000**	**$ 564,000**

Notes:

Refer to Appendix G for a detailed breakdown of response action alternative costs.

TABLE 20
ADIT DISCHARGE ALTERNATIVE COST COMPARISON
KENNEDY CREEK MINING COMPLEX

Item	AD-1: Infiltration		AD-2: Bioreactors + Infiltration		AD-3: Apatite II + Infiltration		AD-4: Treatment Wetlands + Infiltration	
Mobilization and Site Prep	$	9,067	$	12,569	$	14,432	$	17,653
Construction / Capital Costs	$	43,780	$	67,125	$	79,544	$	101,021
Subtotal	**$**	**52,847**	**$**	**79,694**	**$**	**93,975**	**$**	**118,674**
Infiltration Testing & Groundwater Investigation	$	14,000	$	14,000	$	14,000	$	14,000
Design / Project Management (12%)	$	5,254	$	8,055	$	9,545	$	12,122
Construction Oversight (10%)	$	4,378	$	6,713	$	7,954	$	10,102
Contingency (25%)	$	10,945	$	16,781	$	19,886	$	25,255
O&M[1] Net Present Value	$	-	$	120,012	$	179,271	$	-
TOTAL	**$**	**87,000**	**$**	**245,000**	**$**	**325,000**	**$**	**180,000**

Notes:

[1] Operation and Maintenance

Refer to Appendix G for a detailed breakdown of response action alternative costs.

TABLE 21
RESPONSE ACTION ALTERNATIVES COMPARATIVE ANALYSIS SUMMARY
KENNEDY CREEK MINING COMPLEX

Alternative	Description of Technology	Effectiveness	Implementability	Cost
Alternative NA-1 No Action Alternative	No action taken to address impacts associated with mine waste or adit discharge.	Overall effectiveness is poor. Would not reduce risks to human or ecological receptors. Does not address impacts to surface water resulting from mine waste or the adit discharge. No reduction in the toxicity or volume of contaminants at the mine sites.	Technically and administratively feasible. Readily implementable since no action is required.	$0
Mine Waste				
Alternative MW-1 Excavation & On-site Disposal in Repository with Simple Soil Cover	Excavation of waste rock for disposal in on-site repository constructed with simple soil cover. Backfill/regrade and reclaim mine sites.	Would significantly reduce risks to human and ecological receptors and eliminate a source of impacts to surface water. The simple soil cover would allow more precipitation to infiltrate through the waste rock in the repository, and therefore, the alternative is slightly less effective than Alternative MW-2.	Implementable using readily available equipment and materials. Would not require long-term monitoring or maintenance once vegetation is established in disturbed areas.	$394,000
Alternative MW-2 Excavation & On-site Disposal in Repository with Composite Cover	Excavation of waste rock for disposal in on-site repository constructed with a composite cover system. Backfill/regrade and reclaim mine sites.	Highly effective. Composite cover would significantly reduce infiltration through waste rock in the repository. Eliminates a source of impacts to surface water. Exposure of human and ecological receptors through direct contact with waste rock would be eliminated.	Implementable using readily available equipment and materials. Would not require long-term monitoring or maintenance once vegetation is established in disturbed areas.	$564,000
Adit Discharge Alternatives				
Alternative AD-1 Infiltration	Adit discharge captured and directed to subsurface infiltration gallery.	Infiltration of the adit discharge would reduce risks to human and ecological receptors. May not eliminate impacts to surface water since infiltrated groundwater may discharge to Kennedy Creek. Long-term effectiveness and permanence is expected to be high. No long-term monitoring or maintenance would be required.	Readily implementable. May require import of soil to increase infiltration zone depth, depending on depth to site groundwater. On-site testing of infiltration rates and determination of groundwater depth required.	$87,000

TABLE 21
RESPONSE ACTION ALTERNATIVES COMPARATIVE ANALYSIS SUMMARY
KENNEDY CREEK MINING COMPLEX

Alternative	Description of Technology	Effectiveness	Implementability	Cost
Alternative AD-2 Bioreactors and Infiltration	Passive treatment of adit discharge using sulfate-reducing bioreactors. Treated effluent would be infiltrated into subsurface.	Sulfate-reducing bioreactors would be effective in reducing metals concentrations in the adit discharge. Infiltration would further reduce risks to human health and the environment through natural attenuation processes. Long-term effectiveness considered to be poor due to ongoing monitoring and maintenance requirements.	Implementable. Installation of subsurface bioreactors would protect the system from freezing conditions and allow it to operate year round. Depending on the depth to groundwater at the mine, it may be necessary to import soil for the infiltration system to increase separation between the system and groundwater. Bench-scale and/or field-scale testing would be required to optimize the bioreactor design.	$245,000
Alternative AD-3 Chemical Adsorption/Ion Exchange and Infiltration	Passive treatment of adit discharge with the ion exchange media Apatite II in subsurface reactor cells. Treated effluent would be infiltrated into the subsurface.	Effectiveness is comparable to Alternative AD-2. Would effectively reduce metals concentrations in the adit discharge. Concentrations in the treated effluent would be further reduced through infiltration and natural attenuation processes. Long-term effectiveness considered to be poor due to ongoing monitoring and maintenance requirements.	Implementable. Installation of subsurface reactor cells would protect the system from freezing conditions. Similar to Alternative AD-1, it may be necessary to import soil to increase the infiltration zone depth for the infiltration system if groundwater at the site is too shallow. Bench-scale testing would be necessary to optimize the reactor design.	$325,000
Alternative AD-4 Treatment Wetlands and Infiltration	Passive treatment of adit discharge in constructed wetlands. Treated effluent would be infiltrated into the subsurface.	Treatment wetlands would effectively reduce metals concentrations in the adit discharge during the growing season, but would be less effective during winter months. Would not be as effective as other options in reducing potential exposure of human receptors and wildlife to COCs. Treatment wetlands would reduce COC concentrations in the adit discharge, however, human and ecological receptors could be exposed to metals above cleanup goals in the wetlands before treatment is complete. No long-term monitoring or maintenance requirements are anticipated.	Implementable. Monitoring and maintenance of the constructed wetlands may be required until vegetation is fully established. Similar to Alternative AD-1, it may be necessary to import soil to increase the infiltration zone depth for the infiltration system if groundwater	$180,000

APPENDIX A
2011 Analytical Laboratory Reports

Pace Analytical Services, Inc.
602 S 25th Street
Billings, MT 591014549
(406)254-7226

June 27, 2011

Wilhelm Welzenbach
AMEC Geomatrix
1001 South Higgins Ave
Missoula, MT 59801

RE: Project: Kennedy Creek EECA
Pace Project No.: 10160067

Dear Wilhelm Welzenbach:

Enclosed are the analytical results for sample(s) received by the laboratory on June 11, 2011. The results relate only to the samples included in this report.

If you have any questions concerning this report, please feel free to contact me.

Sincerely,

Denise Jensen

denise.jensen@pacelabs.com
Project Manager

Enclosures

Pace Analytical Services, Inc.
602 S 25th Street
Billings, MT 591014549
(406)254-7226

CERTIFICATIONS

Project:	Kennedy Creek EECA
Pace Project No.:	10160067

Minnesota Certification IDs

1700 Elm Street SE Suite 200, Minneapolis, MN 55414
A2LA Certification #: 2926.01
Alaska Certification #: UST-078
Alaska Certification #MN00064
Arizona Certification #: AZ-0014
Arkansas Certification #: 88-0680
California Certification #: 01155CA
EPA Region 8 Certification #: Pace
Florida/NELAP Certification #: E87605
Georgia Certification #: 959
Idaho Certification #: MN00064
Illinois Certification #: 200011
Iowa Certification #: 368
Kansas Certification #: E-10167
Louisiana Certification #: 03086
Louisiana Certification #: LA080009
Maine Certification #: 2007029
Maryland Certification #: 322
Michigan DEQ Certification #: 9909
Minnesota Certification #: 027-053-137
Mississippi Certification #: Pace
Montana Certification #: MT CERT0092
Nebraska Certification #: Pace
Nevada Certification #: MN_00064
New Jersey Certification #: MN-002
New Mexico Certification #: Pace
New York Certification #: 11647
North Carolina Certification #: 530
North Dakota Certification #: R-036
North Dakota Certification #: R-036A
Ohio VAP Certification #: CL101
Oklahoma Certification #: D9921
Oklahoma Certification #: 9507
Oregon Certification #: MN200001
Pennsylvania Certification #: 68-00563
Puerto Rico Certification
Tennessee Certification #: 02818
Texas Certification #: T104704192
Washington Certification #: C754
Wisconsin Certification #: 999407970

Montana Certification IDs

602 South 25th Street, Billings, MT 59101
EPA Region 8 Certification #: 8TMS-Q
Idaho Certification #: MT00012
Montana Certification #: MT CERT0040
NVLAP Certification #: 101292-0
Minnesota Dept of Health Certification #: 030-999-442

Ormond Beach Certification IDs

8 East Tower Circle, Ormond Beach, FL 32174
Alabama Certification #: 41320
Arizona Certification #: AZ0735
Colorado Certification: FL NELAC Reciprocity
Connecticut Certification #: PH 0216
Florida Certification #: E83079
Georgia Certification #: 955
Guam Certification: FL NELAC Reciprocity
Hawaii Certification: FL NELAC Reciprocity
Kansas Certification #: E-10383
Kentucky Certification #: 90050
Louisiana Certification #: LA090012
Louisiana Environmental Certificate #: 05007
Maine Certification #: FL1264
Massachusetts Certification #: M-FL1264
Michigan Certification #: 9911
Mississippi Certification: FL NELAC Reciprocity
Montana Certification #: Cert 0074
Nevada Certification: FL NELAC Reciprocity
New Hampshire Certification #: 2958
New Jersey Certification #: FL765
New York Certification #: 11608
North Carolina Environmental Certificate #: 667
North Carolina Certification #: 12710
Pennsylvania Certification #: 68-547
Puerto Rico Certification #: FL01264
Tennessee Certification #: TN02974
Texas Certification: FL NELAC Reciprocity
Virginia Certification #: 00432
Wyoming Certification: FL NELAC Reciprocity

Pace Analytical Services, Inc.
602 S 25th Street
Billings, MT 591014549
(406)254-7226

SAMPLE SUMMARY

Project: Kennedy Creek EECA
Pace Project No.: 10160067

Lab ID	Sample ID	Matrix	Date Collected	Date Received
10160067001	**ADIT K1**	Water	06/09/11 15:10	06/11/11 11:40
10160067002	**POND K1**	Water	06/09/11 09:45	06/11/11 11:40

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SAMPLE ANALYTE COUNT

Project: Kennedy Creek EECA
Pace Project No.: 10160067

Lab ID	Sample ID	Method	Analysts	Analytes Reported	Laboratory
10160067001	**ADIT K1**	EPA 200.7	IP	6	PASI-M
		EPA 200.8	TL1	7	PASI-M
		SM 2540D	SR1	1	PASI-MT
		EPA 300.0	JH1	2	PASI-MT
		EPA 351.2	CAC	1	PASI-MT
		EPA 353.2	CAC	1	PASI-MT
		SM 4500-P E	SA1	1	PASI-MT
		SM 2320B	MWD	4	PASI-M
		SM 2540C	AS1	1	PASI-M
		SM 5310B	MBS	1	PASI-O
		SM 5310B	MBS	1	PASI-O
10160067002	**POND K1**	EPA 200.7	IP	6	PASI-M
		EPA 200.8	TL1	7	PASI-M
		SM 2540D	SR1	1	PASI-MT
		EPA 300.0	JH1	2	PASI-MT
		EPA 351.2	CAC	1	PASI-MT
		EPA 353.2	CAC	1	PASI-MT
		SM 4500-P E	SA1	1	PASI-MT
		SM 2320B	MWD	4	PASI-M
		SM 2540C	AS1	1	PASI-M
		SM 5310B	MBS	1	PASI-O
		SM 5310B	MBS	1	PASI-O

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PROJECT NARRATIVE

Project: Kennedy Creek EECA
Pace Project No.: 10160067

Method: **EPA 200.7**
Description: 200.7 MET ICP
Client: AMEC Geomatrix, Inc.
Date: June 27, 2011

General Information:
2 samples were analyzed for EPA 200.7. All samples were received in acceptable condition with any exceptions noted below.

Hold Time:
The samples were analyzed within the method required hold times with any exceptions noted below.

Sample Preparation:
The samples were prepared in accordance with EPA 200.7 with any exceptions noted below.

Initial Calibrations (including MS Tune as applicable):
All criteria were within method requirements with any exceptions noted below.

Continuing Calibration:
All criteria were within method requirements with any exceptions noted below.

Method Blank:
All analytes were below the report limit in the method blank with any exceptions noted below.

Laboratory Control Spike:
All laboratory control spike compounds were within QC limits with any exceptions noted below.

Matrix Spikes:
All percent recoveries and relative percent differences (RPDs) were within acceptance criteria with any exceptions noted below.

Duplicate Sample:
All duplicate sample results were within method acceptance criteria with any exceptions noted below.

Additional Comments:

Pace Analytical Services, Inc.
602 S 25th Street
Billings, MT 591014549
(406)254-7226

PROJECT NARRATIVE

Project:	Kennedy Creek EECA
Pace Project No.:	10160067

Method: **EPA 200.8**
Description: 200.8 MET ICPMS
Client: AMEC Geomatrix, Inc.
Date: June 27, 2011

General Information:
2 samples were analyzed for EPA 200.8. All samples were received in acceptable condition with any exceptions noted below.

Hold Time:
The samples were analyzed within the method required hold times with any exceptions noted below.

Sample Preparation:
The samples were prepared in accordance with EPA 200.8 with any exceptions noted below.

Initial Calibrations (including MS Tune as applicable):
All criteria were within method requirements with any exceptions noted below.

Continuing Calibration:
All criteria were within method requirements with any exceptions noted below.

Internal Standards:
All internal standards were within QC limits with any exceptions noted below.

Method Blank:
All analytes were below the report limit in the method blank with any exceptions noted below.

Laboratory Control Spike:
All laboratory control spike compounds were within QC limits with any exceptions noted below.

Matrix Spikes:
All percent recoveries and relative percent differences (RPDs) were within acceptance criteria with any exceptions noted below.

QC Batch: MPRP/26598

A matrix spike and matrix spike duplicate (MS/MSD) were performed on the following sample(s): 10159726041,10160031017

M1: Matrix spike recovery exceeded QC limits. Batch accepted based on laboratory control sample (LCS) recovery.

- MS (Lab ID: 994127)
  - Manganese

Duplicate Sample:
All duplicate sample results were within method acceptance criteria with any exceptions noted below.

Additional Comments:

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Billings, MT 591014549
(406)254-7226

PROJECT NARRATIVE

Project: Kennedy Creek EECA
Pace Project No.: 10160067

Method: **SM 2540D**
Description: 2540D Total Suspended Solids
Client: AMEC Geomatrix, Inc.
Date: June 27, 2011

General Information:
2 samples were analyzed for SM 2540D. All samples were received in acceptable condition with any exceptions noted below.

Hold Time:
The samples were analyzed within the method required hold times with any exceptions noted below.

Initial Calibrations (including MS Tune as applicable):
All criteria were within method requirements with any exceptions noted below.

Continuing Calibration:
All criteria were within method requirements with any exceptions noted below.

Internal Standards:
All internal standards were within QC limits with any exceptions noted below.

Surrogates:
All surrogates were within QC limits with any exceptions noted below.

Method Blank:
All analytes were below the report limit in the method blank with any exceptions noted below.

Laboratory Control Spike:
All laboratory control spike compounds were within QC limits with any exceptions noted below.

Matrix Spikes:
All percent recoveries and relative percent differences (RPDs) were within acceptance criteria with any exceptions noted below.

Duplicate Sample:
All duplicate sample results were within method acceptance criteria with any exceptions noted below.

QC Batch: MT/6162

D6: The relative percent difference (RPD) between the sample and sample duplicate exceeded laboratory control limits.

- DUP (Lab ID: 993866)
  - Total Suspended Solids

Additional Comments:

Pace Analytical Services, Inc.
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PROJECT NARRATIVE

Project: Kennedy Creek EECA
Pace Project No.: 10160067

Method: **EPA 300.0**
Description: 300.0 IC Anions
Client: AMEC Geomatrix, Inc.
Date: June 27, 2011

General Information:
2 samples were analyzed for EPA 300.0. All samples were received in acceptable condition with any exceptions noted below.

Hold Time:
The samples were analyzed within the method required hold times with any exceptions noted below.

Initial Calibrations (including MS Tune as applicable):
All criteria were within method requirements with any exceptions noted below.

Continuing Calibration:
All criteria were within method requirements with any exceptions noted below.

Internal Standards:
All internal standards were within QC limits with any exceptions noted below.

Surrogates:
All surrogates were within QC limits with any exceptions noted below.

Method Blank:
All analytes were below the report limit in the method blank with any exceptions noted below.

Laboratory Control Spike:
All laboratory control spike compounds were within QC limits with any exceptions noted below.

Matrix Spikes:
All percent recoveries and relative percent differences (RPDs) were within acceptance criteria with any exceptions noted below.

Duplicate Sample:
All duplicate sample results were within method acceptance criteria with any exceptions noted below.

QC Batch: MT/6195

D6: The relative percent difference (RPD) between the sample and sample duplicate exceeded laboratory control limits.
- DUP (Lab ID: 998641)
  - Sulfate

Additional Comments:

Pace Analytical Services, Inc.
602 S 25th Street
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PROJECT NARRATIVE

Project: Kennedy Creek EECA
Pace Project No.: 10160067

Method: **EPA 351.2**
Description: 351.2 Total Kjeldahl Nitrogen
Client: AMEC Geomatrix, Inc.
Date: June 27, 2011

General Information:
2 samples were analyzed for EPA 351.2. All samples were received in acceptable condition with any exceptions noted below.

Hold Time:
The samples were analyzed within the method required hold times with any exceptions noted below.

Initial Calibrations (including MS Tune as applicable):
All criteria were within method requirements with any exceptions noted below.

Continuing Calibration:
All criteria were within method requirements with any exceptions noted below.

Internal Standards:
All internal standards were within QC limits with any exceptions noted below.

Surrogates:
All surrogates were within QC limits with any exceptions noted below.

Method Blank:
All analytes were below the report limit in the method blank with any exceptions noted below.

Laboratory Control Spike:
All laboratory control spike compounds were within QC limits with any exceptions noted below.

Matrix Spikes:
All percent recoveries and relative percent differences (RPDs) were within acceptance criteria with any exceptions noted below.

QC Batch: MT/6140

A matrix spike and matrix spike duplicate (MS/MSD) were performed on the following sample(s): 10158158002,10159583003

M2: Matrix spike recovery was below QC limits due to sample dilution. Data acceptance based on laboratory control sample (LCS) recovery.

- MS (Lab ID: 990382)
  - Nitrogen, Kjeldahl, Total

Duplicate Sample:
All duplicate sample results were within method acceptance criteria with any exceptions noted below.

Additional Comments:

Pace Analytical Services, Inc.
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PROJECT NARRATIVE

Project:	Kennedy Creek EECA
Pace Project No.:	10160067

Method: **EPA 353.2**
Description: 353.2 Nitrate + Nitrite pres.
Client: AMEC Geomatrix, Inc.
Date: June 27, 2011

General Information:
2 samples were analyzed for EPA 353.2. All samples were received in acceptable condition with any exceptions noted below.

Hold Time:
The samples were analyzed within the method required hold times with any exceptions noted below.

Initial Calibrations (including MS Tune as applicable):
All criteria were within method requirements with any exceptions noted below.

Continuing Calibration:
All criteria were within method requirements with any exceptions noted below.

Internal Standards:
All internal standards were within QC limits with any exceptions noted below.

Surrogates:
All surrogates were within QC limits with any exceptions noted below.

Method Blank:
All analytes were below the report limit in the method blank with any exceptions noted below.

Laboratory Control Spike:
All laboratory control spike compounds were within QC limits with any exceptions noted below.

Matrix Spikes:
All percent recoveries and relative percent differences (RPDs) were within acceptance criteria with any exceptions noted below.

QC Batch: MT/6201

A matrix spike and matrix spike duplicate (MS/MSD) were performed on the following sample(s): 10160074001,10160702001

M0: Matrix spike recovery and/or matrix spike duplicate recovery was outside laboratory control limits.

- MS (Lab ID: 998844)
  - Nitrogen, NO2 plus NO3

Duplicate Sample:
All duplicate sample results were within method acceptance criteria with any exceptions noted below.

Additional Comments:

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602 S 25th Street
Billings, MT 591014549
(406)254-7226

PROJECT NARRATIVE

Project: Kennedy Creek EECA
Pace Project No.: 10160067

Method: **SM 4500-P E**
Description: SM4500P-E, Total Phosphorus
Client: AMEC Geomatrix, Inc.
Date: June 27, 2011

General Information:
2 samples were analyzed for SM 4500-P E. All samples were received in acceptable condition with any exceptions noted below.

Hold Time:
The samples were analyzed within the method required hold times with any exceptions noted below.

Initial Calibrations (including MS Tune as applicable):
All criteria were within method requirements with any exceptions noted below.

Continuing Calibration:
All criteria were within method requirements with any exceptions noted below.

Internal Standards:
All internal standards were within QC limits with any exceptions noted below.

Surrogates:
All surrogates were within QC limits with any exceptions noted below.

Method Blank:
All analytes were below the report limit in the method blank with any exceptions noted below.

Laboratory Control Spike:
All laboratory control spike compounds were within QC limits with any exceptions noted below.

Matrix Spikes:
All percent recoveries and relative percent differences (RPDs) were within acceptance criteria with any exceptions noted below.

Duplicate Sample:
All duplicate sample results were within method acceptance criteria with any exceptions noted below.

Additional Comments:

Pace Analytical Services, Inc.
602 S 25th Street
Billings, MT 591014549
(406)254-7226

PROJECT NARRATIVE

Project: Kennedy Creek EECA
Pace Project No.: 10160067

Method: **SM 2320B**
Description: 2320B Alkalinity
Client: AMEC Geomatrix, Inc.
Date: June 27, 2011

General Information:
2 samples were analyzed for SM 2320B. All samples were received in acceptable condition with any exceptions noted below.

Hold Time:
The samples were analyzed within the method required hold times with any exceptions noted below.

Method Blank:
All analytes were below the report limit in the method blank with any exceptions noted below.

Laboratory Control Spike:
All laboratory control spike compounds were within QC limits with any exceptions noted below.

Matrix Spikes:
All percent recoveries and relative percent differences (RPDs) were within acceptance criteria with any exceptions noted below.

Duplicate Sample:
All duplicate sample results were within method acceptance criteria with any exceptions noted below.

Additional Comments:

Pace Analytical Services, Inc.
602 S 25th Street
Billings, MT 591014549
(406)254-7226

PROJECT NARRATIVE

Project: Kennedy Creek EECA
Pace Project No.: 10160067

Method: **SM 2540C**
Description: 2540C Total Dissolved Solids
Client: AMEC Geomatrix, Inc.
Date: June 27, 2011

General Information:
2 samples were analyzed for SM 2540C. All samples were received in acceptable condition with any exceptions noted below.

Hold Time:
The samples were analyzed within the method required hold times with any exceptions noted below.

Method Blank:
All analytes were below the report limit in the method blank with any exceptions noted below.

Laboratory Control Spike:
All laboratory control spike compounds were within QC limits with any exceptions noted below.

Matrix Spikes:
All percent recoveries and relative percent differences (RPDs) were within acceptance criteria with any exceptions noted below.

Duplicate Sample:
All duplicate sample results were within method acceptance criteria with any exceptions noted below.

Additional Comments:

Pace Analytical Services, Inc.
602 S 25th Street
Billings, MT 591014549
(406)254-7226

PROJECT NARRATIVE

Project: Kennedy Creek EECA
Pace Project No.: 10160067

Method: **SM 5310B**
Description: 5310B TOC
Client: AMEC Geomatrix, Inc.
Date: June 27, 2011

General Information:
2 samples were analyzed for SM 5310B. All samples were received in acceptable condition with any exceptions noted below.

Hold Time:
The samples were analyzed within the method required hold times with any exceptions noted below.

Initial Calibrations (including MS Tune as applicable):
All criteria were within method requirements with any exceptions noted below.

Continuing Calibration:
All criteria were within method requirements with any exceptions noted below.

Method Blank:
All analytes were below the report limit in the method blank with any exceptions noted below.

Laboratory Control Spike:
All laboratory control spike compounds were within QC limits with any exceptions noted below.

Matrix Spikes:
All percent recoveries and relative percent differences (RPDs) were within acceptance criteria with any exceptions noted below.

Duplicate Sample:
All duplicate sample results were within method acceptance criteria with any exceptions noted below.

Additional Comments:

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PROJECT NARRATIVE

Project: Kennedy Creek EECA
Pace Project No.: 10160067

Method: **SM 5310B**
Description: 5310B Dissolved Organic Carbon
Client: AMEC Geomatrix, Inc.
Date: June 27, 2011

General Information:
2 samples were analyzed for SM 5310B. All samples were received in acceptable condition with any exceptions noted below.

Hold Time:
The samples were analyzed within the method required hold times with any exceptions noted below.

Initial Calibrations (including MS Tune as applicable):
All criteria were within method requirements with any exceptions noted below.

Continuing Calibration:
All criteria were within method requirements with any exceptions noted below.

Method Blank:
All analytes were below the report limit in the method blank with any exceptions noted below.

Laboratory Control Spike:
All laboratory control spike compounds were within QC limits with any exceptions noted below.

Matrix Spikes:
All percent recoveries and relative percent differences (RPDs) were within acceptance criteria with any exceptions noted below.

Duplicate Sample:
All duplicate sample results were within method acceptance criteria with any exceptions noted below.

Additional Comments:

This data package has been reviewed for quality and completeness and is approved for release.

