EXPANDED ENGINEERING EVALUATION & COST ANALYSIS

Lilly/Orphan Boy Mine
Powell County, Montana

Prepared for:
Trout Unlimited
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Missoula, Montana

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NewFields
Perspective. Vision. Solutions.

April 2016
Project 350.0215

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LIST OF ABBREVIATIONS & ACRONYMS

AMSL	above mean sea level
ARAR	applicable or relevant and appropriate requirement
bgs	below ground surface
BMP	best management practice
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
cfs	cubic feet per second
COC	constituent of concern
COPC	constituent of potential concern
DEQ/MWCB	Montana Department of Environmental Quality, Mine Waste Cleanup Bureau
EE/CA	Engineering Evaluation and Cost Analysis
EPA	U.S. Environmental Protection Agency
FHC	Frontier Historical Consultants
GCL	geosynthetic clay liner
gpm	gallons per minute
GSM	Golden Sunlight Mine
GWIC	Montana Bureau of Mines and Geology Groundwater Information Center
HMI	hazardous materials inventory
LOB	Lilly/Orphan Boy
mg/kg	milligrams per kilogram
NCP	National Hazardous Substances Pollution Contingency Plan
NPV	net present value
PAET	Probable Apparent Effects Threshold
QA/QC	quality assurance/quality control
RAO	remedial action objective
RI	reclamation investigation
SHPO	Montana State Historic Preservation Office
SMS	sediment management standard
su	standard units
TCLP	toxicity characteristics leaching procedure
WDOE	Washington Department of Ecology
WRP	waste rock pile
XRF	x-ray fluorescence spectrum analyzer
yd^3	cubic yards

1.0 INTRODUCTION

NewFields Companies, LLC (NewFields) prepared this Expanded Engineering Evaluation and Cost Analysis (Expanded EE/CA) for the Lilly/Orphan Boy Mine in the Little Blackfoot River watershed in Powell County, Montana (**Figure 1**) on behalf of Trout Unlimited in partnership with the Deer Lodge Valley Conservation District. This report presents results of an engineering evaluation and cost analysis of several alternatives to address solid mine waste materials at the Lilly/Orphan Boy Mine Site that include waste rock, soil and sediment.

1.1 Purpose and Objectives

The Lilly/Orphan Boy Mine is an abandoned hard rock mine. Development began in the late 1800's and ceased by the mid-1950's. During the course of developing underground mine workings, waste materials with varying degrees of mineralization were deposited on slopes adjacent to a mine shaft and three adits, and directly in the Telegraph Creek floodplain located immediately adjacent to the mine. These mine waste materials pose potential risks to human health and safety, and to the environment.

The Montana Department of Environmental Quality (DEQ) Water Quality Planning Bureau developed total maximum daily loads (TMDLs) for pollutants and a framework water quality improvement plan for the Little Blackfoot River watershed (DEQ 2011 and 2014). The pollutants included sediments and metals, with goals for reducing pollutant loads. The upper segment of Telegraph Creek, which includes the Lilly/Orphan Boy Mine site, was listed in 2010 by DEQ as impaired for arsenic, beryllium, cadmium, copper, iron and zinc. Given the presence and location of mine waste at the site relative to Telegraph Creek, removal actions at the site would result in direct benefits to water quality and help in achieving TMDL goals for the watershed.

This Expanded EE/CA was developed following the "non-time critical removal action" process outlined in the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended, and the updated National Hazardous Substances Pollution Contingency Plan (NCP). A non-time critical removal action is implemented by the lead agency (the Montana Department of Environmental Quality, Mine Waste Cleanup Bureau [DEQ/MWCB] in this instance) to provide "the cleanup or removal of released hazardous substances from the environment… as may be necessary to prevent, minimize, or mitigate damage to the public health or welfare or to the environment…" (U.S. Environmental Protection Agency [USEPA] 1993). Following EPA's Guidance on Conducting Non-Time Critical Removal Actions Under CERCLA (USEPA 1993), this Expanded EE/CA provides the logic, process, and cost estimate to develop and evaluate potential response action alternatives that may be used to address mine waste at the Lilly/Orphan Boy Mine Site. The objective of this Expanded EE/CA is to develop and evaluate potential response action alternatives to reduce or eliminate potential human health and environmental risks associated with solid waste materials at the Lilly/Orphan Boy Mine site. This Expanded EE/CA identifies the preferred alternative that best satisfies the criteria developed from removal action objectives and used to evaluate the suite of potential reclamation alternatives.

1.2 Document Organization

Following this introductory section, this Expanded EE/CA is organized as follows:

- **Section 2.0** provides a brief description of the mine site.
- **Section 3.0** summarizes key findings of previous assessments of the mine, as well as the results of recent investigation activities completed in November 2015.
- **Section 4.0** presents a streamlined evaluation of potential risks to human health and the environment resulting from historic mining activities.
- **Section 5.0** summarizes the applicable or relevant and appropriate requirements (ARARs) for potential response actions at the mine.
- **Section 6.0** describes the scope, goals, and response action objectives for the mine site.
- **Section 7.0** identifies potential remedial technologies, presents an initial screening of those technologies, and describes the potential response action alternatives developed for further evaluation for the mine.
- **Section 8.0** describes the criteria used to evaluate the alternatives and provides a detailed analysis of each alternative using those criteria.
- **Section 9.0** presents a comparative analysis of the anticipated performance and cost of the alternatives.
- **Section 10** identifies the preferred response action alternative for the Lilly/Orphan Boy Mine based on the comparative alternatives analysis.
- **Section 11.0** presents the references cited in the text.

Figures and tables follow the text of the report. Supporting information for the Expanded EE/CA are contained in three appendices, including:

- **Appendix A**, Preliminary Repository Siting Evaluation;
- **Appendix B**, Applicable or Relevant and Appropriate Requirements (ARARs); and
- **Appendix C**, Estimated Reclamation Action Costs.

2.0 SITE BACKGROUND

The Lilly/Orphan Boy Mine Site (LOB site, or site) is an abandoned hard rock mine located on private land approximately 10.5 miles south of Elliston in Powell County, Montana. The site is situated at an elevation of about 7,000 feet above mean sea level and approximately 1.5 acres was disturbed by mining activities. Development of the mine began in approximately 1893 and ended with the last shipment of ore in 1954 or 1955 (Newman, 2008 as cited in TerraGraphics, 2011). The site is contaminated from metal mining along Telegraph Creek and ranks tenth on the Montana Department of Environmental Quality (DEQ) Mine Waste Cleanup Bureaus' abandoned mine lands priority site list (http://www.deq.mt.gov/AbandonedMines/priority.mcpx). DEQ commissioned a Phase I reclamation investigation in 2008 (Tetra Tech EM Inc. [Tetra Tech] 2009) and a subsequent Phase II reclamation investigation in 2010 (TerraGraphics 2010).

The abandoned mine is adjacent to Telegraph Creek, a tributary to the Little Blackfoot River. Site features are shown on **Figure 2** and include the following from east (upper) to west (lower) portions of the site: an upper collapsed adit; a wooden and steel headframe and shaft surrounded by a fence; upper Waste Rock Pile 1; a mid-slope collapsed adit; Waste Rock Pile 2; Bryan Creek Road; the discharging Lilly adit; and Waste Rock Pile 3 which is bisected by Telegraph Creek. There is about 100 feet of relief at the site. The site is surrounded by private land on three sides and by the Helena National Forest to the west.

The remaining portion of this section provides background information on the site including brief summaries of: mining history; the physical setting; vegetation and wildlife; historic and archaeologically significant features; and ownership. Unless otherwise cited, information for this section was largely obtained from project documents produced for DEQ by Tetra Tech (2008 and 2009) and TerraGraphics (2010 and 2011). Trout Unlimited also provided NewFields an electronic copy of DEQ files containing several other reports cited herein with information regarding the LOB site.

2.1 Mining History

Grand Republic Mining Company likely discovered the Lilly and adjacent Orphan Boy lodes in the early summer of 1890. In late 1893, Empire State Mine Company (Empire State) acquired the mines from Grand Republic and began development. Due to a mortgage debt held by Empire State, the court ordered the Lilly/Orphan Boy Mine property to be sold at public auction in November 1899. The president of Empire State, T. H. Teall, obtained ownership of the Lilly/Orphan Boy Mine property and received a sheriff's deed in December 1900. Ownership of the mine remained under his name until 1927 when the taxes on the claims became delinquent. Powell County received a tax deed to the property early the following year.

Soon after the onset of the Great Depression, a rise in the price of metals re-energized active interest in the Lilly/Orphan Boy Mine. Powell County issued a new lease to Butte miner Ed Linquist around 1934 and later to Dave and Leo Newman in 1943. Between 1934 and 1951, the mine produced a total of 1,228 tons of ore, yielding 333 ounces of gold; 12,520 ounces of silver; 2,753 pounds of copper; 85,377 pounds of lead; and 39,899 pounds of zinc. The last production of ore from the Lilly/Orphan Boy Mine was a 50-ton shipment of ore that occurred in either 1954 or 1955.

2.2 Climate

The Helena, Montana airport, approximately 20 miles east of the site, is the nearest Western Regional Climate Center. As cited in TerraGraphics (2011) the average monthly temperature ranges from 85°F to 53°F in July, and from 30°F to 10°F in January. Average annual precipitation is 12 inches. May and June are, on average, the wettest months of the year, exceeding a monthly average precipitation of 3 inches. Precipitation is mostly in the form of snow in the winter months, snow and rain in the spring and fall, and rain in the summer.

2.3 Geology, Hydrogeology, and Hydrology

The following sections describe the geology, hydrogeology, and hydrology of the LOB site and the area surrounding the site.

2.3.1 Local and Regional Geology

In 1950, Mason Rankin reported on geologic conditions at the Lilly/Orphan Boy Mine (Rankin 1950). He described the property as being located within the Boulder Batholith, a granitic intrusion consisting primarily of quartz monzonite intruded by dike-like bodies of aplite. West of the site the batholith is in contact with andesite, an extrusive rock, and to the northeast near Elliston is in contact with Paleozoic sedimentary rocks. TerraGraphics (2011) reports that the Lilly/Orphan Boy Mine exploited a high-angle (80 degree), northeast trending mineralized vein. Galena, pyrite, sphalerite, arsenopyrite, and tetrahydrite were the main ore minerals for the mine. A detailed geologic description of the mine is found in Aitkin (1950).

2.3.2 Soils

The LOB site has a combination of Typic Cryoboralf and Typic Cryochrept soils, both located in slopes of 25 to 50 percent at elevations ranging from 5,500 to 7,500 feet above mean sea level (AMSL). Typic Cryoboralf soils are derived from moraines and glacial till and are typically defined as cobbly loams or cobbly clay loams. Typic Cryochrept soils are derived from granitic mountain slopes or weathered granite and are defined as very gravelly sandy loams (USDA-NRCS 2008; as cited in Tetra Tech 2008). The soil located in the immediate vicinity of the headframe and shaft area is classified as Typic Cryochrepts. Lodgepole-pine forests develop on these soils and the forest understory produces little forage and is poorly suited to livestock grazing. The USDA-NRCS (2008) does not report these soils as being used for farming.

2.3.3 Hydrogeology

NewFields searched the Montana Bureau of Mines and Geology Groundwater Information Center (GWIC) web mapping application to identify wells with a one-mile radius of the site. Four wells, with domestic, monitoring or unknown uses, are recorded with GWIC as shown in **Chart 1**.

Chart 1. GWIC Wells within a one-mile Radius of LOB Site

GWIC ID	Total Depth	Reported Static Water Level	Date Completed	Purpose	Latitude	Longitude
154880	25	19.5	11/9/1995	Monitoring	46.442562	112.343955
178985	200	40	9/16/1998	Domestic	46.427231	112.347858
248185	63	6.5	9/24/2008	Unknown	46.443383	112.332733
284834	271	27	7/29/2015	Domestic	46.458010	112.340051

GWIC - Ground Water Information Center, Montana Bureau of Mines and Geology, http://mbmggwic.mtech.edu/; accessed December 29, 2015.

The monitoring well with GWIC ID 154880 shown in **Chart 1** was installed as part of an in-situ pilot test of sulfate-reducing bacteria to control acid generation from the Lilly/Orphan Boy Mine (MSE Technology Applications, Inc., 2008); the well intercepted underground workings at 15 feet. Well driller's logs for the other wells listed in **Chart 1** indicate that granitic rock was encountered at 8 to 15 feet below ground surface (bgs) and extended to the total depths of each well. Groundwater yields during one-hour air lift tests ranged from 0.03 to 12 gallons per minute (gpm).

