ENGINEERING EVALUATION/COST ANALYSIS

Livingston Mill
Sawtooth National Forest
Custer County, Idaho

Prepared For:

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Intermountain Region
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Date: June 30, 2006

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ACRONYMS AND ABBREVIATIONS

°F	Degree Fahrenheit
μg/L	Microgram per liter
cfs	Cubic feet per second
dS/m	Decisiemen per meter
ft	Feet
lb/ac	Pound per acre
mg/kg	Milligram per kilogram
mi^2	Square mile
mL	Milliliter
yd^2	Square yard
yd^3	Cubic yard
ABA	Acid Base Accounting
AGP	Acid Generating Potential
AHPA	Archaeological and Historic Preservation Act
ANP	Acid Neutralizing Potential
ARAR	Applicable or Relevant and Appropriate Requirement
ATV	All-terrain vehicle
bgs	Below ground surface
BLM	United States Bureau of Land Management
BMP	Best Management Practice
CERCLA	Comprehensive Environmental Response, Compensation & Liability Act
CCC	Criteria continuous concentration
CFR	Code of Federal Regulations
COC	Contaminant of concern
CSM	Conceptual site model
ECe	Electrical conductivity
EE/CA	Engineering Evaluation/Cost Analysis
EPA	United States Environmental Protection Agency
ESA	Endangered Species Act
ET	Evapotranspiration
FLRMP	Forest Land and Resource Management Plan
FS	U.S. Forest Service
FSH	Forest Service Handbook
FSM	Forest Service Manual
FWS	U.S. Fish and Wildlife Service
GCL	Geosynthetic clay liner
ICDC	Idaho Conservation Data Center
IDFG	Idaho Department of Fish and Game
ITRC	Interstate Technology Regulatory Council
MSE	Millennium Science and Engineering, Inc.

ACRONYMS AND ABBREVIATIONS (continued)

NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NF	National Forest
NFSR	National Forest Service Road
NHPA	National Historic Preservation Act
NNP	Net Neutralization Potential
O&M	Operations and Maintenance
PA	Preliminary Assessment
PCB	Polychlorinated Biphenyl
PPE	Personal protective equipment
RAO	Removal Action Objective
RCRA	Resource Conservation and Recovery Act
RMC	Risk Management Criteria
SACM	Superfund Accelerated Cleanup Model
SHPO	State Historic Preservation Office
SI	Site Inspection
SNRA	Sawtooth National Recreation Area
T&E	Threatened and endangered
TBC	To be considered
TCLP	Toxicity characteristic leaching procedure
TEPCS	Threatened, endangered, proposed, candidate, and sensitive
TRV	Toxicity reference value
USGS	United States Geological Survey
WFIP	Wildland Fire Implementation Plan
WFSA	Wildland Fire Situation Analysis
WRCC	Western Regional Climate Center
XRF	X-Ray Fluorometer

EXECUTIVE SUMMARY

This report presents an Engineering Evaluation/Cost Analysis (EE/CA) for a proposed Comprehensive Environmental Response, Compensation & Liability Act (CERCLA) removal action at the Livingston Mill in central Idaho. The abandoned lead-zinc-silver ore processing facility is located in the Sawtooth National Forest, approximately 26 miles southeast of the town of Clayton. The site is near the confluence of Jim Creek and Big Boulder Creek, which is a tributary to the East Fork Salmon River. The site is not to be confused with the Livingston Mine, which is located on private land approximately 4 miles west of the mill and is not within the scope of this removal action.

The site occupies and areas of approximately 30 acres and consists of two mills and associated structures, and five tailings areas. A former mining camp and several cabins are located directly across Jim Creek from the site. Owners of the mill and patented mining claims periodically occupy the site and serve as caretakers. The site is within the Sawtooth National Recreation Area and a U.S. Forest Service (FS) trailhead and campground are located immediately downstream of the site.

The FS conducted a Preliminary Assessment (PA) of the Livingston Mill Site in 2002. The PA concluded that a Site Inspection (SI) should be performed and Millennium Science and Engineering, Inc. (MSE) completed the SI and submitted a final SI report in 2004. Results of the SI indicated elevated levels of metals, particularly lead and arsenic, in the mine tailings and contaminated soils. A screening level human health and ecological risk assessment indicated significant risks to human and ecological receptor at the site.

Four removal action alternatives were evaluated:

- Alternative 1 – No Action
- Alternative 2 – *In situ* Treatment of Shallow Tailings
- Alternative 3 – On-site Disposal of Bulk Tailings in Tailings Area 4 (TA-4)
- Alternative 4 – Off-site Disposal of Bulk Tailings

The preferred alternative consists of a combination of Alternatives 2 and 3. Mine process reagents will be removed and transported to the U.S. Ecology hazardous waste disposal facility near Grandview, Idaho. Approximately 3,531 cubic yards (yd^3) of shallow tailings and contaminated soils will be treated in place with a mixture of lime, compost, and soil amendments. Approximately 40,566 yd^3 of bulk tailings and contaminated soils will be excavated and consolidated with approximately 17,199 yd^3 of tailings from Tailings Area 4, in an on-site repository within Tailings Area 4. The consolidated wastes will be covered with 6 inches of coarse material and 24 inches of soil, and revegetated. The excavated waste areas will be covered with 6 inches of soil, seeded, and mulched. Surface water controls will be installed upgradient of TA-4 to intercept and divert run-on around the repository.

The proposed removal action would be sequenced over a 2-year period, included 2 years of monitoring and maintenance, and cost approximately **$1,161,928.** The proposed cost includes approximately $25,000 for additional site characterization activities to address data gaps identified during the alternative development and critical to the final design.

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1.0 INTRODUCTION

Millennium Science & Engineering, Inc. (MSE) was contracted by the U.S. Forest Service (FS) to perform an Engineering Evaluation/Cost Analysis (EE/CA) of the Livingston Mill site near Clayton, Idaho (Figure 1). The FS determined, in part through development of a Preliminary Assessment (PA) and completion of a Site Inspection (SI), that a non-time critical Removal Action may be appropriate at the Livingston Mill site. The Livingston Mill site is an abandoned ore processing facility composed of two mills and associated structures, and five mine tailings disposal areas. It is distinct from the Livingston Mine, which is located on private land approximately 4 miles from the Mill, and is not within the scope of this removal action. The removal action goals and objectives are to: (1) reduce human and wildlife surface exposure to potential contaminants of concern (COCs), particularly arsenic and lead, in the tailings, contaminated soils, and mine process reagents; and (2) improve water quality in Jim Creek and Big Boulder Creek by decreasing contaminant loading from the mine tailings areas.

This EE/CA identifies and evaluates potential removal action technologies and alternatives for the cleanup of mining waste remaining at the site. This document fulfills requirements of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) (42 USC 9601 et seq., 1980), under the Superfund Accelerated Cleanup Model (SACM), and the National Oil and Hazardous Substances Contingency Plan (NCP) (40 CFR 300). The EE/CA was prepared in accordance with U.S. Environmental Protection Agency (EPA) guidance for conducting non-time-critical removal actions under CERCLA (EPA 1993).

The EE/CA satisfies environmental review requirements for removal actions, administrative record requirements for documentation of removal action selection, and provides a framework for evaluating and selecting alternative technologies. Objectives of the EE/CA are to: (1) identify potential removal technologies, (2) develop alternatives, (3) evaluate alternatives, and (4) analyze potential alternatives for effectiveness, implementability, and cost.

1.1. EE/CA Process and Report Format

The EE/CA process generally is comprised of the following steps:

- Evaluate existing data from previous documents such as preliminary site assessments, site characterizations, environmental impact statements, and risk evaluations;
- Conduct additional sampling, if necessary;
- Identify applicable or relevant and appropriate requirements (ARARs) for the site;
- Conduct a human health and ecological risk assessment;
- Identify and screen potential removal technologies;
- Develop removal action alternatives;
- Analyze and evaluate alternatives; and
- Recommend a removal action alternative.

A description of the site and background information is provided in Section 2. Results of a SI performed by MSE in 2003 are summarized in Section 3. The removal action scope and objectives are discussed in Section 4 and the removal technologies and removal action alternatives are screened and evaluated in Sections 5, 6, and 7. The recommended alternative is summarized in Section 8 and references are provided in Section 9. Supporting tables and figures are provided at the end of the document. A list of ARARs is provided in Appendix A and a detailed cost estimate is provided in Appendix B.

2.0 SITE DESCRIPTION AND HISTORY

This section provides a brief discussion of the site description, history, and current status, and summarizes previous investigations of the site. Information presented in this section was obtained from the SI report (MSE 2004), U.S. Geological Survey (USGS 2002a, Van Noy, *et al.* 1986, and Mitchell 1997), and conversations with FS personnel.

2.1. Site Location and Description

The Livingston Mill site, shown in Figure 2, contains two historic mills, associated structures, and five tailings areas (TA-1 through TA-5). A former mining camp with several cabins is located directly across Jim Creek from the tailings areas. The site is accessed from Highway 75 approximately 4 miles east of Clayton, south on East Fork Salmon River Road (National Forest Service Road [NFSR] 70120) for approximately 17 miles, and west on Big Boulder Road (NFSR 70667) for approximately 4 miles.

The Livingston Mill is not to be confused with the Livingston Mine, which is located on private land near the head of Jim Creek, approximately 4 miles from the site, and is not within the scope of this removal action. In addition, a nearby mine called the Little Livingston Mine, is also located on private land in the nearby Livingston Creek drainage and is not a subject of this removal action.

2.1.1. Physiography and Vegetation

The project site is located at an elevation of 7,200 feet (ft) in the Upper Salmon watershed, near the confluence of Jim Creek and Big Boulder Creek. Big Boulder Creek is a main tributary to the East Fork of the Salmon River. The site lies in a valley between Railroad Ridge and Red Ridge. Terrain at the site consists of an open alluvial valley surrounded by steep mountains. Elevations along the valley floor range from 7,080 to 7,240 ft and the surrounding mountains reach over 11,000 ft. Slope gradients range from near vertical to 45 percent in the glaciated and fluvial mountains, and 0 to 35 percent in the glacial outwash and depositional lands (FS 2003).

The White Cloud Peaks consist of extremely steep and rugged slopes that provide little opportunity for extensive alpine vegetation development (Richardson and Henderson 1999). Railroad Ridge, however, is an exception with gently sloping terrain that supports some of the most unique and well-developed alpine plant communities in Idaho. Railroad Ridge supports eight community types that represent some of the general physiognomies found in other North American alpine ecosystems (i.e. fell-field, turf, and snowbed) (Richardson and Henderson 1999). However, other communities found on Railroad Ridge are uncommon and known only from a few alpine sites in Idaho and the Great Basin (i.e. *Ivesia gordonii/fellfield*). Indeed, the Northern sagewort, *Artemisia campestris* community has not been documented in any other Idaho alpine studies (Richardson and Henderson 1999). Although there are no plants currently listed as endangered within the Sawtooth National Forest (NF), the White Cloud Peaks are host to several extremely rare species, including several that have state or federal status as threatened, proposed, or candidate species or Region 4 sensitive or proposed sensitive status. A list of the threatened, endangered, proposed, candidate and sensitive (TEPCS) plant species that may be present at the Livingston Mill is provided in Table 1 and discussed below.

Threatened, Endangered, Proposed, and Candidate Plant Species:

Slender Moonwort – *Botrychium lineare*

Slender moonwort, *Botrychium lineare (B. lineare),* was discovered on Railroad Ridge in 2002. This is the only known population of this rare fern in Idaho and it is the largest known population of this species globally. Potential habitat also exists for this species throughout the White Cloud Peaks.

In July 1999, the U.S. Fish and Wildlife Service (FWS) was petitioned to add the slender moonwort, *B. lineare,* to the list of threatened and endangered (T&E) plant species. The FWS published the 90-day petition finding and initiated a 12-month status review in May 2000. On June 6, 2001, the FWS found that a petition to list *B. lineare* as threatened was warranted, but preparation of a proposed rule was precluded by other higher priority listing actions. Therefore, FWS placed the slender moonwort on the candidate species list (Federal Register Vol. 66, No. 109, 2001).

In 2002, the Sawtooth NF sent five samples for identification and species confirmation to Dr. Farrar at Iowa State University. Farrar noted that the samples morphologically look like *B. lineare* but genetically they are somewhat different than *B. lineare* known from other sites. (Farrar 2002) Farrar reports that similar findings were made in a collection taken from southern Nevada in 2002. Farrar believes the FS and FWS should treat them as *B. lineare* but plans to do more work with this species in the future to clarify its taxonomy.

In the United States, slender moonwort, is currently known from a total of ten populations: three in Colorado, two in Oregon, three in Montana, one in Washington, and one in Idaho. The Idaho population was located in 2002 by Sawtooth NF botanists, although genetic testing has not been completed at this time. In 2002, contract botanists and FS botanists surveyed over 500 acres of potential habitat, but no new populations were located.

The total number of individuals for all ten occupied sites is about 352 (190 without the Sawtooth National Recreation Area [SNRA] population, although this number should be viewed as an estimate since *Botrychium* species do not always come up every year and exist below ground for most of their life cycle (Federal Register Vol. 66, No. 109, 2001).

Previous distribution data suggests that the amount of habitat occupied by the *B. lineare* appears to be very small. However, the population found on the SNRA appears to be scattered over a 100-acre area making it the largest known population of this species. Other sites are smaller than 465 square meters (5,000 square feet). The small size of existing slender moonwort populations makes this species vulnerable to extirpation due to random naturally occurring events. A single random event could extirpate a substantial portion or all of the individuals at a given site. This diminutive fern was located on sparsely vegetated rocky outcrops and ridgelines. Associated species included goldenrod, gooseberry, green gentian, oat grass, stonecrop, flax, silvery lupine, littlebunch lupine, mat milkvetch, little flower Penstemon, whiteleaf phacelia, prickly sandwort, paintbrush, yarrow, and sagewort.

There are many threats that have been documented for the slender moonwort. They include impacts associated with recreational activities (trampling by hikers, off-road vehicle use, or pack animals), roads (construction, maintenance, use, and decommissioning), habitat succession, fire suppression, livestock grazing (primarily trampling and soil compaction), and non-native plant invasion. Few threats have been documented in the population of slender moonwort located on the Sawtooth NF; however, unauthorized livestock use may be impacting the occupied habitat for this rare species. Impacts to potential habitat through trampling and congregation within such habitat may also be occurring.

Within the *B. lineare* population located on the SNRA, the number of introduced species is extremely low and no noxious weeds have been identified within the occupied or potential habitat. Smooth Brome is found along closed roads associated with previous mining activity. This often-invasive species was planted to stabilize the soil within these areas and to prevent sedimentation further down slope. The smooth brome populations appear to be isolated to previously disturbed sites and do not appear to be expanding at this time (Taylor and Pierson 2002, personal observation). Dalmatian toadflax has been located along the Big Boulder road and could potentially be transported up to Railroad Ridge and surrounding areas by vehicles, all-terrain vehicles (ATVs), and/or livestock.

Section 7 guidelines are followed where potential habitat for slender moonwort on the Sawtooth NF exists. In 2001, the FWS asked the Sawtooth NF to consider *B. lineare* in our planning but the species was not added to the 90-Day Update of Forest Wide Species List because the distribution and habitat description were “problematic.”

Ute ladies’-tresses Orchid –*Spiranthes diluvialis*

In 1984, Ute ladies’-tresses orchid was named as a new species and was federally listed as threatened on January 17, 1992 under the Endangered Species Act (ESA). *Spiranthes diluvialis* (*S. diluvialis)* occurs in relatively low-elevation riparian, spring, and lakeside wetland meadows in these general areas of the interior western United States. In 1996, *S. diluvialis* was discovered in southeast Idaho, along the Snake River. However, no populations have been found closer to the SNRA than Heise, Idaho. Fairly extensive surveys within the general Salmon River drainage by State, FS, and U.S. Bureau of Land Management (BLM) personnel have not resulted in any additional locations.

Ute’s ladies-tresses orchid is endemic to moist soils in mesic or wet meadows near springs, lakes, and perennial streams. The elevation range of known habitat is 1,500 to 7,000 feet. Most of the occurrences are along riparian edges, gravel bars, old oxbows, and moist-to-wet meadows along perennial streams and rivers, although some localities are near freshwater lakes or springs. *S. diluvialis* occurs primarily in areas where the vegetation is relatively open and not very dense. Potential habitat in the Challis Volcanics and Idaho Batholith regions of Idaho is considered to have an upper limit of 6,500 feet elevation (Moseley 1998). Less than 2 miles of streamside habitat in this area is below 6,500 feet.

S. diluvialis is found infrequently and in scattered locations. Threats include livestock grazing, exotic weed invasion, controlled flooding, dewatering of streams, loss of pollinators, and development. Because it prefers open, early seral riparian areas, its management may be in direct conflict with rare fish habitat management that emphasizes undisturbed climax conditions. Riparian areas that are not properly functioning within the Upper and Lower East Fork allotments may have been degraded to a point that potential habitat may reduced.

The FWS has prepared a draft recovery plan and developed actions designed to restore populations and remove threats. Ecogroup personnel survey potential habitat every year where ground-disturbing activities are proposed and implement appropriate mitigation measures, including stockpiling and returning topsoil, and protection of high potential habitat. The Idaho Conservation Data Center (ICDC) is currently developing a predictive plant habitat model for the state of Idaho, which will further refine focus areas for future surveys and management.

Sensitive, Proposed Sensitive, and Watch Plant Species:

White Cloud milkvetch,-*Astragalus vexilliflexus* var*. nubilus*

White Cloud milkvetch,-*Astragalus vexilliflexus* var*. nubilus,* a Region 4 sensitive species, is endemic to the White Cloud Peaks and is found in high elevations, along ridge crests and exposed alpine talus slopes with sparse vegetation. There are only nine populations known globally, all of which occur near the Livingston Mill site. White Cloud milkvetch is a perennial, low growing cushion plant with irregularly shaped pale yellow flowers with purple tinged keels that are almost hidden in the silvery foliage. It flowers in July and August. Populations occur at high elevations, along ridge crests and upper slopes between 8,400 and 9,900 feet. Primary habitat is exposed alpine talus slopes with sparse vegetation, underlain with volcanic, granitic, and metamorphic rock (Mancuso and Moseley 1990).

Range monitoring has documented that 44 percent (4 of 9) of the populations are experiencing moderate to locally heavy livestock use (grazing, trampling, and loafing) (Phalen 2003, personal communication). One population could be impacted by activities associated with a removal action at the Livingston Mill. All populations are accessible to cattle and changes in salting or herding strategies could also contribute to increased threats for all known population. Several weedy species including Dalmation toadflax, yellow toadflax, and musk thistle, and spotted knapweed have infestations near the impacted populations described above.

Proposed Sensitive Species:

Northern sagewort - *Artemisia campestris* ssp. *borealis* var. *purshii*

Northern sagewwort is a widespread, circumboreal taxon that extends south in North America to Oregon, Arizona, Michigan, and Vermont. It ranges from the high mountains of northern Washington to northern Montana and Colorado (Cronquist 1950) but is known in Idaho only from the White Cloud Peaks. Northern sagewort is a mildly scented, non-woody perennial with several branching stems that bloom from July to September.

The only known population of northern sagewort in Idaho is found on Railroad Ridge. The population of Northern sagewort in the White Cloud Peaks is found in xeric alpine fellfield habitat with southeast aspect, 0 to 15 percent slope, open light, between 4,000 and 12,000 feet elevation. Substrate is gravelly, moderately unstable, and granitic glacial till deposits. The impacts of current livestock use in this population is currently unknown; however, livestock have been observed in the area and may indirectly impact individuals through trampling and soil compaction.

Several other proposed sensitive species on or near Railroad Ridge include wedge-leaf saxifrage, pointed draba/rockcress draba, Farr's willow, Challis milkvetch, and Brewer's sedge.

Non-native Plants:

Competition from invasive non-native species and noxious weeds can result in the loss of habitat, loss of pollinators, species composition conversion, decreased vegetation integrity, and loss or decline of TEPCS species viability. Roads, trails, livestock, and canopy reduction can provide ideal pathways for the introduction of exotic and non-native species.

Within the East Fork, Big Boulder, and Jim Creek drainages, small semi-contained populations of spotted knapweed, diffuse knapweed, spurge, yellow toadflax, musk thistle, black henbane, cheatgrass, and Dalmatian toadflax have been documented, particularly along main road and trail corridors. Disturbance from removal action activities may result in portions of the project area being susceptible to noxious weed and non-native plant invasions and establishment. The main weed of concern for this area is spotted knapweed, a highly invasive species that is currently found in small, scattered populations at the Livingston Mill site and access road to Railroad Ridge.

Along with a small population of spotted knapweed, musk thistle, black henbane, and cheatgrass are found along Bowery Creek both within the exclosure and along the main East Fork road. The largest infestation of Dalmation toadflax is found within the Livingston Mill area along Big Boulder Creek. Dalmation toadflax and yellow toadflax, both aggressive species, are also known to currently occur near populations of White cloud milkvetch.

For TEPCS plant species, the FS is responsible for implementing the ESA within their authorities. These responsibilities include, but are not limited to, efforts to promote the conservation and recovery of listed species, and provisions to conserve the ecosystems upon which listed species depend. Sensitive species require special management efforts and conservation needs under Forest Service Handbook guidelines (FSH 2609.25, 1988) and Forest Service Manual directives (FSM 2670), and they are examined separately from the sensitive species. The FWS monitors and prescribes management for federally listed threatened and endangered plant species. The National Forest Management Act and Forest Service policy require that NF System lands be managed to maintain populations of all existing native animal and plant species at or above minimum viable populations levels. A viable population is the maintenance of enough individuals throughout their range to perpetuate the existence of the species in natural, self-sustaining populations.

The Forest Land and Resource Management Plan (FLRMP) standards applicable to plant diversity and TEPCS plant protection are discussed below.

Management actions shall be designed to avoid or minimize adverse effects to listed species and their habitats (TEST06):

- Management actions that may contribute to establishment or spread of non-native invasive weed species within occupied TEPCS plant habitat shall include measures to avoid weed establishment and spread (TEST10).
- Management actions that occur within occupied sensitive plant species habitat must incorporate measures to ensure habitat is maintained where it is within desired conditions, or restored where degraded (BTST01).
- Projects that may contribute to the spread or establishment of noxious weeds shall include measures to reduce the potential for spread and establishment of noxious weed infestations (NPST10).
- Integrated Weed Management, which include a variety of treatments, (chemical, mechanical, biological) shall be used to maintain or restore habitats for sensitive plants

and other native species of concern where they are threatened by noxious weeds or non-native invasive plants (NPST11).

Revegetation objectives for the Livingston Mill removal action should include:

- Restore willow composition, structure, and density, and hydric forbs and grasses in riparian areas in East Fork Salmon River, Big Boulder Creek, Little Boulder Creek, West Pass Creek, Big Lake Creek, Sullivan Creek, and French Creek drainages by reducing impacts from livestock grazing (Objective 0349).
- Maintain or restore populations and occupied habitats of TEPCS species, including slender moonwort, White Cloud milkvetch, Challis milkvetch, northern sagewort, Farr's willow, silvery/Jones' primrose, wedge-leaf saxifrage, pointed draba/rockcress draba, guardian buckwheat, Stanley whitlow-grass, Lemhi milkvetch, least moonwort, and Brewer's sedge, to contribute to their long-term viability of these species (Objective 0354).

2.1.2. Meteorology

The Livingston Mill area has a mountain climate characterized by cool dry summers and cold, harsh winters. Precipitation and temperature vary significantly with elevation. Daily and annual temperature ranges at the site are large. Mean annual precipitation at the site ranges from approximately 26 to 32 inches per year occurring primarily as snowfall with occasional high intensity summer thundershowers (USGS 2002b). The nearest weather station with comparable elevation and snowfall is Galena, approximately 19 miles southwest of the site. At Galena, winter and summer monthly averages for daily maximum temperature range from 31.6ºF to 76.4ºF, and monthly average daily minimum temperatures range from 2.2ºF to 34.7ºF (Western Regional Climate Center [WRCC] 2005).

2.1.3. Geology

The Livingston Mill site is located along the northeastern portion of the White Cloud Range near the headwaters of the East Fork of the Salmon River. The mill site is near the confluence of Boulder Creek and Jim Creek within an alluvial valley that drains the eastern side of the mountains. The White Cloud Range is characterized by Devonian to Permian age sedimentary rocks that are intruded by Cretaceous granodiorite. Along the eastern margin of the range, Eocene rocks of the Challis Volcanic Group unconformably overlie the sedimentary rocks. Mineralized areas at the headwaters of Jim Creek contain syngenetic stratiform mineral deposits of the Salmon River Assemblage (Haller and Wood, 2004; Link, 2002).