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ANALYTICAL RESULTS

Project: Kennedy Creek EECA
Pace Project No.: 10160067

Sample: ADIT K1 | **Lab ID: 10160067001** | Collected: 06/09/11 15:10 | Received: 06/11/11 11:40 | Matrix: Water

Parameters	Results	Units	Report Limit	DF	Prepared	Analyzed	CAS No.	Qual
200.7 MET ICP	Analytical Method: EPA 200.7 Preparation Method: EPA 200.7							
Calcium	**6270**	ug/L	500	1	06/20/11 19:48	06/21/11 12:53	7440-70-2	
Magnesium	**3020**	ug/L	500	1	06/20/11 19:48	06/21/11 12:53	7439-95-4	
Potassium	**<2500**	ug/L	2500	1	06/20/11 19:48	06/21/11 12:53	7440-09-7	
Sodium	**2760**	ug/L	1000	1	06/20/11 19:48	06/21/11 12:53	7440-23-5	
Sulfur	**4800**	ug/L	1000	1	06/20/11 19:48	06/21/11 12:53		
Total Hardness by 2340B	**28100**	ug/L	3300	1	06/20/11 19:48	06/21/11 12:53		
200.8 MET ICPMS	Analytical Method: EPA 200.8 Preparation Method: EPA 200.8							
Arsenic	**3.6**	ug/L	0.50	1	06/16/11 13:53	06/16/11 23:43	7440-38-2	
Cadmium	**1.1**	ug/L	0.080	1	06/16/11 13:53	06/16/11 23:43	7440-43-9	
Copper	**49.6**	ug/L	0.50	1	06/16/11 13:53	06/16/11 23:43	7440-50-8	
Iron	**611**	ug/L	50.0	1	06/16/11 13:53	06/16/11 23:43	7439-89-6	
Lead	**4.1**	ug/L	0.10	1	06/16/11 13:53	06/16/11 23:43	7439-92-1	
Manganese	**93.3**	ug/L	0.50	1	06/16/11 13:53	06/16/11 23:43	7439-96-5	
Zinc	**3220**	ug/L	500	100	06/16/11 13:53	06/16/11 23:46	7440-66-6	
2540D Total Suspended Solids	Analytical Method: SM 2540D							
Total Suspended Solids	**1.2**	mg/L	1.0	1		06/13/11 15:20		
300.0 IC Anions	Analytical Method: EPA 300.0							
Chloride	**<3.0**	mg/L	3.0	1		06/23/11 23:12	16887-00-6	
Sulfate	**12.5**	mg/L	1.0	1		06/23/11 23:12	14808-79-8	
351.2 Total Kjeldahl Nitrogen	Analytical Method: EPA 351.2							
Nitrogen, Kjeldahl, Total	**0.12**	mg/L	0.10	1		06/15/11 13:32	7727-37-9	
353.2 Nitrate + Nitrite pres.	Analytical Method: EPA 353.2							
Nitrogen, NO2 plus NO3	**0.11**	mg/L	0.010	1		06/21/11 15:25		M0
SM4500P-E, Total Phosphorus	Analytical Method: SM 4500-P E							
Phosphorus	**0.028**	mg/L	0.0050	1		06/20/11 11:42	7723-14-0	
2320B Alkalinity	Analytical Method: SM 2320B							
Alkalinity,Bicarbonate (CaCO3)	**21.6**	mg/L	5.0	1		06/17/11 09:12		
Alkalinity, Carbonate (CaCO3)	**<5.0**	mg/L	5.0	1		06/17/11 09:12		
Alkalinity, Hydroxide (CaCO3)	**<5.0**	mg/L	5.0	1		06/17/11 09:12		
Alkalinity, Total as CaCO3	**21.6**	mg/L	5.0	1		06/17/11 09:12		
2540C Total Dissolved Solids	Analytical Method: SM 2540C							
Total Dissolved Solids	**84.0**	mg/L	10.0	1		06/16/11 12:25		
5310B TOC	Analytical Method: SM 5310B							
Total Organic Carbon	**6.0**	mg/L	1.0	1		06/16/11 02:02	7440-44-0	

REPORT OF LABORATORY ANALYSIS

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ANALYTICAL RESULTS

Project: Kennedy Creek EECA
Pace Project No.: 10160067

Sample: ADIT K1 **Lab ID: 10160067001** Collected: 06/09/11 15:10 Received: 06/11/11 11:40 Matrix: Water

Parameters	Results	Units	Report Limit	DF	Prepared	Analyzed	CAS No.	Qual
5310B Dissolved Organic Carbon	Analytical Method: SM 5310B							
Dissolved Organic Carbon	**6.3**	mg/L	1.0	1		06/17/11 22:20		

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ANALYTICAL RESULTS

Project: Kennedy Creek EECA
Pace Project No.: 10160067

Sample: POND K1 | **Lab ID: 10160067002** | Collected: 06/09/11 09:45 | Received: 06/11/11 11:40 | Matrix: Water

Parameters	Results	Units	Report Limit	DF	Prepared	Analyzed	CAS No.	Qual
200.7 MET ICP	Analytical Method: EPA 200.7 Preparation Method: EPA 200.7							
Calcium	**6100**	ug/L	500	1	06/20/11 19:48	06/21/11 13:06	7440-70-2	
Magnesium	**2870**	ug/L	500	1	06/20/11 19:48	06/21/11 13:06	7439-95-4	
Potassium	**<2500**	ug/L	2500	1	06/20/11 19:48	06/21/11 13:06	7440-09-7	
Sodium	**2610**	ug/L	1000	1	06/20/11 19:48	06/21/11 13:06	7440-23-5	
Sulfur	**4560**	ug/L	1000	1	06/20/11 19:48	06/21/11 13:06		
Total Hardness by 2340B	**27100**	ug/L	3300	1	06/20/11 19:48	06/21/11 13:06		
200.8 MET ICPMS	Analytical Method: EPA 200.8 Preparation Method: EPA 200.8							
Arsenic	**2.4**	ug/L	0.50	1	06/16/11 13:53	06/16/11 23:40	7440-38-2	
Cadmium	**1.4**	ug/L	0.080	1	06/16/11 13:53	06/16/11 23:40	7440-43-9	
Copper	**29.0**	ug/L	0.50	1	06/16/11 13:53	06/16/11 23:40	7440-50-8	
Iron	**292**	ug/L	50.0	1	06/16/11 13:53	06/16/11 23:40	7439-89-6	
Lead	**10.5**	ug/L	0.10	1	06/16/11 13:53	06/16/11 23:40	7439-92-1	
Manganese	**24.2**	ug/L	0.50	1	06/16/11 13:53	06/16/11 23:40	7439-96-5	
Zinc	**3380**	ug/L	100	20	06/16/11 13:53	06/16/11 21:28	7440-66-6	
2540D Total Suspended Solids	Analytical Method: SM 2540D							
Total Suspended Solids	**1.4**	mg/L	0.99	1		06/13/11 15:20		
300.0 IC Anions	Analytical Method: EPA 300.0							
Chloride	**<3.0**	mg/L	3.0	1		06/24/11 00:09	16887-00-6	
Sulfate	**14.1**	mg/L	1.0	1		06/24/11 00:09	14808-79-8	
351.2 Total Kjeldahl Nitrogen	Analytical Method: EPA 351.2							
Nitrogen, Kjeldahl, Total	**0.12**	mg/L	0.10	1		06/15/11 13:33	7727-37-9	
353.2 Nitrate + Nitrite pres.	Analytical Method: EPA 353.2							
Nitrogen, NO2 plus NO3	**0.020**	mg/L	0.010	1		06/21/11 15:27		
SM4500P-E, Total Phosphorus	Analytical Method: SM 4500-P E							
Phosphorus	**0.024**	mg/L	0.0050	1		06/20/11 11:43	7723-14-0	
2320B Alkalinity	Analytical Method: SM 2320B							
Alkalinity,Bicarbonate (CaCO3)	**24.4**	mg/L	5.0	1		06/17/11 09:24		
Alkalinity, Carbonate (CaCO3)	**<5.0**	mg/L	5.0	1		06/17/11 09:24		
Alkalinity, Hydroxide (CaCO3)	**<5.0**	mg/L	5.0	1		06/17/11 09:24		
Alkalinity, Total as CaCO3	**24.4**	mg/L	5.0	1		06/17/11 09:24		
2540C Total Dissolved Solids	Analytical Method: SM 2540C							
Total Dissolved Solids	**53.0**	mg/L	10.0	1		06/16/11 12:26		
5310B TOC	Analytical Method: SM 5310B							
Total Organic Carbon	**7.0**	mg/L	1.0	1		06/16/11 02:16	7440-44-0	

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ANALYTICAL RESULTS

Project: Kennedy Creek EECA
Pace Project No.: 10160067

Sample: POND K1 **Lab ID: 10160067002** Collected: 06/09/11 09:45 Received: 06/11/11 11:40 Matrix: Water

Parameters	Results	Units	Report Limit	DF	Prepared	Analyzed	CAS No.	Qual
5310B Dissolved Organic Carbon	Analytical Method: SM 5310B							
Dissolved Organic Carbon	**7.0**	mg/L	1.0	1		06/17/11 22:34		

REPORT OF LABORATORY ANALYSIS

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QUALITY CONTROL DATA

Project: Kennedy Creek EECA
Pace Project No.: 10160067

QC Batch: MPRP/26640 — Analysis Method: EPA 200.7
QC Batch Method: EPA 200.7 — Analysis Description: 200.7 MET
Associated Lab Samples: 10160067001, 10160067002

METHOD BLANK: 995255 — Matrix: Water
Associated Lab Samples: 10160067001, 10160067002

Parameter	Units	Blank Result	Reporting Limit	Analyzed	Qualifiers
Calcium	ug/L	<500	500	06/21/11 12:45	
Magnesium	ug/L	<500	500	06/21/11 12:45	
Potassium	ug/L	<2500	2500	06/21/11 12:45	
Sodium	ug/L	<1000	1000	06/21/11 12:45	
Sulfur	ug/L	<1000	1000	06/21/11 12:45	
Total Hardness by 2340B	ug/L	<3300	3300	06/21/11 12:45	

LABORATORY CONTROL SAMPLE: 995256

Parameter	Units	Spike Conc.	LCS Result	LCS % Rec	% Rec Limits	Qualifiers
Calcium	ug/L	10000	9010	90	85-115	
Magnesium	ug/L	10000	9070	91	85-115	
Potassium	ug/L	10000	9230	92	85-115	
Sodium	ug/L	10000	9600	96	85-115	
Sulfur	ug/L	20000	19500	97	85-115	
Total Hardness by 2340B	ug/L		59800			

MATRIX SPIKE & MATRIX SPIKE DUPLICATE: 995257 995258

Parameter	Units	10160067001 Result	MS Spike Conc.	MSD Spike Conc.	MS Result	MSD Result	MS % Rec	MSD % Rec	% Rec Limits	RPD	Max RPD	Qual
Calcium	ug/L	6270	10000	10000	15800	15400	95	92	70-130	2	30	
Magnesium	ug/L	3020	10000	10000	12500	12200	94	92	70-130	2	30	
Potassium	ug/L	<2500	10000	10000	10200	9980	95	93	70-130	2	30	
Sodium	ug/L	2760	10000	10000	12600	12700	99	99	70-130	.1	30	
Sulfur	ug/L	4800	20000	20000	25000	24900	101	101	70-130	.3	30	
Total Hardness by 2340B	ug/L	28100			90800	88800				2		

REPORT OF LABORATORY ANALYSIS

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QUALITY CONTROL DATA

Project: Kennedy Creek EECA
Pace Project No.: 10160067

QC Batch: MPRP/26598 Analysis Method: EPA 200.8
QC Batch Method: EPA 200.8 Analysis Description: 200.8 MET
Associated Lab Samples: 10160067001, 10160067002

METHOD BLANK: 994123 Matrix: Water
Associated Lab Samples: 10160067001, 10160067002

Parameter	Units	Blank Result	Reporting Limit	Analyzed	Qualifiers
Arsenic	ug/L	<0.50	0.50	06/16/11 22:12	
Cadmium	ug/L	<0.080	0.080	06/16/11 22:12	
Copper	ug/L	<0.50	0.50	06/16/11 22:12	
Iron	ug/L	<50.0	50.0	06/16/11 22:12	
Lead	ug/L	<0.10	0.10	06/16/11 22:12	
Manganese	ug/L	<0.50	0.50	06/16/11 22:12	
Zinc	ug/L	<5.0	5.0	06/16/11 22:12	

LABORATORY CONTROL SAMPLE: 994124

Parameter	Units	Spike Conc.	LCS Result	LCS % Rec	% Rec Limits	Qualifiers
Arsenic	ug/L	80	83.9	105	85-115	
Cadmium	ug/L	80	81.4	102	85-115	
Copper	ug/L	80	81.3	102	85-115	
Iron	ug/L	1000	1020	102	85-115	
Lead	ug/L	80	80.8	101	85-115	
Manganese	ug/L	80	79.9	100	85-115	
Zinc	ug/L	80	80.6	101	85-115	

MATRIX SPIKE & MATRIX SPIKE DUPLICATE: 994125 994126

Parameter	Units	10159726041 Result	MS Spike Conc.	MSD Spike Conc.	MS Result	MSD Result	MS % Rec	MSD % Rec	% Rec Limits	RPD	Max RPD	Qual
Arsenic	ug/L	0.014 mg/L	80	80	100	103	107	110	70-130	3	20	
Cadmium	ug/L	0.00024 mg/L	80	80	81.4	85.2	102	106	70-130	4	20	
Copper	ug/L	0.054 mg/L	80	80	135	140	101	108	70-130	4	20	
Iron	ug/L	1.3 mg/L	1000	1000	2360	2430	103	110	70-130	3	20	
Lead	ug/L	0.010 mg/L	80	80	90.1	93.7	100	104	70-130	4	20	
Manganese	ug/L	64.6	80	80	143	148	98	104	70-130	3	20	
Zinc	ug/L	0.050 mg/L	80	80	130	131	100	102	70-130	.9	20	

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QUALITY CONTROL DATA

Project: Kennedy Creek EECA
Pace Project No.: 10160067

MATRIX SPIKE SAMPLE: 994127

Parameter	Units	10160031017 Result	Spike Conc.	MS Result	MS % Rec	% Rec Limits	Qualifiers
Arsenic	ug/L	0.0089 mg/L	80	86.0	96	70-130	
Cadmium	ug/L	0.00062 mg/L	80	74.8	93	70-130	
Copper	ug/L	0.086 mg/L	80	153	84	70-130	
Iron	ug/L	1.7 mg/L	1000	2530	85	70-130	
Lead	ug/L	0.037 mg/L	80	106	86	70-130	
Manganese	ug/L	152	80	204	64	70-130	M1
Zinc	ug/L	0.20 mg/L	80	255	70	70-130	

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QUALITY CONTROL DATA

Project: Kennedy Creek EECA
Pace Project No.: 10160067

QC Batch: MT/6162 — Analysis Method: SM 2540D
QC Batch Method: SM 2540D — Analysis Description: 2540D Total Suspended Solids
Associated Lab Samples: 10160067001, 10160067002

METHOD BLANK: 993864 — Matrix: Water
Associated Lab Samples: 10160067001, 10160067002

Parameter	Units	Blank Result	Reporting Limit	Analyzed	Qualifiers
Total Suspended Solids	mg/L	<1.0	1.0	06/13/11 15:20	

LABORATORY CONTROL SAMPLE: 993865

Parameter	Units	Spike Conc.	LCS Result	LCS % Rec	% Rec Limits	Qualifiers
Total Suspended Solids	mg/L	25	29.2	117	71-129	

SAMPLE DUPLICATE: 993866

Parameter	Units	10159797001 Result	Dup Result	RPD	Max RPD	Qualifiers
Total Suspended Solids	mg/L	21.2	17.5	19	20	D6

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QUALITY CONTROL DATA

Project: Kennedy Creek EECA
Pace Project No.: 10160067

QC Batch: MT/6195 | Analysis Method: EPA 300.0
QC Batch Method: EPA 300.0 | Analysis Description: 300.0 IC Anions
Associated Lab Samples: 10160067001, 10160067002

METHOD BLANK: 998638 | Matrix: Water
Associated Lab Samples: 10160067001, 10160067002

Parameter	Units	Blank Result	Reporting Limit	Analyzed	Qualifiers
Chloride	mg/L	<3.0	3.0	06/23/11 22:15	
Sulfate	mg/L	<1.0	1.0	06/23/11 22:15	

LABORATORY CONTROL SAMPLE: 998639

Parameter	Units	Spike Conc.	LCS Result	LCS % Rec	% Rec Limits	Qualifiers
Chloride	mg/L	20	19.4	97	90-110	
Sulfate	mg/L	20	19.5	98	90-110	

MATRIX SPIKE SAMPLE: 998640

Parameter	Units	10160067001 Result	Spike Conc.	MS Result	MS % Rec	% Rec Limits	Qualifiers
Chloride	mg/L	<3.0	20	19.6	92	80-120	
Sulfate	mg/L	12.5	20	32.2	99	80-120	

MATRIX SPIKE SAMPLE: 998642

Parameter	Units	10160709001 Result	Spike Conc.	MS Result	MS % Rec	% Rec Limits	Qualifiers
Chloride	mg/L	<30.0	200	218	98	80-120	
Sulfate	mg/L	4110	4000	8170	101	80-120	

SAMPLE DUPLICATE: 998641

Parameter	Units	10160067002 Result	Dup Result	RPD	Max RPD	Qualifiers
Chloride	mg/L	<3.0	<3.0		20	
Sulfate	mg/L	14.1	18.4	26	20	D6

SAMPLE DUPLICATE: 998643

Parameter	Units	10160709002 Result	Dup Result	RPD	Max RPD	Qualifiers
Chloride	mg/L	<30.0	<30.0		20	
Sulfate	mg/L	5330	5370	.6	20	

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QUALITY CONTROL DATA

Project: Kennedy Creek EECA
Pace Project No.: 10160067

QC Batch: MT/6140 | Analysis Method: EPA 351.2
QC Batch Method: EPA 351.2 | Analysis Description: 351.2 TKN
Associated Lab Samples: 10160067001, 10160067002

METHOD BLANK: 990379 Matrix: Water
Associated Lab Samples: 10160067001, 10160067002

Parameter	Units	Blank Result	Reporting Limit	Analyzed	Qualifiers
Nitrogen, Kjeldahl, Total	mg/L	<0.10	0.10	06/15/11 12:49	

LABORATORY CONTROL SAMPLE: 990380

Parameter	Units	Spike Conc.	LCS Result	LCS % Rec	% Rec Limits	Qualifiers
Nitrogen, Kjeldahl, Total	mg/L	2	1.8	91	90-110	

MATRIX SPIKE SAMPLE: 990382

Parameter	Units	10159583003 Result	Spike Conc.	MS Result	MS % Rec	% Rec Limits	Qualifiers
Nitrogen, Kjeldahl, Total	mg/L	13.8	40	31.2	44	90-110	M2

MATRIX SPIKE SAMPLE: 991190

Parameter	Units	10158158002 Result	Spike Conc.	MS Result	MS % Rec	% Rec Limits	Qualifiers
Nitrogen, Kjeldahl, Total	mg/L	0.68	4	4.5	94	90-110	

SAMPLE DUPLICATE: 990381

Parameter	Units	10159583001 Result	Dup Result	RPD	Max RPD	Qualifiers
Nitrogen, Kjeldahl, Total	mg/L	18.5	18.8	2	20	

SAMPLE DUPLICATE: 991189

Parameter	Units	10158158001 Result	Dup Result	RPD	Max RPD	Qualifiers
Nitrogen, Kjeldahl, Total	mg/L	0.73	0.71	3	20	

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QUALITY CONTROL DATA

Project: Kennedy Creek EECA
Pace Project No.: 10160067

QC Batch: MT/6201
Analysis Method: EPA 353.2
QC Batch Method: EPA 353.2
Analysis Description: 353.2 Nitrate + Nitrite, preserved
Associated Lab Samples: 10160067001, 10160067002

METHOD BLANK: 998838 Matrix: Water
Associated Lab Samples: 10160067001, 10160067002

Parameter	Units	Blank Result	Reporting Limit	Analyzed	Qualifiers
Nitrogen, NO2 plus NO3	mg/L	<0.010	0.010	06/21/11 14:42	

METHOD BLANK: 998849 Matrix: Water
Associated Lab Samples: 10160067001, 10160067002

Parameter	Units	Blank Result	Reporting Limit	Analyzed	Qualifiers
Nitrogen, NO2 plus NO3	mg/L	<0.010	0.010	06/21/11 14:45	

LABORATORY CONTROL SAMPLE: 998839

Parameter	Units	Spike Conc.	LCS Result	LCS % Rec	% Rec Limits	Qualifiers
Nitrogen, NO2 plus NO3	mg/L	.33	0.35	105	90-110	

LABORATORY CONTROL SAMPLE: 998850

Parameter	Units	Spike Conc.	LCS Result	LCS % Rec	% Rec Limits	Qualifiers
Nitrogen, NO2 plus NO3	mg/L	.33	0.33	99	90-110	

MATRIX SPIKE & MATRIX SPIKE DUPLICATE: 998844 998845

Parameter	Units	10160074001 Result	MS Spike Conc.	MSD Spike Conc.	MS Result	MSD Result	MS % Rec	MSD % Rec	% Rec Limits	RPD	Max RPD	Qual
Nitrogen, NO2 plus NO3	mg/L	0.35	.33	.33	0.74	0.68	117	99	90-110	8	20	M0

MATRIX SPIKE SAMPLE: 998847

Parameter	Units	10160702001 Result	Spike Conc.	MS Result	MS % Rec	% Rec Limits	Qualifiers
Nitrogen, NO2 plus NO3	mg/L	0.040	.33	0.40	108	90-110	

SAMPLE DUPLICATE: 998846

Parameter	Units	10160067002 Result	Dup Result	RPD	Max RPD	Qualifiers
Nitrogen, NO2 plus NO3	mg/L	0.020	0.020	0	20	

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QUALITY CONTROL DATA

Project: Kennedy Creek EECA
Pace Project No.: 10160067

QC Batch: MT/6169 | Analysis Method: SM 4500-P E
QC Batch Method: SM 4500-P E | Analysis Description: SM4500P-E, Total Phosphorus
Associated Lab Samples: 10160067001, 10160067002

METHOD BLANK: 994901 Matrix: Water
Associated Lab Samples: 10160067001, 10160067002

Parameter	Units	Blank Result	Reporting Limit	Analyzed	Qualifiers
Phosphorus	mg/L	<0.0050	0.0050	06/20/11 11:26	

LABORATORY CONTROL SAMPLE: 994902

Parameter	Units	Spike Conc.	LCS Result	LCS % Rec	% Rec Limits	Qualifiers
Phosphorus	mg/L	.04	0.038	94	80-120	

MATRIX SPIKE SAMPLE: 994904

Parameter	Units	10159462002 Result	Spike Conc.	MS Result	MS % Rec	% Rec Limits	Qualifiers
Phosphorus	mg/L	0.055	.04	0.093	96	80-120	

SAMPLE DUPLICATE: 994903

Parameter	Units	10159462001 Result	Dup Result	RPD	Max RPD	Qualifiers
Phosphorus	mg/L	0.026	0.027	3	20	

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(406)254-7226

QUALITY CONTROL DATA

Project: Kennedy Creek EECA
Pace Project No.: 10160067

QC Batch: WET/22660 Analysis Method: SM 2320B
QC Batch Method: SM 2320B Analysis Description: 2320B Alkalinity
Associated Lab Samples: 10160067001, 10160067002

METHOD BLANK: 997107 Matrix: Water
Associated Lab Samples: 10160067001, 10160067002

Parameter	Units	Blank Result	Reporting Limit	Analyzed	Qualifiers
Alkalinity, Carbonate (CaCO3)	mg/L	<5.0	5.0	06/17/11 09:10	
Alkalinity, Hydroxide (CaCO3)	mg/L	<5.0	5.0	06/17/11 09:10	
Alkalinity, Total as CaCO3	mg/L	<5.0	5.0	06/17/11 09:10	
Alkalinity,Bicarbonate (CaCO3)	mg/L	<5.0	5.0	06/17/11 09:10	

LABORATORY CONTROL SAMPLE & LCSD: 997108 997109

Parameter	Units	Spike Conc.	LCS Result	LCSD Result	LCS % Rec	LCSD % Rec	% Rec Limits	RPD	Max RPD	Qualifiers
Alkalinity, Total as CaCO3	mg/L	40	39.0	39.7	97	99	90-110	2	30	

MATRIX SPIKE & MATRIX SPIKE DUPLICATE: 997110 997111

Parameter	Units	10160067001 Result	MS Spike Conc.	MSD Spike Conc.	MS Result	MSD Result	MS % Rec	MSD % Rec	% Rec Limits	RPD	Max RPD	Qual
Alkalinity, Total as CaCO3	mg/L	21.6	40	40	61.6	63.0	100	104	80-120	2	30	

MATRIX SPIKE & MATRIX SPIKE DUPLICATE: 997112 997113

Parameter	Units	10160234003 Result	MS Spike Conc.	MSD Spike Conc.	MS Result	MSD Result	MS % Rec	MSD % Rec	% Rec Limits	RPD	Max RPD	Qual
Alkalinity, Total as CaCO3	mg/L	12.3	40	40	52.0	52.3	99	100	80-120	.5	30	

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QUALITY CONTROL DATA

Project: Kennedy Creek EECA
Pace Project No.: 10160067

QC Batch: WET/22641 Analysis Method: SM 2540C
QC Batch Method: SM 2540C Analysis Description: 2540C Total Dissolved Solids
Associated Lab Samples: 10160067001, 10160067002

METHOD BLANK: 995928 Matrix: Water
Associated Lab Samples: 10160067001, 10160067002

Parameter	Units	Blank Result	Reporting Limit	Analyzed	Qualifiers
Total Dissolved Solids	mg/L	<10.0	10.0	06/16/11 12:24	

LABORATORY CONTROL SAMPLE: 995929

Parameter	Units	Spike Conc.	LCS Result	LCS % Rec	% Rec Limits	Qualifiers
Total Dissolved Solids	mg/L	1000	980	98	80-120	

SAMPLE DUPLICATE: 995930

Parameter	Units	10160031017 Result	Dup Result	RPD	Max RPD	Qualifiers
Total Dissolved Solids	mg/L	75.0	73.0	3	20	

SAMPLE DUPLICATE: 995931

Parameter	Units	10160221006 Result	Dup Result	RPD	Max RPD	Qualifiers
Total Dissolved Solids	mg/L	ND	<10.0		20	

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QUALITY CONTROL DATA

Project: Kennedy Creek EECA
Pace Project No.: 10160067

QC Batch: WETA/10625 — Analysis Method: SM 5310B
QC Batch Method: SM 5310B — Analysis Description: 5310B TOC
Associated Lab Samples: 10160067001, 10160067002

METHOD BLANK: 213558 — Matrix: Water
Associated Lab Samples: 10160067001, 10160067002

Parameter	Units	Blank Result	Reporting Limit	Analyzed	Qualifiers
Total Organic Carbon	mg/L	<1.0	1.0	06/16/11 01:27	

LABORATORY CONTROL SAMPLE: 213559

Parameter	Units	Spike Conc.	LCS Result	LCS % Rec	% Rec Limits	Qualifiers
Total Organic Carbon	mg/L	20	19.6	98	90-110	

MATRIX SPIKE SAMPLE: 213561

Parameter	Units	3531997001 Result	Spike Conc.	MS Result	MS % Rec	% Rec Limits	Qualifiers
Total Organic Carbon	mg/L	16.0	20	37.0	105	80-120	

MATRIX SPIKE SAMPLE: 213563

Parameter	Units	3531997002 Result	Spike Conc.	MS Result	MS % Rec	% Rec Limits	Qualifiers
Total Organic Carbon	mg/L	0.50U	20	21.0	105	80-120	

SAMPLE DUPLICATE: 213560

Parameter	Units	3531997001 Result	Dup Result	RPD	Max RPD	Qualifiers
Total Organic Carbon	mg/L	16.0	15.9	.6	20	

SAMPLE DUPLICATE: 213562

Parameter	Units	3531997002 Result	Dup Result	RPD	Max RPD	Qualifiers
Total Organic Carbon	mg/L	0.50U	<1.0		20	

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QUALITY CONTROL DATA

Project: Kennedy Creek EECA
Pace Project No.: 10160067

QC Batch: WETA/10672 Analysis Method: SM 5310B
QC Batch Method: SM 5310B Analysis Description: 5310B Dissolved Organic Carbon
Associated Lab Samples: 10160067001, 10160067002

METHOD BLANK: 214730 Matrix: Water
Associated Lab Samples: 10160067001, 10160067002

Parameter	Units	Blank Result	Reporting Limit	Analyzed	Qualifiers
Dissolved Organic Carbon	mg/L	<1.0	1.0	06/17/11 21:52	

LABORATORY CONTROL SAMPLE: 214731

Parameter	Units	Spike Conc.	LCS Result	LCS % Rec	% Rec Limits	Qualifiers
Dissolved Organic Carbon	mg/L	20	20.1	100	90-110	

MATRIX SPIKE SAMPLE: 214733

Parameter	Units	3531874001 Result	Spike Conc.	MS Result	MS % Rec	% Rec Limits	Qualifiers
Dissolved Organic Carbon	mg/L	1.7	20	22.6	105	80-120	

SAMPLE DUPLICATE: 214732

Parameter	Units	3531874001 Result	Dup Result	RPD	Max RPD	Qualifiers
Dissolved Organic Carbon	mg/L	1.7	1.7	1	20	

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QUALIFIERS

Project: Kennedy Creek EECA
Pace Project No.: 10160067

DEFINITIONS

DF - Dilution Factor, if reported, represents the factor applied to the reported data due to changes in sample preparation, dilution of the sample aliquot, or moisture content.

ND - Not Detected at or above adjusted reporting limit.

J - Estimated concentration above the adjusted method detection limit and below the adjusted reporting limit.

MDL - Adjusted Method Detection Limit.

S - Surrogate

1,2-Diphenylhydrazine (8270 listed analyte) decomposes to Azobenzene.

Consistent with EPA guidelines, unrounded data are displayed and have been used to calculate % recovery and RPD values.

LCS(D) - Laboratory Control Sample (Duplicate)

MS(D) - Matrix Spike (Duplicate)

DUP - Sample Duplicate

RPD - Relative Percent Difference

NC - Not Calculable.

SG - Silica Gel - Clean-Up

U - Indicates the compound was analyzed for, but not detected.

N-Nitrosodiphenylamine decomposes and cannot be separated from Diphenylamine using Method 8270. The result reported for each analyte is a combined concentration.