TerraGraphics installed five monitoring wells and three shallow piezometers at the LOB site in 2010 as part of the Phase II reclamation investigation (TerraGraphics 2011). Wells ranged in depth from 25 to 122 feet bgs with weathered quartz monzonite bedrock encountered from 2.5 to 17 feet bgs. TerraGraphics (2011) recorded depths to groundwater in September 2010 from approximately 8 to 71 feet, and reports that the direction of groundwater flow in the fractured quartz monzonite rock is to the north-northwest. Based on groundwater samples obtained from the wells, TerraGraphics (2011) indicated that water quality was generally good with pH values ranging from 6.28 to 7.79 standard units (su). Highest total metals concentrations were measured in samples collected from monitoring wells nearest the mine shaft (the nearest monitoring well is about 40 feet northwest of the shaft).

The collapsed Lilly Adit, the lowermost adit at the LOB site (**Figure 2**), discharges water intercepted by underground mine workings. At the surface, water appears to flow through waste rock material, then along the eastern edge of Waste Rock Pile 3 where it enters the Telegraph Creek floodplain. MSE (2008) refers to the collapsed Lilly Adit as the mine portal they instrumented during their first year of pilot testing (1994). They report a fairly constant flow rate at less than 2 gpm in 1994, but noted a flow rate of 7.6 gpm during May 1995 spring runoff (MSE 2008).

2.3.4 Surface Water Hydrology

The LOB site is located near the headwaters of Telegraph Creek. The sub-watershed of Telegraph Creek is approximately 19 square miles. Telegraph Creek flows north 7 miles to its confluence with the Little Blackfoot River. Tetra Tech (2008) reports that the creek is perennial and near the LOB site flow is sustained by springs and seeps. Stream discharge measured by TerraGraphics (2011) during base flow conditions on October 1, 2010 indicated a flow of 0.38 cubic feet per second (cfs) at the downstream boundary of the LOB site.

2.3.5 Current Site Setting

The following subsections describe the current physical setting of the LOB site, as well as land ownership and use.

2.3.6 Location and Topography

The LOB site is located on the western edge of the Continental Divide in Powell County, south of Elliston, Montana, in Section 15, Township 8 North, Range 6 West. The site is composed of 1.5 acres of private land along Telegraph Creek, and is situated at an elevation of approximately 6,800 feet AMSL. Total relief from Telegraph Creek to the mine shaft area is about 100 feet. Rankin (1950) describes the topography as follows:

> "The region generally is mountainous, with rather marked relief, but in the immediate vicinity of the properties the topography is rolling, and with very moderate slopes".

Given the granitic geology, the LOB site is characterized by rounded boulder terrain.

The LOB site includes a meadow in the Telegraph Creek floodplain (**Figure 2**). The meadow is vegetated with various grasses and small trees but has not yet been formally designated as a "wetland" according to the Corps of Engineers Wetlands Delineation Manual (Environmental Laboratory 1987) and the Regional Supplement to the Corps of Engineers Wetlands Delineation Manual: Western Mountains, Valleys, and Coast Region (Corps 2010). The Corps wetland delineation methodology prescribes data collection to identify whether the area meets the three-parameter criteria of hydric soil, hydrophytic vegetation, and wetland hydrology. Hydric soil is defined as "soil that is saturated, flooded, or ponded long enough during each growing season to develop anaerobic conditions in the upper part of the soil profile". Hydric soil exhibits characteristics that can be observed in the field including: high organic content, accumulation of sulfides, gley or reduced color, mottling, and low chroma. Wetland hydrology is present when the soil is inundated or saturated within the major portion of the root zone (within 12 inches of the surface) during all or part of the growing season. Indicators of wetland hydrology can be seen on the surface (e.g., surface water, water marks or algal matting), and can be observed in the soils (e.g., saturation, hydrogen sulfide odor, and oxidized root channels).

2.3.7 Vegetation, Fish and Wildlife

The Montana Natural Heritage Program prepared a report for DEQ regarding Montana Species of Concern in the vicinity of the LOB site (Montana Natural Heritage Program 2015). There are no reported threatened or endangered species identified and as a result formal consultation for reclamation of the LOB site with the U.S. Fish and Wildlife Services is not required. The Montana Natural Heritage Program (2015) reports three species of concern within a one-mile buffer of the site including: Clark's Nutcracker; Westslope Cutthroat Trout; and, Wolverine. **Table 1** provides the Natural Heritage Ranks and indicates that the Westslope Cutthroat Trout and Wolverine are listed by the U.S. Forest Service and U.S. Bureau of Reclamation as sensitive species.

It is unlikely that Westslope Cutthroat Trout are present in Telegraph Creek adjacent to the LOB site. Based on a 2008 assessment of fish populations for tributaries of the Upper Clark Fork River basin (including Telegraph Creek) by the Montana Department of Fish, Wildlife and Parks (Montana FWP

2008), there is a steep cascade below the site that likely acts as a natural barrier to upstream fish migration. No fish were captured or observed above the cascade.

A variety of other wildlife is found on or within the vicinity of the site: deer, elk, bobcat, black bear, and miscellaneous smaller mammals (rabbits, squirrels, mice, and voles). Many species of birds are known to be found on the site including songbirds, owls, and raptors (Montana Natural Heritage Program 2008).

TerraGraphics (2010) reports that Lodgepole pine (Pinus contorta), Douglas fir (Pseudotsuga menziesii), and some Engelmann spruce (Picea engelmannii) are on or near the LOB site. Shrubs present include grouse whortleberry (Vaccinium scoparium), snowberry (Symphoricarpos sp.), Phlox (Phlox sp.), and several grasses in the meadows areas around Telegraph Creek. Little or no vegetation is present on waste rock piles.

The Helena-Lewis & Clark National Forest completed a fisheries biological assessment for their Divide Travel Plan which included Telegraph Creek (United States Department of Agriculture [USDA] 2015a). According to the biological assessment, bull trout have not been found in Telegraph Creek but the watershed "serves as adjunct habitat directly adjacent to bull trout focal habitat and an important source of water quality and habitat for the Little Blackfoot River".

The Helena National Forest also completed a terrestrial biological assessment for their Divide Travel Plan in 2015 (USDA 2015b). They report that lynx, a threatened species (**Table 1**), were tracked in the winters of 2008-10 and numerous signs of adult lynx were found in the Telegraph Creek drainage. The Helena National Forest (USDA 2015b) comments that historic mining operations have altered local topography, altered stream flow, generated erosion and left toxic waste in the Forest. With respect to grizzlies and lynx, they state:

> "Historic mining operations displaced grizzlies & lynx from otherwise suitable habitat because of their size, abundance, & the degree to which they used up local resources—in particular, timber. Some abandoned operations continue to exert a certain degree of local impact because of toxic wastes filtering into riparian areas".

As noted above, the Montana Natural Heritage Program (2015) did not report the presence of lynx or grizzlies within a one-mile buffer of the LOB site. It appears that these species may be using other portions of the Telegraph Creek drainage.

2.4 Historic and Archaeologically Significant Features

Based on an assessment performed by Frontier Historical Consultants (FHC) in 2002 for DEQ's Mine Waste Cleanup Bureau, the LOB site may be eligible for inclusion on the National Register of Historic Places. FHC (2002) indicates the site meets two of the possible four criteria:

1) The site was associated with events that have made a significant contribution to the broad patterns of our history; and

2) The site embodied the distinctive characteristics of a type, period, or method of construction, or that represented the work of a master, or that possess high artistic values, or that represented a significant and distinguishable entity whose components may lack individual distinction.

During operations of the Lilly/Orphan Boy Mine, the mine produced enough ore to be a major part of the Elliston Mining District and solidify its contribution to the local mining history. Currently the site still houses sufficient historic features and structures to satisfy the second listed criteria: three collapsed adits; a dozer cut; three waste rock dumps; three collapsed load-outs; one standing log cabin; one collapsed log cabin; a partially collapsed frame building; remains of an outhouse; a head frame and shaft; and a hoist machinery platform. Despite the natural deterioration due to weather and aging, the site has retained a fair degree of integrity (FHC 2002). Should reclamation occur at the LOB site, it is expected that the DEQ would work with the Montana State Historic Preservation Office (SHPO) to provide for historical features.

2.4.1 Land Use and Population

The LOB site is privately owned inholding within the Helena National Forest. Primary land use in the vicinity is recreational although at least one rural home/cabin is located within ½-mile of the site. According to the U.S. Census Bureau in 2000 (cited in Tetra Tech 2008), the estimated population per square mile within a one-mile radius from the site is less than two people. With the exception of a fence surrounding the headframe and mine shaft in the upper portion of the LOB site, there are no road gates or other fences preventing site access.

2.4.2 Land Ownership

Based on a review of Montana cadastral information (http://svc.mt.gov/msl/mtcadastral/), the LOB site is currently owned by Lindsey and Jesse Chaquette of Helena, Montana. According to the DEQ Property Ownership Memo (2010), the property was granted to the Chaquettes on July 19th, 2005. The approximately 1.5 acre mine site is part of a 20.66 acre parcel with a geocode of 28-1681-15-1-01-01-0000 and physical address of 1485 Lower Telegraph Creek Road, Elliston, Montana 59728. The legal property description is Section 15, Township 8 North, Range 6 West.

3.0 WASTE CHARACTERISTICS AND SUMMARY OF EXISTING DATA

Several investigations have been conducted at the LOB site to characterize the nature and extent of mining related impacts at the site. The following lists previous investigations.

- Pioneer Technical Services, Inc. (Pioneer) completed a hazardous materials inventory (HMI) of the LOB site in 1993 on behalf of the Montana Department of State Lands (now the DEQ) that included the collection of soil and surface water samples for laboratory analysis (Pioneer 1994). Pioneer also collected water quality samples from the Lilly adit (classified as groundwater for the purposes of the HMI) and from ponded water above and below the waste rock dump in the Telegraph Creek drainage.

- Tetra Tech EMI, Inc. (Tetra Tech) completed a Phase I reclamation investigation (RI) of the mine site in 2008 for DEQ to characterize the nature and extent of mining-related impacts to soil, surface water, and sediment in Telegraph Creek (Tetra Tech 2009). Soil samples were collected to establish naturally occurring background metals concentrations in site soils.

- DJ&A P.C. (DJ&A) performed a topographic survey of the LOB site in 2009. Their work is presented in Tetra Tech (2009) and has been used in conjunction with soil/waste rock sample analytical results to estimate the volumes of waste rock and impacted soil present at the mine site.

- TerraGraphics Environmental Engineering, Inc. (TerraGraphics) completed additional reclamation investigation activities (Phase II) in 2010 for DEQ to further characterize conditions at the site (TerraGraphics 2011). These included collecting and analyzing soil, surface water and groundwater samples, measuring surface flows, and completing an evaluation of the underground mine workings.

- NewFields completed a sediment data gaps investigation along Telegraph Creek in November 2015 to further describe the extent and magnitude of mine-related impacts in Telegraph Creek sediment, and investigate the thickness of sediment at each sampling location (NewFields 2015a).

Screening levels were selected for the LOB site during the 2008 RI to evaluate concentrations of metals detected in surface water, waste rock, soil, and streambed sediment. The screening levels include risk-based guidelines for recreational users (based on a 50-days per year gold panner/rock hound exposure scenario; Tetra Tech 2004), Montana chronic aquatic life standards for surface water (MDEQ 2012), and Probable Apparent Effects Thresholds (PAETs) for sediment developed by the Washington Department of Ecology (WDOE 1997). Limited groundwater data have also been obtained at the LOB site and those data are screened against Montana Numeric Water Quality Standards in DEQ-7 (MDEQ 2012).

The following sections are organized according to media and provide results of the LOB site characterization studies conducted between 1993 and 2015. Screening levels for the various environmental media are provided in summary tables of metals concentrations detected in soil, waste rock, sediment, surface water and groundwater during previous investigations (see **Tables 2** through **5**); and locations sampled during the previous investigations are shown on **Figure 3**. Refer to **Section 4.0**, below, for additional discussion of screening levels for the LOB site.

3.1 Solid Waste Samples

Waste rock piles, surface soil proximal to waste rock piles, and background surface soil samples were collected during the Phase 1 (Tetra Tech 2009) and Phase II (TerraGraphics 2011) Reclamation investigations. The following sections provide sampling results.