The upper portions of the range were heavily glaciated during the Pleistocene with glacial moraines present along the upper portion of Boulder Creek. Alluvial deposits fill the valley floor in the immediate area of the mill site, with colluvium and alluvial fans from the Challis Volcanics forming the valley sidewalls.

The hydrogeology of the area is not well understood; however, it appears that Boulder Creek is a losing stream recharging groundwater within the valley alluvium. Shallow groundwater migration direction is downvalley towards the east and likely represents the primary groundwater resource in the area. Fractures within bedrock are likely to provide a limited source of groundwater and will be primarily recharged from seasonal precipitation.

2.1.4. Hydrology and Hydrogeology

The site is located in the confluence of the Jim and Big Boulder Creek drainages. The combined drainage areas encompass 19.1 (mi^2) and vary in elevation from 7,200 to over 11,000 ft. According to information gathered during the SI, both Jim and Big Boulder Creeks were losing streams within the site during the 2001-2002 field season. Available historical flow data for Big Boulder Creek is limited to a 4–year period in the 1920s and indicates peaks flows ranging from 100 to 200 cubic feet per second (cfs) (USGS 2002b). Based on this information and observations made during the SI, occasional flooding of the lower portion of the site is likely.

Because of concern regarding the potential for flood events to encroach upon potential waste repository locations at the site, floodplain extents were estimated to determine if Tailings Area 4 (TA-4) is above the floodplain and to assist in identifying alternative repository locations. The floodplain extents were estimated for a 100-year, 24-hour storm event using the limited available site topographic data and simplified methods (*i.e.*, regression equations rather than run-off or flood hydrograph modeling). The 100-year peak flow for Big Boulder Creek was estimated immediately downstream of the confluence with Jim Creek using regression equations developed for the region by the USGS (2002). The regression equations were developed based on flow data and basin and climatic characteristics for 333 gaged sites in Idaho. The equations can be used to estimate peak flows on ungaged streams at selected recurrence intervals for seven hydrologic regions in the Idaho. Similarly, peak flows can be estimated for ungaged sites near gaged sites on the same stream using a drainage-area ratio and region specific correction factor. Average errors of prediction for these equations ranged from +143 to –58.8 percent (USGS 2002b).

Using the regression equation developed specifically for the Sawtooth area (region 6), a 100-year recurrence interval, and a drainage area of 19.1 mi^2, the estimated peak flow for Big Boulder Creek is 532 cfs. Based on the level of error in this equation, the 90 percent confidence interval flow is 1,370 cfs. For comparison, the USGS-estimated 100-year peak flow for a gaged station on nearby Little Boulder Creek with a similar drainage area of 18.3 mi^2 is 671 cfs. To be conservative, a peak flow of 1,370 cfs was used to estimate the floodplain extent at the site. Available site topography was limited to a USGS quadrangle map with 20-ft contours, from which 5-ft contours were interpolated, and the stream channels are not clearly defined (USGS 1980). However, because the creeks are relatively shallow and site is located in a wide valley bottom ranging in width from 500 to 1,000 ft, peak flows during a flood event would likely result in a very shallow depth over a large area. Therefore, the floodplains for Jim and Big Boulder Creeks were combined and treated as a single shallow rectangular stream channel. Manning's equation was used to estimate the floodplain extent assuming a Manning's n of 0.05 and a flow depth of 2 ft. Based on a peak flow of 1,370 cfs and a channel slope of 2.9 percent, the flow channel would be 173 ft wide. TA-4 is over 200 ft from the center of the Jim Creek stream channel and approximately 5 ft above the channel bottom. Therefore, it appears unlikely that a 100-year flood event would encroach upon TA-4.

This preliminary analysis suggests that TA-4 appears is well above the floodplain and only the lowermost areas of the site would be flooded. However, additional topographic data should be gathered to develop more accurate channel cross sections in critical areas of the site and to ensure proposed waste repository locations are above the floodplain. Depending on the necessary level of confidence, hydrologic modeling may also be warranted to more accurately estimate peak flows at the site and storm frequency.

The regional groundwater system at the site is not well documented. It is inferred from site observations that the surrounding mountain slopes receive recharge from precipitation, with lateral groundwater flow along the alluvial slopes within the unconsolidated sediments and through bedrock fractures, eventually discharging along the stream reaches across the valley floor. Groundwater recharge to the glacial and alluvial sediments beneath the valley floor is probably derived from infiltration of precipitation and run-on onto the valley floor, and subsurface flows through the upgradient sediments. Additional recharge may occur as seepage losses from the valley streams.

Groundwater was not encountered by the FS in borings extended to a depth of up to 45 ft below the ground surface in the area directly southeast of TA-2 and 3 (MSE 2004). During the SI, a temporary piezometer was installed in TA-2A near the willows and screened down to the soil contact interface; no groundwater was observed but this may have been because of seasonal conditions. The presence of moist tailings and willows along some of the tailings areas are suggestive of subsurface flows.

2.2. History and Current Use

The Livingston Mill site processed ore from the Livingston Mine, located approximately 4 miles west of the mill site, on private land near the headwaters of Jim Creek. The mine operated intermittently from the late 1800s to the 1950s, and produced approximately 86,700 tons of lead-zinc-silver ore. The first mill facility (Mill 2), located approximately 3,000 ft west of the confluence of Jim Creek with Big Boulder Creek, was reportedly constructed in 1924. Tailings from this facility are believed to have been placed in TA-4 and 5. High metals concentrations in samples from these areas suggest that this mill was somewhat ineffective in the recovery of lead, zinc and silver. The site temporarily closed in 1930, and operated intermittently during the 1930s and 1940s. Following expansion and construction of a new mill facility (Mill 1) in about 1950, mine operators began reprocessing mill tailings from TA-4 and 5 and reportedly recovered significant amounts of lead and zinc. Approximately 60,000 tons of tailings were reprocessed and placed in TA-1, 2 and 3 (Mitchell 1997). Based on visual observations of the site during the SI, it appears that as each tailing area reached capacity, the earthen dike was breached to allow excess tailings to flow into the next tailings area. At some point, presumably during operations, Jim Creek was diverted from its original path south of TA-3 over to Big Boulder Creek, about 2,000 ft upstream of the original confluence. According to the FS, tailings flowed into the former Jim Creek stream channel and riparian areas adjacent to the stream during a large storm event in the 1980s. Surface run-off from TA-1, 2, and 3 also may occasionally carry tailings into the former Jim Creek Channel.

Active operations at the Livingston Mill site stopped in the 1950s. Presently, at least two cabins on the Livingston Mill site are habitable and occupied intermittently by the owners of the mill and associated patented mining claims. The occupants serve as caretakers who periodically check the site to protect their equipment and personal property stored in the remaining buildings.

The site is within the Sawtooth National Recreation Area and receives moderate recreational exposure. A FS trailhead and campground are located immediately downstream of TA-1, along Big Boulder Creek. Evidence of off-road and ATV use on the tailings areas was observed during the SI site visits.

2.3. Previous Investigations

In the 1970s, several reports on the Livingston Mine area were published. According to the reports, high levels of lead (0.5 to over 3 percent) and zinc were present in samples from TA-3 and 4, as well as in a stockpile of material then present directly south of TA-4 (Mitchell 1997). The stockpile could not be located during the SI and is believed to have been relocated into one of the tailings areas. Additional data in the literature also confirms the presence of metals (lead) in stream sediment samples from both Jim Creek and Big Boulder Creek. Concentrations of lead in Jim Creek sediment directly downstream from Livingston Mine, about 4 miles upstream from the site, ranged from 1,000 to 33,000 milligrams per kilogram (mg/kg). Lead concentrations in Big Boulder Creek Stream sediment downstream of Livingston Mill ranged from 70 to 149 mg/kg (Van Noy, *et al*., 1986).

The FS conducted a PA of the Livingston Mill site in 1993. The purpose of the PA was to evaluate and quantify mine tailings at the site, characterize potential COCs in the tailings, and evaluate the potential for COCs to be leached into the groundwater system. The PA concluded the following:

- Tailings in TA-2 and 3 range in thickness from 5 to 10 ft;
- Groundwater was not encountered in borings up to 45 ft below ground surface (bgs) in the area directly southeast of TA-2 and 3;
- Lead is present in the tailings at concentrations up to 38,600 mg/kg;
- Leachable lead and cadmium concentrations in tailings exceeded Resource Conservation and Recovery Act (RCRA) toxicity characteristic limits;
- Some leaching of metals has occurred in the mine tailings areas; and
- A CERCLA SI should be performed.

It should be noted that the 1980 Bevill Amendment to RCRA and subsequent regulatory action by EPA (40 CFR 261.4[b]7) have excluded solid waste uniquely associated with the extraction and beneficiation of ores and minerals and 20 specific mineral processing waste streams from regulation as hazardous waste under Subtitle C of RCRA (EPA undated). Mine tailings and waste rock are thus exempted from RCRA requirements.

Resulting from the PA, the FS contracted with MSE to perform an SI of the Livingston Mill site in 2002. An SI was completed in 2002 and a final SI report was submitted to the FS in January 2004. The SI activities and results are summarized in the following section.

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3.0 SITE INSPECTION SUMMARY

This section presents an overview of the Livingston Mill SI site characterization activities, analytical results, and results of the streamlined human health and ecological risk assessments completed as part of the SI. More detailed information regarding the SI is presented in the SI report (MSE 2004).

3.1. Site Characterization Activities

The objective of conducting an SI was to support a decision whether or not to pursue a removal action at the Livingston Mill site. During the SI, the site was inspected and site characterization data were collected and analyzed to determine whether hazardous substances are present at the site at concentrations presenting a risk to human health or the environment. The SI was not intended to provide a detailed assessment of the extent of contamination or a full risk assessment. Site characterization activities included:

- Visual inspection of the site and assessment of site hydrology;
- Water quality analysis and flow monitoring along Jim Creek and Big Boulder Creek;
- Macroinvertebrate sampling along Jim Creek and Big Boulder Creek to assess whether aquatic biological communities have been impacted;
- Mine waste tailings analysis for metals and acid-base accounting (ABA);
- Process reagents analysis for metals and other contaminants;
- Estimation of tailings volume;
- Agronomic analysis of soil and soil/tailings mixtures to assess suitability as plant growth medium; and
- Geotechnical analysis of tailings and soils for assessment of suitability in a possible containment cell.

SI site visits were conducted on October 11, and 17-18, 2001; and June 19-20, and July 29, 2002. Site characterization samples collected during the SI are summarized in Table 2. Field data collected during the SI included:

- Stream dimensions and flow measurements at each surface water sample location;
- Tailings depths at 28 locations in TA-2 and 3 using a portable auger and split spoon sampler; and
- Extensive photographs of the site.

3.2. Site Characterization Results

The following sections summarize the analytical results of site characterization samples collected during the SI. More detailed information regarding the sampling procedures, quality control, and laboratory analyses is presented in the SI report (MSE 2004).

3.2.1. Mine Tailings

Results from analysis of the mine waste samples are summarized in Table 3. The results show elevated levels of metals, particularly arsenic, lead, copper, zinc, and selenium. Arsenic concentrations exceeded BLM human risk management criteria (RMCs) in all tailings samples. Similarly, lead concentrations exceeded the RMC in 25 of the 27 tailings samples. Copper, selenium, and zinc concentrations also exceeded RMCs in several samples. Metals concentrations are generally highest in TA-5, and lowest in TA-2 and 3.

TA-1 was initially believed to consist of a shallow layer of tailings mixed with native soils. However, samples from this area contained higher concentrations of metals than expected suggesting high tailings content. Agronomic results of samples from this area indicate that the soil-tailings mix is not suitable as a cover material or plant growth medium without significant soil amendments.

The results of ABA testing performed on tailings composites also are presented in Table 3. For each sample, the net neutralization potential (NNP) is strongly negative and the acid neutralization potential/acid generating potential (ANP/AGP) ratio is very low. This indicates the potential for acid generation is high, if the appropriate conditions of water, oxygen and microbial populations are present. However, water quality results from Jim Creek indicate that acid generation is not actually occurring in TA-1 through 4 at rates that impact metals concentrations and pH values in Jim Creek and Big Boulder Creek. The alkalinity and pH value in the TA-5 effluent appear to be inconsistent with net acid generation. The sulfate concentration is also lower in the effluent than in Jim Creek. However, the metals loading in the TA-5 effluent indicates that leaching is probably occurring from these tailings, whatever the mechanism causing it. Geotechnical analyses of the tailing samples are summarized in Table 4.

3.2.2. Contaminated Soil and Mine Process Reagents

The analytical results of samples collected from soils around Mill 1 and mine process reagents from containers inside and outside of Mill 1 are summarized in Table 5. Based on the results, soils around Mill 1 contain elevated concentrations of metals and probably consist of a mix of native soils, ore from stockpiles, and tailings. The extent of contamination has not been characterized and the volume of contaminated soil is unknown. Because of site access issues, the area around Mill 2 also was not characterized during the SI. These data gaps should be addressed in the final removal action design. However, for the purposes of this EE/CA, the volume of contaminated soil (1,600 cubic yards [yd^3]) was estimated based on an average depth of about 12 inches over a 1-acre area.

Materials found in unlabelled drums and boxes at Mill 1 were determined to include copper sulfate and lime containing cyanide salts. These reagents are not Bevill-exempt, and it would be prudent to handle and dispose of them as RCRA hazardous waste. No polychlorinated biphenyls (PCBs) were detected in the sample of oil collected from the electrical transformer. However, two Pyranol™ capacitors that likely contain very high concentrations of PCBs were observed at the site and will require disposal as "large PCB capacitors" under the requirements of 40 CFR 761.

Additional materials and containers identified in and around Mill 1 included:

- 55-gallon drum of Aeroflot 211 (trademark name for dithiophosphoric acid and acid salts)

- 55-gallon drum of Aeroflot 404
- Sodium isopropyl xanthate
- 55-gallon drum of sodium sulfide, flake, 60 to 62 percent sodium sulfide
- 55-gallon drum of sodium cyanide

Although not all of these materials may be classified as a RCRA hazardous waste, they pose a significant human health hazard and it would be prudent to handle and dispose of them as such. Alternatively, salvaging or recycling with the mill equipment may be worth consideration.

3.2.3. Cover Soil

Results of the agronomic analyses of samples from four potential, on-site cover soil borrow sources in the alluvial deposits along Big Boulder Road are summarized in Table 6. Based on the results and visual observations at the site, the alluvial soils are a suitable growth medium that could be improved with some minor soil amendments. The analytical laboratory that processed the samples, Western Laboratories, provided soil amendment recommendations based on generic agricultural practices in Southwestern Idaho. Their recommendations should be reviewed by a FS botanist and revised as necessary for an alpine habitat, site-specific conditions, and plant species appropriate to the site.

The alluvial soils are classified as loam. The soils are slightly to moderately acidic and lime amendment recommendations range from zero to 1,000 pounds per acre. Electrical conductivity (ECe) of the soil extract is a measure of the amount of dissolved salts in the soil solution. High salt content can interfere with plant growth. ECe readings for the alluvial soil samples were in the range of no cropping limitations (less than 0.4 decisiemens per meter (dS/m) to negligible limitations (0.4–0.8 dS/m). Results were based on actual measurements, rather than calculations from cation concentrations. Concentrations of the micronutrients iron and manganese in the alluvial samples were “adequate,” and concentrations for micronutrients boron, copper and zinc ranged from “low” to “good.” Fertilizing with the major nutrients may be desirable. Nitrogen content ranges from “very low” to “medium,” and phosphorus, potassium and sulfate range from “low” to “high.”

Geotechnical results of the potential cover material sample collected north of TA-2 are summarized in Table 4. Although sieve analysis results indicate the fines content is somewhat high, the Atterberg Limits results indicate the risk of erosion is low.

3.2.4. Groundwater

There are no wells on, or in close proximity to, the site; therefore, no groundwater samples were collected during the SI. The nearest well is located about 10 miles northeast of the site at a BLM campground on East Fork of the Salmon River.

Shallow groundwater at the site likely flows in the unconsolidated alluvial deposits along the valley slopes eventually discharging to Jim and Big Boulder Creeks. However, attempts to characterize the shallow groundwater have been unsuccessful. The FS reportedly extended borings to a depth of up to 45 ft bgs in the area directly southeast of TA-2 and 3, but groundwater was not encountered (MSE 2004). During the SI, no groundwater was observed in a temporary piezometer installed in TA-2A and screened down to the soil surface.

Nonetheless, the saturated conditions at TA-5 and presence of moist tailings and willows along TA-2 and 3 are suggestive of subsurface flows. In addition, flow emanating from TA-5 is suggestive of a seep or spring beneath the tailings.

3.2.5. Surface Water

The surface water quality results are summarized in Table 7. The results indicate elevated concentrations of lead and zinc in Jim Creek, and elevated concentrations of lead and selenium in Big Boulder Creek. However, samples of effluent from TA-5 contained the highest concentrations of metals, including copper, zinc, arsenic and lead. The maximum lead concentration in Jim Creek was 13 micrograms per liter (μg/L), compared to a maximum lead concentration of 705 μg/L in the TA-5 effluent. Similarly, maximum concentrations of arsenic, copper, and zinc were significantly higher in the TA-5 effluent than in Jim Creek. Considerable dilution occurs when the TA-5 effluent enters Jim Creek, and there does not appear to be any significant metals loading from the other tailings areas. Additionally, with the exception of zinc, Jim Creek does not appear to contribute significant metals loading to Big Boulder Creek. Clearly most of the impact to surface water at the site is in the vicinity of TA-5.

Background samples collected from Jim Creek upstream of TA-5 are considered representative of background conditions at the site but may be impacted by flows from mine adits upstream of the site. Lead and zinc were both detected in samples from this location at concentrations exceeding the Idaho freshwater Criteria Continuous Concentration (CCC). Samples collected from Big Boulder Creek upstream of the mine tailings and the confluence with Jim Creek are considered representative of background conditions for that stream. Lead was detected in a sample from that location at a concentration of 5 μg/L, which exceeds the Idaho freshwater CCC of 1.2 μg/L.

At the downstream Jim Creek sample location, concentrations of most of the metals, with the exception of lead and selenium, were comparable to concentrations in samples from the background location. In samples collected in June 2002, lead concentrations increased from 2 µg/L upstream of the site, to 13 µg/L downstream of the site. Selenium concentrations slightly increased from below detection limit, to 3 µg/L in the October 2001 samples.

In Big Boulder Creek, with the exception of zinc and a selenium anomaly at one location, metal COC concentrations were below the reporting limit in all samples. However, zinc concentrations increased from less than 5 µg/L upstream of the site to 40 µg/L immediately downstream of the confluence with Jim Creek. Selenium was detected in only one sample from Big Boulder Creek, at a location approximately 1,200 ft downstream of the site, at a concentration of 8 µg/L, which exceeds the Idaho freshwater CCC of 5 µg/L. An evaluation of the analytical data suggests no laboratory error or interference from sulfate or chloride. The reported selenium concentrations could reflect a source under seasonal conditions or ordinary analytical uncertainty of measurements near the reporting limit. However, additional sampling in the fall may be warranted for confirmation.

The former Jim Creek channel was observed to be dry during both SI site visits. However, there was evidence of periodic overtopping of the diversion and the very limited available historic data suggests that this is likely to occur often. An unnamed tributary, referred to as “M1 Creek” in the SI report, flows out of a rocky canyon north of Mill 1 and normally infiltrates into the alluvium north of TA-2A; however, it may contribute to flows in the former channel during high precipitation events.

3.2.6. Macroinvertebrates

Macroinvertebrate samples were collected from two locations in Jim Creek and two locations in Big Boulder Creek. At each location, three subsamples were collected from different run/riffle habitats using a Hess sampler. The samples were submitted to EcoAnalysts, Inc. in Moscow, Idaho for identification. The three subsamples from each location were combined for a 500-count subsample and the macroinvertebrates were identified to the lowest possible taxonomic level.

Results of the analysis indicate macroinvertebrate assemblages are not impaired at any of the sample locations.

3.2.7. Stream Flows

Stream flow measurements were taken during the SI in October 2001 and June 2002. Variability in the Jim Creek flow measurements resulted from difficulties in measuring stream velocities in a narrow channel containing large rocks. In contrast, stream flows in Big Boulder Creek were relatively consistent because of uniform channel conditions. The flow data for both seasons indicate that both Jim Creek and Big Boulder Creek are losing streams within the study area.

In general, flows in Jim Creek ranged from 1.0 to 2.1 cfs in the fall, to 6.7 to 8.2 cfs in the spring. Flows in Big Boulder Creek generally ranged from 5.3 to 7.8 cfs in the fall, to 58.4 to 90.9 cfs in the spring. The effluent flow from TA-5 was too low to measure with the velocity meter. However, the October 2001 flow was estimated by taking the difference in flows measured at upper Jim Creek #2 and Jim Creek #1 (MSE 2004). In June 2002, the flow was estimated by measuring the time to fill a 500-milliliter (mL) bottle. The estimated flows ranged from 0.001 to 0.1 cfs.

Available historical flow data from a USGS gauge somewhere on Big Boulder Creek for a 4–year period in the 1920s indicated maximum annual flow rates ranging from 67 to 206 cfs (USGS 2002b). The maximum flow rate of 206 cfs corresponds to a gauge height of 2.04 ft, which indicates bank overflows at the project site are likely to occur.

3.2.8. Tailings and Contaminated Soil Volume

During the SI, a portable auger was used to measure the depth of tailings at 28 locations in TA-2 and 3. Augering was not performed in TA-4 because it was anticipated that this area would be used for an on-site repository. The seemingly shallow layer of tailings in TA-1 did not require augering, and TA-5 was avoided because a local resident misled field personnel by incorrectly informing them that the area was on private property (according to the FS, there is no private property within 3 miles of the site). In general, the depth of tailings is estimated to range from 6 inches to 10 ft. The depth of tailings in the berm at TA-4 is estimated to be 15 ft.

In addition to the five bulk tailings areas, tailings have been scattered by wind and water erosion resulting in relatively shallow deposits (< 12 inches) of tailings around the periphery of the tailings areas and downstream of TA-1, near the FS campground. Tailings may also have been deposited in the former Jim Creek channel and riparian area during a large storm event in the 1980s and from periodic run-off from TA-1, 2, and 3. The area surrounding Mill 1 also appears have a thin layer of tailings intermixed with soil. The extent and volume of tailings in these areas have not been characterized and represents a data gap that should be addressed in the final design.

For the purposes of this EE/CA and estimating the total tailings volume at the site, general assumptions were made regarding the average depth and acreage of shallow tailings. The area of shallow tailings around the periphery of the five tailings areas and east of TA-1 was estimated to be approximately 3.4 acres at an average depth of 6 inches (~2,725 yd^3). Tailings in the former Jim Creek channel were assumed to extend the length (2,500 ft) of the former channel at an average depth of 2 inches (~770 yd^3). Shallow contaminated soils around Mill 1 were assumed to cover approximately 1 acre at an average depth of 6 inches (~807 yd^3). The combined volume from each area totals 4,302 yd^3 of shallow tailings and contaminated soil. The volume of bulk tailings in each area was estimated based on visual observations and field measurements. The total estimated volume of tailings in the five tailings areas is 63,945 yd^3. Bulk contaminated soils at Mill 1 consist primarily of a few small piles totaling approximately 100 yd^3. The total volume of bulk tailings and contaminated soils is 64,045 yd^3. The estimated volumes are summarized in Table 8.

3.3. Risk Evaluation

As part of the SI, site characterization contaminant levels were compared to RMCs developed by the BLM to assess risks to human and ecological receptors. RMCs provide risk-based screening levels for human and ecological exposure to COCs in various media at abandoned mining sites (Ford 1996). The risks are classified in logarithmic categories, with relative risk expressed in terms of the factor by which contaminant concentrations exceed the reference RMC. The RMCs were developed using available toxicity data and standard EPA exposure assumptions. The intent of RMCs is to provide a baseline concentration, below which adverse health effects from exposure to metals in soil, sediment, and water at abandoned mine sites will not occur.