LABORATORIES

PASI-M	Pace Analytical Services - Minneapolis
PASI-MT	Pace Analytical Services - Montana
PASI-O	Pace Analytical Services - Ormond Beach

ANALYTE QUALIFIERS

D6	The relative percent difference (RPD) between the sample and sample duplicate exceeded laboratory control limits.
M0	Matrix spike recovery and/or matrix spike duplicate recovery was outside laboratory control limits.
M1	Matrix spike recovery exceeded QC limits. Batch accepted based on laboratory control sample (LCS) recovery.
M2	Matrix spike recovery was below QC limits due to sample dilution. Data acceptance based on laboratory control sample (LCS) recovery.

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QUALITY CONTROL DATA CROSS REFERENCE TABLE

Project: Kennedy Creek EECA
Pace Project No.: 10160067

Lab ID	Sample ID	QC Batch Method	QC Batch	Analytical Method	Analytical Batch
10160067001	**ADIT K1**	EPA 200.7	MPRP/26640	EPA 200.7	ICP/11385
10160067002	**POND K1**	EPA 200.7	MPRP/26640	EPA 200.7	ICP/11385
10160067001	**ADIT K1**	EPA 200.8	MPRP/26598	EPA 200.8	ICPM/10854
10160067002	**POND K1**	EPA 200.8	MPRP/26598	EPA 200.8	ICPM/10854
10160067001	**ADIT K1**	SM 2540D	MT/6162		
10160067002	**POND K1**	SM 2540D	MT/6162		
10160067001	**ADIT K1**	EPA 300.0	MT/6195		
10160067002	**POND K1**	EPA 300.0	MT/6195		
10160067001	**ADIT K1**	EPA 351.2	MT/6140		
10160067002	**POND K1**	EPA 351.2	MT/6140		
10160067001	**ADIT K1**	EPA 353.2	MT/6201		
10160067002	**POND K1**	EPA 353.2	MT/6201		
10160067001	**ADIT K1**	SM 4500-P E	MT/6169		
10160067002	**POND K1**	SM 4500-P E	MT/6169		
10160067001	**ADIT K1**	SM 2320B	WET/22660		
10160067002	**POND K1**	SM 2320B	WET/22660		
10160067001	**ADIT K1**	SM 2540C	WET/22641		
10160067002	**POND K1**	SM 2540C	WET/22641		
10160067001	**ADIT K1**	SM 5310B	WETA/10625		
10160067002	**POND K1**	SM 5310B	WETA/10625		
10160067001	**ADIT K1**	SM 5310B	WETA/10672		
10160067002	**POND K1**	SM 5310B	WETA/10672		

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CHAIN-OF-CUSTODY / Analytical Request Document

The Chain-of-Custody is a LEGAL DOCUMENT. All relevant fields must be completed accurately.

Page: 1 of 1

1321626

Section A Required Client Information:

Company:	AMEC Geomatrix
Address:	
Email To:	wilhelm.welzenbach@amec.com
Phone:	406-542-0129
Fax:	
Requested Due Date/TAT:	Normal

Section B Required Project Information:

Report To:	Wilhelm Welzenbach
Copy To:	
Purchase Order No.:	MT10160140
Project Name:	Kennedy Creek EECA
Project Number:	MT 10180140

Section C Invoice Information:

Attention:	Wilhelm Welzenbach
Company Name:	AMEC Geomatrix
Address:	1001 S. Higgins
Pace Quote Reference:	1349
Pace Project Manager:	Denise Jensen
Pace Profile #:	

missoula MT 59801

REGULATORY AGENCY

☐ NPDES ☐ GROUND WATER ☐ DRINKING WATER
☐ UST ☐ RCRA ☐ OTHER ______

Site Location STATE: MT

Section D Required Client Information

Matrix Codes MATRIX / CODE: Drinking Water DW, Water WT, Waste Water WW, Product P, Soil/Solid SL, Oil OL, Wipe WP, Air AR, Tissue TS, Other OT

SAMPLE ID (A-Z, 0-9 / ,-) Sample IDs MUST BE UNIQUE

Requested Analysis Filtered (Y/N)

ITEM #	SAMPLE ID	MATRIX CODE	SAMPLE TYPE (G=GRAB C=COMP)	Composite Start DATE	Composite Start TIME	Composite End/Grab DATE	Composite End/Grab TIME	SAMPLE TEMP AT COLLECTION	# OF CONTAINERS	Unpreserved	H_2SO_4	HNO_3	HCl	NaOH	$Na_2S_2O_3$	Methanol	Other	Analysis Test Y/N	Alkalinity + TDS	TSS by 160.2	TOC	DOC	Total Metals*	Common Ions**	TKN by 351.1	Residual Chlorine (Y/N)	Pace Project No./ Lab I.D. 10160067
1	Adit K1	WT	G			6/9/11	15:10		7	X	X	X							X	X	X	X	X	X	X		001
2	Pond K1	WT	G			6/9/11	9:45		7	X	X	X							X	X	X	X	X	X	X		002
3																											
4																											
5																											
6																											
7																											
8																											
9																											
10																											
11																											
12																											

ADDITIONAL COMMENTS	RELINQUISHED BY / AFFILIATION	DATE	TIME	ACCEPTED BY / AFFILIATION	DATE	TIME	SAMPLE CONDITIONS
*Total Metals = As, Cd, Cu, Fe, Mn, Pb, Zn, and Sulfur	Wilhelm Welzenbach/AMEC	6/10/11					
**Common Ions = Cl⁻, Na, Mg, K, NO_2, NO_3, PO_4, SO_4	Fed Ex	6/11/11	11:40	Denis [illegible] Pace	6-11-11	1140	

Temp in °C	Received on Ice (Y/N)	Custody Sealed Cooler (Y/N)	Samples Intact (Y/N)
3.7	Y	N	Y

ORIGINAL

SAMPLER NAME AND SIGNATURE

PRINT Name of SAMPLER: Wilhelm Welzenbach

SIGNATURE of SAMPLER: [signature] DATE Signed (MM/DD/YY): 06/10/11

*Important Note: By signing this form you are accepting Pace's NET 30 day payment terms and agreeing to late charges of 1.5% per month for any invoices not paid within 30 days.

F-ALL-Q-020rev.07, 15-May-2007

Sample Condition Upon Receipt

Pace Analytical

Client Name: AMEX **Project #** 10160067

Optional
Proj. Due Date:
Proj. Name:

Courier: ☒ Fed Ex ☐ UPS ☐ USPS ☐ Client ☐ Commercial ☐ Pace Other ____

Tracking #: 7948 5088 8710

Custody Seal on Cooler/Box Present: ☐ yes ☒ no Seals intact: ☐ yes ☒ no

Packing Material: ☐ Bubble Wrap ☐ Bubble Bags ☒ None ☐ Other ____ Temp Blank: Yes ✓ No ____

Thermometer Used 1383045 or (135) **Type of Ice:** (Wet) Blue None ☒ Samples on ice, cooling process has begun

Cooler Temperature 3.7 **Biological Tissue is Frozen:** Yes No

Temp should be above freezing to 6°C

Date and Initials of person examining contents: RW 6/14/11

Comments:

				Comments
Chain of Custody Present:	☒ Yes	☐ No	☐ N/A	1.
Chain of Custody Filled Out:	☒ Yes	☐ No	☐ N/A	2.
Chain of Custody Relinquished:	☒ Yes	☐ No	☐ N/A	3.
Sampler Name & Signature on COC:	☒ Yes	☐ No	☐ N/A	4.
Samples Arrived within Hold Time:	☒ Yes	☐ No	☐ N/A	5.
Short Hold Time Analysis (<72hr):	~~☒ Yes~~	(☒ No)	☐ N/A	6.
Rush Turn Around Time Requested:	~~☒ Yes~~	(☒ No)	☐ N/A	7.
Sufficient Volume:	☒ Yes	☐ No	☐ N/A	8.
Correct Containers Used:	☒ Yes	☐ No	☐ N/A	9.
-Pace Containers Used:	☒ Yes	☐ No	☐ N/A	
Containers Intact:	☒ Yes	☐ No	☐ N/A	10.
Filtered volume received for Dissolved tests	☐ Yes	~~☒ No~~	(☒ N/A)	11.
Sample Labels match COC:	☒ Yes	☐ No	☐ N/A	12.
-Includes date/time/ID/Analysis Matrix: AQ				
All containers needing acid/base preservation have been checked. Noncompliance are noted in 13.	☒ Yes	☐ No	☐ N/A	13. ☒ HNO3 ☒ H2SO4 ☐ NaOH ☐ HCl
All containers needing preservation are found to be in compliance with EPA recommendation.	☒ Yes	☐ No	☐ N/A	Samp # (Adit K1, Pond K1) (Adit K1, Pond K1)
Exceptions: VOA,Coliform, (TOC), Oil and Grease, WI-DRO (water)	☒ Yes	☐ No		Initial when completed: RW; Lot # of added preservative
Samples checked for dechlorination:	☐ Yes	☐ No	☒ N/A	14.
Headspace in VOA Vials (>6mm):	☐ Yes	☐ No	☒ N/A	15.
Trip Blank Present:	☐ Yes	☒ No	☐ N/A	16.
Trip Blank Custody Seals Present	☐ Yes	☐ No	☒ N/A	
Pace Trip Blank Lot # (if purchased): ____				

Client Notification/ Resolution: Field Data Required? Y / N

Person Contacted: ____ Date/Time: ____

Comments/ Resolution: ____

Project Manager Review: [signature] **Date:** 6/13/11

Note: Whenever there is a discrepancy affecting North Carolina compliance samples, a copy of this form will be sent to the North Carolina DEHNR Certification Office (i.e out of hold, incorrect preservative, out of temp, incorrect containers)

L213 Rev.00 (05Aug2009) Pace Analytical Services, Inc - MN Lab

Pace Analytical Services, Inc.
602 S 25th Street
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(406)254-7226

September 24, 2011

Wilhelm Welzenbach
AMEC Geomatrix
1001 South Higgins Ave
Missoula, MT 59801

RE: Project: Kennedy Creek Task 2
Pace Project No.: 10168733

Dear Wilhelm Welzenbach:

Enclosed are the analytical results for sample(s) received by the laboratory on September 07, 2011.
The results relate only to the samples included in this report.

If you have any questions concerning this report, please feel free to contact me.

Sincerely,

Kari Poehls

kari.poehls@pacelabs.com
Project Manager

Enclosures

Pace Analytical Services, Inc.
602 S 25th Street
Billings, MT 591014549
(406)254-7226

CERTIFICATIONS

Project:	Kennedy Creek Task 2
Pace Project No.:	10168733

Minnesota Certification IDs

1700 Elm Street SE Suite 200, Minneapolis, MN 55414
A2LA Certification #: 2926.01
Alaska Certification #: UST-078
Alaska Certification #MN00064
Arizona Certification #: AZ-0014
Arkansas Certification #: 88-0680
California Certification #: 01155CA
EPA Region 8 Certification #: Pace
Florida/NELAP Certification #: E87605
Georgia Certification #: 959
Idaho Certification #: MN00064
Illinois Certification #: 200011
Iowa Certification #: 368
Kansas Certification #: E-10167
Louisiana Certification #: 03086
Louisiana Certification #: LA080009
Maine Certification #: 2007029
Maryland Certification #: 322
Michigan DEQ Certification #: 9909
Minnesota Certification #: 027-053-137
Mississippi Certification #: Pace
Montana Certification #: MT CERT0092
Nevada Certification #: MN_00064
Nebraska Certification #: Pace
New Jersey Certification #: MN-002
New Mexico Certification #: Pace
New York Certification #: 11647
North Carolina Certification #: 530
North Dakota Certification #: R-036
North Dakota Certification #: R-036A
Ohio VAP Certification #: CL101
Oklahoma Certification #: D9921
Oklahoma Certification #: 9507
Oregon Certification #: MN200001
Pennsylvania Certification #: 68-00563
Puerto Rico Certification
Tennessee Certification #: 02818
Texas Certification #: T104704192
Washington Certification #: C754
Wisconsin Certification #: 999407970

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SAMPLE SUMMARY

Project: Kennedy Creek Task 2
Pace Project No.: 10168733

Lab ID	Sample ID	Matrix	Date Collected	Date Received
10168733001	**ADIT-INSIDE**	Water	09/02/11 15:30	09/07/11 11:20
10168733002	**ADIT K1**	Water	09/02/11 15:00	09/07/11 11:20
10168733003	**SWK EAST OF ADIT**	Water	09/02/11 15:40	09/07/11 11:20

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SAMPLE ANALYTE COUNT

Project: Kennedy Creek Task 2
Pace Project No.: 10168733

Lab ID	Sample ID	Method	Analysts	Analytes Reported	Laboratory
10168733001	**ADIT-INSIDE**	EPA 200.7	IP	1	PASI-M
10168733002	**ADIT K1**	EPA 200.7	IP	1	PASI-M
10168733003	**SWK EAST OF ADIT**	EPA 200.7	IP	1	PASI-M

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PROJECT NARRATIVE

Project: Kennedy Creek Task 2
Pace Project No.: 10168733

Method: **EPA 200.7**
Description: 200.7 MET ICP
Client: AMEC Geomatrix, Inc.
Date: September 24, 2011

General Information:
3 samples were analyzed for EPA 200.7. All samples were received in acceptable condition with any exceptions noted below.

Hold Time:
The samples were analyzed within the method required hold times with any exceptions noted below.

Sample Preparation:
The samples were prepared in accordance with EPA 200.7 with any exceptions noted below.

Initial Calibrations (including MS Tune as applicable):
All criteria were within method requirements with any exceptions noted below.

Continuing Calibration:
All criteria were within method requirements with any exceptions noted below.

Method Blank:
All analytes were below the report limit in the method blank with any exceptions noted below.

Laboratory Control Spike:
All laboratory control spike compounds were within QC limits with any exceptions noted below.

Matrix Spikes:
All percent recoveries and relative percent differences (RPDs) were within acceptance criteria with any exceptions noted below.

Duplicate Sample:
All duplicate sample results were within method acceptance criteria with any exceptions noted below.

Additional Comments:

This data package has been reviewed for quality and completeness and is approved for release.

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ANALYTICAL RESULTS

Project: Kennedy Creek Task 2
Pace Project No.: 10168733

Sample: ADIT-INSIDE **Lab ID: 10168733001** Collected: 09/02/11 15:30 Received: 09/07/11 11:20 Matrix: Water

Parameters	Results	Units	Report Limit	DF	Prepared	Analyzed	CAS No.	Qual
200.7 MET ICP	Analytical Method: EPA 200.7 Preparation Method: EPA 200.7							
Zinc	**25000**	ug/L	20.0	1	09/13/11 14:34	09/15/11 11:52	7440-66-6	

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ANALYTICAL RESULTS

Project: Kennedy Creek Task 2
Pace Project No.: 10168733

Sample: ADIT K1 **Lab ID: 10168733002** Collected: 09/02/11 15:00 Received: 09/07/11 11:20 Matrix: Water

Parameters	Results	Units	Report Limit	DF	Prepared	Analyzed	CAS No.	Qual
200.7 MET ICP	Analytical Method: EPA 200.7 Preparation Method: EPA 200.7							
Zinc	**2260**	ug/L	20.0	1	09/13/11 14:34	09/15/11 11:59	7440-66-6	

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ANALYTICAL RESULTS

Project: Kennedy Creek Task 2
Pace Project No.: 10168733

Sample: SWK EAST OF ADIT **Lab ID: 10168733003** Collected: 09/02/11 15:40 Received: 09/07/11 11:20 Matrix: Water

Parameters	Results	Units	Report Limit	DF	Prepared	Analyzed	CAS No.	Qual
200.7 MET ICP	Analytical Method: EPA 200.7 Preparation Method: EPA 200.7							
Zinc	**40.1**	ug/L	20.0	1	09/13/11 14:34	09/15/11 12:03	7440-66-6	

REPORT OF LABORATORY ANALYSIS

Pace Analytical Services, Inc.
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(406)254-7226

QUALITY CONTROL DATA

Project: Kennedy Creek Task 2
Pace Project No.: 10168733

QC Batch: MPRP/28377 Analysis Method: EPA 200.7
QC Batch Method: EPA 200.7 Analysis Description: 200.7 MET
Associated Lab Samples: 10168733001, 10168733002, 10168733003

METHOD BLANK: 1052966 Matrix: Water
Associated Lab Samples: 10168733001, 10168733002, 10168733003

Parameter	Units	Blank Result	Reporting Limit	Analyzed	Qualifiers
Zinc	ug/L	<20.0	20.0	09/15/11 11:11	

LABORATORY CONTROL SAMPLE: 1052967

Parameter	Units	Spike Conc.	LCS Result	LCS % Rec	% Rec Limits	Qualifiers
Zinc	ug/L	1000	937	94	85-115	

MATRIX SPIKE & MATRIX SPIKE DUPLICATE: 1052968 1052969

Parameter	Units	10168781001 Result	MS Spike Conc.	MSD Spike Conc.	MS Result	MSD Result	MS % Rec	MSD % Rec	% Rec Limits	RPD	Max RPD	Qual
Zinc	ug/L	<20.0	1000	1000	821	864	82	86	70-130	5	30	

Pace Analytical Services, Inc.
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Billings, MT 591014549
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QUALIFIERS

Project: Kennedy Creek Task 2
Pace Project No.: 10168733

DEFINITIONS

DF - Dilution Factor, if reported, represents the factor applied to the reported data due to changes in sample preparation, dilution of the sample aliquot, or moisture content.

ND - Not Detected at or above adjusted reporting limit.

J - Estimated concentration above the adjusted method detection limit and below the adjusted reporting limit.

MDL - Adjusted Method Detection Limit.

S - Surrogate

1,2-Diphenylhydrazine (8270 listed analyte) decomposes to Azobenzene.

Consistent with EPA guidelines, unrounded data are displayed and have been used to calculate % recovery and RPD values.

LCS(D) - Laboratory Control Sample (Duplicate)

MS(D) - Matrix Spike (Duplicate)

DUP - Sample Duplicate

RPD - Relative Percent Difference

NC - Not Calculable.

SG - Silica Gel - Clean-Up

U - Indicates the compound was analyzed for, but not detected.

N-Nitrosodiphenylamine decomposes and cannot be separated from Diphenylamine using Method 8270. The result reported for each analyte is a combined concentration.

LABORATORIES

PASI-M Pace Analytical Services - Minneapolis

REPORT OF LABORATORY ANALYSIS

Pace Analytical Services, Inc.
602 S 25th Street
Billings, MT 591014549
(406)254-7226

QUALITY CONTROL DATA CROSS REFERENCE TABLE

Project: Kennedy Creek Task 2
Pace Project No.: 10168733

Lab ID	Sample ID	QC Batch Method	QC Batch	Analytical Method	Analytical Batch
10168733001	**ADIT-INSIDE**	EPA 200.7	MPRP/28377	EPA 200.7	ICP/11984
10168733002	**ADIT K1**	EPA 200.7	MPRP/28377	EPA 200.7	ICP/11984
10168733003	**SWK EAST OF ADIT**	EPA 200.7	MPRP/28377	EPA 200.7	ICP/11984

Pace Analytical®
www.pacelabs.com

CHAIN-OF-CUSTODY / Analytical Request Document

The Chain-of-Custody is a LEGAL DOCUMENT. All relevant fields must be completed accurately.

Page: 1 of 1

1311152

Section A Required Client Information:

Company:	AMEC
Address:	1001 S. Higgins B-1 Missoula, MT
Email To:	wilhelm.welzenbach@amec.com
Phone:	406-542-0129
Fax:	
Requested Due Date/TAT:	Normal

Section B Required Project Information:

Report To:	wilhelm.welzenbach@amec.com
Copy To:	matthew.wright@amec.com
Purchase Order No.:	MT 10160146
Project Name:	Kennedy Creek
Project Number:	~~Phase~~ Task 2

Section C Invoice Information:

Attention:	(See Sect. A)
Company Name:	
Address:	
Pace Quote Reference:	
Pace Project Manager:	
Pace Profile #:	

REGULATORY AGENCY

☐ NPDES ☐ GROUND WATER ☐ DRINKING WATER
☐ UST ☐ RCRA ☐ OTHER

Site Location STATE: MT

Section D Required Client Information

Matrix Codes — MATRIX / CODE: Drinking Water DW; Water WT; Waste Water WW; Product P; Soil/Solid SL; Oil OL; Wipe WP; Air AR; Tissue TS; Other OT

SAMPLE ID (A-Z, 0-9 / ,-) Sample IDs MUST BE UNIQUE

Requested Analysis Filtered (Y/N): N

ITEM #	SAMPLE ID	MATRIX CODE	SAMPLE TYPE (G=GRAB C=COMP)	Composite Start DATE	Composite Start TIME	Composite End/Grab DATE	Composite End/Grab TIME	SAMPLE TEMP AT COLLECTION	# OF CONTAINERS	Unpreserved	H_2SO_4	HNO_3	HCl	NaOH	$Na_2S_2O_3$	Methanol	Other	Analysis Test: Zn by 200-Series	Residual Chlorine (Y/N)	Pace Project No./ Lab I.D.
1	Adit - Inside	WT	G	—	—	9/2/11	15:30		1			X						X		001
2	Adit - Surface Exp.	↓	↓	—	—	9/2/11	15:00		1			X						X		002
3	SW East of Adit	↓	↓	—	—	9/2/11	15:40		1			X						HOLD		003
4																				
5																				
6																				
7																				
8																				
9																				
10																				
11																				
12																				

Pace Project No.: 10168733

ADDITIONAL COMMENTS	RELINQUISHED BY / AFFILIATION	DATE	TIME	ACCEPTED BY / AFFILIATION	DATE	TIME
	W Welzenbach	9/5/2011				
	Fedex	9/7/11	1120	Norma Chankle/Pace	9/7/11	1120

SAMPLE CONDITIONS

Temp in °C	Received on Ice (Y/N)	Custody Sealed Cooler (Y/N)	Samples Intact (Y/N)
5.1°	Y	N	Y

ORIGINAL

SAMPLER NAME AND SIGNATURE

PRINT Name of SAMPLER: Wilhelm Welzenbach

SIGNATURE of SAMPLER: [signature] DATE Signed (MM/DD/YY): 9/5/2011

*Important Note: By signing this form you are accepting Pace's NET 30 day payment terms and agreeing to late charges of 1.5% per month for any invoices not paid within 30 days.

F-ALL-Q-020rev.07, 15-May-2007

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CHAIN-OF-CUSTODY / Analytical Request Document

The Chain-of-Custody is a LEGAL DOCUMENT. All relevant fields must be completed accurately.

Page: 1 of 1

1311152

Section A
Required Client Information:

Company:	AMEC
Address:	100 S. Higgins B-1 Missoula MT
Email To:	wilhelm.welzenbach@amec.com
Phone: 406-542-0129	Fax:
Requested Due Date/TAT:	Normal

Section B
Required Project Information:

Report To:	wilhelm.welzenbach@amec...
Copy To:	matthew.wright@amec.com
Purchase Order No.:	MT 1016014C
Project Name:	Kennedy Creek
Project Number:	~~Phase~~ Task 2

Section C
Invoice Information:

Attention:	(See Sect A)
Company Name:	
Address:	
Pace Quote Reference:	
Pace Project Manager:	
Pace Profile #:	

REGULATORY AGENCY

☐ NPDES ☐ GROUND WATER ☐ DRINKING WATER
☐ UST ☐ RCRA ☐ OTHER ______

Site Location STATE: MT

Section D
Required Client Information

Matrix Codes MATRIX / CODE: Drinking Water DW; Water WT; Waste Water WW; Product P; Soil/Solid SL; Oil OL; Wipe WP; Air AR; Tissue TS; Other OT

SAMPLE ID (A-Z, 0-9 / ,-) Sample IDs MUST BE UNIQUE

ITEM #	SAMPLE ID	MATRIX CODE	SAMPLE TYPE (G=GRAB C=COMP)	Composite Start DATE	Composite Start TIME	Composite End/Grab DATE	Composite End/Grab TIME	SAMPLE TEMP AT COLLECTION	# OF CONTAINERS	Unpreserved	H_2SO_4	HNO_3	HCl	NaOH	$Na_2S_2O_3$	Methanol	Other	Analysis Test (Y/N): Zn, Pb, 200 Ser (N)	Residual Chlorine (Y/N)	Pace Project No./ Lab I.D.
1	Adit Inside	WT	G	—	—	9/2/11	15:30		1			X						X		
2	~~Adit Surface Ext~~ *			—	—	9/2/11	15:00		1			X						X		
3	SUK East of Adit	↓	↓	—	—	9/2/11	15:40		1			X						HOLD		
4																				
5	*Change sample name																			
6	to Adit E1																			
7	(ww 9/6/2011)																			
8																				
9																				
10																				
11																				
12																				

ADDITIONAL COMMENTS	RELINQUISHED BY / AFFILIATION	DATE	TIME	ACCEPTED BY / AFFILIATION	DATE	TIME	SAMPLE CONDITIONS
	Wilhelm Welz	9/6/2011					

3

SAMPLER NAME AND SIGNATURE
PRINT Name of SAMPLER: Wilhelm Welzenbach
SIGNATURE of SAMPLER: [signature] DATE Signed (MM/DD/YY): 9/5/2011

Temp in °C | Received on Ice (Y/N) | Custody Sealed Cooler (Y/N) | Samples Intact (Y/N)

*Important Note: By signing this form you are accepting Pace's NET 30 day payment terms and agreeing to late charges of 1.5% per month for any invoices not paid within 30 days.

F-ALL-Q-020rev.07, 15-May-2007

Sample Condition Upon Receipt

Pace Analytical

Client Name: AMEC **Project #** 10168733

Courier: ☒ Fed Ex ☐ UPS ☐ USPS ☐ Client ☐ Commercial ☐ Pace Other ______

Tracking #: 197486092710

Custody Seal on Cooler/Box Present: ☐ yes ☒ no Seals intact: ☐ yes ☒ no

Packing Material: ☐ Bubble Wrap ☐ Bubble Bags ☒ None ☐ Other ______ Temp Blank: Yes ____ No X

Thermometer Used (1383045) or 135 **Type of Ice:** (Wet) Blue None ☒ Samples on ice, cooling process has begun

Cooler Temperature 5.1°

Temp should be above freezing to 6°C

Biological Tissue is Frozen: Yes No

Date and Initials of person examining contents: NCT 9/7/11

				Comments:
Chain of Custody Present:	☒Yes	☐No	☐N/A	1.
Chain of Custody Filled Out:	☒Yes	☐No	☐N/A	2.
Chain of Custody Relinquished:	☒Yes	☐No	☐N/A	3.
Sampler Name & Signature on COC:	☒Yes	☐No	☐N/A	4.
Samples Arrived within Hold Time:	☒Yes	☐No	☐N/A	5.
Short Hold Time Analysis (<72hr):	☐Yes	☒No	☐N/A	6.
Rush Turn Around Time Requested:	☐Yes	☒No	☐N/A	7. NORMAL
Sufficient Volume:	☒Yes	☐No	☐N/A	8.
Correct Containers Used:	☒Yes	☐No	☐N/A	9.
-Pace Containers Used:	☒Yes	☐No	☐N/A	
Containers Intact:	☒Yes	☐No	☐N/A	10.
Filtered volume received for Dissolved tests	☐Yes	☐No	☒N/A	11.
Sample Labels match COC:	☒Yes	☐No	☐N/A	12.
-Includes date/time/ID/Analysis Matrix: H_2O				
All containers needing acid/base preservation have been checked. Noncompliance are noted in 13.	☒Yes	☐No	☐N/A	13. ☒ HNO3 ☐ H2SO4 ☐ NaOH ☐ HCl
All containers needing preservation are found to be in compliance with EPA recommendation.	☒Yes	☐No	☐N/A	Samp # -001 through -003, HNO_3 (1/1)
Exceptions: VOA,Coliform, TOC, Oil and Grease, WI-DRO (water)	☐Yes	☒No		Initial when completed NCT / Lot # of added preservative
Samples checked for dechlorination:	☐Yes	☐No	☒N/A	14.
Headspace in VOA Vials (>6mm):	☐Yes	☐No	☒N/A	15.
Trip Blank Present:	☐Yes	☐No	☒N/A	16.
Trip Blank Custody Seals Present	☐Yes	☐No	☒N/A	
Pace Trip Blank Lot # (if purchased): ______				

Client Notification/ Resolution: Field Data Required? Y / N

Person Contacted: ______ Date/Time: ______

Comments/ Resolution: ______

Project Manager Review: Kari Poehls **Date:** 9-7-11

Note: Whenever there is a discrepancy affecting North Carolina compliance samples, a copy of this form will be sent to the North Carolina DEHNR Certification Office (i.e out of hold, incorrect preservative, out of temp, incorrect containers)

L213 Rev.00 (05Aug2009) Pace Analytical Services, Inc - MN Lab

From: "Welzenbach, Wilhelm" <wilhelm.welzenbach@amec.com>
To: Kari Poehls <Kari.Poehls@pacelabs.com>
Date: 9/7/2011 2:38 PM
Subject: RE: Kennedy Creek
Attachments: Revised CoC_Kennedy Cr.pdf

Kari,
Please change the name of the second Kennedy Creek sample (currently Adit - Surface Exp.) to Adit K1, per the attached amended chain of custody form. Also, please analyze the third sample (SWK East of Adit), and do not put it on hold.
-Willy

Wilhelm Welzenbach
Project Scientist
AMEC
1001 S. Higgins B-1, Missoula, MT, 59801 USA
Tel 406-542-0129 x. 23, (fax 406-542-0130)

From: Kari Poehls [mailto:Kari.Poehls@pacelabs.com]
Sent: Wednesday, September 07, 2011 2:27 PM
To: Welzenbach, Wilhelm
Subject: Kennedy Creek

Hi:
We received some samples this morning for Zn by 200 series. Do you need the 200.8 or 200.7?