3.1.1 Mine Waste

Three waste rock piles are present at the LOB site (**Figure 2**) that contain an estimated 3,430 cubic yards (yd^3) of waste rock (Tetra Tech 2009), as follows:

- Waste Rock Pile 1 (WRP 1): 1,630 yd^3;
- Waste Rock Pile 2 (WRP 2): 1,490 yd^3; and
- Waste Rock Pile 3 (WRP 3): 310 yd^3.

The estimated volumes of waste rock piles were calculated using elevation data from the topographic survey completed by DJ&A in 2009 (Tetra Tech 2009). The elevation of the waste rock pile was compared to an assumed ground surface elevation (based on the elevation of undisturbed ground adjacent to the waste rock piles). Portions of WRP 1 appear to include native soil (non-mine waste) used to construct a support area for mine operations around the upper mine shaft. Although no discrete samples were collected of this apparent native soil material, it may contain lower metals concentrations than waste rock from the mine workings.

Tetra Tech collected five samples (LOB-SS-02, -03, -09, -12 and -13) from the surface (from depths of 0 – 3 inches bgs) of the three waste rock piles in October 2008 and submitted them for laboratory analysis of total metals (Tetra Tech 2009). Analytical results for the samples are summarized in **Table 2** and sample locations are shown on **Figure 3**. Total arsenic and lead were detected at concentrations above their associated screening levels (323 and 2,200 milligrams per kilogram [mg/kg], respectively) in all of the waste rock samples. Antimony was also detected above the screening level (586 mg/kg) in sample SS-03, which was collected from WRP 1.

TerraGraphics completed six test pits within the waste rock piles (two in each pile) at the site in October 2009 to evaluate the suitability of the mine waste for use in cemented backfill of the underground mine workings (TerraGraphics 2011). The test pits were completed to depths ranging from 7 to 12 feet below the surface of the mine waste. Material descriptions and observations regarding depths of mine waste were not recorded by field personnel observing excavation of the test pits. Material samples were collected from each test pit and submitted for analysis of geotechnical parameters. Based on results of gradation (sieve) analyses of the material samples completed by the geotechnical laboratory, the waste rock piles are comprised of a mixture of silty gravels and sand.

3.1.2 Surface Soil

Tetra Tech (2009) and TerraGraphics (2011) obtained surface soil samples (from 0 – 3 inches bgs) proximal to the waste rock piles (**Figure 3**). In total, 25 near-surface material samples were obtained at the LOB site for laboratory analysis of total metals. As shown in **Table 2**, more than half of the surface soil samples contain concentrations of arsenic that exceed the screening level (323 mg/kg). Lead was detected in one sample (SS-07) at a concentration of 2,300 mg/kg, which is above the screening level of 2,200 mg/kg. Based on the soil sample results, Terragraphics (2011) estimated that approximately 470 cubic yards of impacted soil (containing concentrations of arsenic or lead above screening levels, with a minimum thickness of 6 inches) is present proximal to waste rock piles.

Tetra Tech also submitted four of the surface soil samples collected in 2008 for laboratory analysis of agronomic properties to evaluate whether amendments could be added to on-site materials for use in site reclamation. The results of the analyses are provided in Phase 1 RI Report (Tetra Tech 2009) and indicate that adequate volumes of soil suitable for use as growth media in reclamation activities are not present on-site.

3.1.3 Background Samples

Three soil samples collected during the 2008 RI were taken from locations that exhibited no visual indication of prior disturbance (Tetra Tech 2009). These samples (designated LOB-BG-01 through LOB-BG-03; **Figure 3**) were collected to evaluate the naturally occurring concentrations of metals at locations that were apparently not impacted by mining activities. Metals concentrations detected in all three background soil samples were below the recreational cleanup guidelines (**Table 2**).

Hydrometrics (2013) presents background concentrations for metals in Montana surface soil and reports background concentration for arsenic state-wide at 40 mg/kg. Sampling results were not compared to the soil screening level in DEQ's Remediation Division Action Level for arsenic in surface soil (40 mg/kg) because background arsenic levels in mining areas are typically higher than this level.

3.2 Sediment

Sediment samples were collected from the Telegraph Creek drainage at the LOB site on three occasions: 1993 (Pioneer 1994), 2008 (Tetra Tech 2009) and 2015 (NewFields 2015a). **Table 3** summarizes results of total metals analysis and provides Washington State Freshwater Sediment Quality Probable Apparent Effects Thresholds (PAET) screening values and recreational cleanup guidelines based on the 50-day gold panner/rock hound exposure scenario. **Figure 3** shows Tetra Tech and NewFields sediment sampling locations; locations of samples obtained by Pioneer were not mapped but were described relative to the waste rock pile in Telegraph Creek (WRP 3). Pioneer (1994) obtained sample SE-1 (see **Table 3**) approximately 200 feet downstream of WRP 3 and collected sample SE-2 upstream of a pond located above the waste rock pile. Information on the depth of the samples is not recorded.

Tetra Tech (2008) obtained five near-surface sediment samples. Samples SD-01 and SD-05 (**Figure 3**) were collected upstream of WRP 3 and sample SD-02 was obtained from sediments present in the outfall from the lowermost adit (Lilly Adit). Sample LOB-SD-04 was collected just downstream and adjacent to WRP 3 and sample SD-03 was obtained at the downstream property boundary.

NewFields completed a sediment data gaps investigation along Telegraph Creek at the Lilly/Orphan Boy mine site in November 2015 (NewFields 20015a) which involved evaluating the approximate total depth of sediment at eight locations and collecting samples at each location for metals analysis. Six sampling locations were downstream of WRP 3 and two were upstream of WRP 3 (**Figure 3**).

Sediment described by NewFields (2015a) consisted of dark brown, organic-rich material with less than about 15 percent silt. Water was encountered in each borehole at depths ranging from 1 to 8 inches. Dark gray, silty clay is present beneath the organic-rich sediment. At several locations NewFields also observed fine to coarse angular sand with the silty clay material.

Below WRP 3 organic-rich sediment averaged 2.8 feet in thickness, with a maximum depth of 3.5 feet. At sample location SD-11 (**Figure 3**), organic-rich sediment was encountered in the upper 0.5 feet and then at a depth of 1.5 to 3 feet bgs. Between and below the two organic-rich sediment horizons, orange-brown, fine to coarse angular sand was present. No other borehole encountered oxidized materials. Location SD-11 is directly below the western lobe of WRP 3, and therefore it is possible that the orange-brown sandy material represents oxidized mine waste material eroded from the waste rock pile.

Analytical results for metals detected in the 15 LOB mine site sediment samples are presented in **Table 3**. Both PAETs for freshwater sediment from the Washington Department of Ecology (WDOE; 1997) and MDEQ's Recreational Cleanup Guidelines developed by Tetra Tech, Inc. (2004) are presented in **Table 3** for comparison to metals concentrations in Telegraph Creek sediment.

Based on analytical results for the sediment samples, arsenic and to a lesser extent lead (one sample) and manganese (one sample), are constituents of concern for potential exposure from recreational users (i.e., gold panner and/or rock hound; **Table 3**). Eight of the 10 sediment samples collected downstream of WRP 3 exceeded the Recreational Cleanup Guideline for arsenic of 323 mg/kg. The two exceptions (SD-09-18 and SD-03), were samples collected furthest downstream of WRP 3 (**Figure 3**). One sample collected just upstream of WRP 3 (SD-01) also exceeded the Recreational Cleanup Guideline for arsenic.

All 15 sediment samples exceeded the PAET for arsenic, including the five samples obtained upstream of WRP 3 (**Table 3**). The majority of sediment samples obtained downstream of WRP 3 also exceeded PAETs for cadmium, lead, manganese and zinc.

Several factors were considered and subjectively balanced in an effort to determine a reasonable boundary for sediment by the LOB site in the Telegraph Creek floodplain, including:

- It is desirable to retain some amount of the existing wetland habitat at the LOB site which may be currently functioning to attenuate metals being delivered to the wetland in mine site runoff and from the Lilly Adit discharge.

- It is likely that metals from erosion of LOB site mine waste is a primary source for elevated metals detected in sediment samples downstream of WRP 3.
- Metals detected in sediment sample SD-03 may be associated with the adjacent deposit of mine waste (i.e., soil) mapped by TerraGraphics (2011).
- Arsenic in upgradient (upstream of WRP 3) sediment sample SD-01 was detected above both the PAET and Recreational Cleanup Guideline levels.
- All 15 sediment samples exceeded the arsenic PAET, and a majority of samples also exceeded the PAET for cadmium, lead, manganese and zinc.
- Arsenic concentrations (and to a lesser extent lead concentrations) in solid material is a primary factor in determining removal actions at the LOB site; for all solid material samples (mine waste, soil and sediment), arsenic concentrations exceeded the Recreational Cleanup Guideline more frequently than any other metal.
- Mean metals concentrations in sediment samples collected above WRP 3 may be useful to evaluate background concentrations in Telegraph Creek sediment and should be considered when making removal action decisions.

Given the above factors and considerations, a reasonable approach to establish the removal boundary for sediments could be based on comparing sediment data to the mean upstream arsenic concentration (156 mg/kg) and the Recreational Cleanup Guideline for arsenic (323 mg/kg). For the purposes of this Expanded EE/CA, the boundary for impacted wetland sediment removal extends from WRP 3 to just north of sample SD-09-18 (**Figure 3**). Assuming an average sediment thickness of about 2.8 feet, there is an estimated 515 cubic yards of mine-impacted sediment present in the floodplain of Telegraph Creek.

3.3 Surface Water Quality

Telegraph Creek samples have been collected at locations upstream and downstream of WRP 3 (locations denoted with a “SW-“ prefix on **Figure 3**) by either Tetra Tech (2009) or TerraGraphics (2011). As part of the hazardous materials inventory in 1993, Pioneer (1994) obtained one surface water sample just upstream of WRP 3 and another 200 feet downstream of WRP 3 (note that locations were not mapped and are not included on **Figure 3**). In 2008 Tetra Tech (2009) collected two Telegraph Creek samples, one above WRP 3 and the other at the downstream property boundary (stations SW-01 and SW-03; **Figure 3**). During the Phase II reclamation investigation, TerraGraphics (2011) selected five locations to sample Telegraph Creek on several occasions in September, October and December 2010. These included station SW-05 located approximately at the upstream (southern) boundary of the LOB site and station SW-07 located about 275 feet downstream of the LOB site (**Figure 3**). Two other stations were the same as sampled by Tetra Tech (SW-01 and SW-03; **Figure 3**) and a third was located about 80 feet downstream of WRP 3 (SW-06; **Figure 3**). In total, Tetra Tech and TerraGraphics sampled Telegraph Creek at five locations.

In addition, Pioneer (sample GW-1; not shown on **Figure 3**) and Tetra Tech (sample SW-02; **Figure 3**) obtained samples of water discharging from the Lilly Adit. Tetra Tech (2009) also collected a surface water sample on the west edge of WRP 3 (sample SW-04; **Figure 3**). Because the Lilly Adit discharge eventually enters Telegraph Creek, analytical results for samples GW-1, SW-02 and SW-04 are presented in this section.

Analytical results for a suite of metals, pH and hardness from these surface water samples are presented in **Table 4**. Included in the table are Montana Numeric Water Quality Standards (DEQ-7; MDEQ 2012) for: acute aquatic life; chronic aquatic life; and human health. Also included are Recreational Cleanup Guidelines (Tetra Tech 2004) for surface water based on a 50-day gold panner/rock hound exposure scenario. The following are succinct summaries of surface water quality relative to DEQ-7 acute aquatic life standards:

Upstream Telegraph Creek, Stations SW-01 and SW-05

Telegraph Creek samples obtained upstream of WRP 3 and the Lilly Adit discharge exhibited near neutral pH. The only exceedance of an acute aquatic life standard was for zinc (estimated concentration, biased high) in two of the six samples.

Downstream Telegraph Creek, Station SW-03 and SW-07

At the two downstream stations, a total of 21 samples were collected in 2008 and 2010. pH ranged from 6.2 to 7 standard units (su), with the average pH of 6.46 su (acute aquatic life standard is 6.5 to 8.5 su). In most samples, acute aquatic life standards were exceeded for three metals: cadmium; copper; and zinc.