The BLM human health RMCs correspond to either a target excess cancer risk level of 1×10^{-5}, or a target noncancer hazard index of 1.0. For metals posing both carcinogenic and noncancer threats to health, the lower (more protective) concentration is used for the RMC. For a target excess cancer risk of 1×10^{-5}, an individual exposed at the RMC for 30 years, would have a 1 in 100,000 chance to develop any type of cancer in a lifetime as a result of contact with the metal of concern. A hazard index of <1.0 is assigned when the dose of noncancer metals assumed to be received at the site by any of the receptors is lower than the dose that may result in adverse noncancer health effects. The RMCs are protective for exposures to multiple chemicals and media. Because of the limited available toxicological information regarding health risks associated with exposure to lead, the lead RMC was determined from the EPA Integrated Exposure Uptake Biokinetic Model and other EPA regulations and guidance (Ford 1996).

Ford developed RMCs for ecological receptors from a survey of literature for toxicity data relevant to either wildlife receptors at BLM sites or to closely related species. For receptors without available toxicity data, he selected data based on phylogenetic similarity between ecological receptors and the test species for which toxicity data were reported. He obtained soil ingestion data for each receptor from a study on dietary soil content of wildlife from the FWS. For receptors without available dietary soil content data, he assumed soil content was equal to that of an animal with similar diets and habits. The amount of soil ingested by each receptor was estimated as a proportion of their daily food intake. Ford then calculated the food intake in grams for each receptor as a function of body weight.

Ford calculated RMCs for metals in soil based upon assumed exposure factors for the specific receptors, and species- and chemical-specific toxicity reference values (TRVs). The TRVs represent daily doses of the metals for each wildlife receptor that will not result in any adverse toxic effects. Ford computed the metals TRVs for each wildlife receptor/metal combination for which toxicity data were available. Phylogenetic and intraspecies differences between test species and ecological receptors were accounted for by applying uncertainty factors derived from critical toxicity values. These uncertainty factors were applied to protect wildlife receptors that might be more sensitive to the toxic effects of a metal than the test species. The uncertainty factors were applied to the test species toxicity data in accordance with a method developed by BLM. In accordance with this system, Ford applied a divisor of two to the toxicity reference dose for each level of phylogenetic difference between the test and wildlife species (in essence, individual, species, genus, and family).

The following sections discuss the COCs, conceptual site models (CSM), potentially exposed populations, potentially complete exposure routes, and results of the streamlined human health and ecological risk assessments.

3.3.1. Contaminants of Concern

COCs are compounds detected at the site that exceed risk-based screening levels and present potential risk to human or ecological receptors. Based on the site characterization results, COCs in tailings, soil and surface water at the site include arsenic, lead, copper, zinc, and selenium. COCs presenting the greatest risk to human health are arsenic and lead in the tailings and soil around Mill 1. The most significant ecological COCs are zinc and lead in surface water, and arsenic, lead, and zinc in the tailings. The mine process reagents also contain hazardous compounds, such as cyanide and dithiophosphoric acid, that pose a significant threat to human and ecological receptors.

3.3.2. Conceptual Site Models

Human health and ecological CSMs provide the framework for assessing risk by identifying the contaminant sources, transport mechanisms, and potential exposure pathways, exposure routes, and receptors. The CSMs identify:

- The environmental setting and contaminants known or suspected to exist at the site;
- Contaminant fate and transport mechanisms that might exist at the site;
- Mechanisms of toxicity associated with contaminants and potential receptors;
- Complete exposure pathways that might exist at the site; and
- Potential exposed populations.

Human health and ecological CSMs were developed for the Livingston Mill site based on existing data and the current and likely future conditions at the site, and are shown in Figures 3 and 4, respectively.

3.3.3. Potentially Exposed Populations

The Livingston Mill site is intermittently occupied by owners of the mill and associated patented mining claims who serve as caretakers and periodically check the site to protect to protect their equipment and personal property stored at the site. The area is subject to moderate recreational use for camping, hiking and hunting, and includes a trailhead campground for the Sawtooth National Recreation Area. There is evidence of off-road and ATV use on the exposed tailings areas. Future uses of the site are expected to remain the same as current uses. Residential development of the site is believed to be unlikely. Potentially exposed human populations at the Livingston Mill site include:

- Recreationist – Adult and Child Receptors
- Resident – Adult and Child Receptors

The area supports a variety of wildlife, including mule deer, antelope, big horn sheep, elk, moose, bear, cougar, bobcat, fox, skunk, mink, red fox, beaver, squirrels, and various bird species such as grouse, owls, and songbirds. There are six federally listed “threatened” species that potentially occupy areas on or near the site, including the Canada lynx, bald eagle, yellow-billed cuckoo, Chinook salmon, steelhead trout, and bull trout (FS 2003). In addition, an experimental, non-essential pack of gray wolves may have established in the area. The area may also provide habitat for 14 FS designated sensitive species, including the wolverine, fisher, Townsend’s big-eared bat, spotted bat, northern goshawk, northern three-toed woodpecker, flammulated owl, boreal owl, great gray owl, westslope cutthroat trout, greater sage grouse, Pygmy rabbit, peregrine falcon, and spotted frog (FS 2003).

Jim and Big Boulder Creeks are tributaries to the East Fork of the Salmon River, which is habitat for anadromous steelhead, trout and Chinook salmon. No stream segments of Big Boulder Creek, Jim Creek or the East Fork of the Salmon River have been identified as having impaired water quality. These streams do not appear on the 2002 “303(d) list,” so named in reference to section 303(d) of the federal Clean Water Act. Fish species in Jim and Big Boulder Creeks include Chinook salmon, westslope cutthroat trout, steelhead, rainbow trout, and bull trout. Chinook salmon, steelhead, and bull trout are listed as “threatened" species. Westslope cutthroat trout are considered species of concern. Potential ecological receptors at the site include terrestrial wildlife (plants, birds, invertebrates, reptiles and amphibians, and mammals) and aquatic biota (invertebrates and fish).

3.3.4. Potentially Complete Exposure Routes

Humans at the site may be exposed to COCs via several potential pathways, including ingestion and dermal contact with surface water, sediment, soil, tailings, and mine process reagents; ingestion of fish; and inhalation of windblown tailings. Fishing is allowed in Jim and Big Boulder Creeks; however, regulations stipulate that this is a catch-and-release only stream for cutthroat trout (Idaho Department of Fish and Game [IDFG] 2004). Catch-and-release rules require anglers to release the fish immediately back into the water, which should limit consumption of fish from these streams. Nonetheless, fish ingestion-based RMCs were conservatively used in assessing risk from human health exposure to contaminants in surface water at the site. There is no current groundwater use at the site and the nearest water supply well is about 10 miles from the site. Therefore, groundwater ingestion is considered to be an insignificant pathway at the site.

Wildlife at the site may be exposed to metal contamination via several environmental pathways, including inhalation of airborne dust, and ingestion of soil, tailings, vegetation, surface water, and sediment.

3.3.5. Human Health Risk Summary

To assess potential human health risks at the site, tailings, soil and surface water COC concentrations from the site characterization samples were compared to BLM RMCs developed for residential and recreational camper exposure scenarios. Contaminant concentrations in surface water were also compared with Idaho's freshwater CCC for human health (water and organism ingestion) and freshwater aquatic life for all metals except arsenic; the residential fish ingestion RMC was adopted for arsenic, since it is lower than the CCC.

The results of the human health risk evaluation from exposure to tailings, contaminated soil and process reagents, and surface water are summarized in Tables 3, 5 and 7 respectively. The contaminant concentrations are color–coded according to the degree of relative risk they pose to humans based on BLM's logarithmic classification system for relative risk to residents (Ford 1996). Arsenic concentrations in all soil and tailings samples exceeded the residential RMC at extremely high risk levels. Lead concentrations also exceeded the residential RMC in all soil and tailings samples at moderate to high risk levels. Copper, selenium, and zinc concentrations also exceeded the residential RMCs in several soil and tailings samples at moderate risk levels.

The risk to human health from exposure to contaminants in surface water at the site is relatively low, except for the TA-5 effluent. Although no surface water arsenic concentrations exceeded the Idaho toxic substance criterion of 50 µg/L for recreational and domestic uses, arsenic and lead concentrations in the effluent from TA-5 exceeded fish ingestion-based RMCs. However, fish ingestion is unlikely because the TA-5 effluent does not support a viable fish habitat and therefore, the relative risk is probably low.

The primary risk to human health at the site is from exposure to arsenic and lead in the mine tailings at TA-1 through TA-5, and contaminated soils around Mill 1. Risk from exposure to arsenic and lead in the TA-5 effluent also is moderate to extremely high based on fish ingestion. However, risk from exposure to surface water in lower Jim Creek and Big Boulder Creek is much lower. Additional human health risks at the site include physical hazards from the mill buildings and equipment, and exposure to hazardous process reagents at Mill 1.

3.3.6. Ecological Risk Summary

COC concentrations in tailings and soil samples from the site characterization were compared to BLM wildlife RMCs to assess potential ecological risks at the site (Tables 3 and 5, respectively). Four surrogate wildlife species were selected from a limited set to represent the major animal types at the site, including small mammals, large mammals, terrestrial birds and migratory waterfowl. They may not represent actual species that inhabit or migrate to the site. The four surrogate species are the deer mouse, mule deer, robin, and Canada goose. Based on the RMCs for these species, there is significant risk to environmental receptors at the site, particularly to animals such as robins that feed on soil invertebrates, from exposure to metals in the soil around Mill 1 and tailings. Except for selenium, for which a wildlife RMC has not been established, metals concentrations in the soil and tailings exceeded the RMCs for all four receptors. The most significant exceedances were for arsenic and lead.

For surface water, COC concentrations were compared to Idaho's freshwater CCCs for aquatic life (Table 7). Based on the results, risk to aquatic organisms from surface water is driven primarily by concentrations of lead and zinc, particularly in the TA-5 effluent. Arsenic and copper concentrations also exceeded CCCs in the TA-5 effluent at moderate risk levels.

4.0 REMOVAL ACTION SCOPE AND OBJECTIVES

This section discusses the scope, goals, and objectives of the CERCLA non-time critical removal action at the Livingston Mill site.

4.1. Removal Action Scope

The SI and risk evaluation determined that there are significant risks to human health and the environment from exposure to COCs at the site and that a removal action is warranted. The scope of this removal action is focused on eliminating direct contact with the tailings, contaminated soils, and process reagents, and reducing or eliminating the migration of COCs to the environment. Key issues to be addressed within the scope of this removal action include:

- Human and ecological exposure to COCs from direct contact with the mine tailings, contaminated soil around Mill 1, and process reagents;
- Potential impacts to water quality in Jim and Big Boulder Creeks from releases of COCs from the mine tailings areas; and
- Potential impacts to groundwater quality from releases of COCs from the mine tailings areas.

Addressing the primary waste sources (*i.e.* the mine tailings, contaminated soil around Mill 1, and process reagents) should eliminate the potential for direct contact and significantly reduce impacts to the environment. Primary tailings sources consist of the five tailings areas (TA-1, 2, 3, 4, 5). The process reagents consist of hazardous materials found in two containers inside Mill 1 and two drums outside of Mill 1. There are also two Pyranol^{TM} capacitors inside Mill 1 that are presumed under 40 CFR 761.2 to contain PCBs.

Tailings that may have been deposited in, or migrated to, the former Jim Creek channel and riparian area are considered a secondary source and are estimated to represent less than 2 percent of the total tailings volume. The riparian area is well vegetated and the tailings are likely widely dispersed in the dry streambed and intermixed with sand, gravel, and cobbles. Attempting to remove tailings from these areas would be very difficult and likely result in destroying or severely damaging the natural stream channel and riparian areas. Therefore, removal of tailings from this area will not be addressed in this removal action but may require future action, particularly if Jim Creek is re-established in the former channel. To minimize potential migration of tailings in the dry channel to Big Boulder Creek, measures will be taken to prevent overtopping of the existing stream diversion berm. In addition, a series of three small rock check dams will be installed in the former channel to provide sediment containment in the event of channel rehydration or episodic flooding.

Mitigation of physical hazards at the site, such as the mill buildings and associated structures, equipment, and miscellaneous debris, is not within the scope of this removal action. Secondary sources, such as milling process residuals within the equipment, potentially contaminated stream sediments, and water emanating from the toe of TA-5, also are not within the scope of this removal action and may need to be addressed in a future removal action. Surface water in Jim and Big Boulder Creeks is also not within the scope of this removal action. However, periodic surface water monitoring is suggested to evaluate removal action success.

4.2. Removal Action Objectives

Before developing treatment alternatives, removal action objectives (RAOs) were established based on the contaminants and media of interest, exposure pathways, and preliminary removal goals for the site. Based on results of the SI, the primary COCs at the site are lead and arsenic in the mine tailings and contaminated soil around Mill 1. Secondary COCs include copper, zinc, and selenium. Human and wildlife health exposure pathways that have been identified include: dermal contact with contaminated materials, inhalation of airborne contaminants in windblown tailings, and ingestion of contaminated soil and water. The environmental pathways by which COCs in the mine tailings, contaminated soil, and process reagents mobilize and migrate into the environment include:

- Overland flow (run-off) across the tailings during precipitation events and snowmelt;
- Percolation through the tailings and leaching of COCs into baseflow;
- Erosion during flooding or high precipitation events;
- Groundwater baseflow through tailings; and
- Wind transport and dispersion of tailings and contaminated soils.

The RAOs are aimed at protecting human health and the environment based upon chemical-specific ARARs (if available), site-specific risk-related factors (such as exposure to chemicals), and other available information. The objectives allow for a range of treatment and (or) containment alternatives to be developed. RAOs established for the Livingston Mill site are to:

- Eliminate direct exposure to mine tailings, contaminated soil around Mill 1, and process reagents;
- Eliminate the windblown dispersion of mine tailings;
- Maintain or improve water quality in Jim and Big Boulder Creeks by reducing discharge of contaminated groundwater baseflow and/or overland flow to surface water;
- Maintain or improve water quality in Jim and Big Boulder Creeks by reducing the potential transportation of surface soils to the streams; and
- Reduce phytotoxicity and provide for the viability of native plant and animal species.

4.3. Applicable or Relevant and Appropriate Requirements

Section 121(d)(2) of CERCLA of 1980, 42 USC 9621(d)(2), requires that cleanup actions conducted under CERCLA achieve a level or standard of control which at least attains *"any standard, requirement, criteria, or limitation under any Federal environmental law...or any (more stringent) promulgated standard, requirement, criteria or limitation under a State environment or facility siting law...(which) is legally applicable to the hazardous substance concerned or is relevant and appropriate under the circumstances of the release of such hazardous substance or pollutant, or contaminant..."* The standards, requirements, criteria, or limitations identified pursuant to this section are commonly referred to as ARARs.

ARARs are **either** applicable **or** relevant and appropriate. To further define, applicable requirements are those cleanup standards, standards of control, or other substantive environmental protection requirements, criteria or limitations promulgated under Federal or State environmental laws that specifically address a hazardous substance, pollutant, contaminant, cleanup action, location, or other circumstances found at a CERCLA site. Applicable requirements are those that a party or agency would have to comply with by law if the same action were being undertaken apart from CERCLA authorities. Relevant and appropriate requirements are those cleanup standards that address problems or situations sufficiently similar to those encountered at the site that their use is well suited to the particular site. They make sense given the circumstances at the site. Once a requirement has been determined to be relevant and appropriate, it has to be complied with to the same extent as if it were applicable.

State requirements may also be ARARs. For a State requirement to be an ARAR, it must be promulgated, meaning of general applicability and legally enforceable. It also must be more stringent than Federal requirements. Finally, it must be clearly identified by the State in a timely manner.

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

Location-specific ARARs relate to the geographic or physical position of the site, rather than to the nature of the contaminants. These ARARs place restrictions on the concentration of hazardous substances or the conduct of cleanup activities due to their location in the environment. Action-specific ARARs are usually technology- or activity-based requirements or are limitations on actions taken with respect to hazardous substances. A particular removal activity will trigger an action-specific ARAR. Unlike chemical- and location-specific ARARs, action-specific ARARs do not, in themselves, determine the removal alternative. Rather, action-specific ARARs indicate how the selected remedy must be achieved.

Sometimes there are no ARARs to serve as cleanup levels for a particular site or contaminant. In these situations, it is appropriate to consider non-promulgated criteria, advisories, guidance, and proposed standards issued by Federal or State governments. This category of cleanup goals is called “to be considered” or TBCs. TBCs may be relied on in making cleanup decisions, but they are not potential ARARs because they are neither promulgated nor enforceable.

Actions taken on site during a CERCLA cleanup must comply only with the substantive portions of a given ARAR. On-site activities need not comply with administrative requirements such as obtaining a permit, record keeping, and reporting. On-site means the areal extent of the contamination and all suitable areas in very close proximity to the contamination necessary for implementation of the removal action. Actions taken off-site must comply with both the substantive and administrative requirements of applicable laws and regulations.

CERCLA Section 121, 42 USC Section 9621, provides that under certain circumstances, ARARs may be waived. The waivers provided by CERCLA Section 121(d)(4), 42 USC Section 9621(d)(4), are: interim measures, greater risk to health and the environment, technical impracticability, equivalent standards or performance, inconsistent application of State requirement; and fund balancing. Removal actions, as opposed to remedial actions, need only comply with ARARs to the extent practicable given the exigencies of the situation and the scope of the removal action. During most non-time critical removal actions, there is sufficient time to identify and evaluate ARARs. Only ARARs that address activities within the scope of the removal action need to be considered. For example, ARARs pertaining to treatment of a contaminated groundwater aquifer are outside the scope of a cleanup involving capping a waste pile.

A general list of Federal and State of Idaho ARARs is provided in Appendix A.

4.4. Risk-based Cleanup Goals

Solid media cleanup goals for the Livingston Mill site were adopted from BLM’s risk-based RMCs for two potential land use scenarios, recreational and residential. If land use restrictions are implemented to prevent residential inhabitation of the site, the recreational camper scenario should be reasonably representative of future potential exposures at the site. Although wildlife RMCs are lower than human health RMCs for some of the COCs, human health risks from exposure to arsenic and lead in the tailings are driving the removal action. Therefore, the RMCs should be balanced with removal goals for the site and used as guidelines rather than specific action levels. The risk-based cleanup goals are summarized in Table 9.

5.0 SCREENING AND DEVELOPMENT OF REMOVAL ACTION ALTERNATIVES

The selection of removal action alternatives is a tiered process involving (1) identifying and screening general removal technologies and processes applicable to the site, and (2) developing potential removal action alternatives capable of achieving the RAOs. The purpose of screening is to eliminate those technologies or processes that are infeasible and/or do not meet ARARs, while retaining potentially effective options for more detailed analysis. Typically, the proposed alternatives will consist of a combination of one or more of these retained removal actions and technologies.

Removal technologies and processes were identified and evaluated for the contaminated solid media only. No evaluation was conducted for surface water, groundwater, or stream sediments primarily because reclamation of the contaminated soil and tailings should eliminate or mitigate impacts to the other environmental media. Mitigation or removal of physical hazards was also not addressed. Impacts to surface water appear to be almost entirely from the flow of effluent from TA-5 into Jim Creek. By addressing the primary waste source (*i.e.* tailings) at TA-5, impacts to surface water quality should significantly decrease. Similarly, there does not appear to be a migration of contaminants from stream sediments to surface water. Therefore, the alternatives were developed to focus on the primary waste sources (tailings, contaminated soils, and mine process reagents) and exposure routes (inhalation and ingestion of solid media). If future monitoring at the site indicates that a significant risk exists from exposure to surface water or stream sediments, a separate removal action may be warranted.

The following sections discuss the identification and screening of potential removal technologies, and the development of potential removal alternatives.

5.1. Removal Technology Identification and Screening

Potential general removal technologies and processes were identified from a review of technical literature and previous experience at similar sites. The general removal action categories include:

- **No Action** that involves leaving the site as is. The No Action alternative is used as a baseline to compare with the various alternatives;
- **Institutional Controls** that minimize or prevent public exposure by limiting access;
- **Engineering Controls** that minimize uncontrolled migration and exposure to the environment; and
- **Treatment** that involves the physical destruction or immobilization of contaminants.

Within each of these categories, there are several potential removal technologies to be considered. During this initial screening step, the removal actions and potential technologies were evaluated based on the following criteria:

- Effectiveness
- Implementability
- Cost

Based on the screening results, each technology was either eliminated or retained for further consideration in the development of potential removal alternatives.

Available site information regarding contaminant types and concentrations, and on-site physical characteristics, was used in the screening process. Two factors that commonly influence technology screening are: (1) the presence or concentration and types of contaminants that limit the applicability of many types of treatment processes; and (2) site conditions that limit the ability to install or deploy certain technologies. Major site limitations often include limited area, steep topography, remoteness, absence of electrical power, and lack of adequate growth medium for reclamation.

Although many treatment technologies and process options are available and applicable for mine waste, most are not considered feasible for remote abandoned mine sites because of high costs or unproven technologies. Many of these technologies involve a variety of techniques related to physical/chemical processes that would require extensive treatability studies to determine potential success based on site-specific conditions. Therefore, many of these technologies are cost prohibitive, and were therefore screened out on the basis of cost.

The general removal technologies and process options are discussed in the following sections and summarized in Table 10.

5.1.1. No Action

No action consists of leaving the site as is. This removal technology is ***retained***, as required for consideration by the NCP, and serves as a baseline for comparison with other removal actions.

5.1.2. Institutional Controls

Institutional controls are administrative and/or legal controls that help minimize risk and/or protect the integrity of a remedy by limiting future land use or preventing access to the site. Examples include deed restrictions to prohibit residential use of the site and, fencing and warning signs to discourage access to the site. While such controls may not effectively achieve cleanup goals, they are often used to augment other removal alternatives. Therefore, institutional controls are ***retained*** for combination with other technologies.

5.1.3. Engineering Controls

Engineering controls are engineered measures designed to minimize the potential for human exposure to contamination by either limiting direct contact with contaminated areas or controlling migration of contaminants through environmental media. Engineering controls typically consist of containment, surface controls, and on-site or off-site disposal.

<u>Containment</u>
Containment controls are intended to eliminate direct contact and fugitive emissions from contaminated materials by placing a cover over the material. The cover can also be designed to minimize infiltration of precipitation and surface water through the waste material, thereby reducing contaminant leaching. Covering waste material in-place can be a viable alternative when excavation and treatment or disposal costs are prohibitive. However, covering waste in place usually requires capping large areas, particularly at sites where waste deposits are relatively shallow, such as at Livingston Mill. Cover systems may also be employed to cap

waste that has been consolidated or placed in a repository. Success of a cover system will depend on several factors such as the relative toxicity and mobility of contaminants in the waste, ability to establish a vegetative cover, amount of available soil, and surface water controls.

The cover design is a function of the level of hazard posed by the contaminated material, future land uses, and site-specific factors. Potential cover systems range from a simple soil cover to an engineered RCRA hazardous waste cap. A variety of cover materials are available and include materials ranging from natural soils to synthetic materials. The cover technologies described below apply both to in–place covering of waste, and repository caps.

Soil Covers

Soil covers can range from a simple layer of growth medium to multi-layered, water-balance systems developed using site-specific conditions and computer models. Water balance covers, also known as evapotranspiration (ET) covers, consist of a relatively thick layer of soil that prevents direct contact with the waste material and limits infiltration by storing precipitation until it is either evaporated or transpired by surface vegetation. A layer of coarse rock or cobbles is often used to separate the soil cover from the waste material and provide a capillary break. Filter fabric is usually installed between the coarse material and overlying soil cover to prevent piping of fines into the coarse layer. Synthetic liners, or low–permeability materials such as clay, are typically not used in an ET cover (EPA 2003). The applicability of ET covers is highly dependent on site climate and annual precipitation, and they are most successful in arid and semi-arid climates with limited precipitation and high evaporation rates. Typically, depending on the soil used for the cover, a thickness of 3 to 4 times the annual precipitation is required to achieve adequate water storage capacity (Interstate Technology and Regulatory Council [ITRC] 2003). Based on an average annual precipitation at the site of 26 to 32 inches, a soil ET cover would need to be about 6 to 8 ft thick to provide adequate water storage capacity to eliminate percolation. However, a thinner soil cover would still eliminate direct contact with the mine waste and may significantly reduce infiltration with proper revegetation. Soil cover systems are ***retained*** for further analysis.

Synthetic Cover Systems

Synthetic cover systems typically consist of a highly impermeable geosynthetic membrane overlaid with rock or soil and growth medium. A layer of compacted clay can be installed under the liner to provide a smooth surface and additional protection against infiltration in case of leaks through the membrane. When properly installed, synthetic cover systems can essentially eliminate infiltration into the waste material. However, these systems can be relatively expensive and difficult to install. Proper subsurface preparation and liner installation is critical to the success and effectiveness of synthetic cover systems. Synthetic cover systems are ***retained*** for further analysis.