Thanks,
Kari Poehls

Kari Poehls
Project Manager
Pace Analytical - Billings, MT
Main line 406-254-7226
Direct line 406-545-5486

APPENDIX B
2011 Adit Inspection Field Notes and Photographs

DAILY FIELD RECORD

Page 1 of ___

amec

Project and Task Number: MT 10160140		Date: 9/2/2011		
Project Name: Kennedy Cr.		Field Activity: Adit Recon.		
Location: Nimemile, MT		Weather: 65° F, partly cloudy		
PERSONNEL: Name		Company	Time In	Time Out
W. Welzenbach		AMEC		
M. W		AMEC		
Vicki Burkhardt		USFS - Mineral Administrator Lolo National Forest		

PERSONAL SAFETY CHECKLIST

	Steel-toed Boots		Hard Hat		Traffic Vest
	Gloves		Safety Goggles		Ear Protection

TIME	DESCRIPTION OF WORK PERFORMED
12:15	Arrive at road gate.
12:45	Notice: "Packadurn I Gold Placer Claim
	Claim Owners - Arthur P. Kaske /
	Scott Mohn - MSLA MT
	Ph 406-214-7096"
	Posted approx ½ of distance from gate to Nugget
	Mine (see photos of claim map). Vicki Burkhardt w/
	Lolo National Forest passed by, and said she is in
	process of determining claimants' intentions. for
17:00	Finish measuring elevations of creek and adit,
	and inspecting interior of adit - leave site.

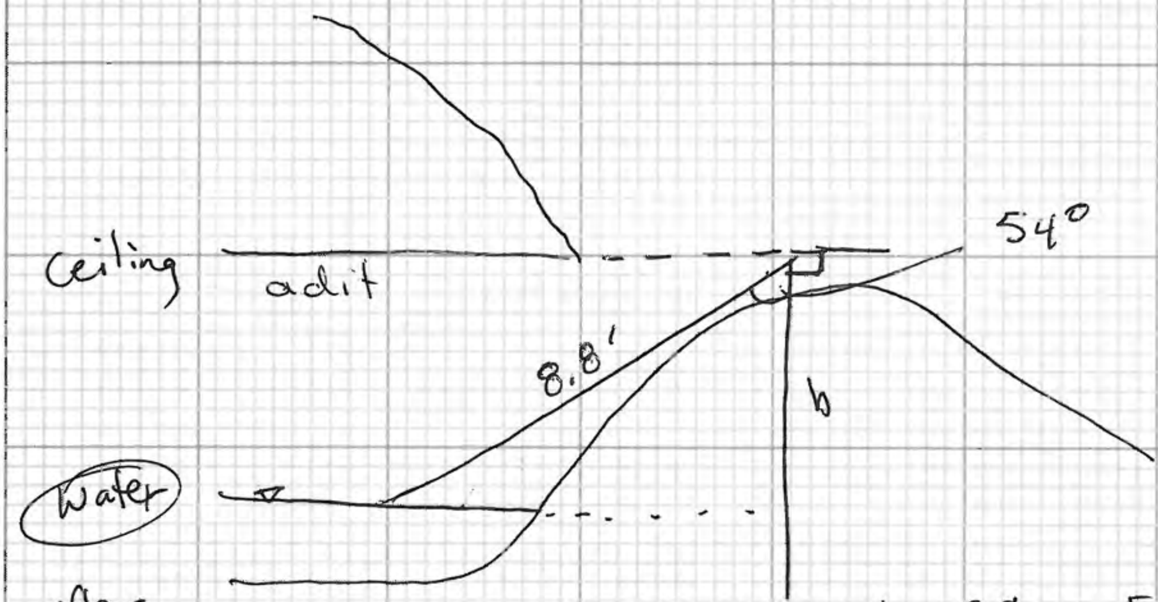
Design Memorandum

Client: TU
Sheet 1 of 1

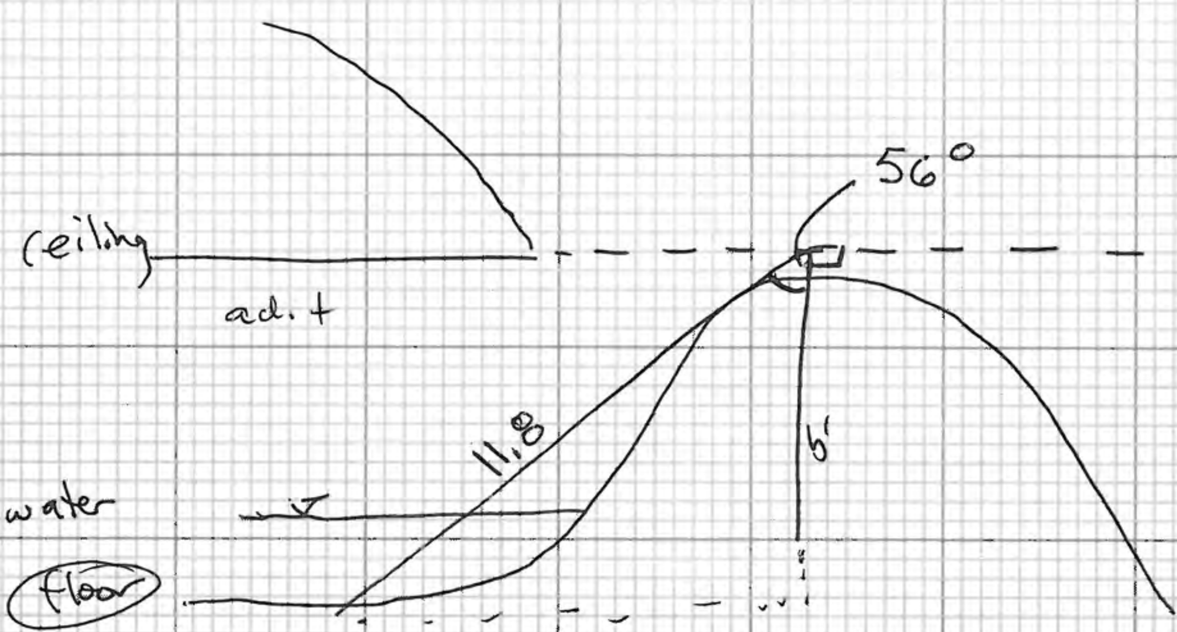
Project: Kennedy Creek
Date: ~~MF~~ 9/2/2011

Description: Adit Elevations - Water + Floor
Project No. MT10160140

Prepared By: calcs by W. Welzenbach (drawing by M. Wright)
Checked By:



$b = 8.8 \cos 54° = 5.2$ ft



$b' = 11.8 \cos 56° = 6.6$ ft

DESIGN MEMORANDUM

amec

CLIENT: TU SHEET 1 OF 1

PROJECT: Kennedy Creek DATE: 9/2/2011

DESCRIPTION: Location of Collection Structure PROJECT NO. MT 10160140

PREPARED BY: CHECKED BY:

Bearings and Distances from Adit

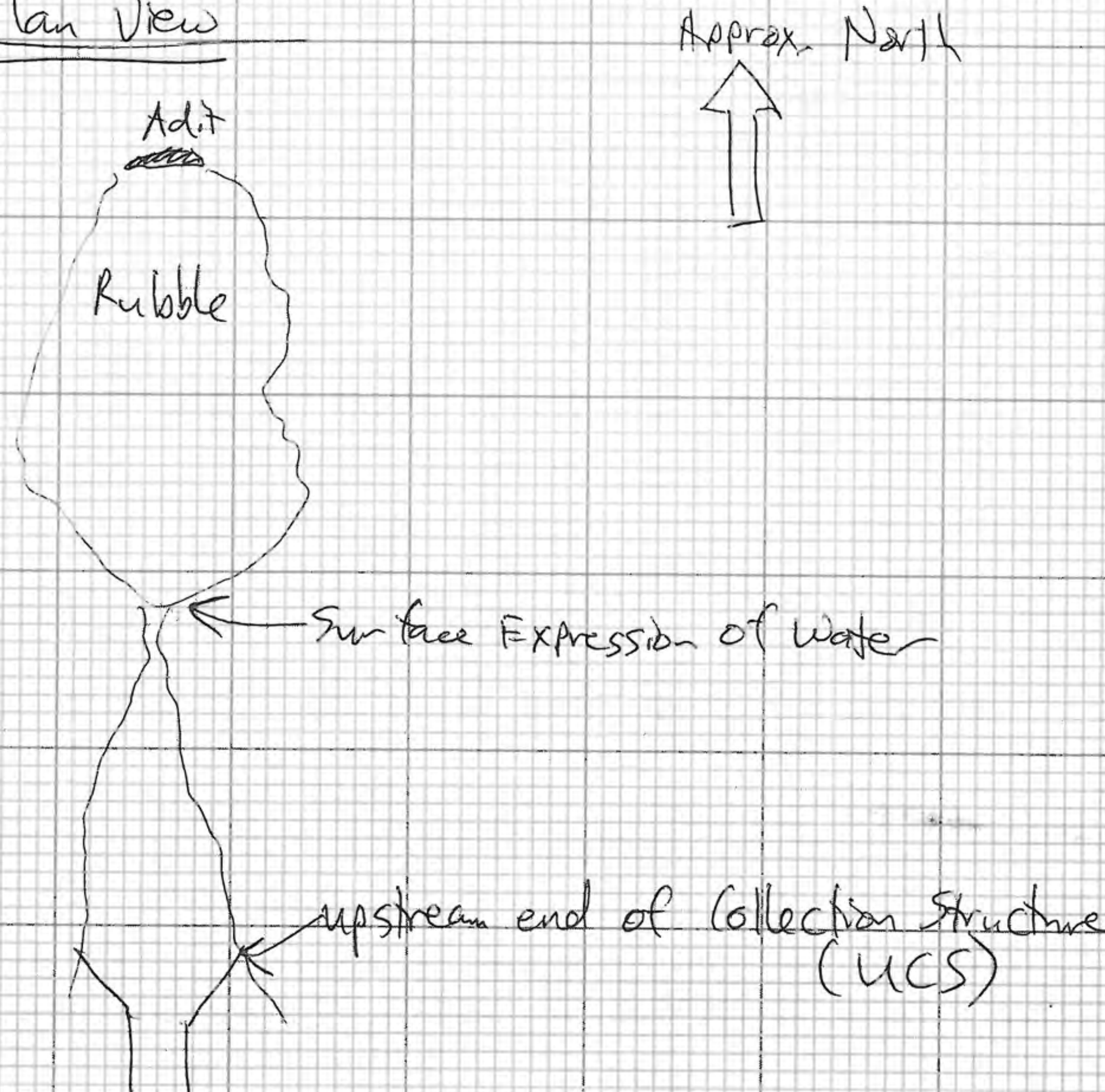
Surface expression (seep)

170° ~~200°~~ from adit opening

- 29 ft

UCS from adit 160° - 44 ft from adit opening

Plan View



DESIGN MEMORANDUM

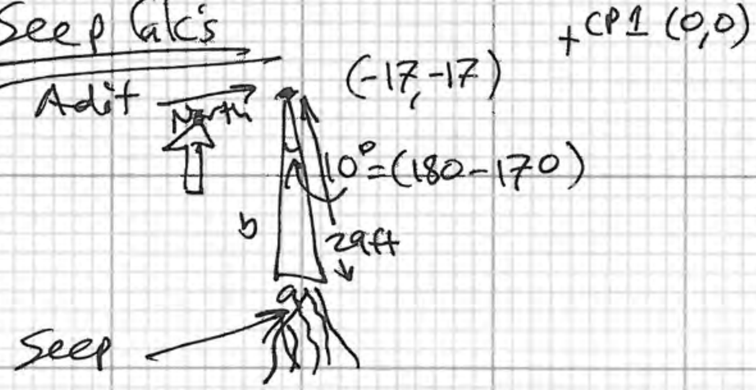
CLIENT: Trout Unlimited SHEET 1 OF 1

PROJECT: Kennedy Creek DATE: 9/28/11

DESCRIPTION: Adit, Seep, CS Locations PROJECT NO. MT10160140

PREPARED BY: W. Welzenbach CHECKED BY:

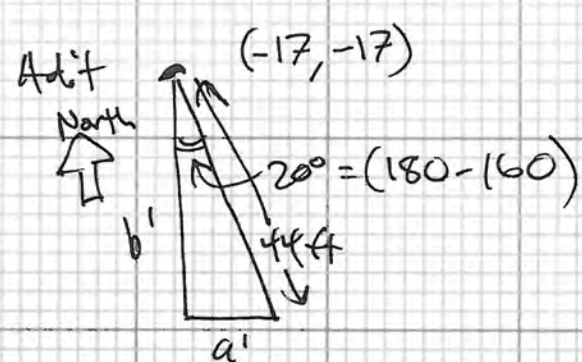
Seep Calc's



a = 29 sin 10° = 5.0 ft from adit to east

b = 29 cos 10° = 28.6 ft from adit to South

Collection Structure (CS) Calc's



a' = 44 sin 20° = 15.0 ft. from adit to east

b' = 44 cos 20° = 41.3 ft. from adit to South

Design Memorandum

CLIENT: TU
SHEET 1 OF 1

PROJECT: Kennedy Creek
DATE: 9/2/2011

DESCRIPTION: Collection Structure Dimensions
PROJECT NO. MT10160140

PREPARED BY:
CHECKED BY:

Collection Structure – August 2011:

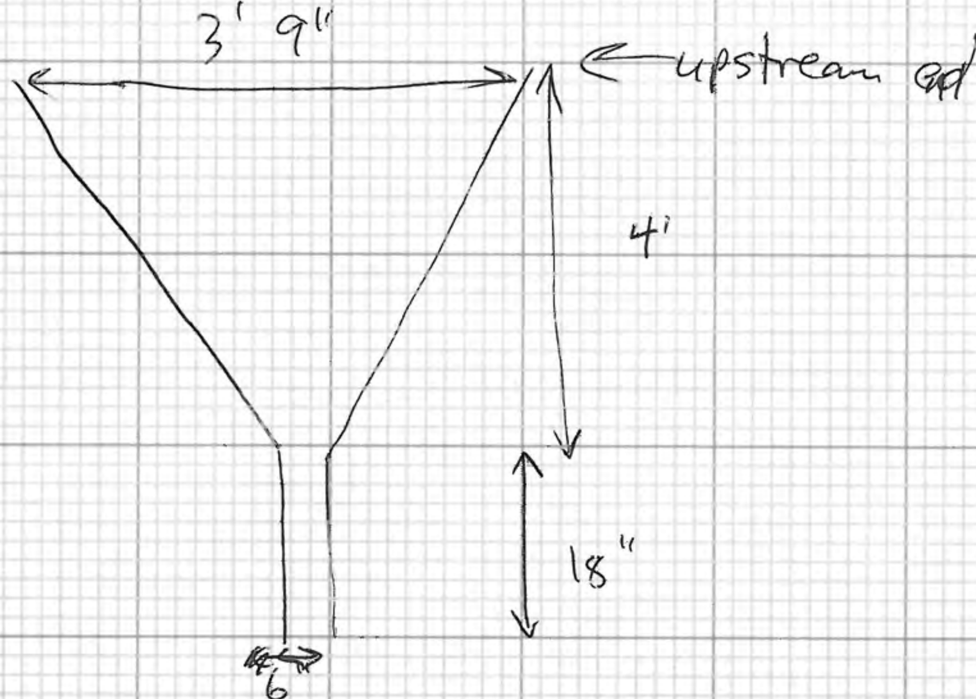


Photo 1: Interior of the adit at the Nugget Mine, facing north from adit entrance.

Photo 2: Rubble pile and surface expression of water, facing south from adit entrance at Nugget Mine.

Photo 3: Measurement of relative surface water elevations in Kennedy Creek.

Photo 4: Kennedy Creek adjacent to Nugget mine. View upstream.

APPENDIX C
2011 Repository Site Evaluation Field Notes

DAILY FIELD RECORD

Page 1 of ____

amec

Project and Task Number:	MT 10160140	Date:	6/9/2011
Project Name:	Kennedy Creek	Field Activity:	EE CA Field Reconnaissance
Location:	Nugget Mine and western Repository	Weather:	50°F, slight rain

PERSONNEL: Name	Company	Time In	Time Out
W. Welzenbach	AMEC	5:30	
M. Wright	AMEC	6:15	
Jarrod	C and C	7:10	~12:00

PERSONAL SAFETY CHECKLIST

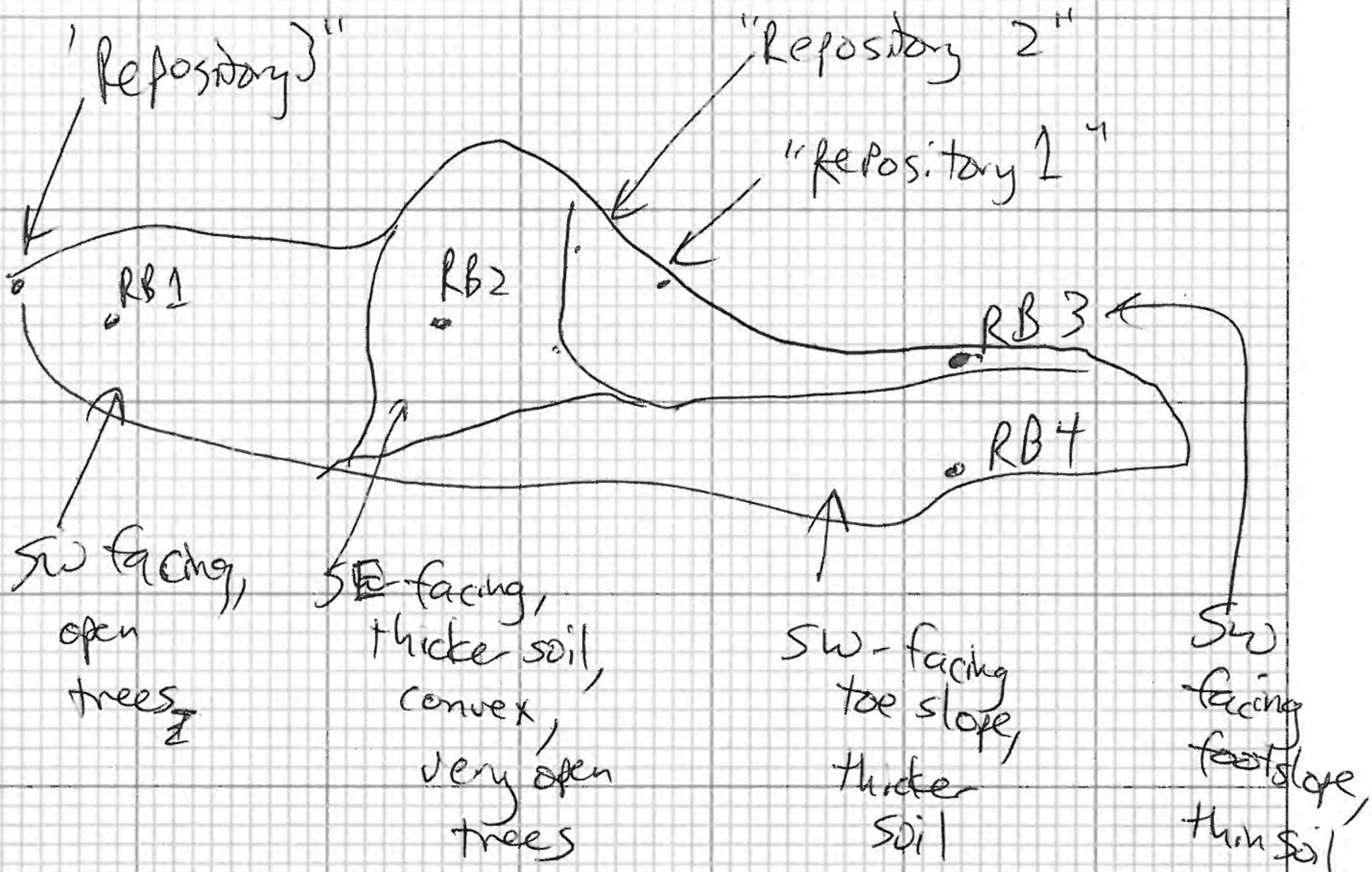
X	Steel-toed Boots		Hard Hat		Traffic Vest	
X	Gloves	X	Safety Goggles		Ear Protection	

TIME	DESCRIPTION OF WORK PERFORMED
5:30 to 6:30	Load documents and equipment.
6:30 to 7:05	Drive to Kennedy Creek Road.
7:10	Jarrod of C and C arrives
8:00 to 9:00	Mobilize to site. Cut downed logs on road. Document
	portal structure and adit opening.
9:00 to 9:40	Review surface features at Lost Cabin mine.
9:40 to 10:00	Surface water sampling at Pond.
10:00	Rob Roberts of Trout Unlimited arrives at Nugget Mine.
10:00 to 11:00	Construct flume near adit.
11:00 to 11:45	Calibrate YSI water meter and place sign at adit
11:45 to 13:00	General repository reconnaissance with Rob Roberts
13:00 to 16:15	~~Test pit~~ Hand augering and continued recon' (M. Wright
	samples Adit K2).
16:15 to 17:00	Monitor flow at adit.
17:15	Leave site

Design Memorandum

CLIENT: Trout Unlimited　SHEET 1 OF 1
PROJECT: Kennedy Creek　DATE: 6/9/2011
DESCRIPTION: Hand Augering Areas　PROJECT NO. MT10160140
PREPARED BY: W. Welzenbach　CHECKED BY:

Sketch of Hand Augering Areas:



SOIL AND VEGETATION SAMPLING FIELD FORM		Project Name: Kennedy Cr.	Site ID: RB 1	Date: 6/9/11
Soil Map Unit Symbol:	Photo #: 50, 51	Landcover Type:	Depth Interval Retained for Laboratory Analysis: N/A	
Weather: overcast, no wind	Temp.: Air: 60°F Soil:	Latitude: Longitude:	N E (50 Yards East of Pt. "Repository 3")	
Describer(s): W. Welzenbach	~~Date,~~ Time: 13:30	Slope (%): ~~5%~~ 10%	Aspect: SSW (200°)	Landscape Position: Toeslope	Slope Shape: (Up & Dn / Across) Flat / Convex

VEGETATION :

SYMBOL	COMMON NAME	%GD COVER
	Douglas fir up to 14in, dbh	5%
	Grasses	40%
	Sedges	55%

MISCELLANEOUS FIELD NOTES / SKETCH :

	Depth (in)	Horizon	Bnd	Matrix Color moist ~~Dry~~	Matrix Color Moist	Mottles	Texture	Rock Frags Knd % Rnd Sz	Structure Grade Sz	Roots Qty Sz	Pores Qty Sz Shp
1	0 - 3/4	Ø		Wet	Black/Y. Brown	—	—				
2	3/4 - 3.5	A		Saturated	10YR4/3	—	SL	Ang. Gr, 50%, <2in.	Crumb	Freq. Fine	
3	3.5 - 22	B		V. moist	10YR5/3	—	SL	Gr, 25%, <4in	Ang. Bl.	Sl. Med.	
4	22 +	C		moist	10YR6/4	—	SL	Gr, 25%, <3in.	Ang. Bl.	Sl. med.	
5	(refusal on large ~~rock~~ gravel at 24 in.)										
6											
7											
8											
9											

SOIL AND VEGETATION SAMPLING FIELD FORM		Project Name: Kennedy Cr.	Site ID: RB2	Date: 6/9/11
Soil Map Unit Symbol:	Photo #: 52, 53	Landcover Type:	Depth Interval Retained for Laboratory Analysis: N/A	
Weather: overcast, Sl. wind	Temp.: Air: 55° F Soil:	Latitude: Longitude:	N E 125 Yds E-NE (70°) from RB1	
Describer(s): W. Welzenbach	~~Date~~, Time: 15:00	Slope (%): 10%	Aspect: SSE (160°)	Landscape Position: Toe Slope	Slope Shape: (Up & Dn / Across) Convex / Convex

VEGETATION :

SYMBOL	COMMON NAME	%GD COVER
	Douglas fir up to 18in. diam.	5%
	Shrubs	10%
	Grasses	40%
	Sedges	45%

MISCELLANEOUS FIELD NOTES / SKETCH :

	Depth (in)	Horizon	Bnd	Matrix Color Moisture ~~Dry~~	Matrix Color Moist	Mottles	Texture	Rock Frags Knd % Rnd Sz	Structure Grade Sz	Roots Qty Sz	Pores Qty Sz Shp
1	0-1	O		wet	Black	/					
2	1-5.5	A		Saturated	10YR 5/2	/	SiL	Gr, 40%, Ang, <1in	Cr	Prev. fine	
3	5.5-26	B		Saturated	10YR 5/3	/	L	Gr, 25%, Ang, <1/2in.	Bl	Sl. med	
4	26-40	C1		V. moist	10YR 6/4	/	S	Gr, 70%, Ang, <2in.	Bl	Sl. med	
5	40-49	C2		moist	10YR 5/4	/	S	Gr, 15%, Ang, <3/4in.	MA	None	
6	(refusal at 49in. on large gravel)					/					
7											
8											
9											

SOIL AND VEGETATION SAMPLING FIELD FORM

Project Name: Kennedy Cr.	**Site ID:** RB3	**Date:** 6/9/11	
Soil Map Unit Symbol:	**Photo #:** 54, 55	**Landcover Type:**	**Depth Interval Retained for Laboratory Analysis:** N/A
Weather: Overcast, Sl. wind	**Temp.:** Air: 50° F Soil:	**Latitude:** **Longitude:**	**N** **E** 115 yds N-NE (70°) from pt. "Repository 1"
Describer(s): W. Welzenbach	~~Date~~, **Time:** 15:30	**Slope (%):** 15%	**Aspect:** SW (220°)
Landscape Position: ~~Toe slope~~ Footslope	**Slope Shape:** (Up & Dn / Across) Convex / Flat		

VEGETATION :

SYMBOL	COMMON NAME	%GD COVER
	Douglas fir up to 14 in. diam.	25%
	Shrubs	10%
	Grasses	55%
	Forbs	10%

MISCELLANEOUS FIELD NOTES / SKETCH :

	Depth (in)	Horizon	Bnd	Matrix Color ~~Dry~~ Moist	Matrix Color Moist	Mottles	Texture	Rock Frags Knd % Rnd Sz	Structure Grade Sz	Roots Qty Sz	Pores Qty Sz Shp
1	0 - 1/2	O		moist	black	—					
2	1/2 - 3	A1		moist	black	—		NA	Pl	Prev. fine	
3	3 - 11	A2		v. moist	7.5YR4/3	—		Gr, 25%, Ang, <3/4 in.	Cr	Prev. fine	
4	11 - ~~36~~ 38	B		moist	10YR 5/4	—		NA	Bl	Sl. fine	
5	~~36~~ 38 to 36	C		moist	10YR6/4	Sl. Orange		Gr, 15%, Ang, <3 in.	Bl	None	
6	(refusal at 36 in. on large gravel)										
7											
8											
9											

SOIL AND VEGETATION SAMPLING FIELD FORM

Project Name: Kennedy Cr.	Site ID: RB4	Date: 6/9/14	
Soil Map Unit Symbol:	Photo #: 56, 57	Landcover Type:	Depth Interval Retained for Laboratory Analysis: N/A
Weather: overcast, Sl. wind	Temp.: Air: 50°F Soil:	Latitude: Longitude:	N E 90 yds south of RB3
Describer(s): W. Welzenbach	Date, Time: 15:50	Slope (%): 10%	Aspect: SSW (210°)
Landscape Position: Toeslope	Slope Shape: (Up & Dn / Across) Concave, ~~Flate~~ Flat		

VEGETATION :

SYMBOL	COMMON NAME	%GD COVER
	Douglas fir up to 16 in. diam.	25%
	Shrubs	10%
	Grasses	40%
	Forbs	25%

MISCELLANEOUS FIELD NOTES / SKETCH :

	Depth (in)	Horizon	Bnd	Matrix Color Moisture ~~Dry~~	Matrix Color Moist	Mottles	Texture	Rock Frags Knd % Rnd Sz	Structure Grade Sz	Roots Qty Sz	Pores Qty Sz Shp
1	0-1	O			Black						
2	1-3	A1		moist	Black		SiL	None	Cr	Prep fine	
3	3-13	A2		Moist	10YR 5/3		SiL	5%, Ang, <½ in.	Bl	Sl. fine	
4	13-23	B		moist	10YR 5/4		S	5%, Ang, <1 in.	Bl	Sl. fine	
5	23-55	C1		V. Moist	10YR 5/4		S	25%, Ang, <4 in.	Sl. Bl	None	
6	~~50~~ 55-60	C2		Sl. moist	10YR 4/6		S Gr	60%, Ang, <3 in.	MA	None	
7											
8											
9											

Photo 1: Location RB1 within preferred repository location.