Telegraph Creek in Wetland Area, Station SW-6

In contrast to the downstream Telegraph Creek samples, the two samples collected from Telegraph Creek in the wetland area exhibited a neutral pH and the only metal with an exceedance was zinc. In this area, Telegraph Creek is on the west side of its floodplain. Because the majority of waste rock in the Telegraph Creek floodplain is on the east side of creek and the Lilly Adit discharge appears to enter the floodplain from the east, it is possible that the portion of the LOB site near station SW-6 is not severely impacted by mine wastes and discharge.

Lilly Adit Discharge and Toe of WRP 3, Stations SW-02 and SW-04

The two adit discharge samples (GW-1 and SW-02) and the single water sample collected at the downstream toe of WRP 3 (SW-04) exhibited the highest concentrations of metals relative to other surface water samples (note: pH data were not collected for these samples). Acute aquatic life standards were exceeded for arsenic, cadmium, copper, lead and zinc.

In DEQ's water quality improvement plan for the Little Blackfoot River watershed, TMDLs were established with goals for reducing sediment and metal's loads to the watershed (DEQ 2014). For the Upper Telegraph Creek watershed which includes the LOB site, the goal is a 16% reduction in the amount of sediment load to the creek due to roads, streambank erosion and from upland sediment sources. For metals, DEQ (2014) notes that TMDLs are being met during low flow conditions, but not during high flow conditions. In their TMDS and allocation examples for various metals in Upper Telegraph Creek (refer to Table 7-25 in DEQ 2014), DEQ's goal for reduction in metal loads during high flow conditions is 17% for cadmium, 43% for copper, 61% for lead and 26% for zinc.

3.4 GROUNDWATER QUALITY

Groundwater quality data for total metals are available from 2008 and 2010 from a total of eight groundwater monitoring points. Tetra Tech (2009) obtained samples from three wells installed into mine workings by MSE, including LOB-GW-01 (MW-Shaft well), LOB-GW-02 (MW-Injection 2), and LOB-GW-03 (LOB-3). They referred to these samples as mine water samples. TerraGraphics (2011) collected samples from the five monitoring wells they installed as part of the Phase II reclamation investigation (see **Section 2.3.3**) for analysis. **Figure 3** shows locations of the eight wells.

Table 5 summarizes groundwater quality data for total metals relative to DEQ-7 human health standards. Additional groundwater quality data are available in Tetra Tech (2009) and TerraGraphics (2011). Four metals exceeded groundwater standards in most samples including arsenic, cadmium, lead and zinc. Arsenic concentrations exceeded the DEQ-7 standard in six of the eight groundwater samples and were highest in the three samples obtained from wells completed in mine workings. Cadmium and zinc concentrations exceeded the DEQ-7 standard in over half the groundwater samples.

TerraGraphics (2011) potentiometric surface map shows a northward direction of groundwater flow. Samples from upgradient well LOB-MW-05 exhibited the lowest concentrations of metals relative to wells completed in or near underground mine workings. Well LOB-MW-04, completed to a depth of 25 feet with a 20-foot length of screen is the further well downgradient of the underground workings. However, concentrations of zinc and cadmium in the sample from LOB-MW-04 exceeded DEQ-7 standards (**Table 5**).

3.5 ASSESSMENT OF PHYSICAL HAZARDS

Due to the nature of an abandoned mine and the location the LOB Mine site, physical hazards are present on site. These hazards include potential slips, trips, and falls from:

- steep rock dumps slopes and variable site terrain;
- loose rock from the rock dumps;
- debris and other obstacles, such as fallen trees; and
- collapsed underground workings including adits, shafts, and drifts.

Any further investigation into the remaining mine facilities come with the potential significant hazard of tunnel collapse due to soft timber or dry rot. Many of the underground mining facilities were filled with water for many years, until dewatered in 2010 which also tends to destabilize mine workings.

3.6 Repository Siting Evaluation

NewFields completed a preliminary repository siting evaluation for the LOB site to support this Expanded EE/CA. Work was performed using ArcGIS and involved a study area generally consisting of the Telegraph Creek watershed with a slight extension on the west side. Trout Unlimited requested that the area around the Tramway Creek Mining Complex in Section 6, Township 8 North, Range 6 West be evaluated for potential repository locations. **Chart 2** below identifies the resources evaluated and siting criteria for each resource, and **Appendix A** provides sources of publically available data used for the analysis.

Chart 2. Repository Siting Criteria

Resource	Siting Criteria
Surficial Geologic Materials	Repository cannot be located in mapped alluvial material
Mapped Faults	Greater than 500 feet from any mapped fault
Streams, Lakes and Ponds	Greater than 500 feet from flowing or ponded water
Wetlands	Greater than 500 feet from mapped wetlands
Depth to Groundwater	Greater than 20 feet
Existing Roads	Sites accessible by existing roads are preferred
Slope	Less than 20 percent
Aspect	Compass direction from 157 to 248 degrees, clockwise from north
Site size	Minimum of 5 acres
Land Ownership	USDA-Forest Service administered land preferred over private land

Data layers for the resources identified in **Chart 2** were simultaneously analyzed using ArcGIS to identify sites that met the criteria assigned to each resource. Because only a few of the potential repository locations were accessible by existing roads, the "existing roads" criteria was dropped from further consideration. Locations that met all criteria are shown on Figure 1 in **Attachment A** and are differentiated between those located on USDA Forest Service lands (red) and those located on private land (orange).

With a few exceptions, most of the potential repository sites on USDA-Forest Service lands and all potential repository sites on private land are located near the Telegraph Creek watershed boundary. The nearest potential repository site to the Lilly/Orphan Boy mine is located approximately 1.8 miles north of the mine. As noted, only a few potential repository sites are adjacent to existing roads.

3.7 Conceptual Site Model

This section addresses the conceptual understanding of solid media (i.e., mine waste, impacted soil and impacted sediment present in the Telegraph Creek drainage) affected by mining operations at the LOB site. The LOB site is an abandoned hard rock mine, with approximately 1.5 acres of mining-related disturbance on private land surrounded by the Helena National Forest. The site is situated at an elevation of about 6,800 feet above mean sea level near the headwaters of Telegraph Creek, a tributary to the Little Blackfoot River. The area is characterized by granitic country rock with thin soils.

The abandoned mine is located on a west-facing slope with about 100 feet of relief between the upper (eastern) reaches and Telegraph Creek. Miners accessed ore via a shaft and three adits. The shaft and headframe are still present but previous investigators note that all three of the adits have collapsed. Adjacent to and below the shaft and each adit are piles of waste rock. Investigators mapped the extent of three distinct waste rock piles (WRP 1, 2 and 3) based on topography. The lowermost waste rock pile is associated with the lowest adit (known as the Lilly Adit), and is bisected by Telegraph Creek.

Boundaries of mine-impacted solid material at the LOB site were defined by: physical observations of waste rock, soil and sediment characteristics; topographic evaluations; and results of chemical analyses of waste rock, soil and sediment. Metals concentrations in waste rock and soil were compared to a recreational user cleanup guideline endorsed by DEQ which is based on a 50-day per year exposure scenario for a gold panner/rock hound. Physical locations where exceedances of arsenic (but also associated lead) were measured in waste rock and soil helped define the boundary of impacts. Based on the topographic expression of waste rock and adjacent soil, and a minimum assumed impacted soil thickness of 6 inches assumed by TerraGraphics (2011), previous investigators have estimated volume the volume of impacted waste rock and soil exceeding the cleanup guidelines at 3,900 cubic yards.

The approximate boundary of metal-impacted sediment at the LOB site is based on several considerations including a comparison of analytical testing results for 15 sediment samples to PAETs, Recreational Cleanup Guidelines and mean concentrations of five upstream sediment samples. In establishing a sediment removal boundary, consideration was given to retaining some of the existing wetland habitat in the lower reach of Telegraph Creek on the LOB site. Based on these factors and an average sediment thickness of about 2.8 feet, an estimated volume of mine-impacted sediment in the floodplain of Telegraph Creek is approximately 515 cubic yards.

4.0 RISK EVALUATION

In 2008, Montana DEQ commissioned an RI for the Lilly/Orphan Boy Mine site to delineate the nature and extent of wastes on site and assess the associated risks this contamination may pose to human and health and the environment via both a human health and ecological risk assessment. To this end, Tetra Tech (2009) conducted an RI to support human health and ecological risk assessments, including determining the magnitude and extent of metal contamination from waste in surface soil; evaluating the magnitude and extent of metal contamination in sediment; delineating the magnitude of metal contamination in surface and mine water and establishing the background concentrations of metals in soil. The results of the screening-level human health and ecological risk assessments are summarized below, along with supplemental soil, surface water, and sediment sampling results collected by TerraGraphics (2010) and NewFields (2015a).

4.1 Potentially Exposed Populations

Human populations that may potentially be exposed to mine waste or metals-impacted water at the LOB site include recreational users such as gold panners/rock hounds, hunters and hikers. Tetra Tech (2009) determined that recreational use at the site is high based on its location off Telegraph Creek road, its proximity to the surrounding communities of Elliston, Avon, and Helena, and due to the presence of two actively used recreational cabins located within a half-mile radius of the site.

As outlined in TetraTech (2009), three groups of ecological receptors are potentially affected by metal contamination at the LOB site, as summarized below:

- Terrestrial plant communities – The absence of vegetation has been documented previously on some of the waste rock piles. Potential causes may be attributable to toxic and inhibitory levels of metals in the plant root zone, along with other detrimental physical and chemical (infertility) properties of the soil. Plant communities represent the first trophic level in the food chain and are consumed by many higher trophic level animals, thus they are of concern as an ecological receptor.

- Terrestrial wildlife – Evidence of both elk and mule deer use of the site has been previously documented (Tetra Tech 2009) and the Montana Natural Heritage Program (2015) reports wolverine and Clark's Nutcracker may use the general area of the LOB site as habitat. Grazing by wildlife species at this site is a concern because of the potential to consume contaminated vegetation, ingest soil and evaporative salts; and they also may directly consume creek water containing elevated metals concentrations.

- Aquatic life communities. Telegraph Creek provides suitable habitat for aquatic life, though the flow rate of this perennial stream is low (Tetra Tech 2009).

4.2 Exposure Pathways

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

Ecological receptors could be affected by high concentrations of metals in the waste rock and adit discharge. Tetra Tech (2009) reported that the vegetative communities on site have been affected by metals toxicity, as evidenced by the lack of vegetation on the waste rock piles. Aquatic ecological receptors at the Site could be completely immersed in and continually ingesting surface water (e.g., in Telegraph Creek). Aquatic receptors would have direct contact with streambed sediment at multiple life stages, including eggs and juvenile life forms. Waste materials and vegetation in the area are easily accessible to humans and wildlife, and consumption of or contact with either could result in significant ecological effects.

4.3 Selected Screening Levels

Screening levels used to assess human and ecological exposure to metals are discussed below. The discussion includes description of the sources of reference concentrations such as adopted regulatory criteria, evaluation of the exposure models of the screening levels to determine if the models correspond with exposure scenarios at the Lilly/Orphan Boy Mine Site, and comparison of screening levels to detected concentrations of metals at the mine sites.

4.3.1 Human Health

The primary source of human health screening levels used in the RI (Tetra Tech 2009) and carried forward in this assessment is a document entitled Risk- Based Cleanup Guidelines for Abandoned Mine Sites (Tetra Tech 2004). The 2004 guidelines were produced for the Montana DEQ Abandoned Mine Reclamation Bureau, and were designed to address potential exposure to metals at abandoned mine sites in Montana. Screening levels derived from the 2004 guidelines for the human health-associated constituents of potential concern (COPCs) are presented in **Table 6**.

4.3.2 Ecological Risk

The criteria used for evaluation of ecological risk in surface water are the Montana Numeric Water Quality Standards (MDEQ 2012). In the case of metals, the Montana surface water quality criteria are typically based on recommended water quality criteria for protection of aquatic life in a freshwater environment (USEPA 2015). As shown in **Table 7**, Montana criteria for cadmium, chromium, copper, lead, nickel, silver, and zinc in surface water are hardness-dependent.

Washington State PAET values were used as reference values during the RI (Tetra Tech 2009) and carried through for review of 2015 analytical results because the state of Montana does not have established sediment quality standards. The WDOE issued new sediment management standards (SMSs) in 2013, which include screening levels and cleanup objectives for sediment in freshwater environments (WDOE 2015). However, the WDOE guidance allows the continued use of PAETs if it can be demonstrated that PAETs are sufficiently protective of benthic organisms. For the purposes of this Expanded EE/CA, the PAETs were selected as the sediment screening criteria for the site to maintain continuity with previous investigations completed at the site (Tetra Tech 2009 and TerraGraphics 2011) and the ecological risk assessment completed by Tetra Tech (2009).