Clay Covers

Low permeability clay has been used for years at a variety of sites to cover wastes and limit infiltration. A synthetic geomembrane is often combined with the low-permeability clay layer to provide protection against infiltration of surface water and improve long-term performance. A common substitute is a geosynthetic clay liner (GCL) that consists of a thin layer of dry bentonite sandwiched between layers of geotextile fabric. GCLs exhibit very low permeabilities (less than 10^{-7} centimeters per second).

Recent studies have shown that in most climates, clay covers tend to rapidly break down from desiccation and freeze-thaw cycles and lose their effectiveness after only a few years (ITRC 2004). GCLs may also suffer from the same processes. Clay covers are ***not retained*** for further analysis because of high costs and questionable long-term effectiveness.

Biological Covers

A number of biological covers are being developed and evaluated for mine waste applications. Biological covers consist of applying carbohydrate- or protein-based nutrient mixes to cover soils to stimulate sulfate-reducing and oxygen-consuming microorganisms. Studies show that biological covers can increase soil pH, adjust oxidation potential and decrease metals concentrations in the leachate from the waste material. Preliminary results appear to be strongly dependent on the nutrient mixture used and a pilot or treatability study would be required to determine site-specific applicability and potential success (EPA 2000). Therefore, biological covers are ***not retained*** for further analysis.

Shotcrete or Polyurethane Grout Covers

Shotcrete is the spray application of concrete or mortar to form a continuous low-permeability cover. Fiber-reinforced shotcrete is commonly used to provide a long lasting cover system because of its durability and resistance to cracking. However, the application is typically limited to smaller areas because of relatively high cost and maintenance requirements. Shotcrete covers are subject to cracking from waste settling and degradation from the underlying acid-generating wastes.

An alternative to cementitious shotcrete is the application of a flexible polyurethane grout cover. Results from cover studies by the EPA indicate that polyurethane grouts compare favorably with cement-based grout, have greater retention of plasticity, deteriorate less from acidic conditions and waste settlement, and have better rheological characteristics. However, no data are available regarding the long-term stability of the polyurethane product with respect to sunlight and seasonal temperature changes (EPA 2000).

Significant drawbacks to this type of cover system include limitations on future land uses and the inability to revegetate the area. Therefore, this cover technology is ***not retained*** for further consideration.

Surface Controls

Surface controls are used to minimize contaminant migration resulting from surface water and wind erosion. Typical controls include consolidation, grading, surface water containment or diversion, erosion protection, and revegetation. These controls alone will not eliminate direct contact with the contaminated material so they are usually used to augment other technologies such as containment.

Consolidation involves grouping contaminated materials of a similar type in a common area for more effective management or treatment. This can be particularly applicable at sites consisting of several small waste piles or with piles in sensitive areas such as wetlands or floodplains.

Grading consists of reshaping and compacting areas to stabilize slopes, promote run-off, and reduce infiltration. Grading usually includes the waste areas as well as peripheral areas for run-on/run-off control, site access, etc.

Surface water controls are used to control surface water run-on and run-off around the waste materials and typically consist of diversion channels and sediment control ponds. Erosion protection, such as riprap, is usually incorporated in the surface water controls to prevent erosion of the waste materials. Erosion resistant materials, such as mulch and natural or synthetic fabric mats, may also be used in other areas to minimize water and wind impacts.

Revegetation generally involves the selection of appropriate plant species, preparation of the seeding area, seeding and/or planting, mulching and/or chemical stabilization, and fertilization. Revegetation may also involve adding growth medium and/or soil amendments to provide nutrients and organic materials to establish vegetation. Neutralizing agents and/or additives to improve pH conditions and/or the water storage capacity of the waste may also be appropriate. Neutralizing agents such as lime product, kiln dust, or limestone can be mixed to varying depths, or throughout the entire volume of waste materials. Revegetation is essential to controlling water and wind erosion processes and minimizing infiltration of water through plant evapotranspiration processes. Periodic maintenance may be required during the establishment of vegetation to address erosion issues, adjust soil amendments or seed mixtures, and help establish a self-sustaining plant community. Site controls may also be necessary to limit disturbance of the area until adequate vegetation can be established.

Surface controls alone will not provide adequate protection; however, they are ***retained*** for further analysis in combination with other technologies.

On-Site Disposal

On-site disposal consists of excavating, consolidating and placing the untreated or treated waste materials in an engineered on-site repository or existing waste area. This applies to Bevill-exempt solid wastes from the beneficiation of ores and minerals. The mine process reagents are not Bevill-exempt and may require disposal in a RCRA hazardous waste repository if they fail to meet toxicity characteristic leaching procedure (TCLP) criteria. The disposal area design is dependent on the toxicity, mobility, and type of waste. The design could range from simply consolidating the materials in an existing waste area, such as TA-4, to a fully-encapsulated repository with a leachate collection system.

The presence of steep valley sidewalls and a large flood plain in the valley limit the available locations for an on-site repository. However, there appears to be a number of suitable on-site and off-site locations in the alluvial fans along Big Boulder Road leading to the site. TA-4 appears to be the most suitable location that is central to the site and easily accessible from the other tailings areas. Another suitable candidate location is along the alluvial fan north of TA-1 and 2. However, this area does not appear to offer significant advantages over TA-4 and would require excavating and hauling a greater volume of tailings. Both areas are above the 100-year floodplain for Jim and Big Boulder Creeks, easily accessible, and have sufficient area to accommodate a large volume of tailings. Capping alternatives for the repository were discussed above under containment.

Several technical factors determine the cost or practicality of excavation and disposal. Improvements to the existing roads and construction of temporary roads should not be necessary to access the tailings areas, repository, and borrow sources. However, the road to TA-5 may require minor widening and blading to clear vegetation and sloughing soil and rock.

On-site disposal can be a permanent source control measure that effectively eliminates direct contact with the contaminated material and minimizes contaminant migration. However, depending on the level of design required, costs can be high. On-site disposal is ***retained*** for further consideration.

Off-Site Disposal
Off-site disposal involves excavating the waste materials and transporting to an off-site disposal facility permitted to accept such materials. Off-site disposal options include an existing nearby mine waste repository, solid-waste landfill, RCRA-permitted facility, and an engineered repository. Non-Bevill exempt hazardous materials, such as the mine process reagents, would require disposal in a RCRA hazardous waste facility. Less toxic materials could be disposed of in a permitted solid waste or sanitary landfill. However, it is generally not acceptable to dispose of mining waste in a sanitary landfill. Off-site disposal is ***retained*** for further analysis.

5.1.4. Treatment

Treatment involves chemical, physical, and thermal processes employed to reduce the toxicity and/or volume of contaminants in the waste material. These processes also can be used to concentrate contaminants for further treatment or facilitate metals recovery. Some treatment processes require excavating the waste material while others can be performed *in situ*. Several treatment methods are discussed below.

Reprocessing
Reprocessing involves excavating the waste material and either processing on site or hauling to an off-site mill or smelter for processing and recovery of valuable metals. Applicability of this option is highly dependent on the concentration of economically viable metals and the proximity of a processing facility or equipment. On-site processing would require obtaining the necessary resources and equipment and transporting to the site. Regulatory agency approval and permitting would also be required.

Reprocessing of mine wastes is usually not economically feasible, because of low metal concentrations, permit requirements, and hauling costs, particularly if the wastes cannot be reprocessed on site. Therefore, reprocessing is ***not retained*** for further consideration.

Fixation/Stabilization
This technology involves the use of materials to reduce the mobility of a contaminant (fixation) or encapsulate it with an inert material (stabilization). Reagents or binding agents can be mixed directly into the tailings to form a stable matrix, or the tailings can be excavated for more complete incorporation of the fixation agents with the contaminated media. Typically, *in situ* treatments are less effective than excavate and treat processes because of less complete mixing of the reagents or additives. Common fixation reagents include lime, calcium carbonate, and calcium hydroxide. Stabilization processes commonly use pozzolan or cement as additives.

The tailings could be excavated, mixed with Portland cement, synthetic resins, or cement kiln dust to stabilize the contaminants, and stored in an on–site encapsulation cell. Alternatively, the reagents could be mixed directly into the tailings and the stabilized material could be covered in-place. However, in-place stabilization would only be practical for relatively shallow tailing deposits or localized areas. The need for fixation and stabilization may be limited though because primary exposure pathways at the Livingston Mill site appear to be physical contact and erosion. Also, fixation and stabilization technologies have limited success for metals, such as arsenic, that have species that exist as anions. The success of both methods is also highly dependent on the depth and adequacy of mixing with the contaminated materials, which can be a critical limitation.

In situ fixation in the form of incorporating a neutralizing agent into the shallow waste areas is ***retained*** for further analysis; *ex situ* treatment is ***not retained*** because of high costs.

Physical/Chemical Treatment

Physical processes concentrate contaminants into a smaller volume for disposal or further treatment while chemical processes treat contaminants by adding a chemical reagent that removes, fixates, or reduces the toxicity of the contaminant. Chemical processes are usually combined with physical processes to flush the contaminated media with water, acids, bases, or surfactants. Potentially applicable physical/chemical treatment processes include acid extraction, soil washing, and alkaline leaching.

Acid extraction involves excavating and placing the waste material into an enclosed vessel and applying an acidic solution to dissolve the contaminated media. The dissolved contaminants are then precipitated for additional treatment and/or disposal. A similar process is alkaline leaching by applying a solution of ammonia, lime, or caustic soda. Both methods are potentially effective for removing the majority of metals from mine waste; however, the success of alkaline leaching for arsenic removal is not well documented. The addition of alkaline materials can create an oxide armoring on sulfide materials which may reduce arsenic releases from arsenic-bearing sulfide materials.

Soil washing involves excavating the waste material and washing with water to dissolve water-soluble contaminants. This process is only applicable for water-soluble contaminants that are small enough for dissolution to occur within a practical retention time. The dissolved contaminants are precipitated from the water solution as insoluble compounds and the precipitates form a sludge that requires additional treatment or disposal. The process also generates relatively large quantities of water that may require some form of treatment and disposal.

Physical/chemical treatment processes are ***not retained*** for further analysis because of the need for a pilot study to determine site-specific effectiveness, hazardous material generation, and high application costs.

Thermal Treatment

Vitrification involves heating the contaminated media to above 2,800 °F to melt and oxidize metals. The molten material cools to form an inert, non-leachable, glassy slag. Volatile contaminants and sulfur oxides are emitted as gases and the non-volatile component is vitrified when it cools. Vitrification can be done either *ex situ* or *in situ*. *In situ* vitrification would require the transportation of the necessary equipment to the project site and the presence of an energy source. This process requires a significant energy source and an off-gas treatment system. The high energy requirements of this technology make it an unlikely choice for the project site. *Ex situ* vitrification would require excavating the waste material and hauling to a thermal treatment facility. Other potentially applicable thermal treatments that evaporate and oxidize metals in the contaminated media include a fluidized bed reactor, rotary kiln, and multi-hearth kiln. Thermal treatment processes are ***not retained*** for further consideration because of high costs.

5.2. Removal Alternative Development

Four potential removal action alternatives were developed from the general removal technologies retained from the preliminary screening process:

- **Alternative 1 – No Action**
- **Alternative 2 – *In Situ* Treatment of Shallow Tailings**
- **Alternative 3 – On-site Disposal of Bulk Tailings in TA-4**
- **Alternative 4 – Off-site Disposal of Bulk Tailings**

With the exception of the no action alternative, the alternatives consist of a combination of one or more general removal technologies. The removal action alternatives are described in Section 6 and summarized below and in Table 11:

- **Alternative 1 – No Action.** No removal actions would be performed and the site would remain as is.
- **Alternative 2 – *In situ* Treatment of Shallow Tailings.** Relatively shallow deposits of tailings and areas where the tailings are mixed with soil or not clearly defined would be graded to a stable configuration and treated to a depth of 12 inches with a neutralizing agent and soil amendments, then revegetated. This alternative would not be applicable for the bulk tailings and would only apply to shallow deposits such as around the periphery of the tailings areas and the contaminated soils around Mill 1. This alternative does not address the mine process reagents.
- **Alternative 3 – On-site Disposal of Bulk Tailings in TA-4.** The bulk tailings and contaminated soils would be excavated and consolidated in TA-4. A cover would be placed over the consolidated wastes and revegetated. Three cover options were evaluated:

    - **Cover option 3a: Soil Cover** – Soil cover consisting of 6 inches of coarse material and 24 inches of soil.
    - **Cover option 3b: Pretreated Soil Cover** – Amending the top layer of tailings to a depth of 12 inches with a neutralizing agent and soil amendments, and placing 6 inches of coarse material and 18 inches of soil over the treated tailings.
    - **Cover option 3c: Synthetic Cover** – Synthetic cover consisting of a 6-inch bedding layer of screened tailings, a geosynthetic membrane, 6-inch drainage layer of coarse material, and 18 inches of soil.

    A diversion channel would be installed upgradient of TA-4 to intercept surface water run-on. The excavated areas would be covered with 6 inches of growth medium and revegetated. This alternative applies only to the bulk tailings and contaminated soils, and does not address the shallow tailings or mine process reagents.

- **Alternative 4 – Off-site Disposal of Bulk Tailings.** The bulk tailings and contaminated soils would be excavated and transported, along with the mine process reagents, to a RCRA-C permitted facility for disposal. The excavated areas would be covered with 6 inches of growth medium and revegetated. This alternative applies only to the bulk tailings and contaminated soils, and does not address the shallow tailings.

6.0 ANALYSIS OF REMOVAL ALTERNATIVES

This section presents an analysis and evaluation of the removal action alternatives developed from the general removal technology screening. The following subsections present the evaluation criteria, construction elements common to all action alternatives, and a detailed analysis of the removal action alternatives.

6.1. Evaluation Criteria

Each removal action alternative was evaluated based on the following criteria:

- Effectiveness
- Ease of implementation
- Relative cost

Effectiveness is defined as the ability of an alternative to:

- Achieve RAOs – pertains to the ability of an alternative to achieve, at least to some degree, the project RAOs;
- Protect human health and the environment – addresses whether or not the remedy provides adequate protection and describes how risks posed through each pathway are eliminated, reduced, or controlled through treatment, engineering controls, or institutional controls;
- Comply with ARARs – addresses whether or not a remedy will meet state and federal environmental statutes;
- Provide long-term effectiveness and permanence – refers to the ability of a remedy to maintain reliable protection of human health and the environment over time once cleanup goals have been met;
- Reduce toxicity, mobility, or volume through treatment – refers to the anticipated performance of the treatment technologies; and
- Provide short-term effectiveness – qualitatively addresses the period of time needed to achieve protection and any adverse impacts on human health and the environment that may be posed during the construction and implementation period until cleanup goals are achieved.

Ease of implementation encompasses both the technical and administrative feasibility of implementing a removal action alternative. It also takes into account legal considerations. Factors of particular consideration include construction and operational feasibility; availability of equipment, personnel, and treatment capacity; community acceptance; and the ability to obtain necessary permits for off-site actions.

The relative costs of each alternative are evaluated based on professional experience, engineering judgment, and standard cost estimating references such as R.S. Means (2004, 2005). Primary cost considerations include (1) capital costs, (2) engineering and design costs, and (3) annual operation and maintenance (O&M) costs based on 2 to 3 years of post construction monitoring and maintenance. The costs are estimated at the conceptual level, as defined by the American Association of Cost Engineers. The estimated costs are intended for alternative comparison only and are not for construction bid purposes. General assumptions used to develop the cost estimates are summarized below and assumptions specific to each alternative regarding construction tasks and post-construction maintenance and monitoring activities are discussed in later sections:

- An estimated cost may range from 50 percent higher than estimated, to 30 percent less than estimated;
- Fees based on construction costs include 20 percent for design, 10 percent for construction management, and a 20 percent contingency fee on total project costs, unless otherwise noted;
- Significant improvements to roads leading to the site will not be needed for heavy equipment access;
- Characterization of groundwater and subsurface conditions at TA-4 is included in the cost estimated for Alternative 3 and will be completed before final design and construction;
- All tailings and contaminated soils will be easily accessible;
- The bulk tailings and contaminated soils will be relatively dry and not require dewatering or special handling (with the exception of a small volume [~340 yd^3] of tailings at TA-5);
- There are no tailings, contaminated soils, or mine process reagents at Mill 2 that will require disposal;
- Material quantities and volumes are based on the assumptions and estimates described under each alternative;
- Vegetation test plots will not be used;
- A water truck will be used during the removal action to apply water from Boulder Creek for dust suppression;
- Traffic control will not be required during any removal actions;
- All required cover soil can be provided from a single on-site borrow source located in the alluvial fan north of TA-1 and 2;
- All required coarse material and riprap can be generated by screening soils from the on-site borrow source;
- All lime, compost, fertilizer, seed, and synthetic materials will be transported to the site from suppliers in the southern Idaho and Nevada;
- All production rates assume no personal protection equipment (PPE) above level D will be required. If PPE is required, production rates will be reduced, resulting in higher costs; and
- Present value corrections were not calculated because of the short duration of the removal action and monitoring.

The estimated costs for each task are summarized in Table 12 and detailed costs for the various alternatives are presented in Appendix B.

6.2. Construction Elements Common to All Action Alternatives

Alternatives 2, 3, and 4 have common elements and activities related to preparation of the site and reclamation of disturbed areas to complete the removal action. These common tasks include:

- Establish a staging area and site controls;
- Implement best management practices (BMPs) along Jim and Big Boulder Creeks to contain run-off, minimize erosion, and prevent sedimentation of the streams during the removal action;
- Establish access to the tailings areas and borrow sources;
- Clear and grub borrow sites, and stockpile cover soil for reapplication and use in soil covers;
- Remove mine process reagents and transport to an off-site hazardous waste disposal facility;
- Stabilize existing Jim Creek diversion to prevent overtopping and install sediment controls in the former channel;
- Reclaim disturbed and excavated waste areas by scarifying compacted surfaces, applying 6 inches of soil; and
- Apply seed and mulch to covers and reclaimed areas to revegetate.

Access to the site is via Big Boulder Road (NFSR 70667) and East Fork Salmon River Road (NFSR 70120). The existing roads are in good condition and significant improvements should not be required for heavy equipment access. The tailings areas are all accessible from Big Boulder Road and Mill 1 where a central staging area will be established. BMPs will be implemented in critical areas before construction activities begin to control surface water run-on and run-off and to prevent sediment loading to Jim and Big Boulder Creeks. Specific BMPs will depend on the removal action selected and may include, but not be limited to, silt fencing, straw bales, check dams, temporary surface water diversions, sediment retention ponds, and dust control.

Containerized mine process reagents at Mill 1 will be removed and transported to the U.S. Ecology hazardous waste disposal facility near Grandview, Idaho, approximately 265 miles from the site. Because of site access issues, the area around Mill 2 was not inspected during the SI. This area should be checked and any identified hazardous materials be combined with those from Mill 1 for disposal.

Jim Creek has been diverted from its original path south of TA-3, approximately 2,500 ft upstream of the historic confluence with Big Boulder Creek. Based on observations during the SI, the diversion is subject to occasional overtopping, which rehydrates the former channel and may transport tailings in the dry streambed to Big Boulder Creek. To prevent this from occurring, approximately 10 yd^3 of borrow fill material will be used to raise the height of the existing berm about 2 ft and riprap erosion protection will be added where appropriate. As a secondary measure, a series of three small check dams will be constructed across the former channel near TA-1 to facilitate sediment deposition, provide on-site containment, and minimize potential transport of tailings into Big Boulder Creek.

The proposed cover soil borrow source is located in the alluvial fan north of TA-1 and 2. The source is adjacent to the site and easily accessible from the existing road. Agronomic analysis of soil samples from this area indicate the alluvial soils are suitable for use as a cover soil and can be used for growth medium with minor soil amendments. Up to 24,759 yd^3 of borrow material may be required, depending on the removal action alternative implemented. Assuming an average borrow excavation depth of 3 ft, up to 5.1 acres may be required. The borrow site will be cleared and grubbed and topsoil stripped from the area and stockpiled for reapplication following borrow soil removal. Once topsoil is reapplied to the disturbed area, the surface will be seeded and mulched to establish vegetation.

The staging area, temporary access roads, and other disturbed areas will be reclaimed following completion of the removal action by scarifying compacted areas, replacing the topsoil to a depth of 6 inches, and applying an appropriate seed mixture and mulching. Fertilizer should not be required for these areas.

Seed mixtures and fertilizer requirements will be developed based on site-specific conditions and will likely combine native and metals tolerant species. The areas should be seeded in the fall, and vegetation test plots may be used to determine the optimum seed mixture and soil amendments. Certified weed-free straw mulch will be applied to all newly seeded areas at a rate of 2 tons per acre. Large rocks will be placed in critical areas to deter ATV traffic. Where necessary, temporary fences may be installed to prevent access and protect sensitive areas during re-establishment of a vegetated cover.

To ensure that non-native plant species concerns are addressed during the Livingston Mill removal action, the following forest plan direction will be considered. Detailed direction for non-native plant mitigation can be found in Chapter III of the Sawtooth FLRMP (pages III-36 and III-37). Key actions and/or requirements will be summarized here to ensure this project meets FLRMP standards for non-native plants:

- Prevent new infestations of undesirable non-native plants or noxious weed species, with emphasis on areas of high susceptibility where those species have a strong probability for establishment and spread.
- Re-establish vegetation that is compatible with desired long-term vegetative conditions, Forest-wide management direction, and management area priorities.
- Only certified weed-free hay, straw, feed, mulch, and all seed should be used in the project area.
- All seed used on NF lands will be certified to be free of seeds from noxious weeds listed on the current All States Noxious Weeds List.
- To prevent invasion/expansion of noxious weeds, the following provisions will be included in all special use authorizations, timber sale contracts, service contracts, or operating plans where land-disturbing activities are associated with the authorized land use (additional direction may be found in timber sale and service contract provisions and in FSHs):
    a) Revegetate areas, as designated by the FS, where the soil has been exposed by ground-disturbing activity. Implement other measures, as designated by the FS, to supplement the influence of re-vegetation in preventing the invasion or expansion of noxious weeds. Potential areas would include: construction and development sites,

underground utility corridors, skid trails, landings, firebreaks, slides, slumps, temporary roads, cut and fill slopes, and travelways of specified roads.

b) Earth-disturbing equipment used on NF lands--such as cats, graders, and front-loaders--shall be cleaned to remove all visible plant parts, dirt, and material that may carry noxious weed seeds. Cleaning shall occur prior to entry onto the project area and again upon leaving the project area, if the project area has noxious weed infestations. This also applies to fire suppression earth-disturbing equipment contracted after a Wildland Fire Situation Analysis/Wildland Fire Implementation Plan (WFSA/WFIP) has been completed.

- FS botanists will be consulted to determine if reseeding is necessary following implementation of the proposed action. If seeding were determined necessary, a FS botanist would recommend a FS approved and appropriate native seed mix.
- Contractors, with the exception of fire suppression prior to completion of WFSA/WFIP, shall be required to clean earth-disturbing, construction, and road maintenance equipment, of all sizes, to remove all plant parts, dirt, and material that may carry noxious weed seeds, prior to entry onto the NF, or movement from one project area to another.
- Materials such as hay, straw, or mulch that are used for rehabilitation and reclamation activities shall be free of noxious weed seed, and shall comply with the 1995 weed-free forage special order against use of non-certified hay, straw, or mulch. Materials that are not covered under a weed seed free certification, and that have the potential to contain noxious weed seed, shall be inspected and determined to be free of weed seed before purchase and use.
- Source sites for gravel and borrow materials shall be inspected for noxious weeds before materials are processed, used, or transported from the source site into the project area or onto the Sawtooth NF.
- Gravel or borrow material source sites with noxious weed species present shall not be used, unless effective treatment or other mitigation measures are implemented.
- The NF shall comply with the intent and direction established in the above provisions or clauses in a manner similar to that required of contractors or permittees.
- Projects that may contribute to the spread or establishment of noxious weeds shall include measures to reduce the potential for spread and establishment of noxious weed infestations.
- Identify areas with extensive noxious weed infestations where precautionary actions are necessary when planning and implementing management activities. In areas of extensive weed infestations, designated wash sites should be established as part of project planning. Wash sites should be located: (1) where they are easily accessible and useable, (2) on gravelly or well-drained soils, (3) where wash water runoff will not carry seeds away from site, (4) where wash water runoff will not directly enter streams, and (5) where they may be used repeatedly for several projects or activities within the area.
- Treat weeds prior to ground disturbing activities. If areas identified for project implementation are within known noxious weed sites, treatment/eradication efforts must be made prior to ground disturbing activities. Control noxious weeds during operational

phases to limit the amount of seed in the soil. Control weeds on the topsoil stockpile through treatment or planting preferred species in these storage areas.