Photo 2: Location RB2 within the preferred repository location, viewed to south.

Photo 3: Location RB3 at the uphill edge of the preferred repository location showing the adjacent slope, viewed to west.

Photo 4: Location RB4 within the preferred repository location, viewed to south.

Photo 13: Two-track road to preferred repository.

APPENDIX D
Potential Human Exposure Routes – 1996 Guidelines

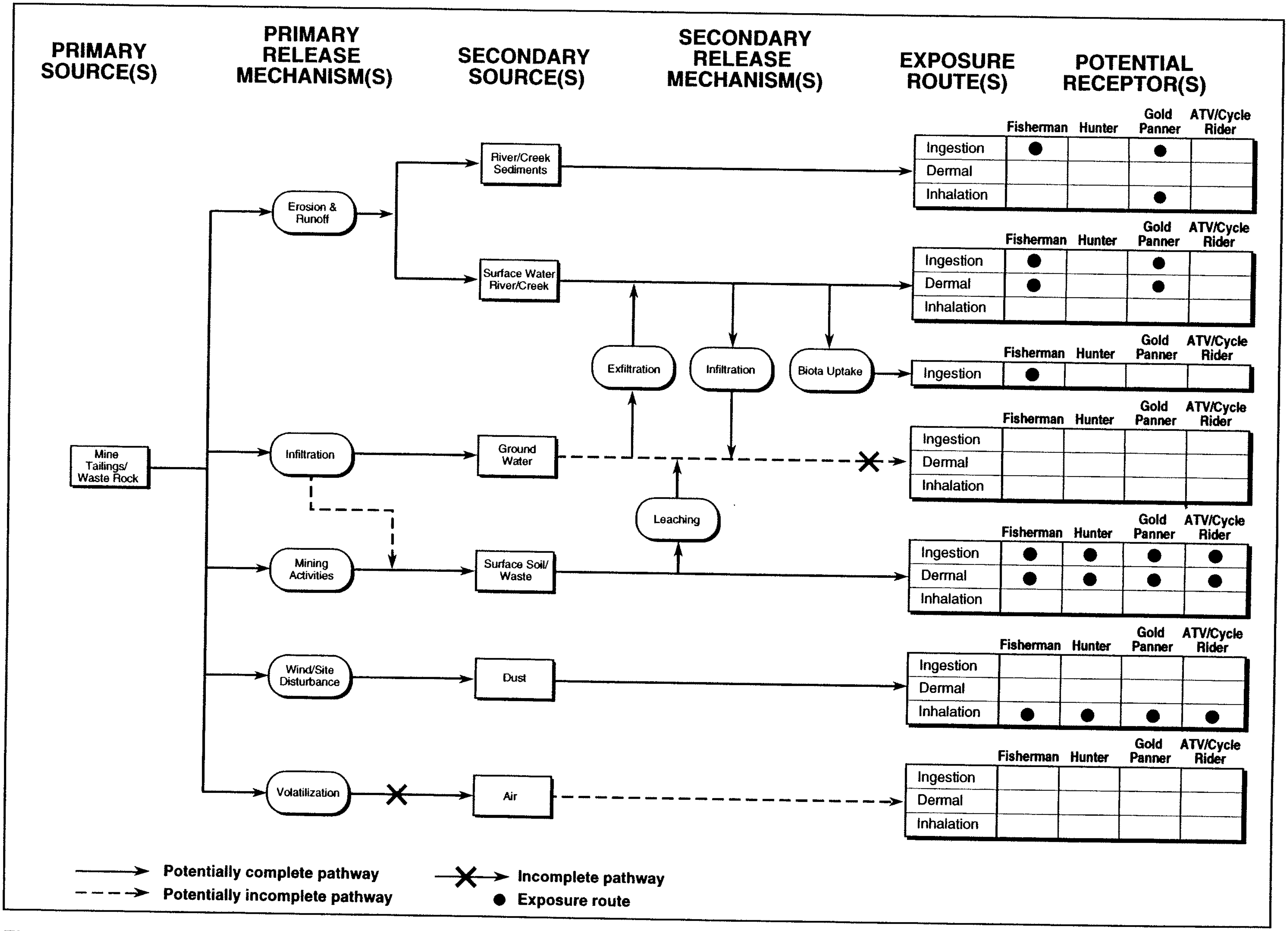


Figure ES-1. Conceptual model of contaminant migration and potential human exposure routes at abandoned mine sites.

APPENDIX E
Applicable or Relevant and Appropriate Requirements (ARARs)

- Preliminary Identification of Federal ARARs
- Montana Abandoned Mine Lands Reclamation Program *ARARs for Reclamation Projects*, November 2008

Preliminary Identification of Applicable or Relevant and Appropriate Requirements Kennedy Creek Mine Complex			
Standard, Requirement, Criteria or Limitation	**Citation**	**Description**	**ARAR Status**
FEDERAL: CONTAMINANT-SPECIFIC			
Safe Drinking Water Act	40 USC § 300		Not applicable or relevant. Surface water at the site is not used for public water supply and this removal action does not address groundwater.
National Primary Drinking Water Regulation	40 CFR Part 141	Establishes health-based standards (MCLs) for public water systems.	
National Secondary Drinking Water Regulation	40 CFR Part 143	Establishes welfare-based standards (secondary MCLs) for public water systems.	
Clean Water Act	33 USC § 1251-13871	Ch. 26 Water Pollution Prevention & Control	
Water Quality Standards	40 CFR Part 131 Quality Criteria for Water	Sets criteria for water quality based on toxicity to aquatic organisms and human health.	Relevant and Appropriate
FEDERAL: LOCATION-SPECIFIC			
National Historic Preservation Act	16 USC § 470; 36 CFR Part 800; 40 CFR part 6.310(b)	Requires Federal agencies to take into account the effect of any Federally-assisted undertaking or licensing on any district, site, building, structure, or object that is included in or eligible for inclusion in the National Register of Historic Places and to minimize harm to any National Historic Landmark adversely or directly affected by an undertaking.	Not applicable or relevant. No historic structures are present on the site.
Archaeological and Historic Preservation Act	16 USC § 469; 40 CFR 6.301 (c)	Establishes procedures to provide for preservation of historical and archaeological data which might be destroyed through alteration of terrain as a result of a Federal construction project or a Federally licensed activity or program.	Applicable
Historic Sites, Buildings, and Antiquities Act	36 CFR § 62.6(d)	Requires Federal agencies to consider the existence and location of landmarks on the National Registry of Natural Landmarks to avoid undesirable impacts on such landmarks.	Not applicable or relevant. No historic structures are present on the site.
Protection of Wetlands Order	40 CFR Part 6	Avoid adverse impacts to wetlands.	Applicable

Preliminary Identification of Applicable or Relevant and Appropriate Requirements Kennedy Creek Mine Complex			
Standard, Requirement, Criteria or Limitation	**Citation**	**Description**	**ARAR Status**
Migratory Bird Treaty Act	16 USC § 703 et seq.	Establishes a Federal responsibility for the protection of international migratory bird resource.	Applicable
Fish and Wildlife Coordination Act	16 USC § 661 et seq.; 40 CFR Part 6.302(g)	Requires consultation when Federal department or agency proposes or authorizes any modification or any stream or other water body and adequate provision for protection for protection of fish and wildlife resources.	Applicable
Floodplain Management Order	40 CFR Part 6	Requires Federal agencies to evaluate the potential effects of actions they may make in a floodplain to avoid the adverse impacts associated with direct and indirect development of a floodplain, to the extent possible.	Applicable
Bald Eagle Protection Act	16 USC § 668 et seq.	Establishes a federal responsibility for protection of bald and golden eagles. Requires consultations with the USFWS.	Applicable
Endangered Species Act	16 USC §§ 1531-1543; 40 CFR Part 6.302(h); 50 CFR Part 402	Requires action to conserve endangered species within critical habitat upon which species depend. Includes consultation with US Department of Interior.	Applicable
FEDERAL: ACTION-SPECIFIC			
Clean Water Act National Pollutant Discharge Elimination System	33 USC § 1251-1387 40 CFR Parts 121, 122, 125	Requires permits for the discharge of pollutants from any point source into waters of the United States.	Relevant and Appropriate
Clean Air Act National Primary and Secondary Ambient Air Quality Standards	42 USC § 7409; 40 CFR Part 50.12	Air quality levels that protect public health.	Applicable
Surface Mining Control and Reclamation Act	30 CFR parts 816, 784	Reclamation requirements for coal and certain non-coal mining.	Relevant and Appropriate
Resources Conservation and Recovery Act	42 USC § 6901	Defines those solid wastes that are subject to regulation as hazardous wastes under 40 CFR Parts 262-265 and parts 124, 270, and 271	Not applicable or appropriate
	40 CFR Part 257.3	Governs waste handling and disposal.	Not applicable or appropriate
	40 CFR Part 264.310	Provisions regarding run-on and run-off controls.	Relevant and appropriate

Preliminary Identification of Applicable or Relevant and Appropriate Requirements Kennedy Creek Mine Complex			
Standard, Requirement, Criteria or Limitation	**Citation**	**Description**	**ARAR Status**
Occupational Safety and Health Act Hazardous Waste Operations and Emergency Response	29 USC § 655 29 CFR 1910.120	Defines standards for employee protection during initial site characterization and analysis, monitoring activities, material handling activities, training, and emergency response.	Applicable

APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

(ARARS)

FOR

RECLAMATION PROJECTS

NOVEMBER, 2008

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ARARS FOR RECLAMATION PROJECTS

1.0 INTRODUCTON - HISTORY OF ARARS AT ABANDONED MINED LAND RECLAMATION SITES

After the enactment of the Federal Surface Mining Control and Reclamation Act in 1977 ("SMCRA", 30 USC §§ 1201-1238), the State of Montana could be delegated the authority to implement the Abandoned Mined Lands Reclamation ("AMLR") program authorized by that Act, as well as funding for implementation of that program, by the Federal Office of Surface Mining, Reclamation, and Enforcement ("OSM"). The State enacted necessary legislation to implement the AMLR program according to State law and had a plan ("Reclamation Plan") to do so, which was approved by OSM. Delegation of exclusive authority for the program would follow. Montana passed necessary legislation for reclamation of coal mines (Title 82, Chapter 4, Part 2, MCA), as well as legislation for reclamation of other types of mines (Title 82, Chapter 4, Part 3, MCA – Metal Mine Reclamation, and Title 82, Chapter 4, Part 4, Part 4, MCA – Open Cut Mining Reclamation).

Satisfaction of the requirements of SMCRA by the State of Montana resulted in the delegation by OSM to the State of Montana of the exclusive authority to implement the Reclamation Plan in the State of Montana on November 24, 1980. While the delegation of the program in 1980 was limited to abandoned coal mine reclamation, it was expanded by Montana's showing it had reclaimed all eligible abandoned coal mines, whereupon OSM approved the 1995 amendments to the State's Reclamation Plan to include non-coal abandoned mines. This approval resulted in additional delegation of authority to the State of Montana to implement reclamation of abandoned hardrock mines as well as quarries.

In the 1995 Amendments to its Reclamation Plan, the State of Montana stated that the AMLR program would comply with the National Contingency Plan ("NCP"). Among other things, the NCP provides a procedure for evaluating alternative cleanup methods for hazardous wastes. The NCP also establishes cleanup standards for hazardous wastes, which standards are referred to in the NCP as "ARARs." By requiring compliance with the NCP, the State adopted the NCP procedures for evaluation of alternatives in addressing AMLR Reclamation Projects, as well as ARARS. At the same time, utilization of the evaluation of alternatives procedures found in the NCP satisfied the evaluation of alternatives required for major Federal actions undertaken by the Federal government which could have a significant effect on the environment as required by the Federal National Environmental Policy Act ("NEPA", 42 USC 4321 – 4370).

AMLR, which is based upon SMCRA, is one of several legal authorities available in the State of Montana for cleanup of mine wastes, the others being the Federal Comprehensive Environmental Response, Compensation, and Liability Act ("CERCLA" or "Superfund", 42 USC 9601 – 9675) and the State's counterpart to the Federal

Superfund law, the Comprehensive Environmental Cleanup and Responsibility Act ("CECRA," §§ 75-10-701 - 752 MCA).

To paraphrase the Federal Superfund statute, at 42 USC 121(d)(E)(4), in remedy selection for cleanup of an hazardous waste site, if a State ARAR is not consistently applied, a remedy may be selected by the Federal government which does attain that ARAR. Such a decision could result in State standards not being applied to Federal mine waste cleanups in the State of Montana. Consequently, to avoid the risk that State standards would not be applied within the State of Montana, ARARs should be consistently applied in the State's three mine waste cleanup programs (Superfund, CECRA, and AMLR).

The interaction of SMCRA and CERCLA requirements, particularly the interaction of the consistency requirement of CERCLA and the adoption of the NCP in Montana's 1995 Reclamation Plan, resulted in procedures and standards for the Montana AMLR program which address NEPA alternatives analysis and incorporate CERCLA standards (i.e., ARARs).

The ARARs described below are, by necessity, generic because they are to be used as part of the evaluation process developed by the AMLR program for analysis of alternatives for AMLR Projects. This evaluation results in the Expanded Engineering Evaluation/Cost Analysis ("EEE/CA") which precedes selection of a Reclamation alternative.

The ARARs listed below are based upon those identified for the Neihart Operable Unit 1, Carpenter-Snow Creek Mining District NPL Site (June, 2007). The wastes include both mining and milling wastes, which exist at a typical AMLR site. The text of the ARARs analysis used has been updated and adapted to allow its application to AMLR sites in general.

2.0 TYPES OF ARARS

ARARs are either applicable or relevant and appropriate. Applicable requirements are those standards, requirements, criteria, or limitations promulgated under federal or state environmental or facility siting laws that specifically address a hazardous substance, pollutant, or contaminant, remedial action, location or other circumstances found at a CERCLA site. 40 CFR Section 300.5 Relevant and appropriate requirements are those "Standards, requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that, while not "applicable" to hazardous substances, pollutants, contaminants, remedial actions, locations, or other circumstances found at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site such that their use is well suited to the particular site." Id. Factors which may be considered in making this determination are presented in 40 CFR 300.400 (g)(2).

Each ARAR or group of related ARARs indentified herein is followed by a specific statutory or regulatory citation, a classification describing whether the ARAR is applicable or relevant and appropriate, and a description which summarizes the requirements.

ARARs are divided into contaminant specific, location specific, or action specific requirements, as described in the NCP and EPA Guidance.

Contaminant specific ARARs include those laws and regulations governing the release to the environment of materials possessing certain chemical or physical characteristics or containing specific chemical compounds. Contaminant specific ARARs generally set health or risk based numerical values or methodologies which, when applied to site specific conditions, result in the establishment of numerical values. These values establish the acceptable amount or concentration of a chemical that may be found in, or discharged to, the ambient environment. Location specific ARARs are restrictions placed on the concentration of hazardous substances or the conduct of cleanup activities because they are in specific locations. Location specific ARARs relate to the geographic or physical position of the site, rather than to the nature of the contaminants. Action specific ARARs are usually technology or activity based requirements or limitations on actions taken with respect to hazardous substances.

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

As noted previously, the 1995 Reclamation Plan provides that the NCP was adopted for Reclamation activities. Those activities are directly analogous to "removal actions" under CERCLA. As stated in the NCP at 55 FR 8695 (March 8, 1990):

> The purpose of removal actions generally is to respond to a release…so as to prevent, minimize, or mitigate harm to human health and the environment. Although all removals must be protective…removals are distinct from remedial actions in that they may mitigate or stabilize the threat rather than comprehensively address all the threats at a site. Consequently, <u>removal actions cannot be expected to attain all ARARs.</u> Remedial actions, in contrast, must comply with all ARARs or obtain a waiver. (emphasis supplied).

Consequently, the NCP, at 40 CFR 300.410 provides that ARARS at removal actions:

> …shall, to the extent practicable, considering the exigencies of the situation, attain…[ARARs]. In determining whether compliance with ARARs is

practicable, the lead agency may consider appropriate factors, including:

a) the urgency of the situation; and

b) the scope of the removal action to be conducted.

Therefore, based upon the NCP, after an ARAR has been identified for a Reclamation project, the EEE/CA should evaluate how the alternatives will attain ARARs and select an alternative that complies with ARARs to the extent practicable. If an ARAR cannot be complied with, the EEE/CA should indicate why, utilizing the two part test set out above, attainment is not practicable.

3.0 CONTAMINANT-SPECIFIC ARARs

3.1 Federal

3.1.1 Safe Drinking Water Act

Safe Drinking Water Act, 42 U.S.C. ' 300f, et seq., National Primary and Secondary Drinking Water Regulations, 40 CFR Parts 141 and 142 (relevant and appropriate). The National Primary and Secondary Drinking Water Regulations (40 CFR Parts 141 and 143) establish maximum contaminant levels (MCL) for chemicals in drinking water distributed in public water systems. These are enforceable in Montana under the Public Water Supplies, Distribution, and Treatment Act and corresponding regulations, MCA ' 75-6-101, et seq., and ARM ' 17.38.203. Safe Drinking Water Act MCLs are relevant and appropriate to for reclamation projects because the groundwater in a reclamation project area is a potential source of drinking water.

The determination that the drinking water standards are relevant and appropriate for reclamation projects is supported by the regulations and guidance. The Preamble to the NCP clearly states that the MCLs are relevant and appropriate for ground or surface water that is a current or potential source of drinking water. See 55 Fed. Reg. 8750, March 8, 1990, and 40 CFR ' 300.430(e)(2)(I)(B). MCLs developed under the Safe Drinking Water Act generally are ARARs for current or potential drinking water sources. See, EPA Guidance On Remedial Action For Contaminated Groundwater at Superfund Sites, OSWER Dir. #9283.1-2, December 1988.

In addition, maximum contaminant level goals (MCLG) may also be relevant and appropriate . See 55 Fed. Reg. 8750-8752. MCLGs are health-based goals which are established at levels at which no known or anticipated adverse effects on the health of persons occur and which allow an adequate margin of safety. According to the NCP, MCLGs that are set at levels above zero must be attained for ground or surface waters that are current or potential sources of drinking water. Where the MCLG for a contaminant has been set at a level of zero, the MCL promulgated for that contaminant must be attained.

The MCLs and MCLGs for contaminants of concern are:

Contaminant	MCL (mg/L)	MCLG[a] (mg/L)
Antimony	0.006	0.006
Arsenic	0.01	NE
Cadmium	0.005[b]	0.005[b]

Copper	1.3[c]	1.3[c]
Iron	0.3[d]	NE
Lead	0.015[c]	0
Manganese	0.05[d]	NE
Mercury	0.002[b]	0.002[b]
Silver	NE	NE
Thallium	0.002[b]	0.0005
Zinc	5.0[d]	NE

NE - Not Established

[a] 40 CFR ' 141.51(b)
[b] 40 CFR ' 141.62(c)
[c] 40 CFR ' 141.80(c) B No MCL, but specifies BAT to be applied.
[d] 40 CFR ' 143.3 B Secondary MCL

ARM 17.38.203 incorporates by reference into State law the MCLs for inorganic substances set forth in 40 CFR Part 141 (Primary Drinking Water Standards).

3.1.2 Clean Water Act

Federal Surface Water Quality Requirements, Clean Water Act, 33 USC ' 1251, et seq. (applicable). As provided under Section 303 of the Clean Water Act, 33 U.S.C. ' 1313, the State of Montana has promulgated water quality standards. See the discussion concerning State surface water quality requirements.

3.1.3 National Ambient Air Quality Standards

National Ambient Air Quality Standards, 40 CFR ' 50.6 (PM-10); 40 CFR ' 50.12 (lead) (applicable). These provisions establish standards for PM-10 and lead emissions to air. (Corresponding state standards are found at ARM ' 17.8.222 [lead] and ARM ' 17.8.223 [PM-10].) The PM-10 standard is 150 micrograms per cubic meter ($\mu g/m^3$), 24-hour average concentration, and the lead standard is 1.5 $\mu g/m^3$, maximum arithmetic mean averaged over a calendar quarter.

3.2 State

3.2.1 Groundwater Protection

ARM 17.30.1005 (applicable) explains the applicability and basis for the groundwater standards in ARM ' 17.30.1006, which establish the maximum allowable changes in groundwater quality and may limit discharges to groundwater.

ARM 17.30.1006 (applicable) provides that groundwater is classified into Classes I through IV based on its specific conductance and establishes the applicable ground water quality standards with respect to each groundwater classification.

Concentrations of dissolved substances in Class I or II groundwater may not exceed the human health standards listed in department Circular DEQ-7.[1] These levels are listed below for the primary contaminants of concern.

---

[1] Montana Department of Environmental Quality, Water Quality Division, Circular DEQ-7, Montana Numeric Water Quality Standards (February 2008).

Contaminant	**DEQ-7 Standard (mg/L)[a]**
Antimony	0.006
Arsenic	0.01
Cadmium	0.005
Copper	1.3
Iron	NE[b]
Lead	0.015
Manganese	NE[b]
Mercury	0.002
Silver	0.1
Thallium	0.002
Zinc	2.0

NE- Not Established

[a] DEQ-7 standards for metals and arsenic in ground water are based on the dissolved portion of the sample (after filtration through a 0.45 Φm membrane filter).

[b] Concentrations of iron and manganese must not reach values that interfere with the uses specified in the surface and groundwater standards (ARM 17.30.601 et seq. and ARM 17.30.1001 et seq.). The secondary maximum contaminant levels of 300 Φg/L and 50 Φg/L, respectively, may be considered guidance to determine levels that will interfere with the specified uses.

Reclamation projects must meet the DEQ-7 standards for all contaminants at a Reclamation site. In addition, for Class I and Class II ground water, no increase of a parameter may cause a violation of Section 75-5-303, MCA (nondegradation).

ARM 17.30.1006 requires that concentrations of other dissolved or suspended substances must not exceed levels that render the waters harmful, detrimental or injurious to public health. Maximum allowable concentrations of these substances also must not exceed acute or chronic problem levels that would adversely affect existing or designated beneficial uses of groundwater of that classification.

ARM 17.30.1011 (applicable)

This section provides that any groundwater whose existing quality is higher than the standard for its classification must be maintained at that high quality in accordance with Section 75-5-303, MCA, and ARM Title 17, Chapter 30, Subchapter 7.

An additional concern with respect to ARARs for groundwater is the impact of groundwater upon surface water. If significant loadings of contaminants from groundwater sources to any surface water within a Reclamation Project contribute to the inability of the stream to meet classification standards, then alternatives to alleviate such groundwater loading must be evaluated and, if appropriate, implemented. Groundwater in certain areas may have to be remediated to levels more stringent than the groundwater classification standards in order to achieve the standards for affected surface water. See Compliance with Federal Water Quality Criteria, OSWER Publication 9234.2-09/FS (June 1990) (AWhere the ground water flows naturally into the surface water, the ground-water remediation should be designed so that the receiving surface-water body will be able to meet any ambient water-quality standards [such as State WQSs or FWQC] that may be ARARs for the surface water.@)

3.2.2 Montana Water Quality Act

State of Montana Surface Water Quality Requirements, Montana Water Quality Act, Section 75-5-101, et seq., MCA, and implementing regulations (applicable). General. The Clean Water Act, 33 U.S.C. ' 1251, et seq., provides the authority for each state to adopt water quality standards (40 CFR Part 131) designed to protect beneficial uses of each water body and requires each state to designate uses for each water body. The Montana Water Quality Act, Section 75-5-101, et seq., MCA, establishes requirements to protect, maintain and improve the quality of surface and groundwater. Montana's regulations classify State waters according to quality, place restrictions on the discharge of pollutants to State waters, and prohibit degradation of State waters. Pursuant to this authority and the criteria established by Montana surface water quality regulations, ARM ' 17.30.601, et seq., Montana has established the Water-Use Classification system. The classification for specific surface water bodies within the State are set for in ARM 17.30.607 et. seq. The applicable standards for each classification are set forth in ARM 17.30.621 through ARM 17.30.629, inclusive.

ARM 17.30.637 (applicable). Provides that surface waters must be free of substances attributable to industrial practices or other discharges that will: (a) settle to form objectionable sludge deposits or emulsions beneath the surface of the water or upon adjoining shorelines; (b) create floating debris, scum, a visible oil film (or be present in concentrations at or in excess of 10 milligrams per liter) or globules of grease or other floating materials; (c) produce odors, colors or other conditions which create a nuisance or render undesirable tastes to fish flesh or make fish inedible; (d) create concentrations or combinations of materials which are toxic or harmful to human, animal, plant or aquatic life; (e) create conditions which produce undesirable aquatic life.

ARM 17.30.637 also states that no waste may be discharged and no activities conducted which, either alone or in combination with other waste activities, will cause violation of surface water quality standards.

In addition, ARM 17.30.637 provides that leaching pads, tailings ponds, or water or waste or product holding facilities must be located, constructed, operated and maintained in such a manner and of such materials to prevent any discharge, seepage, drainage, infiltration, or flow which may result in pollution of state waters, and a monitoring system may be required to ensure such compliance.

Section 75-5-605, MCA (applicable) provides that it is unlawful to cause pollution of any state waters or to place or cause to be placed, any wastes where they will cause pollution of aany state waters.

Section 75-5-303, MCA (applicable) states that existing uses of state waters and the level of quality of state waters necessary to protect those uses must be maintained and protected.

ARM 17.30.705 (applicable). For all state waters, existing and anticipated uses and water quality necessary to support those uses must be maintained and protected.

3.2.3 Montana Ambient Air Quality Regulations

Montana Ambient Air Quality Regulations, ARM 17.8.206, -.222, -.220, and -.223 (applicable). The following provisions establish air quality standards.

ARM 17.8.206. This provision establishes sampling, data collection, and analytical requirements to ensure compliance with ambient air quality standards.

ARM 17.8.222. Lead emissions to ambient air shall not exceed a ninety (90) day average of 1.5 micrograms per cubic liter of air.

ARM 17.8.220. Settled particulate matter shall not exceed a thirty (30) day average of 10 grams per square meter.

ARM 17.8.223. PM-10 concentrations in ambient air shall not exceed a 24 hour average of 150 micrograms per cubic meter of air and an annual average of 50 micrograms per cubic meter of air.

4.0 LOCATION-SPECIFIC ARARS

The statutes and regulations set forth below relate to solid waste, floodplains, floodways, streambeds, and the preservation of certain cultural, historic, natural or other national resources located in certain areas that may be adversely affected by Reclamation.