The surface water and sediment screening levels listed above apply to fish and aquatic life. As previously discussed, terrestrial animals may also be exposed to metals at the LOB site.

4.4 Contaminants of Concern

4.4.1 Human Health

Tetra Tech (2009) conducted a hazard identification to identify potential COPCs at the LOB site based on the following criteria established by USEPA (1989), which included: (1) the constituent is present at the site; (2) the measured concentrations of the constituent are significantly above background concentrations; (3) 20 percent of the measured concentrations of the constituent must be above the method detection limit; and (4) the analytical results for each constituent must meet the quality assurance/quality control (QA/QC) criteria established for the data set. These analytical data were then screened against the DEQ risk-based recreational cleanup levels for metals at sites with maximum use (50-day gold panner/rock hound scenario; see **Section 4.3** for details).

Based on this hazard identification and associated recreational risk assessment, arsenic and lead were found to be the metals that pose the greatest risks to recreational users (e.g., human health) at the Lilly/Orphan Boy Mine Site (Tetra Tech 2009). Data from the 2010 Phase II RI (TerraGraphics 2011) and 2015 sediment sampling completed by NewFields (**Section 3.4**), confirm that arsenic is present in soil, mine waste, and sediment at the LOB site at concentrations that pose potential risks to human health (see **Tables 2** and **3**). Lead was also detected in the 2015 sediment samples at concentrations that exceed the human health screening level. No constituents were detected in surface water samples collected during the 2010 Phase II RI at concentrations that exceed the risk-based recreational screening levels.

4.4.2 Ecological Health

Similarly, Tetra Tech (2009) performed a baseline ecological risk assessment at the Lilly/Orphan Boy Mine Site for terrestrial plant communities, aquatic life communities, and terrestrial wildlife exposure scenarios using contaminant concentrations identified during the RI. Supplemental surface water samples were collected by TerraGraphics during the 2010 Phase II RI (TerraGraphics 2011) and additional sediment sampling was conducted by NewFields in 2015 (**Section 3.4**). Upon review of results and in light of Tetra Tech's baseline ecological risk assessment, five metals meet the COC criteria for ecological risk. These included arsenic, cadmium, copper, lead, and zinc.

Both aluminum and iron were detected in surface water samples at concentrations above Montana chronic aquatic life standards. However, aluminum has not been detected above the acute aquatic life standard for surface water and there is no acute aquatic life standard for iron. Sediment samples collected to date have not been analyzed for aluminum and a PAET has not been established for iron. Therefore, aluminum and iron were not considered COCs for ecological risk.

4.5 Health Effects of Contaminants of Concern

The health effects of arsenic, cadmium, copper, lead, and zinc are discussed below. The discussion includes details regarding effects for human and ecological receptors as applicable based on the results of the human health and ecological risk assessments (Tetra Tech 2009) discussed in **Section 4.4** above.

Arsenic

Arsenic is considered a carcinogen, teratogen and possible mutagen in mammals (including humans; USEPA 2015). Arsenic (and arsenic compounds), especially organic arsenicals, are readily absorbed into the body after inhalation, ingestion, or dermal contact (Tetra Tech 2009). Ingesting very high levels of arsenic can result in death. Exposure to lower levels can cause nausea and vomiting, decreased production of red and white blood cells, abnormal heart rhythm, damage to blood vessels, and a sensation of "pins and needles" in hands and feet. Ingestion of inorganic arsenic can increase the risk of skin cancer and cancer in the liver, bladder, and lungs. Inhalation of inorganic arsenic can cause increased risk of lung cancer. Ingesting or breathing low levels of inorganic arsenic over a long time period can cause a darkening of the skin and the appearance of small wart-like bumps on the palms, soles, and torso and skin contact with inorganic arsenic may cause redness and swelling according to the Agency for Toxic Substances and Disease Registry (ATSDR 2007a).

The effects of arsenic on mammals vary by species, exposure route or pathway, and the physical and chemical form of the arsenic (Tetra Tech 2009). Terrestrial plants accumulate arsenic by root uptake from the soil and by adsorption of airborne arsenic deposited on the leaves (Tetra Tech 2009). USEPA (2015) reports that both cancer-causing and genetic mutation-causing effects can occur in aquatic organisms; with aquatic bottom feeders being the most susceptible. Exposure to arsenic can affect behavior, reduce growth, lessen appetite and result in metabolic failure.

Cadmium

Cadmium is a known human carcinogen. ATSDR (2012) reports that cadmium exposure can damage the kidneys, lungs, and bones. Breathing high levels of cadmium can severely damage the lungs, while consumption of food or drinking water with very high levels severely irritates the stomach, leading to vomiting and diarrhea. Long term exposure can lead to buildup of cadmium in the kidneys (causing kidney disease) and result in lung damage and fragile bones. Animal studies indicate that children are more susceptible to loss of bone and decreased bone strength from cadmium exposure.

As reported by USEPA (2015), cadmium is highly toxic to wildlife and is considered a carcinogen, teratogen and possible mutagen in mammals with severe sub-lethal and lethal effects at low concentrations (USEPA 2015). Cadmium can affect respiratory function, enzyme level, growth and reproduction and is known to bioaccumulate at all trophic levels. Cadmium accumulates in the livers and kidneys of fish and can be toxic to plants at soil concentrations lower than other heavy metals. Cadmium is also noted to be more readily taken up than other metals.

Copper

Small amounts of copper are essential for good health in humans. However, breathing high levels can cause irritation of the nose and throat, and ingestion can cause vomiting, diarrhea, stomach cramps, nausea, and even death (ATSDR 2004).

USEPA (2015) reports that copper is a micronutrient and toxin and is toxic in aquatic environments with highly toxic effects on fish, invertebrates and amphibians. Copper is considered the most toxic common heavy metal to aquatic organisms with toxicity inversely related to the hardness of the water. The harder the water, the less toxic copper is to aquatic organism (Tetra Tech 2009). Studies indicate that copper is highly toxic to plants and will cause chlorosis and root malformation (Tetra Tech 2009). There is moderate potential for bioaccumulation in plants but no biomagnification (USEPA 2015). Mammals are not as sensitive to copper as aquatic organisms but toxicity can be associated with liver cirrhosis, necrosis in kidneys and the brain, gastrointestinal problems, lesions, and fetal mortality in mammals. Continued ingestion of copper by animals can lead to accumulation in tissues, particularly in the liver (Tetra Tech 2009).

Lead

Human health effects from exposure to lead are typically related to elevated blood-lead concentrations that can result in a variety of toxicological effects, such as damage to the nervous system, kidneys and reproduction system, depending on the level of exposure. The general symptoms of chronic lead poisoning include gastrointestinal disturbances, anemia, insomnia, weight loss, motor weakness, muscle paralysis, and nephropathy (Tetra Tech 2009). Human health effects of lead include decreased nervous system function, weakness in fingers, wrists, and ankles, anemia, and damage to the brain and kidneys, which can lead to death at high exposure levels. Children are more vulnerable to lead poisoning than adults. Lead is most dangerous for young and unborn children with potential effects including premature births, smaller babies, decreased mental ability in the infant, learning difficulties, and reduced growth in young children (ATSDR 2007b).

Lead can negatively affect fish, aquatic invertebrates, and algae, with limited adverse effects in amphibians, (e.g., loss of sodium, developmental problems). Exposure to lead can cause fish to exhibit muscular degeneration, reduced growth, reproductive problems, paralysis, and death. Lead can impair reproduction of invertebrates, and can reduce algal growth (USEPA 2015).

At elevated levels in plants, lead can cause reduced growth, photosynthesis, mitosis, and water absorption. Similar to humans, mammals can suffer effects from lead poisoning including damage to the nervous system, kidneys, liver, sterility, growth inhibition, developmental retardation, and detrimental effects in blood (USEPA 2015).

Zinc

As with copper, zinc is an essential human nutrient. However, high doses of zinc in the short term can cause stomach cramps, nausea, and vomiting while chronic exposure can cause anemia and changes in cholesterol levels (ATSDR 2005). Preliminary animal studies showed development of infertility in rats exposed to high doses of zinc. Inhaling large amounts of zinc dust can cause a short-term condition called metal fume fever, which resembles the flu. Zinc is likely to cause skin irritation. Zinc has not been classified regarding its human carcinogenicity.

Although zinc is an essential nutrient to aquatic biota, toxic effects at high concentrations can include mortality, reduced growth, and inhibited reproduction. Embryos and juveniles have been found to be most sensitive to the effects of zinc. In addition, the effects of zinc on aquatic organisms are increased by the presence of other metals such as cadmium and mercury (Tetra Tech 2009). In mammals, elevated levels can cause cardiovascular, developmental, immunological, liver and kidney problems, neurological, hematological, pancreatic, and reproductive problems (USEPA 2015).

Soluble forms of zinc are easily taken up by plants, particularly by the root systems. Zinc will commonly accumulate in the upper soil horizons during weathering processes (Tetra Tech 2009). Elevated levels of zinc are associated with adverse effects on plant growth, survival and reproduction (USEPA 2015). Growth, survival and reproduction are adversely affected in many types of aquatic plants and animals (USEPA 2015).

5.0 SUMMARY OF APPLICABLE OR RELEVANT & APPROPRIATE REQUIREMENTS

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

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

The State of Montana has the authority, delegated by the U.S. Office of Surface Mining, Reclamation, and Enforcement, to administer the Abandoned Mines Reclamation Program in accordance with the State of Montana's Reclamation Plan. The DEQ/MWCB has developed a summary of federal and state ARARs for abandoned mine lands reclamation projects (MDEQ/MWCB 2008) that would apply to the LOB Mine. A preliminary list of ARARs for the removal action at the LOB Mine is provided in **Table B-1** (**Appendix B**).

The response action under consideration for the LOB Mine is an initial response to the release of hazardous substances. The scope of the response action is focused on the reduction or elimination of uncontrolled releases of metals to soil, surface water, and sediment from mine waste present at the site. This removal action may not be the sole response taken at the mine; however, no additional response actions are currently planned.

6.0 RECLAMATION GOALS & OBJECTIVES

The primary goal of the response action under consideration for the LOB Mine is to limit potential human and ecological exposure to mine-related contaminants through the reduction or elimination of uncontrolled releases of metals to soil, surface water, and sediment from mine waste present at the site.

6.1 ARAR-Based Reclamation Goals

Alternatives presented in the Expanded EE/CA are reclamation actions to mitigate threats from uncontrolled mine waste. A preliminary list of ARARS for the LOB site is provided in **Table B-1** (**Appendix B**). ARAR-based cleanup goals are limited to groundwater and surface water because no contaminant specific ARARs exist for soils, mine waste, or sediment.

Surface water ARARs include established aquatic life and human health water quality standards. Montana aquatic life standards include both chronic and acute criteria. Chronic standards are applicable to long-term exposure scenarios and are lower than acute aquatic life standards. Therefore, chronic aquatic life standards were used for this ARAR evaluation. The more stringent of the human health or chronic aquatic life water quality standard was selected as the ARAR-based reclamation goal for surface water for each COC at the LOB site. The ARAR-based reclamation goals for surface water are summarized in **Table 8**. Several constituents, including arsenic, cadmium, copper, lead, and zinc have been detected in surface water samples collected from Telegraph Creek at concentrations that exceed the ARAR-based reclamation goals. Although surface water treatment is not addressed by this Expanded EE/CA, the mine waste mitigation measures under consideration may affect COPC concentrations in Telegraph creek through the removal of mine waste in contact with the creek, as well as sediment with elevated metals concentrations.

Although groundwater (and mine water) remediation is not addressed by this Expanded EE/CA, ARAR-based groundwater reclamation goals are included in **Table 8** for informational purposes. ARAR-based reclamation goals for the LOB site are based on Montana DEQ-7 human health standards for groundwater.

6.2 Risk-Based Reclamation Goals

Reclamation goals for project COCs in sediment and soil are listed in **Table 9**. The results of the human health and ecological risk assessment for the site indicate that arsenic, cadmium, copper, lead, and zinc are COCs for the LOB site. Risk-based reclamation goals for soil at the LOB site were selected for recreational users of the site (50-day gold panner/rock hound scenario). These reclamation goals are from the *Risk-Based Cleanup Guidelines for Abandoned Mine Sites* developed by DEQ/MWCB (Tetra Tech, 2004).