- Where feasible and practical, staging and parking areas should be located in weed free sites.

6.3. Detailed Analysis of Alternatives

The following subsections present a detailed analysis of the removal action alternatives based on the criteria discussed above. The removal action alternatives are conceptual designs only. The estimated material quantities were not rounded for consistency with cost estimating spreadsheets and to facilitate internal review and verification.

6.3.1. Alternative 1 – No Action

This alternative consists of leaving the site as is in the present condition. No reclamation would be performed and no further investigation or monitoring would be conducted.

Effectiveness
This alternative will not achieve any of the project RAOs or comply with ARARs. There would be no protection of human health and the environment. The exposed tailings would continue to provide a human health and environmental hazard from direct contact and continued erosion. The mill buildings and equipment, process reagents, and debris would continue to pose a physical hazard. The potential for contaminant migration to Jim and Boulder Creeks would continue and flood events may result in significant erosion of the tailings and deposition in the stream channels.

Implementability
This alternative is both technically and administratively feasible. However, agency and public acceptance is not likely.

Cost
There are no capital or O&M costs associated with this alternative. However, there may be significant long-term costs associated with future impacts or releases. There may also be non-monetary costs associated with ecological impacts to wildlife and the aquatic community.

Summary
This alternative is required for comparative purposes by the NCP.

6.3.2. Alternative 2 – In Situ Treatment of Shallow Tailings

This alternative focuses on areas where the depth of tailings or contaminated soils is less than 12 inches and areas where the tailings are intermixed with soil and not well defined, such as around the periphery of the tailings areas and Mill 1, and east of TA-1. In those areas, a neutralizing agent and soil amendments will be incorporated *in situ* to a depth of 12 inches and the areas will be vegetated. This alternative does not apply to the bulk tailings deposits, and therefore is intended to be combined with other alternatives for addressing the primary waste sources.

The area to be treated totals approximately 4.4 acres based on 1.0 acre for the area around Mill 1 and 3.4 acres for the peripheral areas around the five tailings areas and east of TA-1. The areas will first be graded to remove surface irregularities, blend with surrounding topography, and prevent ponding of surface water. A mixture of lime, compost, and fertilizer would be incorporated to a depth of 12 inches using standard tilling equipment. The lime application rate will be based on the recommended rate from agronomic results presented in the SI report (MSE 2004). The volume of compost to be added will be based on an average depth of 2 inches. The lime and compost will be transported to the site from suppliers in southern Idaho and Nevada, approximately 200 to 350 miles from the site. The treated tailings will be seeded and mulched as described in Section 6.2.

Specific tasks for this alternative include:

- Perform minimal grading to prevent ponding, promote run-off, and prepare for lime amendment and compost application;
- Treat approximately 3,531 yd^3 of tailings and contaminated soil by incorporating a mixture of approximately 48 tons of lime (at 22,000 lbs/acre), 1,178 yd^3 of compost, and fertilizer to a depth of 12 inches; and
- Apply seed and approximately 9 tons of mulching at 2 tons/acre.

Effectiveness

In situ treatment of the shallow tailings deposits and contaminated soils would significantly decrease the soil phytotoxicity and mobility of soluble metals in the tailings, and should promote the establishment of a viable vegetative cover. This alternative would achieve the RAOs to some extent but may not completely eliminate direct exposure to the mine tailings and contaminated soils. However, overall contaminant mobility should be reduced thereby decreasing the risk of exposure and contaminant transport. A vegetated cover should also reduce windblown dispersion of the tailings and contaminant transport from surface water erosion and infiltration by increasing evapotranspiration and limiting infiltration. Phytotoxicity would be decreased and the treated soil should be able to support native plant species.

Risks to human health and the environment would be reduced because of the reduction in contaminant mobility. Contaminant migration to groundwater and Jim and Big Boulder Creeks should also be reduced, particularly once a vegetative cover has established, by reducing runoff and increasing evapotranspiration.

Compliance with ARARs will not be fully achieved. In many areas, the amended waste would remain in the 100-year floodplain for Jim and Big Boulder Creeks and may be washed downstream during an extreme event. However, the volume of shallow waste to be treated represents only five percent of the total estimated waste at the site and only a portion of the treated waste would remain in the floodplain. Contaminant concentrations in the amended waste will vary and depend on the mixing efficiency and successful treatment.

Long-term effectiveness will depend on the thoroughness of mixing and vegetative success. Selecting plant species that are metal tolerant and adapted to high altitudes and short growing seasons should enhance vegetation success. Reacidification once the neutralizing capacity of the soil amendments has been consumed is a potential risk that may impact long-term effectiveness. Periodic maintenance and reapplication of amendments may be required.

Short-term effectiveness will be similar to the no action alternative but improve as the density of vegetative cover increases. Until a vegetative cover is established, the amended waste will be vulnerable to wind and surface water erosion. However, the quality of water infiltrating and percolating through the amended waste should immediately improve thereby decreasing potential impacts to groundwater.

Implementability
This alternative is both technically and administratively feasible. Lime and compost application, and establishing vegetation are readily implementable technologies that use conventional construction techniques and equipment. Design methods and requirements have been thoroughly tested and the necessary construction equipment is readily available and widely used.

Cost
The total estimated cost for Alternative 2 is **$90,358**. A detailed cost analysis is presented in Appendix B.

Summary
This alternative is not applicable to the bulk tailings areas and applies only to areas where the tailings are not well defined, less than 12 inches deep, and intermixed with soil. Advantages and disadvantages of Alternative 2 are summarized below:

Advantages:

- Does not require excavating or transporting the tailings and contaminated soil
- Minimizes the unnecessary removal of excess uncontaminated soils intermixed with the tailings
- Inexpensive and easily implementable

Disadvantages:

- Leaves some waste material within the 100-year floodplain
- May require periodic maintenance and retreatment
- Does not reduce the toxicity or volume of waste

6.3.3. Alternative 3 – On-site Disposal of Bulk Tailings in TA-4

This alternative involves excavating the bulk tailings and contaminated soils, placing them in an on-site repository, applying a soil or synthetic cap, revegetating, and installing surface water controls. This alternative applies to the five tailings areas and contaminated soils around Mill 1, and does not include the shallow tailings and contaminated soils.

There appears to be a number of potential locations for an on-site repository, including TA-4 and along the alluvial fan north of TA-2. TA-4 appears to be the most suitable and easily accessible location and consolidating in TA-4 would require less overall excavation and hauling of waste. The area is on a bench and a preliminary hydrologic analysis, discussed in Section 2.1.4, suggests the area is above the 100-year floodplain for Jim and Big Boulder Creeks.

However, a more accurate floodplain delineation is recommended before completing a final design. In addition, subsurface conditions at TA-4 have not been characterized and should be evaluated (geotechnical properties, depth to bedrock, compaction characteristics, etc.). Installation of temporary piezometers in the tailings in TA-4 is also recommended to characterize the underlying soil and to determine the tailings thickness and moisture content. Installation of monitoring wells immediately upgradient and down gradient of TA-4 is recommended to determine depth to groundwater and seasonal static water level fluctuations, establish a baseline for groundwater quality, and enable long-term groundwater quality monitoring.

TA-4 will be prepared to receive tailings by grading to remove surface irregularities and compacting the repository subgrade. Tailings from the berm along the south side of TA-4 and from the periphery of TA-4 outside of the repository footprint will be placed in the repository. The bulk tailings and contaminated soil from the remaining four tailings areas and Mill 1 will be excavated and transported to the repository. Removal of bulk tailings and contaminated soil will be relatively straightforward and accomplished using standard construction equipment and methods. An X-ray fluorometer (XRF) will be used during removal to assist in delineating the extent of excavation and to field check removal efforts. Confirmation samples will be collected from each area to verify waste removal to site cleanup levels.

The tailings and contaminated soil will be placed and compacted in 12-inch lifts to the approximate configuration shown in Figure 5, and graded to blend with the surrounding topography. The maximum side slope will be 3H:1V and the top surface will be sloped to promote run off and prevent surface ponding. Three cover options were evaluated:

- **Cover Option 3a: Soil Cover -** Involves capping the consolidated tailings and contaminated soil with 6 inches of coarse material and 24 inches of soil. The coarse material will serve as a capillary break to prevent sodification or acidification of the overlying soil from the upward migration of contaminants in the waste. A layer of filter fabric will be placed between the coarse material and cover soil to prevent the downward migration of fines into the coarse material. Approximately 15,643 square yards (yd^2) of filter fabric will be required. Approximately 2,577 yd^3 of coarse material and 10,309 yd^3 of soil will be required from an on-site borrow source.
- **Cover Option 3b: Pretreated Soil Cover -** Involves pre-treating the final layer of consolidated waste to a depth of 12 inches with a neutralizing agent and soil amendments, such as lime and compost, using standard tilling equipment and methods. The lime application rate will be based on the maximum net acid generating potential of the composite tailings samples collected during the SI. A 6-inch layer of coarse material and 18 inches of soil will be placed over the treated waste. A layer of filter fabric would be placed between the coarse material and cover soil to prevent the downward migration of fines. Approximately 15,463 yd^2 of filter fabric will be required. Approximately 860 yd^3 of compost and 162 tons of lime (based on a rate of 22,000 pounds per acre [lb/acre]) will be required from off-site sources. Approximately 2,577 yd^3 of coarse material and 7,731 yd^3 of soil will be required from an on-site borrow source.
- **Cover Option 3c: Synthetic Cover -** Involves capping the waste with a synthetic cover system consisting of a 6-inch bedding layer of screened tailings, a 40-mil geomembrane, a 6-inch drainage layer of coarse sand, and 18 inches of soil. The bedding layer will be generated from on-site screening of tailings. The 40-mil geomembrane will be installed over the bedding layer and a 6-inch layer of clean sand will be placed over the geomembrane to promote lateral drainage. Filter fabric will be placed over the sand to

prevent downward migration of fines and 18 inches of soil will be placed in two 9-inch lifts. The bedding layer will consist of approximately 2,577 yd^3 of screened tailings. Approximately 7,731 yd^3 of soil and 2,577 yd^3 of coarse material will be required from an on-site borrow source. Approximately 15,463 yd^2 of geomembrane and 15,463 yd^2 of filter fabric will be required.

The soil cover in all three options will be seeded with a mixture of native, acid and salt tolerant species, and certified weed-free straw mulch will be applied at a rate of 2 tons per acre. The seed mixture and fertilizer requirements will be developed based on site-specific conditions and native species. The areas will be seeded in the fall and vegetation test plots may be used to determine the optimum seed mixture and soil amendments.

Railroad Ridge Road starts at the Livingston Mill and runs along the hillside above TA-4. The road provides a slope break that intercepts surface water and diverts it to an area that discharges onto the west end of TA-4. To prevent this, a small diversion channel, approximately 1,000-ft long, will be established along the uphill side of the road to divert run-off to a natural drainage that flows into Jim Creek east of TA-4 (Figure 5). In addition, an 800-ft diversion channel will be constructed immediately upgradient of TA-4 to intercept surface water run-on. The diversions will consist of v-shaped channels, approximately 1 to 2 ft deep, with 2H:1V side slopes. Actual channel dimensions will depend on results of hydrologic flow analysis to be performed during the final design. The channels should be designed to be self-cleaning and riprap erosion protection will be specified, where needed, and at the channel outlets. In areas where the channels cross talus slopes, a synthetic liner may be required to prevent percolation of channel flow into the slope above TA-4.

The excavated waste areas will be reclaimed by scarifying compacted surfaces and grading to blend with surrounding topography and prevent ponding of surface water. Cover soil from an on-site borrow source will be placed over the areas in a 6-inch loose lift. The areas will be seeded with a mixture of native, acid and salt tolerant species, and certified weed-free straw mulch will be applied at a rate of 2 tons per acre.

Tasks specific to this alternative includes:

- Excavate and stockpile approximately 22,171 to 24,749 yd^3 of soil from an on-site borrow source (quantity is cover option dependent);
- Screen stockpiled soil or crush rock from an on-site source to generate approximately 2,577 yd^3 of coarse material (all cover options);
- Improve the existing drainage ditch (1,000 ft) along the Railroad Ridge Road above TA-4 and install an 800-ft diversion channel immediately upgradient of TA-4 to intercept surface water run-on;
- Prepare TA-4 to receive tailings by grading and compacting the subgrade;
- Move tailings (17,119 yd^3) from the berm and periphery of TA-4 into the repository footprint and compact in 12-inch lifts;
- Excavate 40,566 yd^3 of tailings and contaminated soils from the TA-1, 2, 3, and 5, and around Mill 1 and transport to TA-4;
- Screen and stockpile 2,577 yd^3 tailings for liner bedding layer (cover option 3c only);

- Place and compact waste to the approximate configuration shown in Figure 5 and blend with the surrounding landscape to the extent possible;
- Install one of the repository cover alternatives described above;
- Apply seed and approximately 6 tons of mulch to the repository cover;
- Scarify compacted surfaces and grade the excavated waste areas (approximately 14.7 acres) to blend with surrounding topography; and
- Apply approximately 11,853 yd^3 of soil to the excavated waste areas in a 6-inch loose lift, seed, and approximately 30 tons of mulch.

Effectiveness

Consolidation of the tailings in TA-4 would achieve the RAOs by eliminating direct exposure to the tailings and contaminant migration from wind dispersion and surface water erosion, reducing contaminant transport to groundwater from surface water infiltration, and providing a viable cover for supporting native vegetation. The level of overall effectiveness would depend on the cover alternative selected. Cover options 3a and 3b utilize a soil cover and capillary break that should significantly reduce surface water percolation into the waste and reduce leachate generation. Cover option 3b relies on pretreating the top layer of waste material to provide a suitable growth medium and reduce the amount of borrow cover soil required. However, reacidification of the waste may occur once the neutralizing capacity of the soil amendments has been consumed and may impact long-term effectiveness. Reapplication of amendments to the waste would be difficult because of the coarse capillary break layer. Cover option 3c utilizes an impermeable synthetic liner, which would effectively isolate the tailings and prevent percolation through the waste and into groundwater. All cover options should significantly reduce percolation once a vegetative cover has established by increasing water storage capacity and evapotranspiration, which will reduce surface water infiltration.

Subsurface flow into the consolidated waste from the upgradient hillside could potentially limit the effectiveness of this alternative. Subsurface flows could potentially saturate the lower layers of consolidated waste and transport contaminants to groundwater. Therefore, characterization of subsurface flows at TA-4 is recommended before implementing this alternative.

Risks to human health and the environment would be significantly reduced by eliminating direct exposure to the tailings and reducing contaminant migration. Future risks would depend on the long-term integrity of the cap. If the cover is significantly disturbed or allowed to erode, the tailings may be exposed.

Compliance with ARARs would be fully achieved. Waste placed in the repository would be fully contained on site and outside of the 100-year floodplain. Surface water quality in Jim and Big Boulder Creeks should improve because of waste containment and decreased contaminant migration. Air quality should also improve. Certain cultural and historic features may be affected and may require clearance from the FS archaeologist. Requirements of the National Historic Preservation Act (NHPA) and Archaeological and Historic Preservation Act (AHPA) should be satisfied through consultation with the State Historic Preservation Office (SHPO) by the FS archaeologist. Action-specific ARARs for storm water run-off and dust suppression should be complied with through the implementation of BMPs during construction.

Consolidating and capping the waste should be a permanent solution requiring little maintenance and providing long-term effectiveness. However, proper cap construction and quality control is critical and long-term effectiveness will depend on vegetative success and cap integrity. Selecting plant species that are shallow rooted, metal tolerant, and adapted to high altitudes and short growing seasons should enhance vegetation success. Burrowing animals, vehicular traffic, or episodic flooding may damage the cap and re-expose the tailings. Periodic maintenance and reapplication of cover soil and seed may be required.

Contaminant mobility will be significantly reduced because of waste containment. However, the toxicity or volume of waste will not be reduced.

Short-term effectiveness will be limited because the removal action will likely require two construction seasons to complete. During that time, there may be short-term impacts from excavating and transporting the waste. However, those impacts should be minimized through proper staging and the implementation of BMPs during removal activities.

Implementability

This alternative is both technically and administratively feasible. The bulk tailings and contaminated soil are easily accessible and removal should be relatively easy. Observations during the SI and results of the tailings sample geotechnical analysis suggest the tailings are relatively dry and not require de-watering. However, some of the tailings at TA-5 may be saturated because of the subsurface flow emanating from tailings and may require special handling and drying before placing in the repository. This may be accomplished by (1) placing the saturated tailings in a thin layer (6 inches or less) in an isolated area of the repository and allowing to dry, or (2) actively mixing the saturated tailings with dry tailings from other areas to achieve the desired moisture content.

Waste excavation and consolidation are common removal actions that use conventional construction techniques and equipment. Design methods and requirements have been thoroughly tested and the necessary construction equipment is readily available and widely used. Installation of the synthetic liner for cover option 3c requires specialized equipment and trained personnel and would be more difficult to construct than the soil covers in options 3a and 3b.

Cost

The cost for Alternative 3 depends on the selected cover option. The total estimated cost for Alternative 3 is **$1,076,290** for cover option 3a, **$1,158,566** for cover option 3b, and **$1,311,551** for cover option 3c. A detailed cost analysis is presented in Appendix B.

Summary

Advantages and disadvantages of Alternative 3 are summarized below:

Advantages:

- Waste is fully contained on site and outside of the 100-year floodplain
- Easily implementable

Disadvantages:

- May require periodic maintenance and cover re-application
- Somewhat dependent on cover vegetative success

6.3.4. Alternative 4 – Off-site Disposal of Bulk Tailings

This alternative involves excavating the bulk tailings and contaminated soils and disposing in an off-site permitted hazardous waste disposal facility. The nearest hazardous waste disposal facility is U.S. Ecology near Grandview, Idaho, approximately 265 miles from the site. This alternative applies to the five tailings areas and contaminated soils around Mill 1, and does not include the shallow tailings and contaminated soil.

The waste material will be excavated as described under Alternative 3, and hauled to a staging area for loading and transport to the disposal facility. The excavated waste areas will be reclaimed by scarifying compacted surfaces and grading to blend with the surrounding topography and prevent ponding of surface water. Soil from an on-site borrow source will be placed over the excavated waste areas in one 6-inch loose lift. The areas will be seeded with a mixture of native, acid and salt tolerant species, and certified weed-free straw mulch will be applied at a rate of 2 tons per acre.

Tasks specific to this alternative include:

- Excavate and stockpile approximately 14,430 yd^3 of soil from the on-site borrow source;
- Excavate approximately 67,576 yd^3 of contaminated soil and tailings and transport to the off-site disposal facility;
- Scarify compacted surfaces and grade the excavated areas (approximately 17.9 acres) to blend with surrounding topography; and
- Place approximately 14,430 yd^3 of soil over the excavated areas in one loose, 6-inch lift, apply fertilizer, seed, and approximately 36 tons of mulch.

Effectiveness

Removal of the wastes and disposal in an off-site facility would be the most effective alternative for reducing exposure and contaminant migration by eliminating the waste source. RAOs would be achieved and the maximum protection to human health and the environment at the site would be achieved. However, there would be short-term risks to human health and the environment during the removal action and transport to the off-site disposal facility.

Compliance with ARARs would be fully achieved similar to the on-site disposal alternative. Removal of the wastes would improve surface water quality in Jim and Big Boulder Creeks, and air quality at and downwind of the site. Certain cultural and historic features may be affected in developing the borrow source and may require clearance from the FS archaeologist. Requirements of the NHPA and AHPA should be satisfied through consultation with the SHPO by the FS archaeologist. Action-specific ARARs for storm water run-off and dust suppression should be complied with through the implementation of BMPs during construction.

Removing the waste would be a permanent solution requiring minimal maintenance and providing the maximum long-term effectiveness. Periodic inspection and maintenance of the revegetated waste areas may be needed to ensure vegetative success.

The toxicity or volume of waste would not be reduced but contaminant mobility would be eliminated by removing the waste.

The removal action should be completed in one construction season so short-term effectiveness will be high. There may be short-term impacts from excavating and transporting the waste. However, those impacts should be minimized through proper staging and the implementation of BMPs during removal activities.

Implementability

This alternative is both technically and administratively feasible. The bulk tailings and contaminated soil are easily accessible and removal should be relatively easy. Observations during the SI and results of the tailings sample geotechnical analysis suggest the tailings are relatively dry and not require de-watering. However, some of the tailings at TA-5 may be saturated because of the subsurface flow emanating from tailings and may require special handling.

There may be FS administrative concerns regarding the long-term liability associated with disposal of the wastes in a facility not under FS control.

Cost

The total estimated cost for Alternative 4 is **$76,942,220**. A detailed cost analysis is presented in Appendix B.

Summary

Advantages and disadvantages of Alternative 4 are summarized below:

Advantages:

- All waste is removed from the site and fully contained
- Does not require additional surface disturbance for a repository
- Most effective at reducing human health and environmental risks at the site

Disadvantages:

- Requires excavating and transporting the tailings and contaminated soil off site
- May be difficult to excavate tailings from the former Jim Creek channel and riparian area
- Long-term liability may still exist
- Expensive

6.4. Data Gaps

Additional data that should be obtained to clarify key issues and assist in preparation of a final design include:

- Mill 2 – Characterize Mill 2 and the surrounding soils to determine whether any contaminated soils or mine process reagents are present that may require treatment or disposal, and to what extent.

- Mill 1 – Characterize Mill 1 and the surrounding soils to determine the extent of contamination and quantity of material that requires treatment or disposal.
- Background soil – Characterize soils in undisturbed areas at or near the site to determine background concentrations of COCs to assist in establishing site cleanup levels.
- Borrow source – Characterize potential borrow sources to evaluate the growth medium horizon and determine the quantity of suitable material available.
- TA-4 Subsurface conditions – Characterize subsurface conditions at TA-4 to determine depth to groundwater and flow direction, depth and moisture content of tailings, and subsurface soil characteristics.
- Floodplain – More accurately delineate the floodplain, particularly at the toe of TA-4, to ensure the proposed mine waste repository is above the floodplain.
- Site topography – Develop sufficient topographic data to ensure that the proposed repository is outside of the floodplain and to assist in the final repository design.

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7.0 COMPARATIVE ANALYSIS OF SELECTED ALTERNATIVES

This section presents a comparative analysis of the removal action alternatives developed in the previous section. The alternatives were compared based on the following nine criteria:

- Overall protectiveness of public health, safety, and welfare
- Compliance with ARARs
- Long-term effectiveness and permanence
- Reduction in toxicity, mobility, and volume through treatment
- Short-term effectiveness
- Implementability
- Cost
- State acceptance
- Community acceptance

The comparative analysis is summarized in Table 12. The alternatives were also compared based on relative effectiveness, implementability, and cost.

Effectiveness
Overall, Alternative 4 is the most effective alternative evaluated. Alternative 3 is more effective than Alternative 2 because the tailings are removed from the floodplain and contained in a repository. The effectiveness of Alternative 3 will depend on the cover option selected. Cover option 3c incorporates a synthetic cover, which would more effectively limit surface water percolation than the soil covers in options 3a and 3b. Cover option 3a would likely be more effective than option 3b because of a thicker cover layer of clean soil. Alternative 2 does not apply to the bulk tailings but would be effective for the shallow tailings areas. The no action alternative would be ineffective.

Alternatives 3 and 4 would both achieve RAOs. Alternative 2 would achieve some RAOs but does not address the bulk waste and must be combined with other alternatives. Alternative 1 would not achieve any RAOs.

Alternative 4 probably provides the greatest overall protection to human health and the environment because the wastes would be fully contained in an engineered hazardous waste facility. However, Alternative 3 should also provide significant protection because the wastes will be isolated in an on-site repository. Cover option 3c should provide more protection than options 3a or 3b because of the synthetic liner and greater reduction in surface water percolation through the waste. Alternative 1 will provide no protection.

Alternatives 3 and 4 both fully comply with ARARs. Alternative 2 complies with most ARARs but would leave some waste within the floodplain. Alternative 1 does not comply with ARARs.

Alternatives 3 and 4 would both be effective in the long term; however, Alternative 4 is presumed to be slightly more effective and permanent because the wastes would be contained in a regulated and monitored hazardous waste facility. Alternative 4 would also require the least amount of long-term maintenance by the FS. The long-term effectiveness of Alternative 3 should be similar for all three cover options and depend on the vegetative success. The long-term effectiveness of Alternative 2 will depend on incorporation of the proper neutralizing agent and soil amendments, thorough mixing, and the absence of a significant flood event during the first few years when the vegetative cover is being established. Periodic reapplication of amendments may be required to prevent re-acidification of the treated waste. Both Alternatives 2 and 3 will require regular maintenance to ensure vegetative success. Maintenance will generally consist of minor reseeding and mobilizing a backhoe to the site to implement BMPs and repair areas impacted by erosion. Alternative 1 would not be effective.