4.1 Federal

4.1.1 National Historic Preservation Act

National Historic Preservation Act, 16 USC ' 470, 40 CFR ' 6.301(b), 36 CFR Part 63, Part 65, and Part 800 (NHPA) (applicable). This statute and implementing regulations require Federal agencies to take into account the effect of Reclamation upon any district, site, building, structure, or object that is included in or eligible for the Register of Historic Places. If the effect of Reclamation cannot be reasonably avoided, Measures will be implemented to minimize or mitigate the potential effects of the activity. In addition, Indian cultural and historical resources must be evaluated and effects avoided, minimized or mitigated.

4.1.2 Archaeological and Historic Preservation Act

Archaeological and Historic Preservation Act, 16 USC ' 469, 40 CFR 6.301(c) (applicable). This statute and implementing regulations establish requirements for the evaluation and preservation of historical and archaeological data, including Indian cultural and historic data, which may be destroyed through alteration of terrain as a result of a Federal program (such as AMLR). This requires the AMLR Program to survey the site for covered scientific, prehistorical or archaeological artifacts. If eligible scientific, prehistoric, or archeological data are developed during reclamation, they shall be preserved in accordance with these requirements.

4.1.3 Historic Sites Act of 1935

Historic Sites Act of 1935, 16 USC ' 461, et seq., 40 CFR 6.310(a) (applicable). This statute and implementing regulations require federal agencies to consider the existence and location of land marks on the National Registry of National Landmarks and to avoid undesirable impacts on such landmarks.

4.1.4 Protection and Enhancement of the Cultural Environment

Executive Order 11593 Protection and Enhancement of the Cultural Environment, 16 USC ' 470 (applicable). Directs federal agencies to institute procedures to ensure programs contribute to the preservation and enhancement of non-federally owned historic resources. Consultation with the Advisory Council on Historic Preservation is required if Reclamation activities should threaten cultural resources.

4.1.5 The Archaeological Resources Protection Act of 1979

The Archaeological Resources Protection Act of 1979, 16 USC ' ' 470aa-47011 (relevant and appropriate). Requires a permit for any excavation or removal of archeological resources from public lands or Indian lands. Substantive portions of this act may be relevant and appropriate if archeological resources are encountered during Reclamation activities.

4.1.6 American Indian Religious Freedom Act

American Indian Religious Freedom Act, 42 U.S.C. ' 1996. (applicable). This Act establishes a federal responsibility to protect and preserve the inherent right of American Indians to believe, express and exercise the traditional religions of American Indians. This right includes, but is not limited to, access to sites, use and possession of sacred objects, and the freedom to worship through ceremonials and traditional rites. The Act requires Federal agencies to protect Indian religious freedom by refraining from interfering with access, possession and use of religious objects, and by consulting with Indian organizations regarding proposed actions affecting their religious freedom.

4.1.7 Native American Graves Protection and Repatriation Act

Native American Graves Protection and Repatriation Act, 25 U.S.C. ' 3001, et seq. (applicable). The Act prioritizes ownership or control over Native American cultural items, including human remains, funerary objects and sacred objects, excavated or discovered on Federal or tribal lands. Federal agencies and museums that have possession or control over Native American human remains and associated funerary objects are required under the Act to compile an inventory of such items and, to the extent possible, identify their geographical and cultural affiliation. Once the cultural affiliation of such objects is established, the Federal agency or museum must expeditiously return such items, upon request by a lineal descendent of the individual Native American or tribe identified.

4.1.8 Fish and Wildlife Coordination Act

Fish and Wildlife Coordination Act, 16 USC ' 661, 40 CFR 6.302 (applicable). This statute and implementing regulations require that Federal agencies or federally funded projects ensure that any modification of any stream or other water body affected by any action authorized or funded by the Federal agency provide for adequate protection of fish and wildlife resources. This ARAR requires consultation with the U.S. Fish and Wildlife Service and the Montana Department of Fish, Wildlife, and Parks. Further consultation will occur during Reclamation design and construction.

4.1.9 Endangered Species Act

Endangered Species Act, 16 USC ' 1531, 50 CFR Parts 17 and 402 (applicable). This statute and implementing regulations provide that federal activities not jeopardize the continued existence of any threatened or endangered species. This ARAR will be achieved through consultation with the U.S. Fish and Wildlife Service and the Montana Department of Fish, Wildlife and Parks during Reclamation design and construction action. Specific avoidance or other mitigation measures identified shall be incorporated into the Reclamation design and implemented as part of construction.

4.1.10 Floodplain Management Regulations

Floodplain Management Regulations, Executive Order No. 11988 and 40 CFR ' 6.302(b) (applicable). These require that actions be taken to avoid, to the extent possible, adverse effects associated with direct or indirect development of a floodplain, or to minimize adverse impacts if no practicable alternative exists.

4.1.11 Protection of Wetlands Regulations

Protection of Wetlands Regulations, 40 CFR Part 6, Appendix A, and Executive Order No. 11990 (applicable). Steps will be taken to avoid or mitigate the adverse impacts associated with the destruction or loss of wetlands to the extent possible and avoidance of new construction in wetlands if a practicable alternative exists. Wetlands are defined as those areas that are inundated or saturated by groundwater or surface water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Compliance with this ARAR will be achieved through consultation with the U.S. Fish and Wildlife Service and the U.S. Army Corps of Engineers, to determine the existence and category of wetlands present at the site, and any avoidance or mitigation and replacement which may be necessary.

4.1.12 Clean Water Act

Section 404, Clean Water Act, 33 USC ' ' 1251 et seq., 33 CFR Part 330 (applicable). Regulates discharge of dredged or fill materials into waters of the United States. Substantive requirements of portions of Nationwide Permit No. 38 (General and Specific Conditions) are applicable to Reclamation activities conducted within waters of the United States within the Reclamation Project area.

4.1.13 Migratory Bird Treaty Act

Migratory Bird Treaty Act, 16 USC ' 703, et seq. (applicable). This requirement establishes a federal responsibility for the protection of the international migratory bird resource and requires continued consultation with the USFWS during Reclamation design and construction to ensure that Reclamation of the site does not unnecessarily impact migratory birds.

4.1.14 Bald Eagle Protection Act

Bald Eagle Protection Act, 16 USC ' 668, et seq. (applicable). This requirement establishes a federal responsibility for protection of bald and golden eagles, and requires continued consultation with the U.S. Fish and Wildlife Service during Reclamation design and construction to ensure that Reclamation of the site does not unnecessarily adversely affect bald and golden eagles.

4.1.15 Resource Conservation and Recovery Act

Resource Conservation and Recovery Act and regulations, 40 CFR ' 264.18 (a) and (b) (relevant and appropriate). These regulations provide seismic and floodplain restrictions on the location of a waste management unit.

4.2 State

4.2.1 Montana Antiquities Act

Montana Antiquities Act, Section 22-3-421, et seq., MCA (relevant and appropriate). The Montana Antiquities Act addresses the responsibilities of State agencies regarding historic and prehistoric sites including buildings, structures, paleontological sites, archaeological sites on state owned lands. Each State agency is responsible for establishing rules regarding historic resources under their jurisdiction which address National Register eligibility, appropriate permitting procedures and other historic preservation goals. The State Historic Preservation Office maintains information related to the responsibilities of State Agencies under the Antiquities Act.

4.2.2 Montana Human Skeletal Remains and Burial Site Protection Act

Montana Human Skeletal Remains and Burial Site Protection Act (1991), Section 22-3-801, MCA (applicable). The Human Skeletal Remains and Burial Site Protection Act is the result of years of work by Montana Tribes, State agencies and organizations interested in ensuring that all graves within the State of Montana are adequately protected. If human skeletal remains or burial sites are encountered during Reclamation, then requirements will be applicable.

4.2.3 Montana Floodplain and Floodway Management Act

Montana Floodplain and Floodway Management Act and Regulations, Section 76-5-401, et seq.,MCA, ARM 36.15.601, et seq. (applicable). The Floodplain and Floodway Management Act and regulations specify types of uses and structures that are allowed or prohibited in the designated 100-year floodway[2] and floodplain.[3] If a Reclamation Project contains streams or creeks that run through areas that can flood, these standards are applicable to Reclamation Projects within these floodplain areas.

A. Prohibited uses. Uses prohibited anywhere in either the floodway or the floodplain are:

- solid and hazardous waste disposal; and
- storage of toxic, flammable, hazardous, or explosive materials.

ARM 36.15.605(2) and 36.15.703 (Applicable); see also ARM 36.15.602(5)(b) (Applicable). These provisions effectively prohibit the placement of mine waste repositories within the 100-year floodplain and require mine wastes addressed by Reclamation to be removed from the floodplain.

[2] The "floodway" is the channel of a watercourse or drainway and those portions of the floodplain adjoining the channel that are reasonably required to carry and discharge the floodwater of the watercourse or drainway. ARM 36.15.101(13).

[3] The "floodplain" is the area adjoining the watercourse or drainway which would be covered by the floodwater of a base (100-year) flood except for sheetflood areas that receive less than one foot of water per occurrence. The floodplain consists of the floodway and flood fringe. ARM 36.15.101(11).

In the floodway, additional prohibitions apply, including prohibition of:

- P a building for living purposes or place of assembly or permanent use by human beings;
- P any structure or excavation that will cause water to be diverted from the established floodway, cause erosion, obstruct the natural flow of water, or reduce the carrying capacity of the floodway; and
- P the construction or permanent storage of an object subject to flotation or movement during flood level periods.

Section 76-5-403, MCA (Applicable).

B. Applicable considerations in use of floodplain or floodway. Applicable regulations also specify factors that must be considered in allowing diversions of the stream, changes in place of diversion of the stream, flood control works, new construction or alteration of artificial obstructions, or any other nonconforming use within the floodplain or floodway. Many of these requirements are set forth as factors that must be considered in determining whether a permit can be issued for certain obstructions or uses. While permit requirements are not directly applicable to Reclamation construction conducted entirely on site, the substantive criteria used to determine whether a proposed obstruction or use is permissible within the floodway or floodplain are applicable standards. Factors which must be considered in addressing any obstruction or use within the floodway or floodplain include:

- P the danger to life and property from backwater or diverted flow caused by the obstruction or use;
- P the danger that the obstruction or use will be swept downstream to the injury of others;
- P the availability of alternate locations;
- P the construction or alteration of the obstruction or use in such a manner as to lessen the danger;
- P the permanence of the obstruction or use; and
- P the anticipated development in the foreseeable future of the area which may be affected by the obstruction or use.

See Section 76-5-406, MCA; ARM 36.15.216 (Applicable, substantive provisions only). Conditions or restrictions that generally apply to specific activities within the floodway or floodplain are:

- P the proposed activity, construction, or use cannot increase the upstream elevation of the 100-year flood a significant amount (2 foot or as otherwise determined by the permit issuing authority) or significantly increase flood velocities, ARM 36.15.604 (Applicable, substantive provisions only); and
- P the proposed activity, construction, or use must be designed and constructed to minimize potential erosion. See ARM 36.15.605.

For the substantive conditions and restrictions applicable to specific obstructions or uses, see the following applicable regulations:

Excavation of material from pits or pools - ARM 36.15.602(1).

Water diversions or changes in place of diversion - ARM 36.15.603.

Flood control works (levees, floodwalls, and riprap must comply with specified safety standards) - ARM 36.15.606.

Roads, streets, highways and rail lines (must be designed to minimize increases in flood heights) - ARM 36.15.701(3)(c).

Structures and facilities for liquid or solid waste treatment and disposal (must be floodproofed to ensure that no pollutants enter flood waters and may be allowed and approved only in accordance with Montana Department of Environmental Quality (DEQ) regulations, which include certain additional prohibitions on such disposal) - ARM 36.15.701(3)(d).

Residential structures - ARM 36.15.702(1).

Commercial or industrial structures - ARM 36.15.702(2).

4.2.4 Montana Stream Protection Requirements

Montana Natural Streambed and Land Preservation Act and Regulations, Section 75-7-101, et.seq., MCA, and ARM 36.2.401, et.seq., (applicable). Applicable if Reclamation alters or affects a streambed or its banks. The adverse effects of any such action must be minimized.

ARM 36.2.410 (applicable) establishes minimum standards which would be applicable if Reclamation alters or affects a streambed, including any channel change, new diversion, riprap or other streambank protection project, jetty, new dam or reservoir or other commercial, industrial or residential development. Reclamation Projects must be designed and constructed using methods that minimize adverse impacts to the stream (both upstream and downstream) and future disturbances to the stream. All disturbed areas must be managed during construction and reclaimed after construction to minimize erosion. Temporary structures used during construction must be designed to handle high flows reasonably anticipated during the construction period. Temporary structures must be completely removed from the stream channel at the conclusion of construction, and the area must be restored to a natural or stable condition. Channel alterations must be designed to retain original stream length or otherwise provide hydrologic stability. Streambank vegetation must be protected except where removal of such vegetation is necessary for the completion of the Reclamation project. When removal of vegetation is necessary, it must be kept to a minimum. Riprap, rock, and other material used in a project must be of adequate size, shape, and density and must be properly placed to protect the streambank from erosion. The placement of road fill material in a stream, the placement of debris or other materials in a stream where it can erode or float into the stream, Reclamation projects that permanently prevent fish migration, operation of construction equipment in a stream, and excavation of streambed gravels are prohibited unless specifically authorized by the district. Such projects must also protect the use of water for any useful or beneficial purpose. See Section 75-7-102, MCA.

Sections 87-5-502 and 504, MCA (applicable -- substantive provisions only). provide that a state agency or subdivision shall not construct, modify, operate, maintain or fail to maintain any construction project or hydraulic project which may or will obstruct, damage, diminish, destroy, change, modify, or vary the natural existing shape and form of any stream or its banks or tributaries in a manner that will adversely affect any fish or game habitat.

While the administrative / procedural requirements, including the consent and approval requirements set forth in these statutes and regulations are not ARARs, consultation with the Montana Department of Fish, Wildlife and Parks, and any conservation district or board of county commissioners (or consolidated city/county government) is encouraged during the design and implementation of Reclamation to assist in the evaluation of the factors discussed above.

4.2.5 Montana Solid Waste Management Act

Montana Solid Waste Management Act and regulations, Section 75-10-201, et seq., MCA, ARM 17.50.505 (applicable) . Sets forth requirements applying to the location of any solid waste management facility. Among other things, the location must have sufficient acreage, must not be within a 100-year floodplain, must be located so as to prevent pollution of ground, surface, and private and public water supply systems, and must allow for reclamation of the land.

Under ARM 17.50.505, a facility for the treatment, storage or disposal of solid wastes:

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

2. may not be located in a 100-year floodplain;

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

4. must be located to allow for reclamation and reuse of the land;

5. drainage structures must be installed where necessary to prevent surface runoff from entering waste management areas; and

6. where underlying geological formations contain rock fractures or fissures which may lead to pollution of the ground water or areas in which springs exist that are hydraulically connected to a proposed disposal facility, only Class III disposal facilities may be approved[4].

Even Class III landfills may not be located on the banks of or in a live or intermittent stream or water saturated areas, such as marshes or deep gravel pits which contain exposed ground water. ARM 17.54.505(2)(j).

[4] Group III consist of primarily inert wastes, including industrial mineral wastes which are essentially inert and non-water soluble and do not contain hazardous waste constituents. ARM 17.50.503(1)(b).

These standards apply to any facility for the treatment, storage, or disposal of mine wastes, including, for example, any mine waste repository, tailings deposit, or waste rock pile that is actively managed as part of a Reclamation Project.

<u>Section 75-10-212, MCA.</u> For solid wastes, Section 75-10-212, MCA, prohibits dumping or leaving any debris or refuse upon or within 200 yards of any highway, road, street, or alley of the State or other public property, or on privately owned property where hunting, fishing, or other recreation is permitted.

4.2.6 Endangered Species and Wildlife

Sections 87-5-106, 107 and 111, MCA (applicable). Endangered species should also be protected in order to maintain and to the extent possible, enhance their numbers. These Sections list endangered species, prohibited acts, and penalties. Section 87-5-201, MCA (applicable) concerns protection of wild birds, nests and eggs and under ARM 12.5.201 certain activities are prohibited with respect to specified endangered species.

5.0 ACTION-SPECIFIC ARARS

5.1 Federal and State Water Protection Requirements

5.1.1 Clean Water Act

Clean Water Act, Point Source Discharges requirements, 33 USC ' 1342 (applicable, substantive provisions only). Section 402 of the Clean Water Act, 33 USC ' 1342, et seq., authorizes the issuance of permits for the Adischarge@ of any Apollutant.@ This includes storm water discharges associated with Aindustrial activity.@ See, 40 CFR ' 122.1(b)(2)(iv). AIndustrial activity includes inactive mining operations that discharge storm water contaminated by contact with or that has come into contact with any overburden, raw material, intermediate products, finished products, byproducts or waste products located on the site of such operations, see, 40 CFR ' 122.26(b)(14)(iii); landfills, land application sites, and open dumps that receive or have received any industrial wastes including those subject to regulation under RCRA subtitle D, see, 40 CFR ' 122.26(b)(14)(v); and construction activity including clearing, grading, and excavation activities, see, 40 CFR ' 122.26(b)(14)(x). Because the State of Montana has been delegated the authority to implement the Clean Water Act, these requirements are enforced in Montana through the Montana Pollutant Discharge Elimination System (MPDES). The MPDES requirements are set forth below.

5.1.2 Montana Pollutant Discharge Elimination System Requirements

Substantive MPDES Permit Requirements, ARM 17.30.1342-1344 (applicable). These set forth the substantive requirements applicable to all MPDES and National Pollutant Discharge Elimination System (NPDES) permits. The substantive requirements, including the requirement to properly operate and maintain all facilities and systems of treatment and control are applicable requirements for a repository containing mine waste.

Technology-Based Treatment, ARM 17.30.1203 and 1344 (applicable). Provisions of 40 CFR Part 125 for criteria and standards for the imposition of technology-based treatment requirements are adopted and incorporated in MPDES permits. Although the permit requirement would not apply to on-site discharges, the substantive requirements of Part 125 are applicable, i.e., for toxic and nonconventional pollutants treatment must apply the best available technology economically achievable (BAT); for conventional pollutants, application of the best conventional pollutant control technology (BCT) is required. Where effluent limitations are not specified for the particular industry or industrial category at issue, BCT/BAT technology-based treatment requirements are determined on a case by case basis using best professional judgment (BPJ). See CERCLA Compliance with Other Laws Manual, Vol. I, August 1988, p. 3-4 and 3-7.

5.1.3 Water Quality Statutes and Regulations

Causing of Pollution, Section 75-5-605, MCA (applicable). This section of the Montana Water Quality Act prohibits the causing of pollution of any state waters. Pollution is defined as contamination or other alteration of physical, chemical, or biological properties of state waters which exceeds that permitted by the water quality standards. Also, it is unlawful to place or caused to be placed any wastes where they will cause pollution of any state waters.

Nondegradation, Section 75-5-303, MCA (applicable). This provision states that existing uses of state waters and the level of water quality necessary to protect the uses must be maintained and protected. Section 75-5-317, MCA, provides an exemption from nondegradation requirements which allows changes of existing water quality resulting from an emergency or Reclamation that is designed to protect the public health or the environment and that is approved, authorized, or required by the department. Degradation meeting these requirements may be considered nonsignificant.

Surface Water, ARM 17.30.637 (applicable). Prohibits discharges containing substances that will: (a) settle to form objectionable sludge deposits or emulsions beneath the surface of the water or upon adjoining shorelines; (b) create floating debris, scum, a visible oil film (or be present in concentrations at or in excess of 10 milligrams per liter) or globules of grease or other floating materials; (c) produce odors, colors or other conditions which create a nuisance or render undesirable tastes to fish flesh or make fish inedible; (d) create concentrations or combinations of materials which are toxic or harmful to human, animal, plant or aquatic life; or (e) create conditions which produce undesirable aquatic life.

ARM 17.30.705 (applicable). This provides that forall state waters, existing and anticipated uses and the water quality necessary to protect these uses must be maintained and protected unless degradation is allowed under the nondegradation rules at ARM 17.30.708.

5.1.4 Stormwater Runoff Control Requirements

ARM 17.24.633 (applicable). All surface drainage from a disturbed area must be treated by the best technology currently available.

General Permits (applicable). Pursuant to ARM 17.30.1341, DEQ has issued general storm water permits for certain activities. The substantive requirements of the following permits are applicable for the following activities: for construction activities B General Permit for Storm Water Discharge Associated with Construction Activity, Permit No. MTR100000 (April 16, 2007); for mining activities B General Discharge Permit for Storm Water Associated with Mining and with Oil and Gas Activities, Permit No. MTR300000 (November 17, 2002);[5] and for industrial activities B General Permit for Storm Water Discharge Associated with Industrial Activity, Permit No. MTR000000 (October 1, 2006).[6]

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5 This permit covers point source discharges of storm water from mining and milling activities (including active, inactive, and abandoned mine and mill sites) including activities with Standard Industrial Code 14 (metal mining).

6 Industrial activities are defined as all industries defined in 40 CFR ' ' 122, 123, and 124, excluding construction, mining, oil & gas extraction activities and storm water discharges subject to effluent limitations guidelines. This includes wood treatment operations, as well as the production of slag.

Generally, the permits require the permittee to implement best management practice (BMP) and to take all reasonable steps to minimize or prevent any discharge which has a reasonable likelihood of adversely affecting human health or the environment. However, if there is evidence indicating potential or realized impacts on water quality due to any storm water discharge associated with the activity, an individual MPDES permit or alternative general permit may be required.

A related mine reclamation requirement is set out in ARM 17.24.633 (relevant and appropriate), which requires that all surface drainage from disturbed areas that have been graded, seeded or planted must be treated by the best technology currently available (BTCA) before discharge. Sediment control through BTCA practices must be maintained until the disturbed area has been reclaimed, the revegetation requirements have been met, and the area meets state and federal requirements for the receiving stream.

5.2 Federal and State RCRA Subtitle C Requirements

Federal and State RCRA Subtitle C Requirements, 42 U.S.C. Section 6921, et seq. (relevant and appropriate for solid wastes, applicable for hazardous wastes). The presentation of RCRA Subtitle C requirements in this section assumes that there will be solid wastes left in place in Awaste management areas@ (i.e., a repository) as a result of Reclamation. Because of the similarity of this waste management area to the RCRA Awaste management unit,@ certain discrete portions of the RCRA Subtitle C implementing regulations will be relevant and appropriate for Reclamation. RCRA Subtitle C and implementing regulations are designated as applicable for any hazardous wastes that are actively Agenerated@ as part of this remedial action or that were Aplaced@ or Adisposed@ after 1980. Also, should hazardous wastes be discovered as part of any Reclamation , EPA reserves the right to identify RCRA Subtitle C requirements in more detail at a later date. All federal RCRA Subtitle C requirements set forth below are incorporated by reference as State of Montana requirements as provided for under ARM 17.53.105(2) unless mentioned otherwise below.

40 CFR Part 264 Subpart F.

General Facility Standards. These are potentially relevant and appropriate for solid wastes at Reclamation sites. Any waste management unit or similar area would be required to comply with the following requirements.

> **40 CFR ' 264.92, .93. and .94.** Prescribes groundwater protection standards.
>
> **40 CFR ' 264.97.** Prescribes general groundwater monitoring requirements.
>
> **40 CFR ' 264.98.** Prescribes requirements for monitoring and detecting indicator parameters.

Closure requirements.

> **40 CFR ' 264.111.** Provides that the owner or operator of a hazardous waste management facility must close the facility in a way that minimizes the need for further maintenance, and controls or eliminates the leaching or escape of hazardous waste or its constituents, leachate, or runoff to the extent necessary to protect human health and the environment.

40 CFR ' 264.117. Incorporates monitoring requirements in Part 264, including those mentioned at Part 264.97 and Part 264.303. It governs the length of the post-closure care period, permits a lengthened security period, and prohibits any use of the property which would disturb the integrity of the management facility.

40 CFR ' 264.310. Specifies requirements for caps, maintenance, and monitoring after closure.

40 CFR ' 264.301. Prescribes design and operating requirements for landfills.

40 CFR ' 264.301(a). Provides for a single liner and leachate collection and removal system.

40 CFR ' 264.301(f). Requires a run-on control system.

40 CFR ' 264.301(g). Requires a run-off management system.

40 CFR ' 264.301(h). Requires prudent management of facilities for collection and holding of run-on and run-off.

40 CFR ' 264.301(i). Requires that wind dispersal of particulate matter be controlled.

5.3 Federal and State RCRA Subtitle D and Solid Waste Management Requirements

40 CFR Part 257 establishes criteria under Subtitle D of the Resource Conservation and Recovery Act for use in determining which solid waste disposal facilities and practices pose a reasonable probability of adverse effects on health or the environment. See 40 CFR ' 257.1(a). This part comes into play whenever there is a Adisposal@ of any solid or hazardous waste from a Afacility.@ ADisposal@ is defined as Athe discharge, deposit, injection, dumping, spilling, leaking, or placing of any solid waste or hazardous waste into or on any land or water so that such solid waste or hazardous waste or any constituent thereof may enter the environment or be emitted into the air or discharged into any waters, including ground waters.@ See 40 CFR ' 257.2. AFacility@ means Aany land and appurtenances thereto used for the disposal of solid wastes.@ Solid waste requirements are either applicable to mine wastes as solid waste or are relevant and appropriate for the management, handling, storage, monitoring and disposal of the mine wastes to be addressed in a Reclamation Project.

5.3.1. Federal Requirements

40 CFR ' 257 (applicable). ExtablishesCriteria for Classification of Solid Waste Disposal Facilities and Practices. Reclamation will comply with the following requirements.

40 CFR ' 257.3-1. Washout of solid waste in facilities in a floodplain posing a hazard to human life, wildlife, or land or water resources shall not occur.

40 CFR ' 257.3-2. Facilities shall not contribute to the taking of endangered species or the endangering of critical habitat of endangered species.

40 CFR ' 257.3-3. A facility shall not cause a discharge of pollutants, dredged or fill material, into waters of the United States in violation of Sections 402 and 404 of the

Clean Water Act, as amended, and shall not cause non-point source pollution, in violation of applicable legal requirements implementing an area wide or statewide water quality management plan that has been approved by the Administrator under Section 208 of the Clean Water Act, as amended.

<u>40 CFR ' 257.3-4</u>. A facility shall not contaminate an underground source of drinking water beyond the solid waste boundary or beyond an alternative boundary specified in accordance with this section.

<u>40 CFR ' 257.3-8(d)</u>. Access to a facility shall be controlled so as to prevent exposure of the public to potential health and safety hazards at the site.

5.3.2. State of Montana Solid Waste Requirements.

The Montana Solid Waste Management Act, Section 75-10-201 et seq., MCA, and regulations are applicable to the management and disposal of all solid wastes, including mine wastes at sites that are not currently subject to operating permit requirements.

<u>ARM ' 17.50.505(1) and (2) (applicable)</u>. Sets forth standards that all solid waste disposal sites must meet, including the requirements that (1) Class II landfills must confine solid waste and leachate to the disposal facility. If there is the potential for leachate migration, it must be demonstrated that leachate will only migrate to underlying formations which have no hydraulic continuity with any state waters; (2) adequate separation of group II wastes from underlying or adjacent water must be provided[7]; and (3) no new disposal units or lateral expansions may be located in wetlands. ARM 17.50.505 also specifies general soil and hydrogeological requirements pertaining to the location of any solid waste management facility.

<u>ARM 17.50.506 (applicable)</u>. Specifies design requirements for landfills. Landfills must either be designed to ensure that MCLs are not exceeded or the landfill must contain a composite liner and leachate collection system which comply with specified criteria.

<u>ARM 17.50.511 (applicable)</u>. Sets forth operational and maintenance and design requirements for solid waste management facilities using land filling methods. Specific requirements specified in ARM 17.50.511 that are applicable are run-on and run-off control systems requirements, requirements that sites be fenced to prevent unauthorized access, and prohibitions of point source and nonpoint source discharges which would violate Clean Water Act requirements.

[7] The extent of separation shall be established on a case-by-case basis, considering terrain and the type of underlying soil formations, and facility design.

ARM 17.50.523 (applicable). Specifies that solid waste must be transported in such a manner as to prevent its discharge, dumping, spilling or leaking from the transport vehicle.