The WDOE issued new SMSs in 2013, which include screening levels and cleanup objectives for sediment in freshwater environments (WDOE 2015). However, the WDOE guidance allows the continued use of PAETs developed by the WDOE (1997) if it can be demonstrated that PAETs are sufficiently protective of benthic organisms. For the purpose of this Expanded EE/CA, the PAETs were selected as the sediment reclamation goals for the site to maintain continuity with previous investigations completed at the site (Tetra Tech 2009 and TerraGraphics 2011) and the ecological risk assessment completed by Tetra Tech (2009).

6.3 Restoration Goals

Restoration goals have been established for this Expanded EE/CA. The waste rock piles have created a perched and exposed disturbed area that is susceptible to increased runoff and erosion, and Telegraph Creek has been confined by Waste Rock Pile 3. The stream channel is aggraded though most of the mine site and the channel exhibits signs of instability. This project addresses direct remediation of these impacts through mine waste removal, regrading hillslopes and reconstructing approximately 300 feet of stream channel.

Improving habitat for terrestrial wildlife is a restoration goal for the project. Removal of mine waste on the hillslopes above Telegraph Creek and spreading growth media and mulch over the recontoured slopes will promote revegetation of the site. Revegetation, over the long-term, would help restore habitat for the Clark's Nutcracker and wolverine, and may promote use of the site by the snowshoe hare and potentially increase habitat for lynx and grizzly bear.

A goal of this project is to improve Telegraph Creek's ecological function to be accomplished through stream channel rehabilitation, planting of native riparian vegetation, removal of upland and floodplain mine waste, and revegetating slopes. The new channel will improve sediment and water routing, provide a diversity of habitat, and also ensure surface flow connectivity. Furthermore, a restored floodplain will allow the creek to achieve dynamic stability and dissipate energy during high flows. The net result will be a creek with fewer sediment sources, lower water temperatures, and greater overall stability – a favorable environment for fish, plants and other aquatic and terrestrial wildlife species. The improved habitat resulting from this restoration project should provide secure habitat for wild fish at all stages of life history as well as restore wildlife habitat.

7.0 DEVELOPMENT & SCREENING OF RECLAMATION ALTERNATIVES

This section of the Expanded EE/CA identifies reclamation technologies that could be implemented alone or in conjunction with other technologies to reduce or eliminate potential human health and environmental risks associated with waste rock and soil with elevated metals concentrations at the LOB mine. The technologies were initially screened according to their ability to meet the reclamation goals presented in **Section 6.0** and practical considerations of their implementation at the site. The technologies retained from the initial screening process were then used to develop reclamation alternatives for detailed analysis based on their effectiveness, implementability, and cost. The detailed evaluation of alternatives is presented in **Section 8.0**.

7.1 IDENTIFICATION AND PRELIMINARY SCREENING OF RECLAMATION TECHNOLOGIES

Reclamation technologies with potential to address elevated concentrations of metals in waste rock and soil at the LOB Mine were identified based on NewFields experience at similar sites, engineering judgement, and a review of available literature. The technologies identified for preliminary screening can be classified into four general categories:

- Institutional Controls – measures that restrict or control access to or use of a site as means to reduce exposure of the public to COCs.
- Engineering Controls – technologies that reduce contaminant mobility and eliminate exposure pathways through the use of physical barriers.
- Excavation and Disposal – excavation of contaminated material for disposal at either an on-site repository or an off-site permitted disposal facility.
- Treatment – destruction or immobilization of contaminants by treatment of soils and waste rock with elevated metals concentrations. This includes reprocessing of mine waste for extraction of metals and disposal of the resulting tailings.

Reclamation technologies for soil and mine waste are summarized in **Table 10** with the preliminary screening results and discussed below.

7.2 INSTITUTIONAL CONTROLS

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

A deed restriction could be placed on the property that includes the LOB site to restrict future use of the site. Physical barriers, such as fences, are readily implementable around the waste rock piles to control access by the public. The shaft opening at the LOB site is currently fenced off. Posting of signs notifying the public of potential hazards associated with the LOB site may also be potentially effective deterrents to public use of the mine site.

Institutional controls would not be effective as stand-alone reclamation actions. However, when combined with other actions institutional controls may increase the protectiveness of the alternative. Therefore, institutional controls were retained for further consideration through inclusion with other reclamation actions.

7.3 Engineering Controls

Engineering controls use physical barriers to reduce contaminant mobility and eliminate (or mitigate) exposure pathways. Engineering controls typically include containment, run-on/runoff controls, and revegetation. As discussed below and in **Table 10**, these reclamation actions would not reduce contaminant concentrations or the volume of impacted media. This reclamation action could be used with another action, but by itself will not receive further consideration.

7.3.1 Containment

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

Waste Rock Pile 3 is in direct contact with Telegraph Creek and would need to be excavated back from the creek channel prior to capping. All three waste rock piles would need to be regraded to reduce their slopes and limit the potential for erosion of the cap. In addition, it would be necessary to import cover materials to the site because sufficient volumes of suitable soils for cover construction are not present at the LOB site.

In-place containment of mine waste and impacted soil at the LOB site was not retained for further consideration because steep site slopes, slope aspects, and proximity of mine waste to Telegraph Creek make the site unsuitable for on-site containment.

7.3.2 Surface Controls

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

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

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

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

7.4 Excavation and Disposal

Excavation and disposal of impacted media in an on-site or off-site repository or at an off-site permitted landfill is a permanent source control measure. An estimated 3,430 cubic yards of mine waste is present in three waste rock piles at the site and an additional approximately 470 cubic yards of impacted soil (containing concentrations of arsenic or lead above screening levels) is present on site around the waste rock piles. In addition, an estimated 515 cubic yards of sediment containing arsenic concentrations above screening levels is present in the wetland area along Telegraph Creek downstream of Waste Rock Pile 3. It would also be necessary to import growth media to reclaim the excavation areas following removal of the mine waste and impacted soil.

7.4.1 On-Site Disposal

Under this scenario, mine waste and impacted soil / sediment would be excavated and placed in a repository constructed on-site. The repository would include a cover system designed to limit infiltration of precipitation into the underlying mine waste and soil/sediment. Diversion channels would be constructed to direct storm water run-on/runoff away from the repository to prevent erosion of the soil component of the cover system and further limit infiltration. It would be necessary to import cover materials and growth media to the LOB site because suitable quantities of growth media are not present on-site for cover construction and reclamation of excavation areas.

As discussed in **Section 3.7**, NewFields conducted a repository siting evaluation to identify potential sites in proximity to the LOB site that would be suitable for construction of a mine waste repository. Sites within the Telegraph Creek watershed were evaluated based on the following criteria:

- The site cannot be located in mapped alluvial material;
- Potential repository locations must be more than 500 feet from any mapped fault;
- Sites must be greater than 500 feet from surface water or mapped wetlands;
- The depth to water must be more than 20 feet;
- Site slopes must be less than 20 percent and the aspect must have a compass direction between 157 to 258 degrees (clockwise from north);
- Sites located in proximity to existing roads are preferred; and
- A minimum of five acres must be available on the property for construction of the repository.

The parcel that encompasses the LOB site is approximately 20.7 acres in size (Montana Cadastral Mapping Project 2016). As shown on **Figure 2**, the parcel is bisected by Telegraph Creek. The portion of the parcel on the east side of the creek is not suitable for an on-site repository because it has slopes up to 43 percent, slope aspects ranging from approximately 60 to 90 degrees (clockwise from north), and the majority of this portion of the property is less than 500 feet from Telegraph Creek.

The portions of the parcel on the west side of Telegraph Creek have slopes greater than 20 percent. This area also has a north facing slope thus does not meet the criteria for slope aspect. In addition, a pond is located approximately 400 feet from the southwest property boundary, and five acres of area are not available west of Telegraph Creek that are more than 500 feet from either the creek or the pond.

Based on this analysis the parcel that encompasses the LOB site does not meet the repository siting criteria. Therefore, excavation of mine waste for placement in an on-site repository was not retained for further evaluation.

7.4.2 Off-Site Disposal

Under this scenario, excavated mine waste and impacted soil/sediment would be hauled to a repository constructed off-site or a permitted landfill for disposal. Mine waste and site soils have not been sampled to determine the leachability of metals present in the material using the toxicity characteristic leaching procedure (TCLP; USEPA Method 1311). However, total metals concentrations of some COCs (e.g., arsenic, cadmium, lead, zinc) have been detected in mine waste / soil samples collected from the site that indicate the material may exceed the regulatory levels for toxicity characteristics. Therefore, it is unlikely that municipal solid waste landfill (permitted under 40 Code of Federal Regulations [CFR] Part 258 - Subtitle D of the Resource Conservation and Recovery Act [RCRA]) could accept the waste. Disposal in a licensed hazardous waste facility would likely be cost prohibitive and is not considered further.

NewFields conducted a repository siting evaluation to identify locations within the Telegraph Creek watershed (and a slight extension on the west side) that would potentially be suitable for the construction of a repository for mine waste and impacted soil/sediment (containing concentrations of COCs above site reclamation goals). A number of locations were identified during the evaluation that met the siting criteria (refer to **Section 3.7**). The majority of these sites are located on land administered by the USDA-FS, although some privately-owned parcels were identified at the north end of the Telegraph Creek watershed that also satisfied the preliminary evaluation criteria. Approval of the USDA-FS would be required for the construction of a repository on land administered by them. It would be necessary to purchase property or obtain a long-term agreement for construction of an off-site repository on privately-owned land.

Another potential off-site repository site was identified during the siting evaluation. The LOB site is located in relatively close proximity (approximately 6.6 road miles) to the Luttrell Abandoned Mine Waste Repository, which is located in the Luttrell Pit of the historic Basin Creek Mine (**Figure 4**). The Luttrell Repository is multi-agency collaborative effort and is operated by USEPA under the authority of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA). A design basis report for the repository was prepared by CDM Federal Programs Corporation for USEPA in 2003 (CDM, 2003). The repository can receive mine waste from abandoned mine sites located within the Boulder-Elkhorn and Upper Tenmile Creek Watershed (located in the Lake Helena Watershed; USDA-FS 2005) and according to DEQ can accept mine waste from the Telegraph Creek drainage. Based on information provided by DEQ, the repository includes 5 waste cells and after startup in 1999 through 2012, approximately 510,500 cubic yards of mine wastes/soils have been placed in the repository by the USEPA, US Forest Service and DEQ. Approximately 75% of this material has come from USEPA cleanup projects in the Tenmile Creek and Basin Creek watersheds.

The agreement between the DEQ, USDA-FS, and USEPA for the operation of the repository has expired and is currently being renegotiated. The Montana DEQ will have the long-term Operation and Maintenance obligation for the site (personal communication with Joel Chavez, DEQ Project Manager, on February 8, 2016).

Excavation and off-site disposal of mine waste was retained for further evaluation.

7.5 In-Situ Treatment

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

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

7.6 Ex-Situ Treatment

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

7.6.1 Reprocessing

Reprocessing consists of subjecting mine waste to physical/chemical extraction processes for the beneficial recovery of metals, which reduces the concentrations of the contaminants in the mine waste (and after processing, the waste is often not returned to the site). One potential reprocessing facility is Barrick Gold Corporation's (Barrick) Golden Sunlight Mine (GSM), which is an open pit gold mine and milling operation located near Whitehall, Montana. GSM's mill has accepted ore from outside sources in the past for processing. The resulting tailings from reprocessing in GSM's mill would be disposed of in the active tailings storage facility at GSM.

It would be necessary to conduct assay tests on samples of the mine waste from the LOB site to determine whether recoverable metal concentrations in the waste are high enough to make reprocessing economical. It is unlikely that all mine waste at the site contains metal concentrations that are high enough to warrant economic reprocessing and recovery, and therefore, reprocessing is not a stand-alone reclamation action for the LOB site. The amount of screening and crushing (if necessary) the mine waste would require, as well as the haul distance from the site to the reprocessing mill, would also affect the economic viability of reprocessing.

In addition to the viability concerns, Barrick restricts metals concentrations in outside ore / mine waste it accepts for processing at the GSM mill to the following limits:

- Mercury – 1 mg/kg
- Arsenic – 200 mg/kg
- Lead – 100 mg/kg
- Zinc – 200 mg/kg
- Total Copper – 1,000 mg/kg
- Cyanide Soluble Copper – 250 mg/kg
- Selenium – 1 mg/kg
- Barium – 500 mg/kg
- Chromium – 100 mg/kg
- Cobalt – 100 mg/kg
- Nickel – 100 mg/kg
- Cadmium – 1 mg/kg

Arsenic, cadmium, lead, and zinc have been detected in mine waste samples from the LOB site at concentrations that exceed these limits (**Table 2**). It is unlikely that GSM would accept mine waste from the LOB site. Therefore, reprocessing was not retained for further evaluation.