None of the alternatives will reduce the toxicity or volume of contaminants. However, with the exception of the no action alternative, they will all reduce contaminant mobility to some degree through either containment or treatment. Alternative 2 will reduce contaminant mobility by treating the waste with a neutralizing amendment and Alternatives 3 and 4 reduce mobility by containing the waste and minimizing surface water percolation through the waste.

The short-term effectiveness of the alternatives varies based on the anticipated construction duration for each alternative. Alternatives 2 and 4 can be completed in one field season and are the most effective in the short-term. Alternative 3 will require two field seasons to complete and will be the least effective in the short term.

Implementability

With the exception of the no action alternative, the remaining alternatives are all technically and administratively feasible. *In situ* treatment using lime and compost is a readily and easily implementable technology that uses conventional techniques and equipment. Waste excavation, repository construction, and off-site disposal are all very common and tested removal actions that use conventional construction equipment and methods. Construction of the synthetic cover (option 3c) would be more difficult than cover options 3a or 3b and would require specialized equipment and experienced installers. Alternative 4 is easily implementable because the wastes are simply excavated and hauled off site and construction of a repository is not required; however, the long-term liability associated with off-site disposal may be an administrative concern to the FS.

Cost

Alternative 1, no action, is the least expensive alternative; however, there may be potential long-term costs associated with impacts to human health and the environment. Alternative 4, off-site disposal is the most costly alternative at $$76,942,220. The cost of Alternative 2, *in situ* treatment of shallow tailings, cannot be directly compared to the estimated costs of the other alternatives because it only addresses a portion of the waste and is intended to be combined with another alternative. The cost of Alternative 3, on-site disposal, depends on the cover option selected and ranges from $1,076,290 to $1,311,551. A detailed cost analysis is presented in Appendix B.

8.0 RECOMMENDED REMOVAL ACTION ALTERNATIVE

The recommended removal action alternative consists of a combination of Alternatives 2 and 3. Pre-removal action activities will consist of collecting site-specific data to address the data gaps discussed in Section 6.4. A site visit will be conducted to: (1) characterize Mill 2, (2) collect seven background soil samples for analysis of COCs, (3) complete a land survey of TA-4 and the stream channel, (4) install three monitoring wells around TA-4, and (5) install 12 piezometers in TA-4. Information gathered from the site visits and analytical results of samples collected will be used to assist in the final design of an on-site repository in TA-4.

The mine process reagents will be removed and transported to the US Ecology hazardous waste disposal facility near Grandview, Idaho for disposal. Bulk tailings and contaminated soils that exceed the cleanup criteria will be excavated and consolidated in TA-4. The bulk tailings will be excavated from TA-1, 2, 3, and 5, and bulk contaminated soils will be excavated from around Mill 1. Shallow tailings that exceed cleanup criteria and are less than 12 inches deep or intermixed with soil and not well defined, will be treated in place with a mixture of lime, compost, and soil amendments. Those areas will include around the periphery of the bulk tailings areas and around Mill 1. An XRF will be used during removal to assist in delineating the extent of excavation and to field check removal efforts. Confirmation samples will be collected from each area to verify waste removal to site cleanup levels.

Tailings that may have been deposited in the former Jim Creek channel, while within the scope of this removal action, will not be addressed at this time because they are considered a secondary source and removal would be very difficult. The tailings are likely widely dispersed in the dry streambed and intermixed with sand, gravel, and cobbles. Attempting to remove tailings would likely result in destroying or severely damaging the natural stream channel and riparian areas. Therefore, removal of tailings from this area will not be addressed in this removal action but may require future action. However, measures will be taken to prevent overtopping of the existing stream diversion berm and remobilization of the tailings. A series of three small rock check dams will be installed in the former channel to provide sediment containment in the event of channel rehydration or episodic flooding.

The consolidated wastes will be placed in the repository and compacted in 12-inch lifts to the approximate configuration shown in Figure 5 and graded to blend with the surrounding topography. The wastes will be covered with 6-inches of coarse material and 24 inches of soil (cover option 3a), seeded, and mulched. A 4-strand, barbed wire fence will be installed around the repository and warning signs posted to discourage human access. The excavated waste areas will be ripped where compacted, graded to blend with the surrounding topography and prevent surface water ponding, covered with 6 inches of soil, seeded, and mulched.

Tasks specific to the preferred alternative includes:

- Visually inspect Mill 2 for tailings, contaminated soil, and mine process reagents, and collect three characterization samples for analysis of COCs;
- Collect seven background soil samples for analysis of COCs to determine background concentrations and aid in establishing site cleanup levels;
- Complete a land survey of TA-4 and the stream channel to enable an accurate delineation of the floodplain extents relative to the proposed repository;

- Install three groundwater monitoring wells around TA-4 to establish baseline data and monitor long-term ground water quality;
- Install 12 temporary piezometers within the repository footprint at TA-4 to determine the depth and moisture content of tailing and characterize the underlying material;
- Remove the mine process reagents and transport to the US Ecology hazardous waste disposal facility near Grandview, Idaho;
- Add approximately 10 yd^3 of clean borrow soil to the existing Jim Creek diversion berm to increase the height approximately 2 ft and install a series of three small rock check dams in the former channel;
- Improve the existing drainage ditch (approximately 1,000 ft) along the Railroad Ridge Road above TA-4 and Install an 800-ft diversion channel immediately upgradient of TA-4 to intercept surface water run-on;
- Excavate and stockpile approximately 23,942 yd^3 of soil from an on-site borrow source;
- Screen the stockpile borrow soil to generate approximately 2,577 yd^3 of coarse material for the repository cover capillary break layer;
- Prepare TA-4 to receive tailings by grading and compacting subgrade;
- Move tailings (17,119 yd^3) from the berm and periphery of TA-4 into the repository footprint and compact in 12-inch lifts;
- Excavate 40,566 yd^3 of tailings and contaminated soils from the TA-1, 2, 3, and 5, and around Mill 1 and transport to TA-4;
- Place and compact waste to the approximate configuration shown in Figure 5 and blend with the surrounding landscape to the extent possible;
- Place 6 inches of coarse material (~2,577 yd^3), approximately 15,463 yd^2 of filter fabric, and 24 inches of soil (~10,309 yd^3) over the consolidated wastes and apply seed and approximately 6 tons of straw mulch;
- Apply approximately 11,046 yd^3 of soil to the excavated waste areas in a 6-inch loose lift, seed, and approximately 36 tons of straw mulch;
- Perform minimal tilling of shallow tailings deposits and areas where tailings are intermixed with soil (approximately 4.4 acres for peripheral tailings areas, east of TA-1, and around Mill 1); and
- Treat approximately 3,531 yd^3 of shallow tailings and contaminated soils by incorporating a mixture of approximately 48 tons of lime, 1,178 yd^3 of compost, and fertilizer into the tailings to a depth of 12 inches, and apply seed and approximately 9 tons of straw mulch.

The proposed removal action would be sequenced over a 2-year period. The first year would involve completing the design, preparing the repository and stockpiling borrow materials. The waste would be excavated and the site reclaimed during the second year. If necessary, the removal action could be spread over a 3-year period to allow 2 years for construction. Post-construction maintenance and monitoring will consist of collecting annual groundwater samples from the monitoring wells around TA-4, installing and maintaining BMPs and sediment controls, repairing areas impacted by erosion, and minor re-seeding. Annual stream sampling is also recommended at locations upstream and downstream of the site.

The total estimated cost for the preferred alternative is **$1,161,928**. A detailed cost analysis is presented in Appendix B.

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TABLES

Table 1. Threatened, Proposed, Candidate, Sensitive or Proposed Sensitive, or Watch Species in Proximity to the Livingston Mill

Scientific Name	Common Name	Status	Habitat Description
Botrychium lineare	Slender Moonwort	**Candidate**	Alpine, grassland, meadow, forest, cliff
Spiranthes diluvialis	Ute ladies'-tresses Orchid	**Threatened**	Riparian, streamside, lakeside
Artemisia campestris ssp. borealis var. purshi	Northern Sagewort	Proposed Sensitive	Alpine,
Astragalus vexilliflexus var. *nubilus*	White Cloud milkvetch	Sensitive	Subalpine/alpine

Table 2. Summary of Samples Collected During the Site Inspection

Media	Samples(a)	Description	Laboratory Analysis	Sample Date
Mine Tailings	6	Surface fines from TA-1	As, Cu, Pb, Se, Zn, Ca, CN	10/2001
	12	Two samples each from TA-2 and 3; three samples each from TA-4 and 5		
	5	Composite samples of six subsamples each from TA-1, 2, 3, 4, 5	Acid-base accounting analysis	
	4	*In situ* samples collected in brass tubes from TA-2A, 2B, 3, and 4 for geotechnical evaluation	*In situ* dry density and *in situ* moisture content	
	1	Composite of two tailings samples each from TA-1, 2A, 2B, 3, 4, 5	Sieve analysis and modified proctor curve	
	3	TA-1 upper 6 inches, mix of thin layer of tailings and soil, analyzed for potential cover material	Soil pH, soluble salts, lime, organic matter, nitrates, phosphorus, K, Ca, Al, Mg, Na, Zi, Mn, Fe, Cu, B, sulfate, CEC	
Mine Process Residuals	4	Discolored material and soil around Mill 1	As, Cu, Pb, Se, Zn, Ca, CN	10/2001
	1	Drum of white granular solid outside Mill 1		7/2/2002
	1	Drum of yellowish granular solid outside Mill 1		
	1	Box of blue crystalline material inside Mill 1	As, Cu, Pb, Se, Zn, Na, K, Ca, Mg, sulfate, nitrate, chloride, corrosivity, total sulfur, total CN	7/2002
	1	Container of grayish powder inside Mill 1	As, Cu, Pb, Se, Zn, Na, K, Ca, Mg, corrosivity, total sulfur, total CN	
Other	1	Transformer oil sample	PCBs	7/2002
Borrow Soil	1	One grab sample from area north of Big Boulder Road, across from TA-2	Sieve analysis and modified proctor curve	10/2001
	4	Soil from four potential borrow source locations	Agronomic analysis - pH, SMP pH, conductivity, CEC, lime, nitrates, P, K, sulfate, OM, Ca, Al, Mg, Na, B, Cu, Fe, Mn, Zn	6/2002
Surface Water	4	Jim Creek	Unfiltered samples analyzed for As, Ca, Cu, Mg, Zn, Pb, Se, hardness, pH	10/2001 & 6/2002
	8	Big Boulder Creek		10/2001 & 6/2002
	2	Flow emanating from TA-5		11/2001 & 6/2002
Macro-invertebrates	12	Four sets of three macroinvertebrate samples collected from three different riffle/run habitats at two locations each in Jim and Big Boulder Creeks	Taxonomic analysis	10/2001

Notes:

(a) Does not include duplicate samples

CEC = cation exchange capacity

OM = organic matter

PCBs = polychlorinated biphenyls

SMP = Shoemaker, MacLean, and Pratt (Marx, et al. 1999)

Table 3. Summary of Tailings Sample Analytical Results

Tailings Area	Maximum Detected Concentration (mg/kg)					ABA
	Arsenic	**Copper**	**Lead**	**Selenium**	**Zinc**	**NNP**
TA-1	3000	370	25400	82	5570	-41.3
TA-2	1930	183	16300	31	2020	-25.0
TA-3	973	168	11100	20	1700	-28.1
TA-4	2080	285	23900	42	6890	-38.4
TA-5	8120	236	32800	55	3430	-28.1
BLM Human Health RMCs						
Camper	20	5000	1000	700	40000	
Resident	1	250	400	35	2000	
BLM Wildlife RMCs						
Deer mouse	230	640	142	--	419	
Mule deer	200	102	106	--	222	
Robin	4	7	6	--	43	
Canada goose	671	161	34	--	271	

Concentration Range	Relative Risk
< Residential RMC	Low
1 to 10X Residential RMC	Moderate
10 to 100X Residential RMC	High
> 100X Residential RMC	Extremely High

Notes:

ABA = acid-base accounting

NNP = net neutralization potential in tons of $CaCO_3$ per 1,000 tons of rock

RMC = Risk Management Criteria

mg/kg = milligram per kilogram

Table 4. Summary of Geotechnical Analysis Results

Sample Description	Classification	Max Dry Density (pcf)	Optimum Moisture Content	*In situ* Density (pcf)	*In situ* Moisture Content	Atterberg Limits	
						LL	PL
Tailings sample from TA-2A	Sand	--	--	82.3	7.4%	--	--
Tailings sample from TA-2B	Sand silt	--	--	82.2	12.6%	--	--
Tailings sample from TA-3	Fine silt	--	--	87.2	9.9%	--	--
Tailings sample from TA-4	Silty sand	--	--	90.6	3.3%	--	--
Composite tailings sample from TA-1, 2A, 2B, 3, 4, & 5	Sand	116.5	12.5%	--	--	--	--
Sample of potential cover soil from alluvium north of TA-2	Clayey sand with gravel and organics	125.0	10.0%	--	--	46%	20%

Notes:

LL = liquid limit

PL = plastic limit

pcf = pound per cubic foot

Table 5. Summary of Soil and Mine Process Reagent Sample Analytical Results

Sample Description	Maximum Detected Concentration (mg/kg)				
	Arsenic	Copper	Lead	Selenium	Zinc
Discolored soil/material outside southeast corner of Mill 1	2190	309	29800	46.7	3550
Discolored soil/material outside east side of Mill 1	1820	209	15800	37.3	5710
Discolored soil/material above Mill 1	152	79.3	2980	9.5	2460
Discolored soil/material around outside of Mill 1	2610	491	31500	51.7	22500
White granular solid from drum outside Mill 1	25.1	5.8	165	<1.0	210
Yellow granular solid from drum outside Mill 1	1430	325	22000	69.7	7070
Blue crystalline material from box inside Mill 1	8.9	23.9%	117	<1.0	41.1
White-gray powder from container inside Mill 1	195	114	3240	<1.0	59900
BLM Human Health RMCs					
Camper	20	5000	1000	700	40000
Resident	1	250	400	35	2000
BLM Wildlife RMCs					
Deer mouse	230	640	142	--	419
Mule deer	200	102	106	--	222
Robin	4	7	6	--	43
Canada goose	671	161	34	--	271

Concentration Range	Relative Risk
< Residential RMC	Low
1 to 10X Residential RMC	Moderate
10 to 100X Residential RMC	High
> 100X Residential RMC	Extremely High

Notes:

RMC = Risk Management Criteria

mg/kg = milligram per kilogram

Table 6. Summary of Tailings and Borrow Soil Agronomic Results

Sample Description	Classification	pH	SMP pH	ECe dS/m	CEC meq/100g	Lime %	Nitrates mg/kg	P mg/kg	K mg/kg	Sulfate mg/kg	Fe mg/kg	Mn mg/kg	B mg/kg	Cu mg/kg	Z mg/kg
Mixture of tailings and soil from TA-1 (T1M1, T1M2, T1M4)	Loamy sand	4.2	5.4	0.34	8	0	3	28	123	6	188	26	0.1	7.4	10.5
		strongly acidic		good	very low	very low	very low	high	low	low	high	adequate	low	high	high
	Sandy loam	3.4	4.5	0.59	10	0	6	20	102	21	497	10	0.1	1.5	20.8
		strongly acidic		good	low	very low	low	medium	low	adequate	very high	adequate	low	adequate	high
	Sandy loam	3.2	5.5	0.58	10	0	6	30	106	42	581	11	0.1	1.1	4.5
		strongly acidic		good	low	very low	low	high	low	high	very high	adequate	low	adequate	high
Alluvial soil north of TA-2 (SOIL1)	Loam	7.8	NA	0.61	16	0.3	23	22	175	12	14	3	0.5	0.5	0.6
		moderately basic		good	medium	low	medium	medium	low	adequate	adequate	adequate	adequate	Low	low
Alluvial soil northeast of TA-2 (SOIL2)	Loam	6.3	6.6	0.22	17	0	7	6	368	7	33	5	0.2	0.3	2
		slightly acidic		good	medium	very low	low	low	medium	low	adequate	adequate	low	Low	good
Alluvial soil east of the site (SOIL3)	Loam	6.5	NA	0.20	17	0	2	7	457	11	32	6	0.2	0.8	1.5
		slightly acidic		good	medium	very low	very low	low	high	adequate	adequate	adequate	low	adequate	good
Alluvial soil northeast of TA-4 (SOIL4)	Loam	6.8	NA	0.20	17	0	5	7	355	10	25	4	0.2	0.4	1.3
		neutral		good	medium	very low	very low	low	medium	adequate	adequate	adequate	low	Low	good

Notes:

SMP = Shoemaker, MacLean, and Pratt (Marx, et al. 1999)

CEC = cation exchange capacity

ECe = electrical conductivity

dS/m = decisiemen per meter

meq/100g = millequivalent per 100 gram

mg/kg = milligram per kilogram

NA = not analyzed for

Table 7. Summary of Surface Water Sample Analytical Results

Source	Description	Sample Date	pH	alk. mg/L	hard. mg/L	Ca mg/L	Mg mg/L	Maximum Detected Concentration (μg/L)				
								Cu	Zn	As	Pb	Se
Jim Creek	Jim Creek upstream of site (background)	10/01	8.06	—	81.9	28	2.9	<3	97	1	<1	<2
		6/02	7.9	47.2	64.1	21.7	2.44	<3	410	2	2	3
	Jim Creek above confluence with Big Boulder Creek	10/01	8.09	—	83.2	28.3	3.03	<3	102	1	1	2
		6/02	7.98	47.8	64.8	21.8	2.54	<3	342	2	13	3
Big Boulder Creek	Big Boulder Creek upstream of site (background)	10/01	7.83	—	41.1	14.7	1.05	<3	<5	<1	<1	<2
		6/02	7.48	17.1	19.9	7.22	0.46	<3	<5	<1	5	<1
	Big Boulder Creek downstream of confluence with Jim Creek	6/02	7.64	22.1	25	8.91	0.68	<3	40	<1	1	<1
	Big Boulder Creek across from TA-1	6/02	7.63	22.3	25.2	9.02	0.66	<3	39	<1	<1	<1
	Big Boulder Creek about 800 feet downstream of site	10/01	7.86	—	49.3	17.3	1.5	<3	17	<1	<1	<2
	Big Boulder Creek about 1000 feet downstream of site	10/01	7.87	—	48.9	17.2	1.46	<3	16	<1	<1	<2
	Big Boulder Creek about 1200 feet downstream of site	10/01	7.86	—	49.1	17.3	1.47	<3	16	<1	<1	8
	Big Boulder Creek about 1250 feet downstream of site	6/02	7.67	22.7	25.3	9.01	0.69	<3	39	<1	<2	<1
Tailings Area 5 Effluent	Water discharging from TA-5 into Jim Creek	11/01	—	—	66.6	22.1	2.76	7	490	36	705	<2
		6/02	7.23	38.5	41.3	13.4	1.88	9	1760	43	619	3
Idaho Toxics Water Quality Criteria (adjusted for average water hardness)												
	Human Health (water and organisms)		None					None	7400	50	None	None
	Freshwater CCC		6.5–9					6	60	150	2.5	5
BLM Human Health RMCs												
	Camper (boater)							11490	92909	81	50	1548
	Fish ingestion by resident							2907	23505	24	200	392
	Fish ingestion by camper							5984	48390	48	200	807

Concentration Range	Relative Risk
< Reference Criterion[(a)]	Low
1 to 10X Reference Criterion[(a)]	Moderate
10 to 100X Reference Criterion[(a)]	High
> 100X Reference Criterion[(a)]	Extremely High

Notes:

[(a)] Residential fish ingestion RMC for arsenic; freshwater CCC for other metals.

alk. = alkalinity
CCC = criterion continuous concentration
hard. = hardness

mg/L = milligram per liter
μg/L = microgram per liter
RMC = Risk Management Criteria

Table 8. Estimated Volume of Tailings and Contaminated Soil

Area	Surface Area (acre)	Estimated Thickness (feet)	Estimated Volume (cyd)
Bulk Tailings and Contaminated Soil:			
Tailings Area 1	2.6	< 2	6,200
Tailings Area 2A	1.3	< 1 to 9	32,905
Tailings Area 2B	6.7		
Tailings Area 3	2.1		
Tailings Area 4	3.9	< 1 to 15	23,479
Tailings Area 5	0.3	< 1 to 8	1,361
Mill 1 (several small piles)	<0.1	<1 to 3	100
Former Jim Creek Channel(a)	2.9	< 1	770
Total Bulk Tailings and Contaminated Soil =			64,815
Shallow Tailings and Contaminated Soil:			
Peripheral Tailings Areas	3.4	< 1	2,725
Around Mill 1(b)	1.0	< 1	807
Total Shallow Tailings and Contaminated Soil =			3,531
		Total Volume =	**68,346**

Notes:

(a) Assumed average of 2 inches of tailings over 50-ft width x 2,500-ft channel length

(b) Assumed average of 6 inches of contaminated soil over 1 acre

cyd = cubic yard

Table 9. Solid Media Risk-based Clean Up Goals

Exposure Scenario	BLM Human Health RMC (mg/kg)				
	Arsenic	Copper	Lead	Selenium	Zinc
Resident	1	250	400	35	2000
Camper	20	5000	1000	700	40000

Notes:
mg/kg = milligram per kilogram
RMC = Risk Management Criteria

Table 10. Screening of General Removal Technologies

General Response Action	Removal Technology	Application	Description	Initial Screening Based on Technical Feasibility	Effectiveness	Ease of Implementation	Relative Cost	Final Screening
No Action	None	--	No Action - site remains as is	Provides baseline for comparison with other alternatives	Will not achieve remedial action objectives	Easily implemented	None	**Retained for baseline comparison**
Institutional Controls	Access Restrictions	**Fencing and Signs**	Fences installed around tailings; signs posted to notify public of risks	Potentially applicable in conjunction with other alternatives	May limit access but will not reduce contaminant transport	Easily implemented	Low capital; low O & M	**Retained**
		Land Use Controls	Legal restrictions to control current and future land uses	Potentially applicable in conjunction with other alternatives	May limit access but will not reduce contaminant transport	Easily implemented	Low capital; low O & M	**Retained**
Engineering Controls	*In Situ* or Repository Capping	**Soil Cover**	Native or imported soil placed over tailings to prevent direct contact and reduce contaminant transport	Potentially applicable	Highly effective for eliminating direct contact. May be effective in limiting contaminant transport.	Moderate to implement but dependent on availability of suitable material	Moderate capital; no O & M	**Retained**
		Synthetic Cover	Combination of soil and geosynthetic membrane placed over tailings to prevent direct contact and reduce contaminant transport	Potentially applicable	Highly effective for eliminating direct contact and limiting contaminant transport.	Moderate to difficult to implement	Moderate to high capital; no operating, low maintenance	**Retained**
		Clay Cover	Low permeability clay or combination clay and synthetic geomembrane (GCL) to significantly limit infiltration	Potentially applicable	Limited effectiveness in dry or semi-arid environments	Moderate to difficult to Implement	High capital; no operating, low maintenance	Eliminated because of cost and limited effectiveness
		Biological Cover	Soil mixed with carbohydrate- or protein-based nutrients to increase soil pH, and decrease metals concentrations in leachate.	Potentially applicable	Effectiveness site specific and requires a pilot or treatability study	Moderate to difficult to implement depending on agent and volume	Moderate to high capital; may require amendments	Eliminated because of unknown effectiveness
		Shotcrete or Polyurethane Grout Cover	Cementitious shotcrete or flexible grout that provides a continuous low-permeability cover	Potentially applicable	Highly effective for smaller areas; long-term effectiveness unknown	Moderate to difficult to implement	High capital; O&M may be required for repairs	Eliminated because of high costs

Table 10. Screening of General Removal Technologies (continued)