ARM 17.50.530 (applicable). Sets forth the closure requirements for landfills. Class II landfills must meet the following criteria: (1) install a final cover that is designed to minimize infiltration and erosion; (2) design and construct the final cover system to minimize infiltration through the closed unit by the use of an infiltration layer that contains a minimum 18 inches of earthen material and has a permeability less than or equal to the permeability of any bottom liner, barrier layer, or natural subsoils or a permeability no greater than 1 X 10-5 cm/sec, whichever is less; (3) minimize erosion of the final cover by the use of a seed bed layer that contains a minimum of six inches of earthen material that is capable of sustaining native plant growth and protecting the infiltration layer from frost effects and rooting damage; (4) revegetate the final cover with native plant growth within one year of placement of the final cover.

ARM17.50.531 (applicable). Sets forth post closure care requirements for Class II landfills. Post closure care must be conducted for a period sufficient to protect human health and the environment. Post closure care requires maintenance of the integrity and effectiveness of any final cover, including making repairs to the cover as necessary to correct the effects of settlement, subsidence, erosion, or other events, and preventing run-on and run-off from eroding or otherwise damaging the cover and comply with the groundwater monitoring requirements found at ARM Title 17, chapter 50, subchapter 7.

Section 75-10-206, MCA, allows variances to be granted from solid waste regulations if failure to comply with the rules does not result in a danger to public health or safety or compliance with specific rules would produce hardship without producing benefits to the health and safety of the public that outweigh the hardship.

5.4 Federal and State Mine Reclamation Requirements

5.4.1 Surface Mining Control and Reclamation Act

Surface Mining Control and Reclamation Act, 30 USC ' ' 1201-1326 (relevant and appropriate). This Act and implementing regulations found at 30 CFR Parts 784 and 816 establish provisions designed to protect the environment from the effects of surface coal mining operations, and to a lesser extent non-coal mining. These requirements are relevant and appropriate to the covering of discrete areas of contamination. The regulations require that revegetation be used to stabilize soil covers over reclaimed areas. They also require that revegetation be done according to a plan which specifies schedules, species which are diverse and effective, planting methods, mulching techniques, irrigation if appropriate, and appropriate soil testing. Reclamation performance standards are currently relevant and appropriate to mining waste sites.

5.4.2 Montana Statutory and Regulatory Requirements

Montana Strip and Underground Mine Reclamation Act, Section 82-4-201, et seq., MCA (relevant and appropriate) and Montana Metal Mining Act, Section 82-4-301, et seq., MCA (relevant and appropriate). The specified portions of the following statutory or regulatory provisions, as identified below, are relevant and appropriate requirements.

Section 82-4-231, MCA. Requires operators to reclaim and revegetate affected lands using most modern technology available. Operators must grade, backfill, topsoil, reduce high walls, stabilize subsidence, control water, minimize erosion, subsidence, land slides, and water pollution.

Section 82-4-233, MCA. Operators must plant vegetation that will yield a diverse, effective, and permanent vegetative cover of the same seasonal variety native to the area and capable of self-regeneration.

Section 82-4-336, MCA. Disturbed areas must be reclaimed to utility and stability comparable to adjacent areas.

ARM 17.24.501. Provides general backfilling and grading requirements. Backfill must be placed so as to minimize sedimentation, erosion, and leaching of acid or toxic materials into waters, unless otherwise approved. Final grading must be to the approximate original contour of the land and final slopes must be graded to prevent slope failure, may not exceed the angle of repose, and must achieve a minimum long term static safety factor of 1:3. The disturbed area must be blended with surrounding and undisturbed ground to provide a smooth transition in topography.

ARM 17.24.519. Requires monitoring of settling of regraded areas.

ARM 17.24.631(1), (2), (3)(a) and (b). Requires minimization of disturbances to the prevailing hydrologic balance. Changes in water quality and quantity, in the depth to groundwater and in the location of surface water drainage channels will be minimized. Other pollution minimization devices must be used if appropriate, including stabilizing disturbed areas through land shaping, diverting runoff, planting quickly germinating and growing stands of temporary vegetation, regulating channel velocity of water, lining drainage channels with rock or vegetation, mulching, and control of acid-forming, and toxic-forming waste materials.

ARM 17.24.633. Surface drainage from a disturbed area must be treated by the best technology currently available (BTCA). Treatment must continue until the area is stabilized.

ARM 17.24.634. Requires disturbed drainages be restored to the approximate pre-disturbance configuration. Drainage design must emphasize channel and floodplain dimensions that approximate the pre-mining configuration and that will blend with the undisturbed drainage above and below the area to be reclaimed. The average stream gradient must be maintained with a concave longitudinal profile. This regulation provides specific requirements for designing the reclaimed drainage to: (1) approximate an appropriate geomorphic habit or characteristic pattern; (2) remain in dynamic equilibrium with the system without the use of artificial structural controls; (3) improve unstable premining conditions; (4) provide for floods and for the long-term stability of the landscape; and (5) establish a premining diversity of aquatic habitats and riparian vegetation.

ARM 17.24.635 through 17.24.637 set forth requirements for temporary and permanent diversions.

ARM 17.24.638. Sediment control measures must be implemented during operations.

ARM 17.24.639. Sets forth requirements for construction and maintenance of sedimentation ponds.

ARM 17.24.640. Discharges from sedimentation ponds, permanent and temporary impoundments, must be controlled to reduce erosion and enlargement of stream channels, and to minimize disturbance of the hydrologic balance.

ARM 17.24.641. Establishes practices to avoid drainage from acid or toxic forming spoil material into ground and surface water.

ARM 17.24.643 through 17.24.646. Provisions for groundwater protection, groundwater recharge protection, and groundwater and surface water monitoring.

ARM 17.24.701 and 702. Requirements for redistributing and stockpiling of soil for reclamation. Also, outlines practices to prevent compaction, slippage, erosion, and deterioration of biological properties of soil.

ARM 17.24.703. When using materials other than, or along with, soil for final surfacing in reclamation, the operator must demonstrate that the material (1) is at least as capable as the soil of supporting the approved vegetation and subsequent land use, and (2) the medium must be the best available in the area to support vegetation. Such substitutes must be used in a manner consistent with the requirements for redistribution of soil in ARM 17.24.701 and 702.

ARM 17.24.711. Requires that a diverse, effective, and permanent vegetative cover of the same seasonal variety native to the area of land to be affected shall be established except on road surfaces and below the low-water line of permanent impoundments. See also Section 82-4-233, MCA (Relevant and Appropriate). Vegetative cover is considered of the same seasonal variety if it consists of a mixture of species of equal or superior utility when compared with the natural vegetation during each season of the year. This requirement may not be appropriate where other cover is more suitable for the particular land use or another cover is requested by the landowner.

ARM 17.24.713. Seeding and planting of disturbed areas must be conducted during the first appropriate period favorable for planting after final seedbed preparation.

ARM 17.24.714. Mulch or cover crop or both must be used until adequate permanent cover can be established.

ARM 17.24.716. Establishes method of revegetation.

ARM 17.24.717. Relates to the planting of trees and other woody species if necessary, as provided in Section 82-4-233, MCA, to establish a diverse, effective, and permanent vegetative cover of the same seasonal variety native to the affected area and capable of self-regeneration and plant succession at least equal to the natural vegetation of the area, except that introduced species may be used in the revegetation process where desirable and necessary to achieve the approved land use plan.

ARM 17.24.718. Requires soil amendments, irrigation, management, fencing, or other measures, if necessary to establish a diverse and permanent vegetative cover.

ARM 17.24.721. Specifies that rills or gullies in reclaimed areas must be filled, graded or otherwise stabilized and the area reseeded or replanted if the rills and gullies are disrupting the reestablishment of the vegetative cover or causing or contributing to a violation of water quality standards for a receiving stream.

ARM 17.24.723. States that operators shall conduct approved periodic measurements of vegetation, soils, water, and wildlife, and if data indicate that corrective measures are necessary, shall propose such measures.

ARM 17.24.724. Specifies that revegetation success must be measured against approved technical standards or unmined reference areas. Reference areas and standards must be representative of vegetation and related site characteristics occurring on lands exhibiting good ecological integrity. Required management for these reference areas is set forth.

ARM 17.24.726. Requires standard and consistent field and laboratory methods to obtain and evaluate revegetated area data with reference area data and/or technical standards, and sets out the required methods for measuring productivity.

ARM 17.24.731. If toxicity to plants or animals on the revegetated area or the reference area is suspected due to the effects of the disturbance, comparative chemical analyses may be required.

ARM 17.24.751. Sets forth requirements to protect and enhance fish and wildlife habitat.

ARM 17.24.824. If land use is to be other than grazing land or fish and wildlife habitat, areas of land affected by mining must be restored in a timely manner to higher or better uses achievable under criteria and procedures set forth.

5.5 Air Requirements

Remedial activities will comply with the Montana Ambient Air Quality Regulations (above) and with the following requirements to ensure that existing air quality will not be adversely affected by Reclamation.

ARM 17.8.308(1), (2) and (3) (applicable). Airborne particulate matter. There shall be no production, handling, transportation, or storage of any material, use of any street, road, or parking lot, or operation of a construction site or demolition project unless reasonable precautions are taken to control emissions of airborne particles. Emissions shall not exhibit an opacity exceeding 20% or greater averaged over 6 consecutive minutes.

ARM 17.8.304(2) (applicable). Visible Air Contaminants. Emissions into the outdoor atmosphere shall not exhibit an opacity of 20% or greater averaged over 6 consecutive minutes.

ARM 17.8.604 (applicable). Lists certain wastes that may not be disposed of by open burning, including oil or petroleum products, RCRA hazardous wastes, chemicals, and treated lumber and timbers. Any waste which is moved from the site where it was generated and any trade waste (material resulting from construction or operation of any business, trade, industry, or demolition project) may be open burned only in accordance with the substantive requirements of ARM 17.8.611 or 612.

ARM 17.24.761 (relevant and appropriate). Specifies a range of measures for controlling fugitive dust emissions during mining and reclamation activities. Some of these measures could be considered relevant and appropriate to control fugitive dust emissions in connection with excavation, earth moving and transportation activities conducted as part of Reclamation at the site. Such measures include, for example, paving, watering, chemically stabilizing, or frequently compacting and scraping roads, promptly removing rock, soil or other dust-forming debris from roads, restricting vehicle speeds, revegetating, mulching, or otherwise stabilizing the surface of areas adjoining roads, restricting unauthorized vehicle travel, minimizing the area of disturbed land, and promptly revegetating regraded lands.

5.6 Noxious Weeds

Noxious Weeds, Section 7-22-2101(8)(a), MCA. Defines "noxious weeds" as any exotic plant species established or that may be introduced in the state which may render land unfit for agriculture, forestry, livestock, wildlife, or other beneficial uses or that may harm native plant communities and that is designated: (I) as a statewide noxious weed by rule of the department; or (ii) as a district noxious weed by a board, following public notice of intent and a public hearing. Designated noxious weeds are listed in ARM 4.5.201 through 4.5.204 and must be managed consistent with weed management criteria developed under Section 7-22-2109(2)(b), MCA.

6.0 TO BE CONSIDERED (TBC) DOCUMENTS

A list of TBC documents is included in the Preamble to the NCP, 55 Fed. Reg. 8765 (March 8, 1990). Those documents, plus any additional similar or related documents issued since that time, should be considered during the conduct of the Reclamation design and construction.

7.0 OTHER LAWS (NON-EXCLUSIVE LIST)

CERCLA defines as ARARs only federal environmental and state environmental and siting laws. Reclamation design, implementation, and operation and maintenance must comply with other applicable laws, except as may be provided in SMCRA.

The following Aother laws@ are included here to provide a reminder of other legal requirements Reclamation activity. They are not an exhaustive list of such requirements, but are included because they set out matters that must be addressed and, in some cases, may require advance planning. They are not included as ARARs because they are not Aenvironmental or facility siting laws.@ Because they are not ARARs, they are not subject to ARAR waiver provisions.

7.1 Other Federal Laws

Occupational Safety and Health Regulations. The federal Occupational Safety and Health Act regulations found at 29 CFR Part 1910 and Part 1926 are applicable to worker protection during the conduct of Reclamation .

7.2 Other State Laws

A. Groundwater Act

The Groundwater Act, ' 85-2-501, et seq., MCA, and implementing regulations, ARM 17.30.601, et seq. govern uses of groundwater and provide measures to protect groundwater from depletion or contamination. The regulations also set requirements for water wells.

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

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

B. Public Water Supply Regulations

If remedial action at the site requires any reconstruction or modification of any public water supply line or sewer line, the construction standards specified in ARM 17.38.101(4) (Applicable) must be observed.

C. Water Rights

Section 85-2-101, MCA, declares that all waters within the state are the state's property, and may be appropriated for beneficial uses. The wise use of water resources is encouraged for the maximum benefit to the people and with minimum degradation of natural aquatic ecosystems.

Parts 3 and 4 of Title 85, Chapter 2, MCA, set out requirements for obtaining water rights and appropriating and utilizing water. All requirements of these parts are laws which must be complied with in any action using or affecting waters of the state. Some of the specific requirements are set forth below.

Section 85-2-301, MCA, of Montana law provides that a person may only appropriate water for a beneficial use.

Section 85-2-302, MCA, specifies that a person may not appropriate water or commence construction of diversion, impoundment, withdrawal or distribution works therefor except by applying for and receiving a permit from the Montana Department of Natural Resources and Conservation. While the permit itself may not be required under federal law, appropriate notification and submission of an application should be performed and a permit should be applied for in order to establish a priority date in the prior appropriation system.

Section 85-2-306, MCA, specifies the conditions on which groundwater may be appropriated, and, at a minimum, requires notice of completion and appropriation within 60 days of well completion.

Section 85-2-311, MCA, specifies the criteria which must be met in order to appropriate water and includes requirements that:

1. there are unappropriated waters in the source of supply;
2 the proposed use of water is a beneficial use; and
3. the proposed use will not interfere unreasonably with other planned uses or developments.

Section 85-2-402, MCA, specifies that an appropriator may not change an appropriated right except as provided in this section with the approval of the DNRC.

Section 85-2-412, MCA, provides that, where a person has diverted all of the water of a stream by virtue of prior appropriation and there is a surplus of water over and above what is actually and necessarily used, such surplus must be returned to the stream.

D. Controlled Ground Water Areas

Pursuant to Section 85-2-507, MCA, the Montana Department of Natural Resources and Conservation may grant either a permanent or a temporary controlled ground water area. The maximum allowable time for a temporary area is two years, with a possible two-year extension.

Pursuant to Section 85-2-506, MCA, designation of a controlled ground water area may be proposed if: (i) excessive ground water withdrawals would cause contaminant migration; (ii) ground water withdrawals adversely affecting ground water quality within the ground water area are occurring or are likely to occur; or (iii) ground water quality within the ground water area is not suited for a specific beneficial use.

E. Occupational Health Act, Section 50-70-101, et seq., MCA.

ARM 17.74.101 addresses occupational noise. In accordance with this section, no worker shall be exposed to noise levels in excess of the levels specified in this regulation. This rule is applicable only to limited categories of workers and for most workers the similar federal standard in 29 CFR § 1910.95 applies.

ARM 17.74.102 addresses occupational air contaminants. The purpose of this rule is to establish maximum threshold limit values for air contaminants under which it is believed that nearly all workers may be repeatedly exposed day after day without adverse health effects. In accordance with this rule, no worker shall be exposed to air contaminant levels in excess of the threshold limit values listed in the rule. This rule is applicable only to limited categories of workers and for most workers the similar federal standard in 29 CFR § 1910.1000 applies.

F. Montana Safety Act

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

G. Employee and Community Hazardous Chemical Information

Sections 50-78-201, 202, and 204, MCA, state that each employer must post notice of employee rights, maintain at the work place a list of chemical names of each chemical in the work place, and indicate the work area where the chemical is stored or used. Employees must be informed of the chemicals at the work place and trained in the proper handling of the chemicals.

APPENDIX F
Estimated Response Action Costs

Engineer's Estimate

Mine Waste Alternative MW-1: Excavation and Disposal in On-Site Repository with Simple Soil Cover

Engineering Evaluation and Cost Analysis

Kennedy Creek Mining Complex - Nugget & Lost Cabin Mines

Cost Item	Units	Unit Cost		Quantity	Est. Subtotal		References / Comments
Road re-alignment & improvement							
Cut & chip trees	acre	$	7,200	0.1	$	720	assumes assocaited debris burned on site
Clearing and grubbing	acre	$	6,900	0.1	$	690	includes stump removal
Rough grading	HR	$	120	8	$	960	Assume a dozer with a ripper at $120/hr for 16 hours.
Fine Grading	HR	$	125	8	$	1,000	Excavator for 8 hrs at $125
Select limbing / tree removal	LS	$	1,000	1	$	1,000	engineer's estimate
				Subtotal	$	**4,370**	
Stream Diversions							
Diversion berm	ea	$	3,500	2	$	7,000	
Diversion piping, installed	LF		10.88	1,030	$	11,206	
Sedimentation basins	ea		3,500	2	$	7,000	
				Subtotal	$	**25,206**	
Lost Cabin Mine Waste Removal							
Excavate & Stockpile Non-Mine Fill	BCY	$	2.25	1,040	$	2,340	
Excavate, load, haul mine waste	CY	$	4.94	1,830	$	9,040	
Backfill - common earth	CY	$	2.69	1,040	$	2,798	backfill with stockpiled non-mine fill
Rough grading	CY	$	1.00	1,040	$	1,040	
Stream reconstruction	LF	$	38.00	420	$	15,960	
Salvage topsoil from borrow area	CY	$	19.71	420	$	8,278	
Import / spread topsoil	CY	$	4.44	420	$	1,865	
Fine grading	SY	$	1.00	2,500	$	2,500	
Revegetation	SY	$	0.49	2,500	$	1,225	
				Subtotal	$	**45,046**	
Nugget Mine Waste Removal							
Excavate & Stockpile Non-Mine Fill	BCY	$	2.25	1,310	$	2,948	
Excavate, load, haul mine waste	CY	$	4.94	2,020	$	9,979	
Backfill - common earth	CY	$	2.69	1,310	$	3,524	
Rough grading	CY	$	1.00	3,090	$	3,090	rough grade non-mine fill and remaining mine waste (1,780 CY)
Stream reconstruction	LF	$	38.00	560	$	21,280	
Salvage topsoil from borrow area	CY	$	19.71	680	$	13,403	
Import / spread topsoil	CY	$	4.44	680	$	3,019	
Fine grading	SY	$	1.00	4,100	$	4,100	
Revegetation	SY	$	0.49	4,100	$	2,009	
				Subtotal	$	**63,351**	
Repository Construction							
Surveying	LS	$	5,000	1	$	5,000	
Cut & chip trees	acre	$	7,200	1.5	$	10,800	assumes associated debris burned on site
Clearing and grubbing	acre	$	6,900	1.5	$	10,350	
Strip / stockpile topsoil	BCY	$	0.72	1,129	$	813	
Excavate / stockpile subsoil in footprint	BCY	$	2.25	4,517	$	10,164	assume 4 ft of subsoil excavated (Means)
Rough grade subgrade	HR	$	120	6	$	720	
Compact subgrade	ECY	$	1.26	1,210	$	1,525	

Engineer's Estimate

Mine Waste Alternative MW-1: Excavation and Disposal in On-Site Repository with Simple Soil Cover

Engineering Evaluation and Cost Analysis

Kennedy Creek Mining Complex - Nugget & Lost Cabin Mines

Cost Item	Units		Unit Cost	Quantity		Est. Subtotal	References / Comments
Place and compact tailings	LCY	$	5.78	4,810	$	27,802	assumes 25% bulking factor for loose (excavated) waste rock
Grade and shape tailings	LCY	$	2.62	4,810	$	12,602	
Replace subsoil & topsoil	LCY	$	2.62	6,353	$	16,644	
Broadcast seeding with hydromulch	SY	$	0.49	7,260	$	3,557	
Runoff / runon control ditches	LS	$	2,000	1	$	2,000	
Sediment/ erosion control	LS	$	1,500	1	$	1,500	silt fence, straw wattles, etc.
				Subtotal	$	**103,477**	
Subtotal - Direct Capital Costs					$	**241,450**	
Mobilization and Site Prep							
Mobilization	%	$	241,450	10%	$	24,145	
Construction BMPs	%	$	241,450	5%	$	12,073	
Demobilziation and Cleanup	LS	$	2,500	1	$	2,500	
				Subtotal	$	**38,718**	
Engineering / Support Costs							
Design, Project Management	%	$	241,450	12%	$	28,974	
Construction Management	%	$	241,450	10%	$	24,145	
				Subtotal	$	**53,119**	
Contingency							
25% of capital and construction costs	%	$	241,450	25%	$	60,363	
TOTAL DESIGN AND CONSTRUCTION COSTS					$	**393,649**	

Assumptions

1. Approximately 2,020 BCY and 1,830 BCY of mine waste at the Nugget and Lost Cabin Mines to be removed, respectively.
2. An additional 1,310 BCY and 1040 BCY of surficial (non-mine waste) fill are present at the Nugget and Lost Cabin Mines, respectively.
3. Topsoil will be salvaged within the potential repository area for placement at the reclaimed mines and use in respository cover.
4. Total depth of mine waste within the repository will be four feet.
5. Four feet of subsoil will be excavated from the repository foot-print. Subsoil will be used for cover construction and mine site reclamation
6. No liner will be required for the repository.
7. Existing on-site materials are suitable for constructing the repository base and cover layers.
8. The existing access road to the repository is sufficient for construction purposes and no improvements will be required.
9. Minimal improvements to the mine access road are required, including removal of select trees & tree limbs.
10. The mine access road will be re-aligned to the northwest around the existing slump. The total linear distance of the re-aligment will be 120 ft.
11. Debris from clearing and grubbing will be burned on site.

Engineer's Estimate

Mine Waste Alternative MW-2: Excavation and Disposal in On-Site Repository with Composite Cover

Engineering Evaluation and Cost Analysis

Kennedy Creek Mining Complex - Nugget & Lost Cabin Mines

Cost Item	Units		Unit Cost	Quantity		Est. Subtotal	References / Comments
Road re-alignment & improvement							
Cut & chip trees	acre	$	7,200	0.1	$	720	assumes assocaited debris burned on site
Clearing and grubbing	acre	$	6,900	0.1	$	690	includes stump removal
Rough grading	HR	$	120	8	$	960	Assume a dozer with a ripper at $120/hr for 16 hours.
Fine Grading	HR	$	125	8	$	1,000	Excavator for 8 hrs at $125
Select limbing / tree removal	LS	$	1,000	1	$	1,000	engineer's estimate
				Subtotal	$	**4,370**	
Stream Diversions							
Diversion berm	ea	$	3,500	2	$	7,000	
Diversion piping, installed	LF		10.88	1,030	$	11,206	
Sedimentation basins	ea		3,500	2	$	7,000	
				Subtotal	$	**25,206**	
Lost Cabin Mine Waste Removal							
Excavate & Stockpile Non-Mine Fill	BCY	$	2.25	1,040	$	2,340	
Excavate, load, haul mine waste	CY	$	4.94	1,830	$	9,040	
Backfill - common earth	CY	$	2.69	1,040	$	2,798	backfill with stockpiled non-mine fill
Rough grading	CY	$	1.00	1,040	$	1,040	
Stream reconstruction	LF	$	38.00	420	$	15,960	
Salvage topsoil from borrow area	CY	$	19.71	420	$	8,278	
Import / spread topsoil	CY	$	4.44	420	$	1,865	
Fine grading	SY	$	1.00	2,500	$	2,500	
Revegetation	SY	$	0.49	2,500	$	1,225	
				Subtotal	$	**45,046**	
Nugget Mine Waste Removal							
Excavate & Stockpile Non-Mine Fill	BCY	$	2.25	1,310	$	2,948	
Excavate, load, haul mine waste	CY	$	4.94	2,020	$	9,979	
Backfill - common earth	CY	$	2.69	1,310	$	3,524	
Rough grading	CY	$	1.00	3,090	$	3,090	rough grade non-mine fill and remaining mine waste (1,780 CY)
Stream reconstruction	LF	$	38.00	560	$	21,280	
Salvage topsoil from borrow area	CY	$	19.71	680	$	13,403	
Import / spread topsoil	CY	$	4.44	680	$	3,019	
Fine grading	SY	$	1.00	4,100	$	4,100	
Revegetation	SY	$	0.49	4,100	$	2,009	
				Subtotal	$	**63,351**	
Repository Contstruction							
Surveying	LS	$	5,000	1	$	5,000	
Cut & chip trees	acre	$	7,200	1.5	$	10,800	assumes associated debris burned on site
Clearing and grubbing	acre	$	6,900	1.5	$	10,350	
Strip / stockpile topsoil	BCY	$	0.72	1,129	$	813	
Excavate / stockpile subsoil in footprint	BCY	$	2.25	4,517	$	10,164	assume 4 ft of subsoil excavated (Means)
Rough grade subgrade	HR	$	120	6	$	720	
Compact subgrade	ECY	$	1.26	1,210	$	1,525	
Place and compact tailings	LCY	$	5.78	4,810	$	27,802	assumes 25% bulking factor for loose (excavated) waste rock
Grade and shape tailings	LCY	$	2.62	4,810	$	12,602	
Geosynthetic cover, installed	SY	$	12.14	3,400	$	41,276	Layfield budgetary estimate, includes installation

Engineer's Estimate

Mine Waste Alternative MW-2: Excavation and Disposal in On-Site Repository with Composite Cover

Engineering Evaluation and Cost Analysis

Kennedy Creek Mining Complex - Nugget & Lost Cabin Mines

Cost Item	Units	Unit Cost		Quantity	Est. Subtotal		References / Comments
Deliver drain rock to site	CY	$	27.50	1,700	$	46,750	
Cover drainage layer installation	SY	$	5.00	3,400	$	17,000	
Replace subsoil & topsoil	LCY	$	2.62	6,353	$	16,644	
Broadcast seeding with hydromulch	SY	$	0.49	7,260	$	3,557	1.5 acre dsiturbed area
Runoff / runon control ditches	LS	$	2,000	1	$	2,000	
Sediment/ erosion control	LS	$	1,500	1	$	1,500	silt fence, straw wattles, etc.
				Subtotal	**$**	**208,503**	
Subtotal - Direct Capital Costs					**$**	**346,476**	
Mobilization and Site Prep							
Mobilziation	%	$	346,476	10%	$	34,648	
Construction BMPs	%	$	346,476	5%	$	17,324	
Demobilziation and Cleanup	LS	$	2,500	1	$	2,500	
				Subtotal	**$**	**54,471**	
Engineering / Support Costs							
Design, Project Management	%	$	346,476	12%	$	41,577	
Construction Management	%	$	346,476	10%	$	34,648	
				Subtotal	**$**	**76,225**	
Contingency							
25% of capital and construction costs	%	$	346,476	25%	$	86,619	
TOTAL DESIGN AND CONSTRUCTION COSTS					**$**	**563,791**	

Assumptions

1. Approximately 2,020 BCY and 1,830 BCY of mine waste at the Nugget and Lost Cabin Mines to be removed, respectively.
2. An additional 1,310 BCY and 1040 BCY of surficial (non-mine waste) fill are present at the Nugget and Lost Cabin Mines, respectively.
3. Topsoil will be salvaged within the potential repository area for placement at the reclaimed mines and use in respository cover.
4. Total depth of mine waste within the repository will be four feet.
5. Four feet of subsoil will be excavated from the repository foot-print. Subsoil will be used for cover construction and mine site reclamation
6. No liner will be required for the repository base. Geomembrane (HDPE) layer included in composite repository cover.
7. Existing on-site materials are suitable for constructing the repository base and cover layers, excluding cover drainage layer.
8. Material will be imported for construction of the repository cover drainage layer.
9. The existing access road to the repository is sufficient for construction purposes and no improvements will be required.
10. Minimal improvements to the mine access road are required, including removal of select trees & tree limbs.
11. The mine access road will be re-aligned to the northwest around the existing slump. The total linear distance of the re-aligment will be 120 ft.
12. Debris from clearing and grubbing will be burned on site.