7.6.2 Re-Use

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

- The use of mine waste as aggregate in asphalt or concrete mixes;
- The re-use of contaminated soil as a cover material for site remediation; and
- The use of waste rock as a construction material (either directly or following treatment/reprocessing).

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

7.6.3 Physical/Chemical Treatment

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

Soil washing is a physical treatment technology that separates contaminants sorbed onto fine soil particles from bulk soil in a water-based system on the basis of particle size (USEPA 2016). Contaminated media and wash water are mixed ex situ in a tank or treatment unit. A leaching agent, surfactant, or chelating agent may be added to the wash water or the pH of the wash water may be adjusted to enhance the removal of metals. The wash water and various soil fractions are usually separated by gravity settling.

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

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

7.7 Reclamation Alternative Development

The technologies that were retained through the initial screening process are summarized in **Table 10**. These technologies are proven, effective, and implementable over a range of costs. USEPA guidance for non-time critical removal actions (USEPA 1993) recommends that only a limited number of reclamation alternatives be developed for detailed analysis. USEPA guidance also recommends that only the most qualified technologies that apply to the media or source of contamination be included in the reclamation alternatives. Based on this guidance, a limited number of alternatives were developed for further evaluation using the technologies that were retained during the initial screening process summarized in **Section 7.1** of this Expanded EE/CA. **Table 11** lists the reclamation alternatives that were developed for soils and waste rock at the LOB Mine.

In accordance with USEPA guidance (1988), the next step in the reclamation evaluation and selection process is a screening evaluation of the reclamation alternatives developed following the initial technology screening. The alternatives are evaluated against three broad criteria (effectiveness, implementability, and cost) in order to reduce the number of alternatives that are carried forward for a more detailed analysis. As shown in **Table 11**, three reclamation alternatives were developed for the LOB site following the initial technology screening step. The alternative screening step was not performed due to the already limited number of alternatives identified for the LOB site, and because it is unlikely that any of the three alternatives would be eliminated during an additional screening step. All three reclamation alternatives were carried forward for detailed analysis (**Section 8.0**).

8.0 DETAILED ANALYSIS OF RECLAMATION ALTERNATIVES

Reclamation alternatives developed in **Section 7.7** incorporate technologies retained following a preliminary screening of their ability to meet reclamation goals and practical considerations of their implementation at the site. These alternatives represent a range of potential actions or process options that will reduce or eliminate potential human health and ecological risks associated with mine waste and impacted soil / sediment to varying degrees over a range of estimated costs. This section presents a detailed evaluation of the individual reclamation alternatives.

The following alternatives were identified for detailed analysis:

- Alternative 1: No action
- Alternative 2: Excavation and disposal in an off-site repository
- Alternative 3: Excavation and disposal in the Luttrell Repository

These reclamation alternatives only address solid media (i.e., mine waste and soil/sediment containing COCs at concentrations above reclamation goals) at the LOB site, and do not address the discharge from the Lilly adit. Therefore, each of these alternatives is classified as an interim or removal action and is not considered a complete reclamation. It is anticipated, however, that removal of mine waste from the site will reduce the mass of contaminants reaching Telegraph Creek and the adjacent wetland area.

8.1 EVALUATION CRITERIA

The three reclamation alternatives developed in **Section 7.7** were evaluated against the following criteria in accordance with the NCP:

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

Supporting agency and community acceptance are modifying criteria that will be evaluated after the DEQ and the public have reviewed and commented on the Expanded EE/CA.

These criteria fall into three categories, each with distinct functions in selecting the preferred alternative:

- **Threshold Criteria** – overall protection of human health and the environment and compliance with ARARs.
- **Primary Balancing Criteria** - Long-term effectiveness and permanence; reduction in toxicity, mobility, or volume through treatment; short-term effectiveness; implementability; and cost.
- **Modifying Criteria** – supporting agency and community acceptance.

8.1.1 Threshold Criteria

A reclamation alternative that does not satisfy the threshold criteria (overall protection of human health and the environment and compliance with ARARs) cannot be selected as the preferred alternative.

Overall Protection of Human Health the Environment: This criterion is used to evaluate whether an alternative provides adequate protection of human health and the environment. As described in USEPA guidance (1988):

> *"The overall assessment of protection draws on the assessments conducted under other evaluation criteria, especially long-term effectiveness and permanence, short-term effectiveness, and compliance with ARARs."*

Compliance with ARARs: Alternatives are evaluated against this criterion to determine whether they will satisfy state and federal ARARs that have been identified for the project. ARARs for the LOB site are discussed in **Section 5.0** and a preliminary list of ARARs for this site is provided in **Table B-1** (**Appendix B**).

8.1.2 Primary Balancing Criteria

Primary balancing criteria take into account technical considerations of each alternative's ability to achieve long-term reductions in risks to human health and the environment, whether the alternative is technically and administratively feasible, and the overall cost of the alternative. Threshold and primary balancing criteria serve as the basis for the detailed analysis of alternatives and selection of the preferred alternative.

Long-term Effectiveness and Permanence: This criterion is used to evaluate alternatives based on the anticipated risk that remains at the site after reclamation objectives have been achieved (USEPA 1988). The magnitude of residual risk at the site, the adequacy and suitability of controls used to manage untreated waste and treatment residuals, and the long-term reliability of the alternative is assessed.

Reduction in Toxicity, Mobility, or Volume through Treatment: Alternatives are assessed against their ability to permanently reduce principal threats at a site through the destruction of toxic contaminants, irreversible reduction in contaminant mobility, or reduction of total contaminated media volume (USEPA 1988). Factors considered include:

- Treatment process used and the media that will be treated;
- The expected reduction in contaminant toxicity, mobility, or volume, and the degree to which the treatment will be irreversible;
- Treatment residual types and volumes remaining after reclamation; and
- Whether the alternative would satisfy the statutory preference for treatment as a principal element.

Short-term Effectiveness: This criterion is used to evaluate the potential risks posed to human health and the environment by construction and implementation of the alternative until reclamation objectives (e.g., clean-up goals) have been met (USEPA 1988). Factors that are considered include the protection of workers implementing remedial actions, threats to the surrounding community (e.g., generation of dust during excavation, spills of hazardous materials during transportation, etc.), and the time required to meet reclamation objectives.

Implementability: The technical and administrative feasibility of implementing an alternative is examined under this criterion, including the availability of the required materials and services. Technical feasibility refers to the ability to construct, operate, maintain, and monitor treatment technologies associated with the alternative, as well as the ease of implementing future reclamation actions. Administrative feasibility considers the need (and ability) to obtain permits and regulatory approval for components of the action.

Cost: The capital, operation, and maintenance costs of reclamation alternatives are evaluated under this criterion, as well as costs associated with monitoring and reporting. Cost estimates were prepared for each alternative considered in this Expanded EE/CA. The costs estimates include future costs for each alternative over a life of 30 years using present worth analysis. The net present value (NPV) calculations include an annual discount rate (assumed to be 4.2 percent for this Expanded EE/CA) that addresses the time value of money. The discount rate is typically described as the interest rate that could be realized from a prudent investment. An escalation rate of 3.5 percent was used to estimate the annual increase in future costs due to inflation. Cost estimates were prepared in accordance with USEPA guidance on preparing cost estimates for response actions under CERCLA (USEPA 2000).

8.1.3 Modifying Criteria

DEQ's technical and administrative issues and concerns related to the preferred alternative will be formally considered after agency and public comment on the proposed plan. Any public concerns with the reclamation alternative will also be evaluated following the public comment period.

8.2 Quantitative Evaluation of Threshold Criteria

Each reclamation alternative, with the exception of the no-action alternative, is designed to achieve risk-reduction necessary to achieve the reclamation objectives for the LOB site and the risk-based cleanup goals. No additional evaluation or comparison of relative reductions in risk between reclamation alternatives was performed.

8.3 Alternative 1: No Action

The no action alternative was carried forward for detailed analysis to serve as a baseline against which the other reclamation alternatives are compared. Under this alternative the LOB site would be left in its existing condition. Mine waste would be left in place and no action would be taken to control contaminant migration from the site, reduce toxicity, or reduce waste volumes.

8.3.1 Overall Protection of Human Health and the Environment

The no action alternative would do nothing to mitigate current and future risks to human health and the environment associated with mine waste and impacted soil / sediment at the site. There would be no benefits to habitat of the three Sensitive species reported by the Montana Natural Heritage Program (2015) in the general area of the LOB site.

8.3.2 Compliance with ARARs

Several constituents, including aluminum, cadmium, copper, lead, and zinc have been detected in surface water samples collected from Telegraph Creek at concentrations that exceed the ARAR-based reclamation goals (refer to **Section 6.1**). The no action alternative would not reduce concentrations of these constituents in Telegraph Creek and would not meet state or federal contaminant-specific ARARs that are applicable to surface water at the LOB site.

8.3.3 Long-term Effectiveness and Permanence

Risks to human health and the environment posed by the LOB site would remain unchanged under the no action alternative. No administrative or engineering controls would be implemented at the site. Therefore, the no action alternative does not offer long-term effectiveness or permanence.

8.3.4 Reduction of Toxicity, Mobility, or Volume through Treatment

This alternative does not reduce the toxicity, mobility, or volume of mine waste and impacted soil / sediment at the LOB site.

8.3.5 Short-term Effectiveness

No actions would be implemented under this alternative, and therefore, no short-term risks would be created.

8.3.6 Implementability

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

8.3.7 Cost

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

8.4 Alternative 2: Excavation and Disposal in Off-Site Repository

Alternative 2 would include the excavation of mine waste, as well as soil and sediment containing COCs at concentrations that exceed cleanup goals, from the LOB site for disposal in a repository constructed off-site. Preliminary discussions with USDA-FS personnel indicate that it may be difficult to obtain approval to construct a repository on land administered by the USDA-FS for waste from a site not located on USDA-FS land. Therefore, it was assumed that the repository would be located on privately-owned land for the purpose of this alternatives analysis. The preliminary repository siting evaluation (**Section 3.7**) identified several potential repository locations on private land approximately 5 air miles north of the LOB site.

An estimated 4,415 cubic yards of waste and impacted media would be removed from the site, including the three waste rock piles (approximately 3,430 cubic yards), approximately 470 cubic yards of impacted soil, and 515 cubic yards of impacted sediment in the wetland area downstream of WRP-3. Excavation efforts would continue until native soil is exposed beneath the three waste rock pile locations. An x-ray fluorescence spectrum analyzer (XRF) may be used to screen remaining soil and sediment on site to evaluate whether cleanup goals have been met.

Figure 5 shows a conceptual cross-section of the design for the off-site repository. It was assumed that the repository cover system would consist of a geosynthetic clay liner (GCL) overlain by a drainage layer and two feet of cover soil / growth media. The drainage layer would direct meteoric water that infiltrates through the soil cover off the GCL and away from the repository. Depending on the suitability of materials at the repository site, the drainage layer may be constructed using coarse grained soil salvaged on-site or synthetic materials (e.g., geonet).

Alternative 2 would include the following additional elements:

- Repository Site Preparation - Clearing and grubbing the repository site; separating combustible and non-combustible debris; and debris disposal.
- Construct Repository - Items to be completed under this task include:
    - Strip and stockpile topsoil within the footprint of the repository for re-use during cover construction and reclamation;
    - Excavate subsoil to a depth of approximately four feet within the footprint of the repository;

- Compact the subgrade at the base of the repository to a specified density;
- Place and compact the waste rock in the repository;
- Grade and shape waste rock to suitable slopes for cover construction;
- Install repository cover system;
- Construct run-on/runoff control ditches around the perimeter of the repository; and
- Seed repository cover and disturbance area, including application of appropriate fertilizer and mulch.
- The repository would cover an area of approximately 0.6-acres.

- Surface Water Diversion System - It would be necessary to divert Telegraph Creek around the excavation areas for WRP-3 and impacted sediment downstream of WRP-3. The diversion system would include a temporary dam installed across Telegraph Creek upstream of the excavation area. Water in Telegraph Creek would be piped from the temporary diversion dam around the excavation areas to temporary sediment basins prior to discharge back into the creek. Excavation would be completed in late summer / early fall when Telegraph Creek flows are low and the Lilly adit is not discharging.