General Response Action	Removal Technology	Application	Description	Initial Screening Based on Technical Feasibility	Effectiveness	Ease of Implementation	Relative Cost	Final Screening
Engineering Controls (continued)	On-site Disposal	**Unlined Repository**	Excavate tailings and dispose in on-site earthen repository	Potentially applicable	Highly effective for eliminating direct contact. May be effective in limiting contaminant transport.	Moderate to difficult to implement	Moderate to high capital; no operating, low maintenance	**Retained**
		Lined Repository	Excavate tailings and dispose in RCRA on-site lined repository	Potentially applicable	Highly effective for eliminating direct contact and limiting contaminant transport.	Difficult to implement	High capital; no operating, low maintenance	Eliminated because of cost
	Off-site Disposal	**RCRA Landfill**	Excavate tailings and haul to off-site RCRA-C permitted landfill for disposal	Potentially applicable	Highly effective for eliminating direct contact and limiting contaminant transport.	Difficult to implement	Extremely high capital; no O & M	**Retained**
		Solid Waste Landfill	Excavate tailings and haul to off-site solid waste landfill for disposal	Potentially applicable for some waste depending on characterization	Highly effective for eliminating direct contact and limiting contaminant transport.	Difficult to implement	Extremely high capital; no O & M	Eliminated because of cost
	Surface Controls	**Consolidation**	Consolidate tailings into single area on site	Potentially applicable in conjunction with other alternatives	May limit access and reduce contaminant transport	Moderate to difficult to implement	High capital; no operating, low maintenance	**Retained**
		Grading and Compaction	Grade and compact tailings in place to promote run-off and reduce infiltration	Potentially applicable in conjunction with other alternatives	Low effectiveness in reducing contaminant transport; will not eliminate direct contact	Easily implemented	Low capital; no O & M	**Retained**
		Run-on/Run-off Control	Implement controls to divert surface water away from tailings	Potentially applicable in conjunction with other alternatives	Low effectiveness in reducing contaminant transport; will not eliminate direct contact	Moderate to implement	Low capital; low O & M	**Retained**
		Waste Amendment & Revegetation	Amend tailings and seed to promote re-vegetation	Potentially applicable in conjunction with other alternatives	Low effectiveness in reducing contaminant transport; will not eliminate direct contact	Moderate to implement	Low capital; low O & M	**Retained**

Table 10. Screening of General Removal Technologies (continued)

General Response Action	Removal Technology	Application	Description	Initial Screening Based on Technical Feasibility	Effectiveness	Ease of Implementation	Relative Cost	Final Screening
Excavation and Treatment	Reprocessing	Milling and Smelting	Excavate tailings and haul to operating mill or smelter for extraction of precious and non-precious metals	Potentially applicable	Highly effective for eliminating direct contact and limiting contaminant transport.	Difficult to implement	Extremely high capital; no O & M	Eliminated because of cost
	Fixation/ Stabilization	Cement/ Pozzolan Additive	Excavate tailings and add non-leachable cement or pozzolan to solidify material	Potentially applicable; would require pilot study and proper disposal of solidified material	May be effective for eliminating direct contact and limiting contaminant transport.	Moderate to difficult to implement	Very high capital; no O & M	Eliminated because of cost
		Lime Fixation	Excavate tailings and amend with lime to reduce mobility of metals	Potentially applicable; would require pilot study and proper disposal of amended waste material	May be effective for eliminating direct contact and limiting contaminant transport.	Moderate to difficult to implement	Very high capital; no O & M	Eliminated because of cost
	Physical/ Chemical Treatment	Soil Washing	Separate hazardous constituents from tailings via dissolution and precipitation	Potentially applicable; would require pilot study, and proper disposal of hazardous material	Low effectiveness for waste rock because of potential to increase mobility from partial dissolution	Moderate to difficult to implement	Very high capital; no O & M	Eliminated because of low effectiveness and cost
Excavation and Treatment	Physical/ Chemical Treatment	Acid Extraction	Mobilize hazardous constituents in tailings via acid leaching and recover by precipitation	Potentially applicable; would require pilot study and proper disposal of hazardous material	Unknown effectiveness; sulfides would only be soluble under extreme temperature and pressure	Difficult to implement	Very high capital; no O & M	Eliminated because of unknown effectiveness and cost
In Situ Treatment	Physical/ Chemical Treatment	Alkaline Leaching	Use alkaline solution to leach hazardous constituents from tailings in a heap or vat	Potentially applicable; would require pilot study and proper disposal of hazardous material	Unknown effectiveness; not well documented for arsenic	Difficult to implement	Very high capital; no O & M	Eliminated because of unknown effectiveness and cost
		Vitrification	Use extremely high temperatures to melt and/or volatize hazardous constituents in the tailings forming a vitrified, non-leachable mass	Potentially applicable; would require pilot study and proper disposal of vitrified mass	Unknown effectiveness; requires high energy source	Very difficult to implement	Very high capital; no O & M	Eliminated because of unknown effectiveness and cost

Table 10. Screening of General Removal Technologies (continued)

General Response Action	Removal Technology	Application	Description	Initial Screening Based on Technical Feasibility	Effectiveness	Ease of Implementation	Relative Cost	Final Screening
In Situ Treatment (continued)	Physical/ Chemical Treatment	**Lime Fixation**	Incorporate lime amendments into tailings to reduce mobility of metals	Potentially applicable; may require pilot study	Effectiveness limited by depth of mixing; may increase arsenic mobility	Easy to moderate to implement	Low to moderate capital; no O & M	**Retained for shallow tailings deposits and intermixed soil and tailings**
		Solidification	Incorporate solidifying agents into tailings to physically or chemically reduce the mobility of metals	Potentially applicable; would require pilot study	Effectiveness limited by depth and thoroughness of mixing	Easy to moderate to implement	High to very high capital; no O & M	Eliminated because of limited effectiveness and cost
		Soil Flushing	Inject acid/base reagents or chelating agents into tailings to solubilize metals into a pregnant solution that is extracted using dewatering techniques	Potentially applicable; would require pilot study, and proper disposal of pregnant solution	Unknown effectiveness	Very difficult to implement	Very high capital; no O & M	Eliminated because of unknown effectiveness and cost
	Thermal Treatment	Vitrification	Apply extremely high temperatures to the tailings *in situ* to melt and/or volatize hazardous constituents and form a vitrified, non-leachable mass	Potentially applicable; would require pilot study	Unknown effectiveness; requires high energy source	Very difficult to implement	Very high capital; no O & M	Eliminated because of unknown effectiveness and cost

Table 11. Removal Action Alternatives Developed for Analysis

Alternative		Description	Applies to
1	**No Action**	Site remains as is	Entire site
2	***In Situ* Treatment of Shallow Tailings**	Shallow tailings and contaminated soils less than 12 inches deep in areas where the tailings are intermixed with soil or not well defined will be treated *in situ* with a mixture of lime, compost, and soil amendments. The treated areas will be seeded and mulched to establish vegetative cover.	Peripheral areas around the tailings areas, east of TA-1, and around Mill 1
3	**On-site Disposal of Bulk Tailings**	Bulk tailings and contaminated soils will be excavated and consolidated in an on-site repository in TA-4. A soil cap will be placed over the consolidated waste, seeded, and mulched to establish vegetative cover. Diversion channels will be constructed to intercept run-on. The excavated areas will be covered with soil, seeded, and mulched.	Bulk tailings in the five tailings area and bulk contaminated soils from around Mill 1.
4	**Off-site Disposal of Bulk Tailings**	Bulk tailings and contaminated soils will be excavated and hauled to an off-site hazardous waste disposal facility. The excavated areas will be covered with soil, seeded, and mulched.	Bulk tailings in the five tailings area and bulk contaminated soils from around Mill 1. Mine process reagents from Mill 1.

Table 12. Comparative Analysis of Removal Action Alternatives

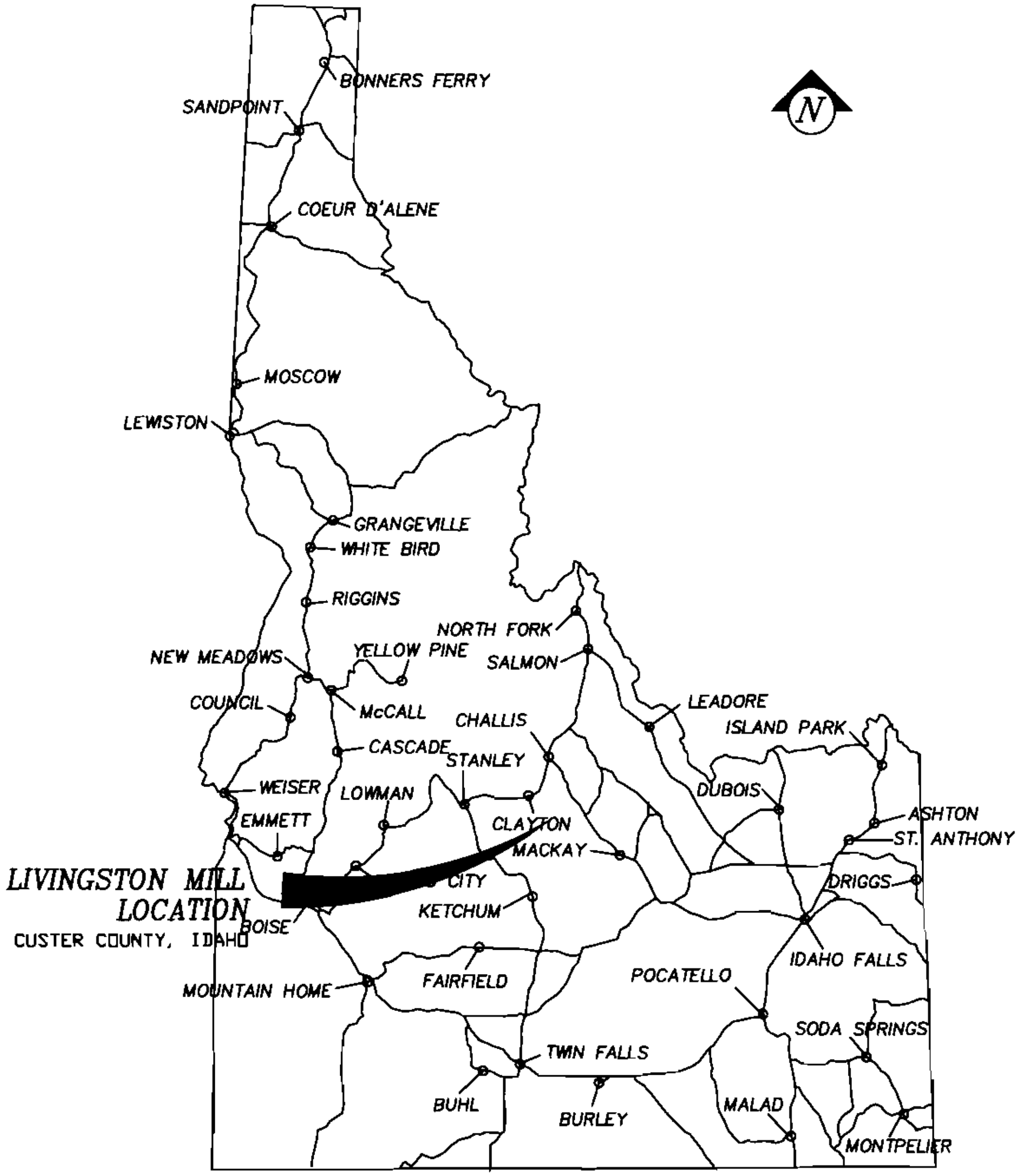
Assessment Criteria	**Alternative 1 No Action**	**Alternative 2 *In Situ* Treatment of Shallow Tailings**	**Alternative 3 On-site Disposal of Bulk Tailings**	**Alternative 4 Off-site Disposal of Bulk Tailings**
Overall Protectiveness of Public Health, Safety, and Welfare	No protection.	Moderate. Decreases risk of exposure by reducing contaminant mobility and migration. Direct exposure will also be decreased once vegetative cover is established	High. Eliminates human and wildlife exposure to tailings and reduces metals loading to stream. Significantly reduces contaminant migration. Does not require transporting waste off site.	High. Eliminates human and wildlife exposure to tailings. Eliminates contaminant migration.
Compliance with ARARs	Does not comply.	Leaves some waste in the 100-year floodplain.	Compliant.	Compliant.
Long-term Effectiveness and Permanence	None.	Low to highly effective. Depends on thoroughness of mixing and vegetative success. May require periodic maintenance.	Moderate to highly effective; permanent. Depends on cover option and vegetative success. Minimal maintenance.	Highly effective; permanent. Removes waste from site to a regulated and monitored facility.
Reduction in Toxicity, Mobility, and Volume Through Treatment	None.	Reduces contaminant mobility but does not decrease toxicity or volume.	Eliminates exposure and reduces mobility of tailings through containment. Does not reduce contaminant volume or toxicity.	Removes hazard and eliminates exposure. Does not decrease volume or toxicity of the waste.
Short-term Effectiveness	None.	Low. Vulnerable to erosion while vegetative cover is establishing	Low to moderate. Effective once the waste has been placed in repository.	Moderate to high. Waste is removed from site. Potential hazards during excavation and transport.
Implementability	Not applicable.	Easy to moderate. No design required and uses conventional construction techniques and equipment.	Moderate to difficult. Construction is feasible and technology is proven. Uses conventional construction techniques and equipment.	Moderate. Requires minimal design and construction. Should not require specialized excavation equipment.
State and Community Acceptance	Not acceptable.	Acceptable.	Acceptable.	Acceptable.
Cost	$0	$90,358	$1,076,290 to $1,311,551	$76,966,220

FIGURES

LIVINGSTON MILL REMOVAL

SAWTOOTH NATIONAL FOREST

CLAYTON, IDAHO



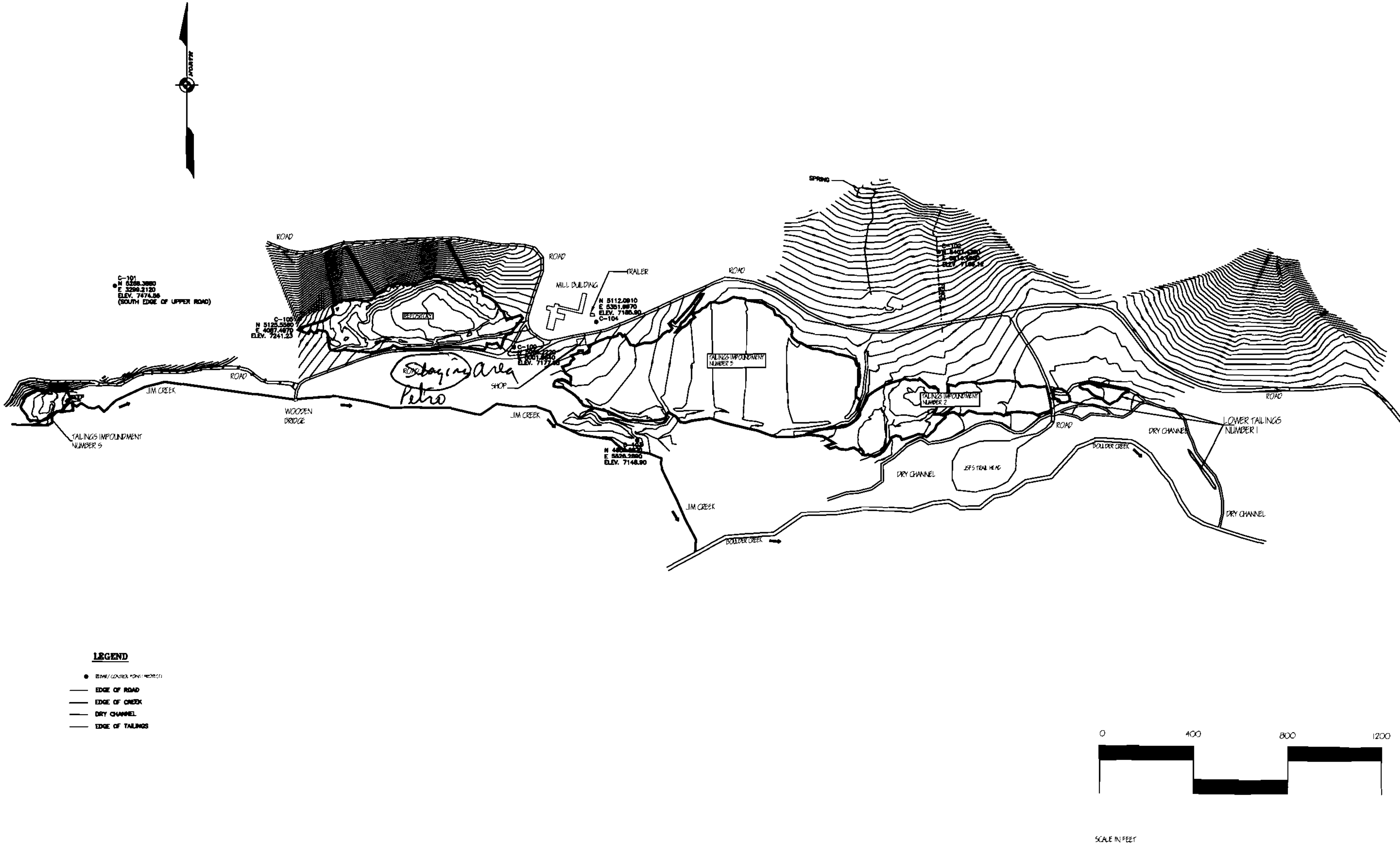
IDAHO

LIST OF DRAWINGS

1 - COVER SHEET AND MAP
2 - LIVINGSTON MILL SITE PLAN
3 - REMOVAL WORK PLAN
4 - MILL BUILDING REMOVAL
5 - REPOSITORY PLAN
6 - REPOSITORY SECTIONS
7 - REPOSITORY DETAILS

APPROVED

LIVINGSTON MILL ON-SCENE COODINATOR | 2/15/08 **DATE**



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TWIN FALLS, IDAHO

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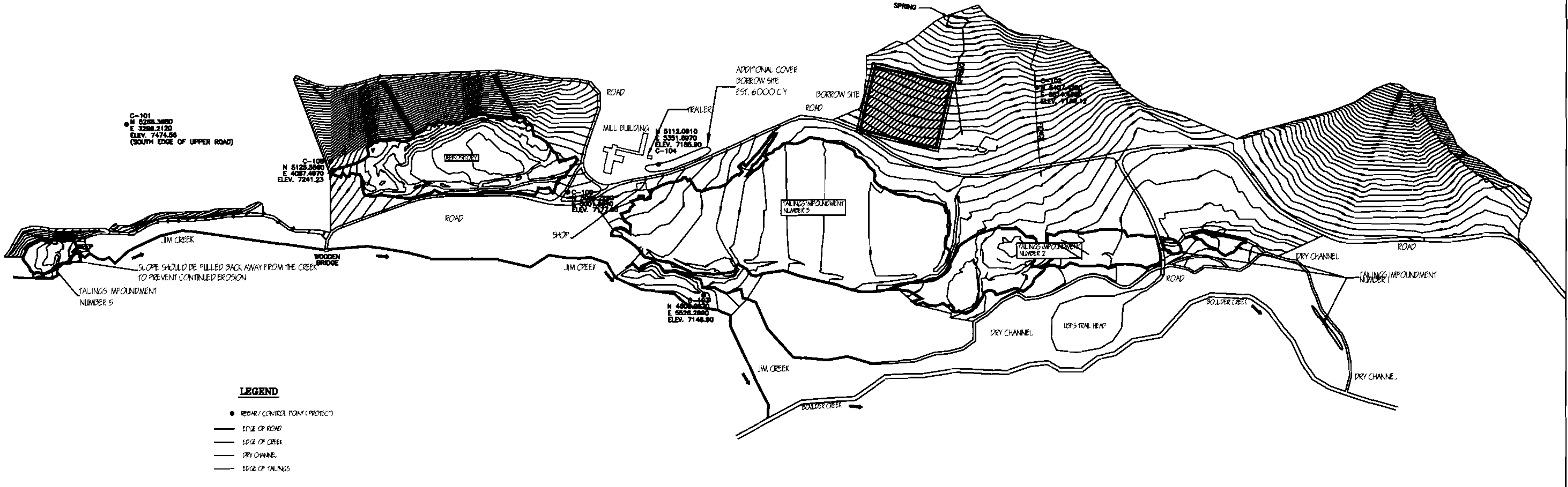
DRAWING	BY: P. TRANOR CHECK: W. HEBEL
APPROVED:	DIRECTOR, ENGINEERING — DATE

LIVINGSTON MILL REMOVAL

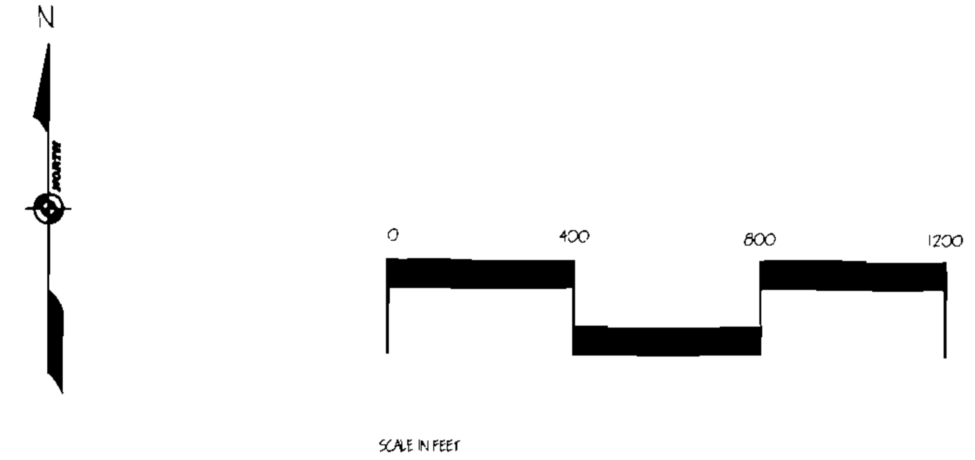
SITE PLAN

PROJECT No.
DRAWING 1 OF 1
SHEET 2 OF 7
FILE NAME & EXT.
LIVINGSTON DESIGNS.DWG



LEGEND

- ● REBAR / CONTROL POINT (PROTECT)
- EDGE OF ROAD
- EDGE OF CREEK
- DRY CHANNEL
- EDGE OF TAILINGS



Estimated Quantities For Consolidation

Tailings Location Number	AREA (SF)	DEPTH(Ft)))	VOLUME (CY)	ACRES
5	19,686	2.8	2,042	0 45
4	193,617	2	4,000	4.44
3	486,932	2.02	36,430	11.18
2	147,881	1.48	8,106	3.39
1	12,394	1	459	0.28
Mill (perimeter)		0.5	500	1
	TOTALS		51,536	20.75

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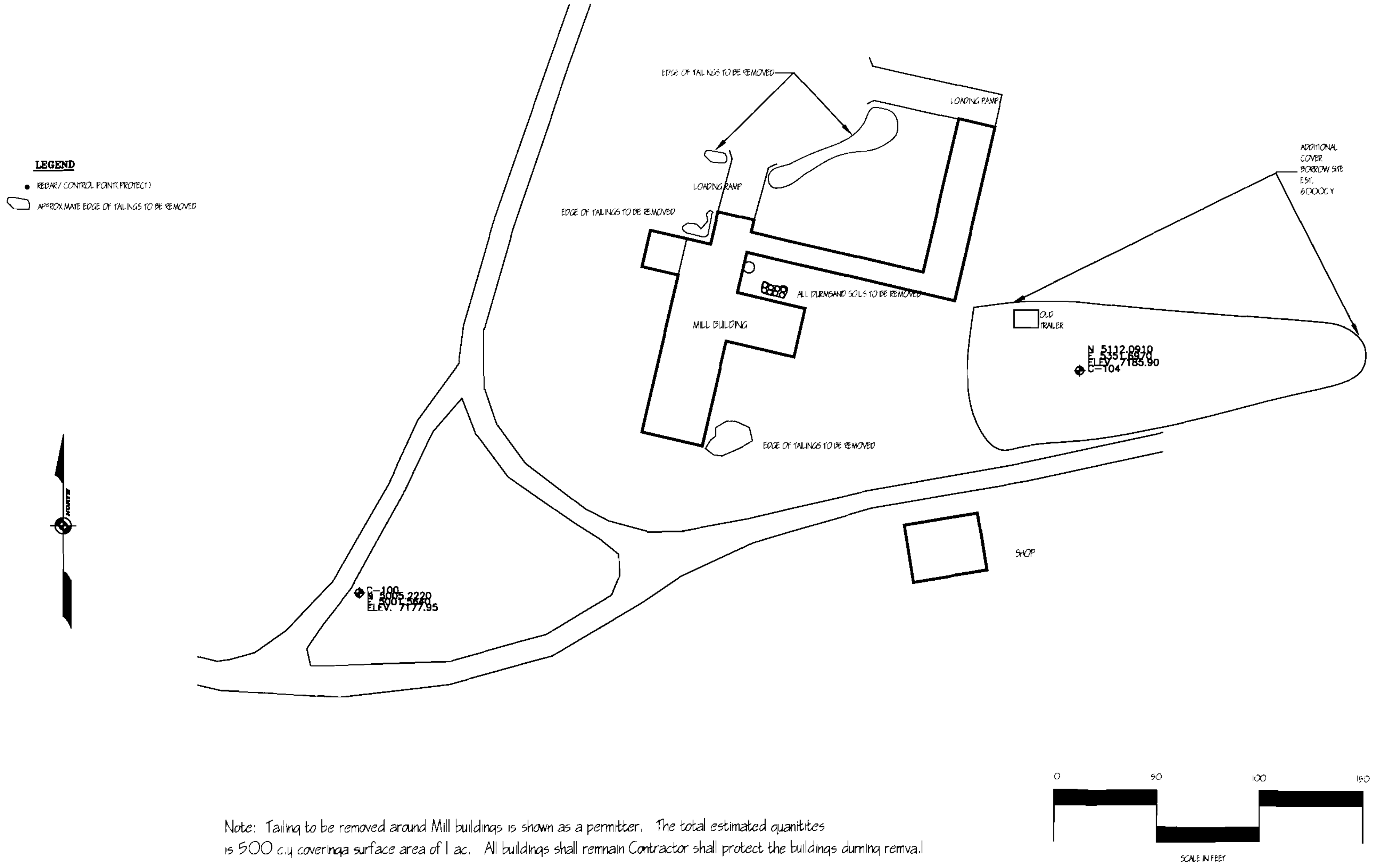
LIVINGSTON MILL REMOVAL