Engineer's Estimate

Adit Discharge Alternative AD-1: Infiltration

Engineering Evaluation and Cost Analysis

Kennedy Creek Mining Complex - Nugget Mine

Cost Item	Units	Unit Cost	Quantity	Est. Subtotal	References / Comments
Infiltration Gallery Construction					
Surveying	LS	$ 2,500	1	$ 2,500	
Adit barrier	LS	$ 1,500	1	$ 1,500	cover over adit entrance
Excavate infiltration gallery	BCY	$ 2.25	2200	$ 4,950	assumes gallery is 100 ft x 200 ft, excavted to 3 ft bgs
Drain rock, delivered	LCY	$ 27.50	740	$ 20,350	gravel layer 1 ft deep across basin
Backfill infiltration gallery	LCY	$ 3.57	740	$ 2,642	includes haul from staging area, placement in trench
Import / spread topsoil	LCY	$ 24.15	135	$ 3,260	includes salvage costs
Broadcast seeding w/ hydromulch	SY	$ 0.49	2,200	$ 1,078	Northwest Landscaping est. (Elmo)
Misc. materials / piping	LS	$ 10,000	1	$ 10,000	
Subtotal - Direct Capital Costs				**$ 43,780**	
Mobilization and Site Prep					
Mobilziation	%	$ 43,780	10%	$ 4,378	
Construction BMPs	%	$ 43,780	5%	$ 2,189	
Demobilziation and Cleanup	LS	$ 2,500	1	$ 2,500	
			Subtotal	**$ 9,067**	
Engineering / Support Costs					
Infiltration testing & groundwater investigation	LS	$ 14,000	1	$ 14,000	
Design, Project Management	%	$ 43,780	12%	$ 5,254	
Construction Management	%	$ 43,780	10%	$ 4,378	
			Subtotal	**$ 23,632**	
Contingency					
25% of capital and construction costs	%	$ 43,780	25%	$ 10,945	
TOTAL DESIGN AND CONSTRUCTION COST				**$ 87,424**	

Assumptions

1. Construction would occur following removal of mine waste and completion of rough grading at the Nugget mine.
2. Topsoil salvage within the potential repository area would be used for reclamation.
3. Depth to groundwater at the site is sufficient for installation / operation of a subsurface infiltration gallery.
4. Subsoil below the gallery will have sufficient infiltration rates to accept discharges.

Engineer's Estimate

Adit Discharge Alternative AD-2: Bioreactor & Infiltration

Engineering Evaluation and Cost Analysis

Kennedy Creek Mining Complex - Nugget Mine

Cost Item	Units	Unit Cost	Quantity	Est. Subtotal	References / Comments
Bioreactors					
6 ft diam. concrete tank	EA	$ 2,535	2	$ 5,070	includes base and hing-assisted lid. Robertson Manufacturing.
Washed gravel, delivered	LCY	$ 27.50	10	$ 275	
Organic substrate (wood chips, hay, etc.)	LS	$ 500	1	$ 500	
Excavation / vessel installation	LS	$ 5,000	1	$ 5,000	
Misc. materials / piping	LS	$ 10,000	1	$ 10,000	
			Subtotal	**$ 20,845**	
Infiltration Gallery Construction					
Surveying	LS	$ 2,500	1	$ 2,500	
Adit barrier	LS	$ 1,500	1	$ 1,500	cover over adit entrance
Excavate infiltration gallery	BCY	$ 2.25	2200	$ 4,950	assumes gallery is 100 ft x 200 ft, excavted to 3 ft bgs
Drain rock, delivered	LCY	$ 27.50	740	$ 20,350	gravel layer 1 ft deep across basin
Backfill infiltration gallery	LCY	$ 3.57	740	$ 2,642	includes haul from staging area, placement in trench
Import / spread topsoil	LCY	$ 24.15	135	$ 3,260	includes salvage costs
Broadcast seeding w/ hydromulch	SY	$ 0.49	2,200	$ 1,078	Northwest Landscaping est. (Elmo)
Misc. materials / piping	LS	$ 10,000	1	$ 10,000	
			Subtotal	**$ 46,280**	
Subtotal - Direct Capital Costs				**$ 67,125**	
Mobilization and Site Prep					
Mobilziation	%	$ 67,125	10%	$ 6,713	
Construction BMPs	%	$ 67,125	5%	$ 3,356	
Demobilziation and Cleanup	LS	$ 2,500	1	$ 2,500	
			Subtotal	**$ 12,569**	
Engineering / Support Costs					
Infiltration testing & groundwater investigation	LS	$ 14,000	1	$ 14,000	
Design, Project Management	%	$ 67,125	12%	$ 8,055	
Construction Management	%	$ 67,125	10%	$ 6,713	
			Subtotal	**$ 28,768**	
Contingency					
25% of capital and construction costs	%	$ 67,125	25%	$ 16,781	
Operation and Maintenance Costs					
O&M Net Present Value	NPV	$ 120,012	1	$ 120,012	
TOTAL DESIGN, CONSTRUCTION, & OPERATION COSTS				**$ 245,254**	

Assumptions

1. Construction would occur following removal of mine waste and completion of rough grading at the Nugget mine.
2. Topsoil salvage within the potential repository area would be used for reclamation.
3. Depth to groundwater at the site is sufficient for installation / operation of a subsurface infiltration gallery.
4. Subsoil below the gallery will have sufficient infiltration rates to accept discharges.
5. Bioreactor media would require replacement every 5 years.
6. Spent bioreactor media would be non-hazardous waste and disposed of at the Allied Waste landfill in Missoula, MT

Engineer's Estimate

Annual Maintenance and Operation Costs

Adit Discharge Alternative AD-2: Bioreactor & Infiltration

Engineering Evaluation and Cost Analysis

Kennedy Creek Mining Complex - Nugget Mine

Year	Annual Monitoring Costs	Annual Maintenance Costs	Total Annual Costs
1	$ 3,000	$ 750	$ 3,750
2	$ 3,105	$ 776	$ 3,881
3	$ 3,214	$ 803	$ 4,017
4	$ 3,326	$ 832	$ 4,158
5	$ 3,443	$ 5,738	$ 9,180
6	$ 3,563	$ 891	$ 4,454
7	$ 3,688	$ 922	$ 4,610
8	$ 3,817	$ 954	$ 4,771
9	$ 3,950	$ 988	$ 4,938
10	$ 4,089	$ 6,814	$ 10,903
11	$ 4,232	$ 1,058	$ 5,290
12	$ 4,380	$ 1,095	$ 5,475
13	$ 4,533	$ 1,133	$ 5,667
14	$ 4,692	$ 1,173	$ 5,865
15	$ 4,856	$ 8,093	$ 12,950
16	$ 5,026	$ 1,257	$ 6,283
17	$ 5,202	$ 1,300	$ 6,502
18	$ 5,384	$ 1,346	$ 6,730
19	$ 5,572	$ 1,393	$ 6,966
20	$ 5,768	$ 9,613	$ 15,380
21	$ 5,969	$ 1,492	$ 7,462
22	$ 6,178	$ 1,545	$ 7,723
23	$ 6,395	$ 1,599	$ 7,993
24	$ 6,618	$ 1,655	$ 8,273
25	$ 6,850	$ 11,417	$ 18,267
26	$ 7,090	$ 1,772	$ 8,862
27	$ 7,338	$ 1,834	$ 9,172
28	$ 7,595	$ 1,899	$ 9,493
29	$ 7,861	$ 1,965	$ 9,826
30	$ 8,136	$ 13,559	$ 21,695
	Net Present Value of Annual Costs		**$120,011.77**

30-year nominal discount rate[1]	4.20%
Annual Escalation Rate	3.50%

Source:

[1] U.S. Office of Management and Budget, 2010. Circular A-94 Discount Rates for Cost-Effectiveness, Lease Purchase, and Related Analyses. Rev. Dec. 2010.

Engineer's Estimate

Adit Discharge Alternative AD-3: Apatite II Reactors & Infiltration

Engineering Evaluation and Cost Analysis

Kennedy Creek Mining Complex - Nugget Mine

Cost Item	Units	Unit Cost	Quantity	Est. Subtotal	References / Comments
Apatite II Reactors					
6 ft diam. concrete tank	EA	$ 2,535	2	$ 5,070	includes base and hinge-assisted lid. Robertson Manufacturing.
Jaeger Tri-packs	CF	$ 3.00	130	$ 390	
Apatite II	LBM	$ 2.65	5775	$ 15,304	3 supersacks (1925 lbs ea). Includes shipping.
Excavation / vessel installation	LS	$ 5,000	1	$ 5,000	
Misc. materials / piping	LS	$ 10,000	1	$ 10,000	
			Subtotal	**$ 35,764**	
Infiltration Gallery Construction					
Surveying	LS	$ 2,500	1	$ 2,500	
Adit barrier	LS	$ 1,500	1	$ 1,500	cover over adit entrance
Excavate infiltration gallery	BCY	$ 2.25	2200	$ 4,950	assumes gallery is 100 ft x 200 ft, excavted to 3 ft bgs
Drain rock, delivered	LCY	$ 27.50	740	$ 20,350	gravel layer 1 ft deep across basin
Backfill infiltration gallery	LCY	$ 3.57	740	$ 2,642	includes haul from staging area, placement in trench
Import / spread topsoil	LCY	$ 24.15	135	$ 3,260	includes salvage costs
Broadcast seeding w/ hydromulch	SY	$ 0.49	2,200	$ 1,078	Northwest Landscaping est.
Misc. materials / piping	LS	$ 10,000	1	$ 10,000	
			Subtotal	**$ 43,780**	
Subtotal - Direct Capital Costs				**$ 79,544**	
Mobilization and Site Prep					
Mobilziation	%	$ 79,544	10%	$ 7,954	
Construction BMPs	%	$ 79,544	5%	$ 3,977	
Demobilziation and Cleanup	LS	$ 2,500	1	$ 2,500	
			Subtotal	**$ 14,432**	
Engineering / Support Costs					
Infiltration testing & groundwater investigation	LS	$ 14,000	1	$ 14,000	
Design, Project Management	%	$ 79,544	12%	$ 9,545	
Construction Management	%	$ 79,544	10%	$ 7,954	
			Subtotal	**$ 31,500**	
Contingency					
25% of capital and construction costs	%	$ 79,544	25%	$ 19,886	
Operation and Maintenance Costs					
O&M Net Present Value	NPV	$ 179,271	1	$ 179,271	
TOTAL DESIGN, CONSTRUCTION, & OPERATION COSTS				**$ 324,632**	

Assumptions

1. Construction would occur following removal of mine waste and completion of rough grading at the Nugget mine.
2. Topsoil salvage within the potential repository area would be used for reclamation.
3. Depth to groundwater at the site is sufficient for installation / operation of a subsurface infiltration gallery.
4. Subsoil below the gallery will have sufficient infiltration rates to accept discharges.
5. Apaptitie II media would require replacement every 5 years.
6. Spent reactor media would be non-hazardous waste and would be disposed of at Allied Waste landfill in Missoula, MT.

Engineer's Estimate

Annual Maintenance and Operation Costs

Adit Discharge Alternative AD-3: Apatite II Reactors & Infiltration

Engineering Evaluation and Cost Analysis

Kennedy Creek Mining Complex - Nugget Mine

Year	Annual Monitoring Costs	Annual Maintenance Costs	Total Annual Costs
1	$ 3,000	$ 500	$ 3,500
2	$ 3,105	$ 518	$ 3,623
3	$ 3,214	$ 536	$ 3,749
4	$ 3,326	$ 554	$ 3,881
5	$ 3,443	$ 20,082	$ 23,524
6	$ 3,563	$ 594	$ 4,157
7	$ 3,688	$ 615	$ 4,302
8	$ 3,817	$ 636	$ 4,453
9	$ 3,950	$ 658	$ 4,609
10	$ 4,089	$ 23,851	$ 27,939
11	$ 4,232	$ 705	$ 4,937
12	$ 4,380	$ 730	$ 5,110
13	$ 4,533	$ 756	$ 5,289
14	$ 4,692	$ 782	$ 5,474
15	$ 4,856	$ 28,327	$ 33,183
16	$ 5,026	$ 838	$ 5,864
17	$ 5,202	$ 867	$ 6,069
18	$ 5,384	$ 897	$ 6,281
19	$ 5,572	$ 929	$ 6,501
20	$ 5,768	$ 33,644	$ 39,411
21	$ 5,969	$ 995	$ 6,964
22	$ 6,178	$ 1,030	$ 7,208
23	$ 6,395	$ 1,066	$ 7,460
24	$ 6,618	$ 1,103	$ 7,721
25	$ 6,850	$ 39,958	$ 46,808
26	$ 7,090	$ 1,182	$ 8,271
27	$ 7,338	$ 1,223	$ 8,561
28	$ 7,595	$ 1,266	$ 8,860
29	$ 7,861	$ 1,310	$ 9,171
30	$ 8,136	$ 47,458	$ 55,593
	Net Present Value of Annual Costs		**$179,270.95**

30-year nominal discount rate[1] 4.20%

Annual Escalation Rate 3.50%

Source:

[1] U.S. Office of Management and Budget, 2010. Circular A-94 Discount Rates for Cost-Effectiveness, Lease Purchase, and Related Analyses. Rev. Dec. 2010.

Engineer's Estimate

Adit Discharge Alternative AD-4: Constructed Wetlands & Infiltration

Engineering Evaluation and Cost Analysis

Kennedy Creek Mining Complex - Nugget Mine

Cost Item	Units	Unit Cost	Quantity	Est. Subtotal	Comments
Constructed Wetlands					
Surveying	LS	$ 5,000	1	$ 5,000	
Excavate forebay	BCY	$ 7.45	110	$ 820	
Rip rap, delivered	LCY	$ 27.50	140	$ 3,850	
Excavate / grade treatment wetland	BCY	$ 5.00	600	$ 3,000	assume wetland area is 60 ft x 150 ft x 2 ft (deep)
Import / spread topsoil	LCY	$ 24.15	135	$ 3,260	includes salvage costs
Wetland sod mats, includes transportation	SY	$ 35.44	850	$ 30,124	
Wetland mat installation	SY	$ 0.82	850	$ 697	
Broadcast seeding w/ hydromulch	SY	$ 0.49	1000	$ 490	Northwest Landscaping est. (Elmo)
Misc. materials / piping / outlet structure	LS	$ 10,000	1	$ 10,000	
			Subtotal	**$ 57,241**	
Infiltration Gallery Construction					
Adit barrier	LS	$ 1,500	1	$ 1,500	cover over adit entrance
Excavate infiltration gallery	BCY	$ 2.25	2200	$ 4,950	assumes gallery is 100 ft x 200 ft, excavted to 3 ft bgs
Drain rock, delivered	LCY	$ 27.50	740	$ 20,350	gravel layer 1 ft deep across basin
Backfill infiltration gallery	LCY	$ 3.57	740	$ 2,642	includes haul from staging area, placement in trench
Import / spread topsoil	LCY	$ 24.15	135	$ 3,260	includes salvage costs
Broadcast seeding w/ hydromulch	SY	$ 0.49	2,200	$ 1,078	Northwest Landscaping est. (Elmo)
Misc. materials / piping	LS	$ 10,000	1	$ 10,000	
			Subtotal	**$ 43,780**	
Subtotal - Direct Capital Costs				**$ 101,021**	
Mobilization and Site Prep					
Mobilziation	%	$ 101,021	10%	$ 10,102	
Construction BMPs	%	$ 101,021	5%	$ 5,051	
Demobilziation and Cleanup	LS	$ 2,500	1	$ 2,500	
			Subtotal	**$ 17,653**	
Engineering / Support Costs					
Infiltration testing & groundwater investigation	LS	$ 14,000	1	$ 14,000	
Design, Project Management	%	$ 101,021	12%	$ 12,122	
Construction Management	%	$ 101,021	10%	$ 10,102	
			Subtotal	**$ 36,225**	
Contingency					
25% of capital and construction costs	%	$ 101,021	25%	$ 25,255	
TOTAL DESIGN AND CONSTRUCTION COSTS				**$ 180,154**	

Assumptions

1. Construction would occur following removal of mine waste and completion of rough grading at the Nugget mine.
2. Topsoil salvage within the potential repository area would be used for reclamation.
3. Depth to groundwater at the site is sufficient for installation / operation of a subsurface infiltration gallery.
4. Subsoil below the gallery will have sufficient infiltration rates to accept discharges.
5. Average flow through wetland area is 7 gpm.
6. 3 day residence time required in wetland for effective treatment.

APPENDIX G
Repository Cover Modeling Approach and Results Summary

The Hydrologic Evaluation of Landfill Performance (HELP) model (version 3.07) was used to perform a comparative analysis of the performance of the two conceptual cover systems considered for the on-site disposal alternative for waste rock at the Lost Cabin and Nugget mines. The HELP model was developed by the U.S. Army Engineer Waterways Experiment Station under agreement with the U.S. EPA to estimate water balances for landfills to allow different landfill designs to be evaluated and compared (USACE 2011). The results of the cover systems analysis is summarized below.

Table G-1 summarizes the components of the two conceptual cover systems that were evaluated. Default material properties in the HELP model were used in the simulation for the different soil and geosynthetic layers in each cover system. Default material textures were selected based on the physical characteristics of the mine waste, top soil, and subsoil observed by AMEC personnel in test pits at the mine sites in 2010 and five shallow soil borings completed in the area of the proposed repository in June 2011.

Table G-1. Conceptual Repository Cover System Designs

Layer	Repository Component	Description	Thickness (inches)	HELP Default Soil Texture
Simple Soil Cover				
1	Topsoil	Loam	12	8
2	Cover soil	Loamy Sand	24	4
3	Mine Waste	Silty Sand	48	4
Composite Soil Cover				
1	Topsoil	Loam	12	8
2	Cover Soil	Loamy Sand	24	4
3	Gravel Dain Layer	Gravel	6	21
4	HDPE Liner	HDPE Liner	0.06 (60 mils)	35
5	Mine Waste	Silty Sand	48	4

CLIMATE DATA

Average annual precipitation within the Kennedy Creek drainage is approximately 27 inches, depending upon the elevation (NRIS 2011a). Average monthly precipitation values for the proposed repository site were estimated using data from the Ninemile Ranger Station obtained from the Western Regional Climate Center (WRCC, 2011). Average monthly precipitation totals at the Ranger Station were used to calculate the average percent of the total annual precipitation that occurs each month. The total annual precipitation (27 inches) at the repository site was then multiplied by the monthly precipitation percentages to estimate the average monthly precipitation totals at the repository. The calculations are presented in **Table H-2**, below.

Table H-2. Estimated Monthly Precipitation

Year	Monthly Precipitation - Ninemile Ranger Station (inches)												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Total**
2001	0.68	0.95	1.03	1.86	0.46	3.55	0.71	0	0.43	2.33	0.8	0.71	13.51
2002	1.65	1.13	1.75	0.68	2.45	1.87	0.69	0.48	0.74	0.1	0.86	0.28	12.68
2003	0.72	0.49	1.56	0.57	1.84	0.47	0.1	0.66	1.19	1.28	2.17	1.38	12.43
2004	0.78	0.98	0.84	1.3	3.79	0.89	0.73	2.06	2.02	0.76	0.5	0.76	15.41
2005	1.44	0.42	1.28	3.04	1.98	3.14	0.07	0.32	1.31	2.23	2.04	2	19.27
2006	1.67	0.96	1.05	3.58	1.5	2.46	0.52	0.94	1.68	1.45	3.47	1.44	20.72
2007	0.33	1.35	1.05	0.58	1.69	1.5	0.19	0.18	1.19	0.7	1.4	1.65	11.81
2008	0.87	1.22	0.75	0.72	0.81	2.28	0.66	1.24	0.93	0.38	1.98	1.17	13.01
2009	1.78	1.15	1.5	0.61	0.9	1.02	1.12	2.28	0.06	0.94	0.36	0.9	12.62
2010	1.12	0.62	1.03	1.85	2.11	3	0.38	1.47	1.19	0.55	1.18	2.27	16.77
2011	2.48	1.62	1.58	1.36	1.57	2.76	0.38	0.51	0.12	---	---	---	---
Ninemile Ranger Station Average	1.23	0.99	1.22	1.47	1.74	2.09	0.50	0.92	0.99	1.07	1.48	1.26	14.95
% of Annual Precipitation	8.2%	6.6%	8.2%	9.8%	11.6%	14.0%	3.4%	6.2%	6.6%	7.2%	9.9%	8.4%	---
Estimated Repository Site Monthly Precipitation	2.22	1.79	2.20	2.65	3.14	3.77	0.91	1.67	1.78	1.94	2.67	2.27	27.0

Mean monthly temperature data for the Ranger Station was used for the repository site. Default wind data in the HELP model for Kalispell, Montana was used to approximate conditions at the repository. Kalispell is the closest location to the repository with default data for climate and evapotranspiration parameters in the model. Solar radiation data was synthetically generated by the HELP model based on data for Kalispell, Montana. The latitude of the repository site was adjusted in the model from 48.18° N for Kalispell to 47.10° N, which is the approximate latitude of the repository.

EVAPOTRANSPIRATION DATA

The evaporative zone depth listed in the HELP model for Kalispell, Montana ranges from 14 inches to 42 inches. An evaporative depth of 20 inches was selected to evaluate the cover systems performance. Default relative humidity data for Kalispell, Montana, as well as the start and end dates of the growing season in Kalispell (roughly mid-May to mid-October), were also used in the model to approximate conditions at the repository site. A leaf area index (LAI) of 3.0 was used to approximate fair to good establishment of vegetation on the cover. A U.S. Soil Conservation Service (SCS) runoff curve number of 58 (meadow-continuous grass in good condition) was used to estimate storm water runoff volumes from the cover systems.

HELP MODEL RESULTS

The results of the modeling effort for the two conceptual cover systems evaluated are summarized in **Table H-3**, below. As shown in **Table H-3**, approximately 21 percent of the total annual precipitation that falls on the repository site (5.75 inches/year) would infiltrate through a soil cover system to the base of the mine waste in the repository. A composite cover system would significantly reduce the amount of infiltration that occurs. Approximately 0.034 inches/year (0.12 percent of the total annual precipitation) is predicted to infiltrate through the composite cover system to the base of the mine waste in the repository.

Table H-3. Modeled Cover System Performance

Item	Volume (inches/year)	Percent of Total Annual Precipitation (%)
Simple Soil Cover		
Annual Precipitation	27.44	100
Runoff	5.32	19.4
Evapotranspiration	16.37	59.6
Infiltration of Precipitation to Base of Mine Waste	5.75	20.95
Composite Cover System		
Annual Precipitation	27.44	100
Runoff	5.32	19.4
Evapotranspiration	16.37	59.6
Lateral Drainage through Gravel Drainage Layer (Layer 3)	2.51	9.16
Percolation through HDPE Liner (Layer 4)	0.045	0.16
Infiltration of Precipitation to Base of Mine Waste	0.034	0.12

The Hydrologic Evaluation of Landfill Performance (HELP) model (version 3.07) was used to perform a comparative analysis of the performance of the two conceptual cover systems considered for the on-site disposal alternative for waste rock at the Lost Cabin and Nugget mines. The HELP model was developed by the U.S. Army Engineer Waterways Experiment Station under agreement with the U.S. EPA to estimate water balances for landfills to allow different landfill designs to be evaluated and compared (USACE 2011). The results of the cover systems analysis is summarized below.

Table G-1 summarizes the components of the two conceptual cover systems that were evaluated. Default material properties in the HELP model were used in the simulation for the different soil and geosynthetic layers in each cover system. Default material textures were selected based on the physical characteristics of the mine waste, top soil, and subsoil observed by AMEC personnel in test pits at the mine sites in 2010 and five shallow soil borings completed in the area of the proposed repository in June 2011.

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3	Mine Waste	Silty Sand	48	4
Composite Soil Cover				
1	Topsoil	Loam	12	8
2	Cover Soil	Loamy Sand	24	4
3	Gravel Dain Layer	Gravel	6	21
4	HDPE Liner	HDPE Liner	0.06 (60 mils)	35
5	Mine Waste	Silty Sand	48	4

CLIMATE DATA

Average annual precipitation within the Kennedy Creek drainage is approximately 27 inches, depending upon the elevation (NRIS 2011a). Average monthly precipitation values for the proposed repository site were estimated using data from the Ninemile Ranger Station obtained from the Western Regional Climate Center (WRCC, 2011). Average monthly precipitation totals at the Ranger Station were used to calculate the average percent of the total annual precipitation that occurs each month. The total annual precipitation (27 inches) at the repository site was then multiplied by the monthly precipitation percentages to estimate the average monthly precipitation totals at the repository. The calculations are presented in **Table H-2**, below.

Table H-2. Estimated Monthly Precipitation

Year	Monthly Precipitation - Ninemile Ranger Station (inches)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2001	0.68	0.95	1.03	1.86	0.46	3.55	0.71	0	0.43	2.33	0.8	0.71	13.51
2002	1.65	1.13	1.75	0.68	2.45	1.87	0.69	0.48	0.74	0.1	0.86	0.28	12.68
2003	0.72	0.49	1.56	0.57	1.84	0.47	0.1	0.66	1.19	1.28	2.17	1.38	12.43
2004	0.78	0.98	0.84	1.3	3.79	0.89	0.73	2.06	2.02	0.76	0.5	0.76	15.41
2005	1.44	0.42	1.28	3.04	1.98	3.14	0.07	0.32	1.31	2.23	2.04	2	19.27
2006	1.67	0.96	1.05	3.58	1.5	2.46	0.52	0.94	1.68	1.45	3.47	1.44	20.72
2007	0.33	1.35	1.05	0.58	1.69	1.5	0.19	0.18	1.19	0.7	1.4	1.65	11.81
2008	0.87	1.22	0.75	0.72	0.81	2.28	0.66	1.24	0.93	0.38	1.98	1.17	13.01
2009	1.78	1.15	1.5	0.61	0.9	1.02	1.12	2.28	0.06	0.94	0.36	0.9	12.62
2010	1.12	0.62	1.03	1.85	2.11	3	0.38	1.47	1.19	0.55	1.18	2.27	16.77
2011	2.48	1.62	1.58	1.36	1.57	2.76	0.38	0.51	0.12	---	---	---	---
Ninemile Ranger Station Average	1.23	0.99	1.22	1.47	1.74	2.09	0.50	0.92	0.99	1.07	1.48	1.26	14.95
% of Annual Precipitation	8.2%	6.6%	8.2%	9.8%	11.6%	14.0%	3.4%	6.2%	6.6%	7.2%	9.9%	8.4%	---
Estimated Repository Site Monthly Precipitation	2.22	1.79	2.20	2.65	3.14	3.77	0.91	1.67	1.78	1.94	2.67	2.27	27.0

Mean monthly temperature data for the Ranger Station was used for the repository site. Default wind data in the HELP model for Kalispell, Montana was used to approximate conditions at the repository. Kalispell is the closest location to the repository with default data for climate and evapotranspiration parameters in the model. Solar radiation data was synthetically generated by the HELP model based on data for Kalispell, Montana. The latitude of the repository site was adjusted in the model from 48.18° N for Kalispell to 47.10° N, which is the approximate latitude of the repository.

EVAPOTRANSPIRATION DATA

The evaporative zone depth listed in the HELP model for Kalispell, Montana ranges from 14 inches to 42 inches. An evaporative depth of 20 inches was selected to evaluate the cover systems performance. Default relative humidity data for Kalispell, Montana, as well as the start and end dates of the growing season in Kalispell (roughly mid-May to mid-October), were also used in the model to approximate conditions at the repository site. A leaf area index (LAI) of 3.0 was used to approximate fair to good establishment of vegetation on the cover. A U.S. Soil Conservation Service (SCS) runoff curve number of 58 (meadow-continuous grass in good condition) was used to estimate storm water runoff volumes from the cover systems.

HELP MODEL RESULTS

The results of the modeling effort for the two conceptual cover systems evaluated are summarized in **Table H-3**, below. As shown in **Table H-3**, approximately 21 percent of the total annual precipitation that falls on the repository site (5.75 inches/year) would infiltrate through a soil cover system to the base of the mine waste in the repository. A composite cover system would significantly reduce the amount of infiltration that occurs. Approximately 0.034 inches/year (0.12 percent of the total annual precipitation) is predicted to infiltrate through the composite cover system to the base of the mine waste in the repository.

Table H-3. Modeled Cover System Performance

Item	Volume (inches/year)	Percent of Total Annual Precipitation (%)
Simple Soil Cover		
Annual Precipitation	27.44	100
Runoff	5.32	19.4
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Infiltration of Precipitation to Base of Mine Waste	5.75	20.95
Composite Cover System		
Annual Precipitation	27.44	100
Runoff	5.32	19.4
Evapotranspiration	16.37	59.6
Lateral Drainage through Gravel Drainage Layer (Layer 3)	2.51	9.16
Percolation through HDPE Liner (Layer 4)	0.045	0.16
Infiltration of Precipitation to Base of Mine Waste	0.034	0.12