REMOVAL WORK PLAN

PROJECT No.
DRAWING 1 OF 1
SHEET 3 OF 7
FILE NAME & EXT. LIVINGSTON DESIGNV3.DWG



Note: Tailing to be removed around Mill buildings is shown as a permitter. The total estimated quanitites is 500 c.y coveringa surface area of 1 ac. All buildings shall remnain Contractor shall protect the buildings durning remva.l

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LIVINGSTON MILL REMOVAL

REMOVAL MILL BUILDING

PROJECT No.
DRAWING 1 of 1
SHEET 4 of 7

FILE NAME & EXT.
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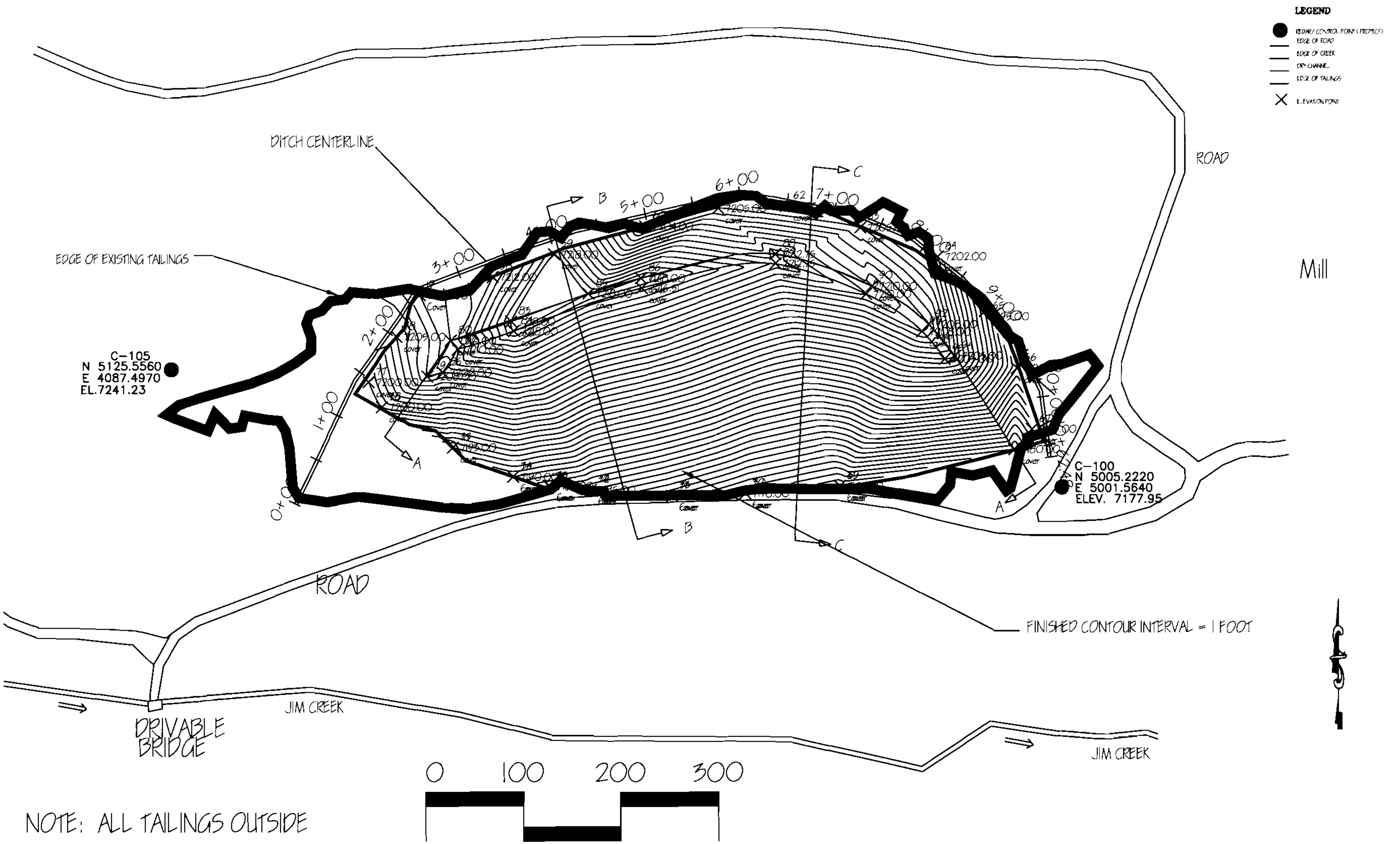

NOTE: ALL TAILINGS OUTSIDE
THE COVER FOOTPRINT SHALL
BE PLACE WITHIN THE COVER.

SCALE 1 INCH = 100 FEET (IF PLOTTED ON 11x17)
OTHERWISE NOT TO SCALE

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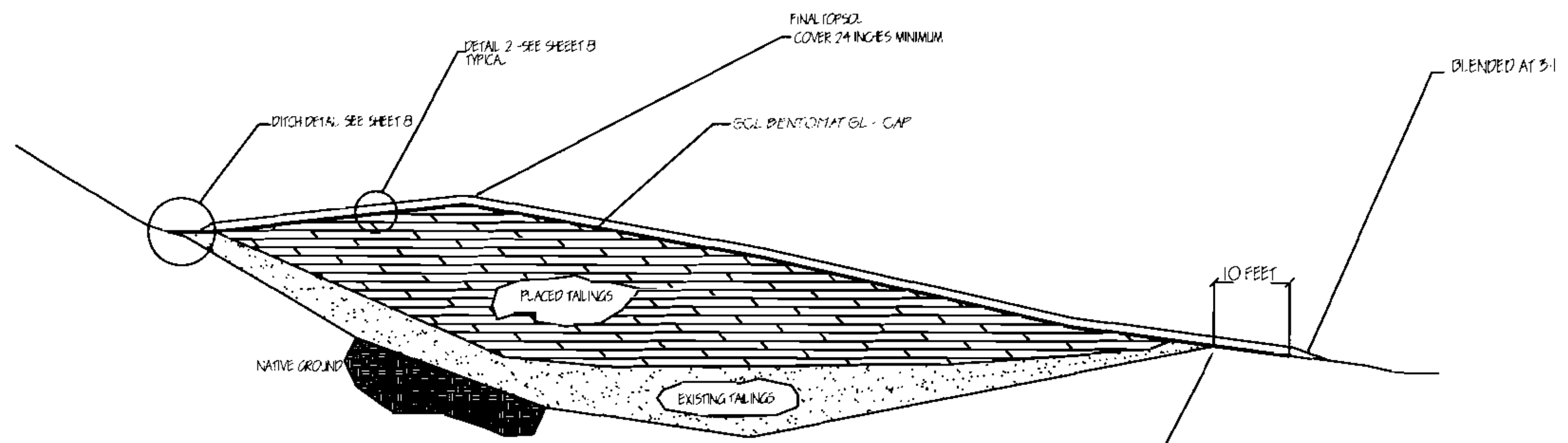
LIVINGSTON MILL REMOVAL
REPOSITORY PLAN

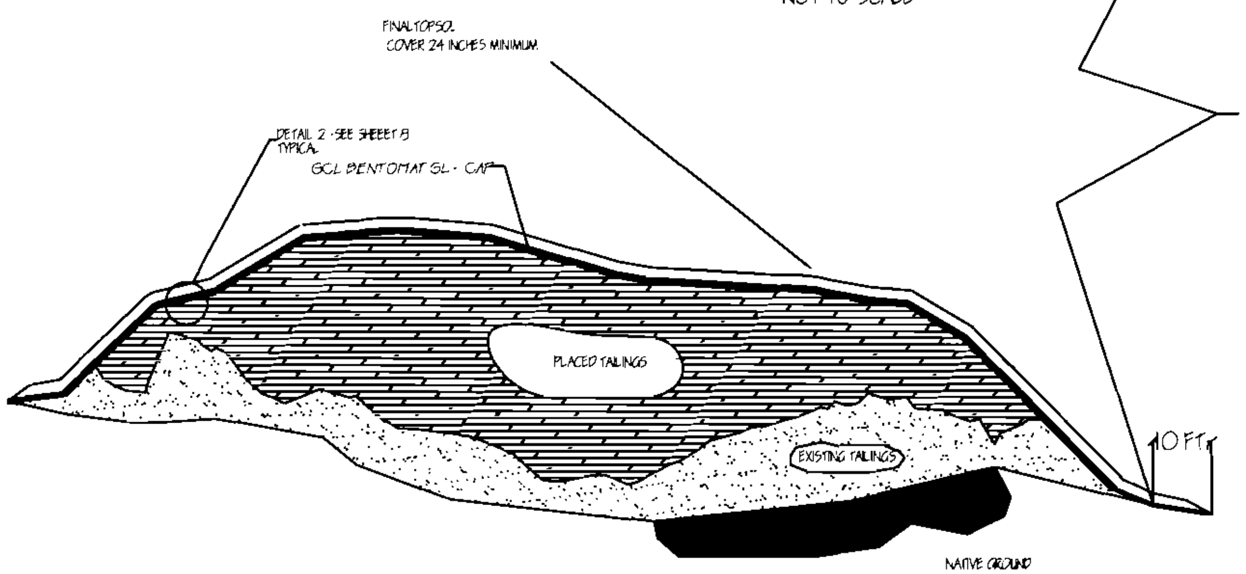
PROJECT No.
DRAWING 1 of 1
SHEET 5 of 7
FILE NAME & EXT.



SECTION B-B

NOT TO SCALE

NOTE: HE COVER SHALL CONTINUE NOT LESS THAT 10 FEET BEYOND THE EDGE OF THE TAILINGS.



SECTION A-A

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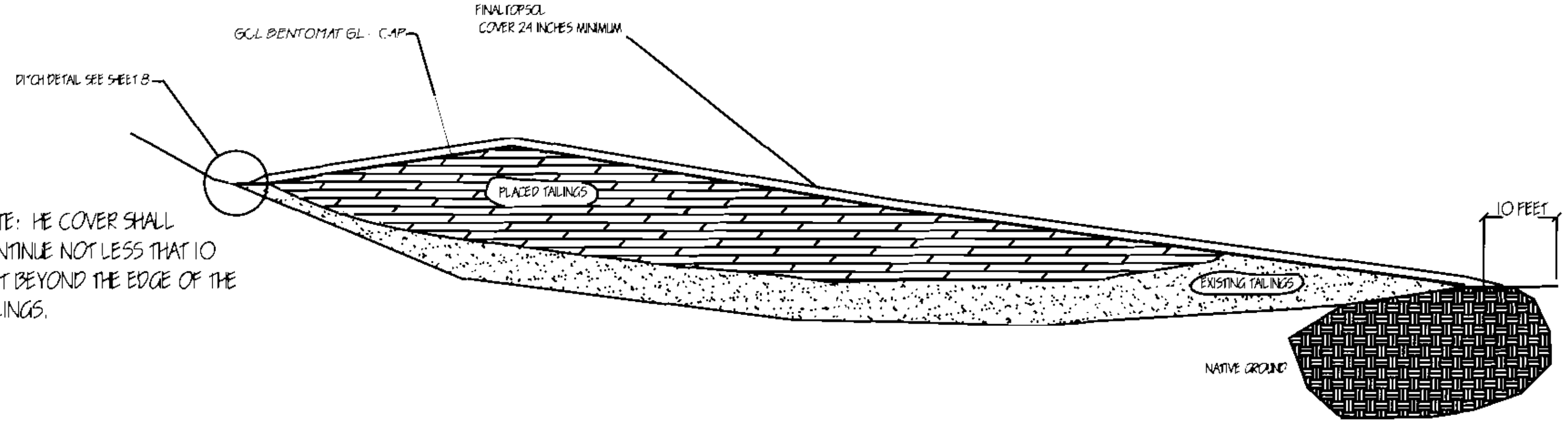
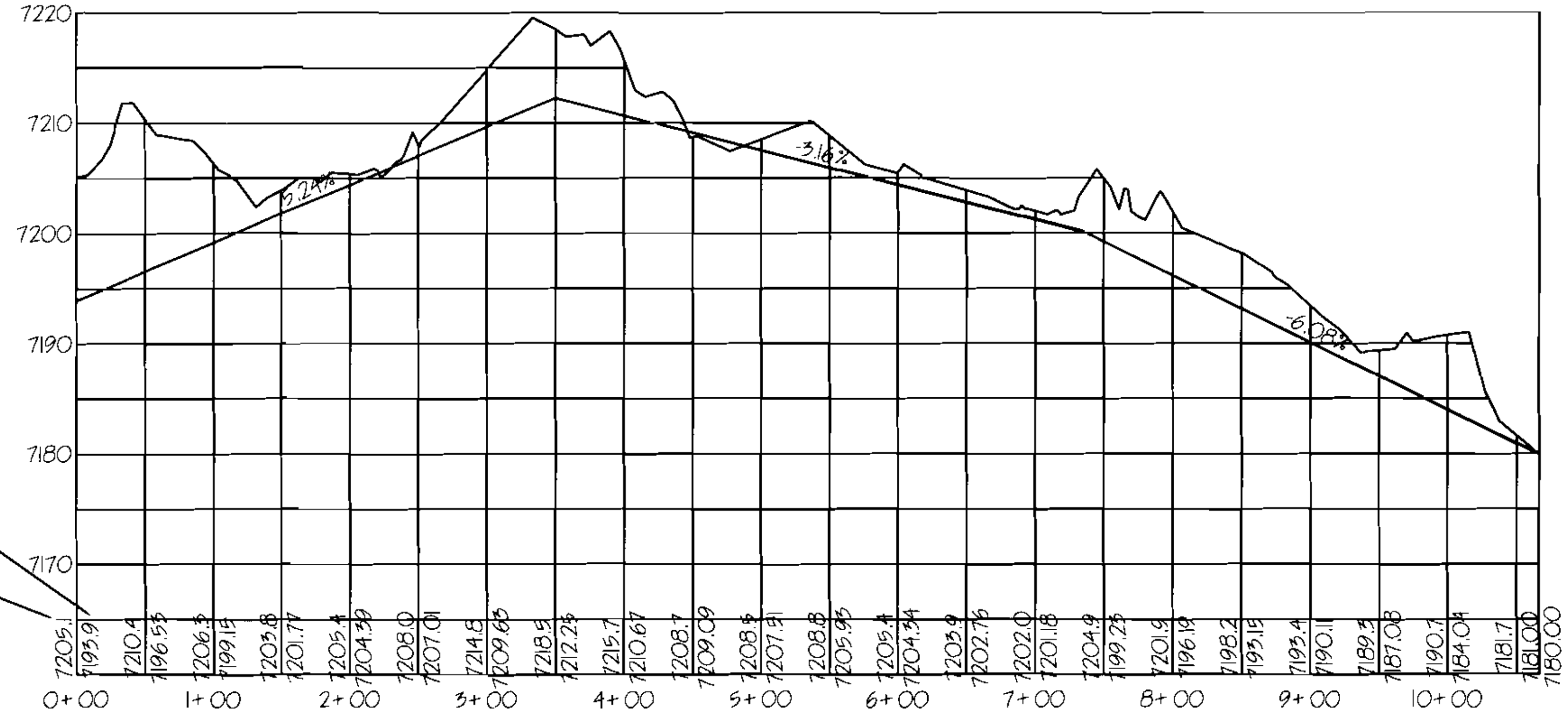


SECTION C-C

NOT TO SCALE



DITCH PROFILE

NOT TO SCALE

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LIVINGSTON MILL REMOVAL

REPOSITORY SECTIONS

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DRAWING	BY: P TRAINOR CHECK: W HEPSEL

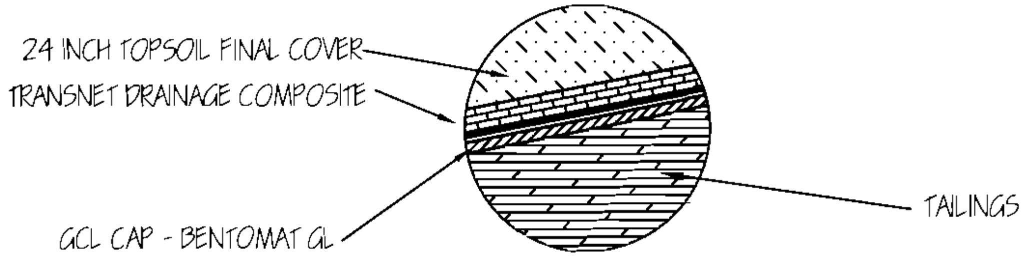
APPROVED: ____ DIRECTOR, ENGINEERING DATE ____

PROJECT No.

DRAWING 1 OF 1

SHEET 6 OF 7

FILE NAME & EXT.



DETAIL 2
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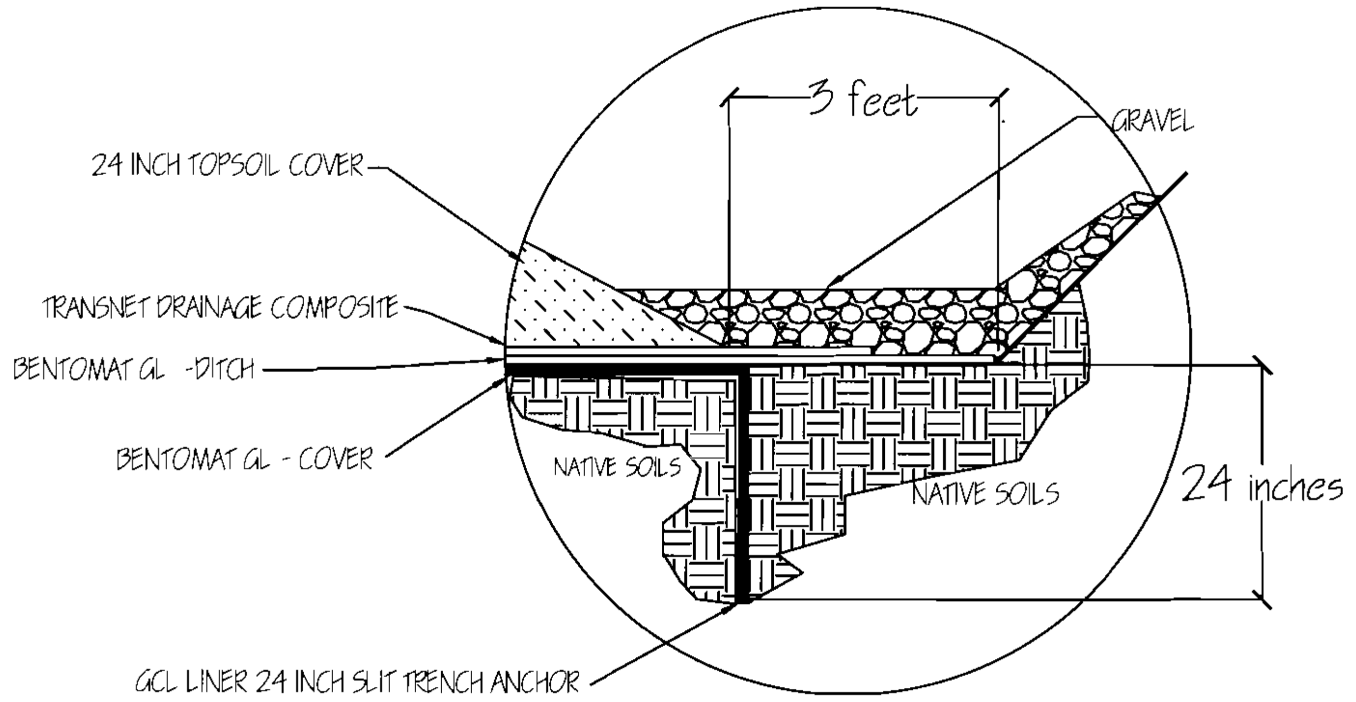

DETAIL 1
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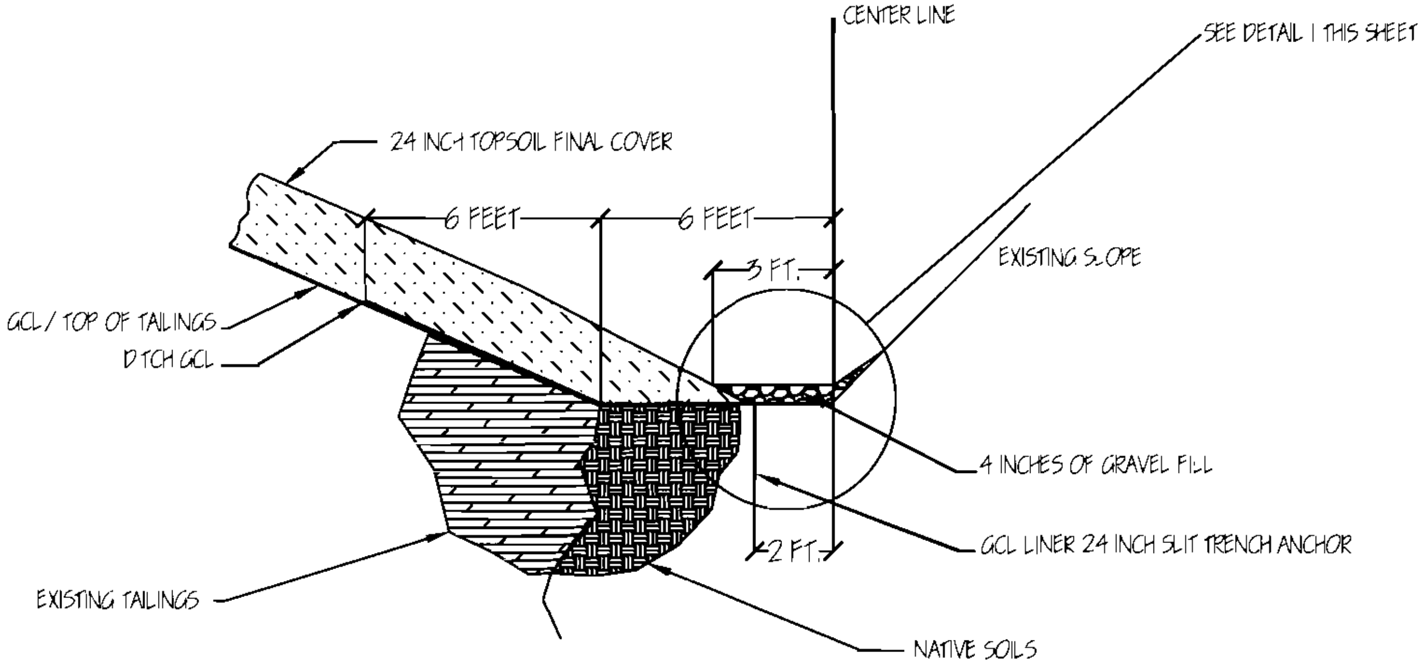

DITCH TYPICAL
NOT TO SCALE

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LIVINGSTON MILL REMOVAL
REPOSITORY DETAILS

PROJECT No.
DRAWING 1 of 1
SHEET 7 of 7
FILE NAME & EXT.