- Excavate, Load, and Haul Waste - Excavate mine waste and impacted media at the LOB site to the approximate lateral limits shown on **Figure 3**. The excavations would extend to native soils beneath the waste rock piles. The mine waste and impacted media would be loaded into haul trucks and transported to the off-site repository for disposal.

The LOB site would be regraded to match pre-existing site slopes. Approximately 300 linear feet of Telegraph Creek would be reconstructed and graded to provide a slope consistent with upstream and downstream portions of the creek that have not been affected by mining activities. Grade control structures would be constructed using materials (e.g., logs, rock, etc.) salvaged from on-site. Imported growth media would be spread over the recontoured excavation areas. Disturbed areas would then be revegetated using soil amendments, re-seeding, streambank plantings, and mulching. Disturbed areas at the LOB site, as well as the repository, would be monitored and maintained (if necessary) until vegetation is fully established. Weed control measures would be employed as necessary.

Note that Alternative 2 (as well as the other alternatives under consideration) does not address the seasonal discharge from the Lilly adit, which would continue to impact surface water quality in Telegraph Creek. Following removal of mine waste and impacted soil around WRP-3, the drainage channel for the adit discharge would be reconstructed.

8.4.1 Overall Protection of Human Health and the Environment

Excavation of mine waste, soil, and sediment containing COCs at concentrations above cleanup goals for disposal at an off-site repository would significantly reduce risks to human health and the environment. This alternative would also substantially meet reclamation objectives and goals for the project (refer to

Section 6.0). Exposure of human and ecological receptors to contaminants through direct contact with mine waste would be eliminated. In addition, the response action would eliminate a source of metals impacts to surface water and sediment in Telegraph Creek. The stream function and aquatic life habitat in Telegraph Creek would also be improved through removal of mine waste in contact with the creek and reconstruction of the streambed. By removing mine wastes, and revegetating and naturalizing the LOB site, the overall long-term habitats for the Clark's Nutcracker and wolverine would be improved and the downstream habitat for the Westslope Cutthroat Trout would be benefited.

8.4.2 Compliance with ARARs

Although this alternative would reduce the load of contaminants discharged to surface water at the LOB site, it may not fully achieve surface water quality ARARs alone because it does not address the discharge from the Lilly adit. Contaminant-specific ARARs for ambient air are expected to be met because the mine waste will be placed in a repository with an engineered cover system and disturbed areas will be revegetated. Dust control measures would be implemented during construction activities to control generation of fugitive dust.

Metals, including arsenic, cadmium, lead, and zinc, have been detected in groundwater at the LOB site at concentrations that exceed DEQ-7 human health standards for groundwater. Groundwater levels in several on-site monitoring wells were affected by mine dewatering activities conducted in October 2010, which indicates some level of interaction between water in the mine workings that contain elevated metals concentrations and groundwater on site. The degree to which groundwater quality on site is affected by the presence of the waste rock piles (through infiltration of meteoric water through the piles to underlying groundwater) is unknown. Removal of mine waste with elevated metals concentrations (above cleanup goals) may improve groundwater quality at the LOB site. However, site groundwater will continue to be affected by interaction with mine water and may not meet groundwater ARARs.

Location-specific ARARs would be met to a substantial degree. Several potentially historic features are present at the mine site (refer to **Section 2.4**). DEQ would work with SHPO during reclamation activities to preserve historical features to the extent practical. The response action would improve habitat for migratory birds, endangered species, and aquatic life. Work would be performed within the floodplain of Telegraph Creek and the removal of metals-impacted sediment is anticipated to have positive long term benefits on Telegraph Creek. Following sediment removal, reconstruction of Telegraph Creek and the adjacent floodplain will be performed in a manner to restore a functioning stream and naturalized riparian area. Potential wetlands at the LOB site (a wetland inventory has not been performed) would be removed by the reclamation action. It may be necessary to conduct a wetland delineation and file a Pre-Construction Notification with the U.S. Army Corps of Engineers for a Nationwide Permit (Section 404 of the Clean Water Act).

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

8.4.3 Long-term Effectiveness and Permanence

Alternative 2 would achieve a high degree of long-term effectiveness and permanence because mine waste containing concentrations of metals above cleanup goals would be permanently removed from the LOB site. The repository cover would be designed to minimize infiltration of meteoric water into the underlying mine waste. Once vegetation has been re-established in disturbed areas, minimal long-term monitoring and maintenance would be required.

8.4.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Mobility of contaminants would be significantly reduced under this alternative by removing mine waste with elevated metals concentrations from the site and placing it in an off-site repository with a cover system that limits infiltration of precipitation and is constructed with BMPs to direct surface run-on / runoff away from the repository. Metals would no longer be susceptible to mobilization due to infiltration of meteoric water through the waste rock piles, erosion into Telegraph Creek, sediment mobility in Telegraph Creek, wind erosion, or human disturbance. However, no reduction in the toxicity or volume of contaminants would be achieved by this alternative.

8.4.5 Short-term Effectiveness

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

8.4.6 Implementability

Removal of mine waste containing concentrations of metals above site cleanup goals at the LOB site for disposal at an off-site repository is both technically and administratively feasible. However, the implementability of Alternative 2 is reduced by:

- The limited availability of privately-owned land that meets repository siting criteria in proximity to the LOB site;
- Uncertainty associated with whether privately-owned land that meets siting criteria can be purchased or whether a long-term agreement can be reached with the existing property owner for construction of the repository; and
- Uncertainty associated with whether a repository could be constructed on land administered by the USDA-FS.

No infrastructure for power would be required at the site or repository during or post-construction. This alternative uses proven technologies that are reliable, relatively simple, and would not require long-term maintenance following the establishment of vegetation in disturbed areas. The area has a short construction season due to heavy winter snows; however, the construction activities proposed under this alternative could be easily implemented in single construction season through advanced planning.

8.4.7 Cost

As shown in **Table 12**, the total estimated net present value (NPV) cost to implement Alternative 2 is $901,800. The estimated NPV cost of Alternative 2 includes five years of maintenance and monitoring costs in addition to estimated capital expenditures during construction. Typically, 30 years of estimated future costs are included in NPV analyses for reclamation actions. In this case it was assumed that no maintenance or monitoring costs would be incurred after vegetation is fully established on the repository cover and disturbed areas. The maintenance and monitoring costs included in the NPV cost of Alternative 2 include invasive weed control and repairs to the repository cover due to erosion/rilling that may occur before vegetation is established. Detailed cost estimates for all three alternatives under evaluation are provided in **Appendix C**.

8.5 Alternative 3: Excavation and Disposal in Luttrell Pit

Similar to Alternative 2, this alternative includes the excavation of mine waste, soil, and sediment containing COCs at concentrations that exceed cleanup goals from the LOB site. However, the material would be transported to the Luttrell Repository for disposal instead. Although the agreement between the DEQ, USDA-FS, and USEPA for the operation of the repository has expired, it is currently being renegotiated. NewFields understands that DEQ/ MWCB intends to include mine waste from the LOB site in the agreement.

Mine waste and impacted media would be excavated at the LOB site to the approximate lateral limits shown on **Figure 3**. An estimated 4,415 cubic yards of impacted media would be removed from the site for disposal in the Luttrell Repository. Excavation efforts would continue until native soil is exposed beneath the three waste rock pile locations. An XRF may be used to screen remaining soil and sediment on site to evaluate whether cleanup goals have been met.

Following placement in the Luttrell Repository, a temporary cover (20-mil polyethylene Dura-Skrim® liner) would be placed over the mine waste, soil, and sediment from the LOB site at the end of the operating season. A permanent cover system will be placed over the repository at the end of its operational life (estimated to be an additional 15 years) that will include a geosynthetic component (e.g., 60-mil high density polyethylene liner).

Telegraph Creek would be diverted around the WRP-3 and sediment excavation areas (**Figure 3**) using the same diversion system described for Alternative 2 (**Section 8.4**). Excavation would be completed in late summer / early fall when Telegraph Creek flows are low and the Lilly adit has minimal discharge.

The LOB site would be regraded to match pre-existing site slopes. Approximately 300 linear feet of Telegraph Creek would be reconstructed and graded to provide a slope consistent with upstream and downstream portions of the creek that have not been affected by mining activities. Grade control structures would be constructed using materials (e.g., logs, rock, etc.) salvaged from on-site. Imported growth media or locally sourced growth media if attainable would be spread over the recontoured excavation areas. Disturbed areas would then be revegetated using soil amendments, seeding, streambank plantings, and mulching. Disturbed areas at the LOB site, as well as the repository, would be monitored and maintained (if necessary) until vegetation is fully established. Weed control measures would be employed as necessary.

Alternative 3 would not address the seasonal discharge from the Lilly adit, which would continue to impact surface water quality in Telegraph Creek. Following removal of mine waste and impacted soil around WRP-3, the drainage channel for water discharging from the adit would be reconstructed.

8.5.1 Overall Protection of Human Health and the Environment

Excavation of mine waste, soil, and sediment containing COCs at concentrations above cleanup goals for disposal at the Luttrell Repository would significantly reduce risks to human health and the environment. This alternative would also substantially meet reclamation objectives and goals for the project (refer to **Section 6.0**). Exposure of human and ecological receptors to contaminants through direct contact with mine waste would be eliminated. In addition, the response action would eliminate a source of metals impacts to surface water and sediment in Telegraph Creek. The stream function and aquatic life habitat in Telegraph Creek would also be improved through removal of mine waste in contact with the creek and reconstruction of the stream. By removing mine wastes, revegetating and naturalizing the LOB site, the overall long-term habitats for the Clark's Nutcracker and wolverine would be improved and the downstream habitat for the Westslope Cutthroat Trout would be benefited. There is expected to be no habitat impacts to sensitive species for using the Luttrell Repository site as the facility is disturbed land and is being managed as a waste repository.

8.5.2 Compliance with ARARs

Alternative 3 would reduce the load of contaminants discharged to surface water at the LOB site. However, it may not fully achieve surface water quality ARARs alone because it does not address the discharge from the Lilly adit. Contaminant-specific ARARs for ambient air are expected to be met because the mine waste will be placed in a repository with an engineered cover system and disturbed areas will be revegetated. Dust control measures would be implemented during construction activities to control generation of fugitive dust.

Similar to Alternative 2, this alternative may improve groundwater quality at the site by removing a potential source of impacts (i.e., infiltration of meteoric water through waste rock piles to underlying groundwater). However, it would not address the potential interaction of mine water containing elevated metals concentrations (above groundwater standards) and site groundwater. Groundwater ARARs may not be met under this alternative due to this interaction.

Location-specific ARARs would be met to a substantial degree. Several potentially historic features are present at the mine site (refer to **Section 2.4**) and actions taken will be in compliance with Section 106 of the National Historic Preservation Act. DEQ would work with SHPO during reclamation activities to preserve historical features, to the extent practical. The response action would improve habitat for migratory birds, endangered species, and aquatic life. Work would be performed within the floodplain of Telegraph Creek; however, reconstruction of Telegraph Creek will be performed in a manner that does not result in lasting impacts to the floodplain. Potential wetlands at the LOB site (a wetland inventory has not been performed) would be removed by the response action. It may be necessary to conduct a wetland delineation and file a Pre-Construction Notification with the U.S. Army Corps of Engineers for a Nationwide Permit (Section 404 of the Clean Water Act). Work in the floodplain will be conducted in compliance with a 404 permit obtained for the project.

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

8.5.3 Long-term Effectiveness and Permanence

Alternative 3 would achieve a high degree of long-term effectiveness and permanence because mine waste containing concentrations of metals above cleanup goals would be permanently removed from the LOB site. Once vegetation has been re-established in disturbed areas, minimal long-term monitoring and maintenance would be required.

8.5.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Mobility of contaminants would be significantly reduced under this alternative by removing mine waste with elevated metals concentrations from the site and placing it in an off-site repository with controls that limit infiltration and direct surface run-on / runoff away from the repository. Metals would no longer be susceptible to mobilization due to infiltration of meteoric water through the waste rock piles, erosion into Telegraph Creek, sediment mobility in Telegraph Creek, wind erosion, or human disturbance. However, no reduction in the toxicity or volume of contaminants would be achieved by this alternative.

8.5.5 Short-term Effectiveness

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

8.5.6 Implementability

Removal of mine waste containing concentrations of metals above site cleanup goals at the LOB site for disposal in the Luttrell Repository is both technically and administratively feasible. Although the existing agreement between the DEQ, USDA-FS, and USEPA for the operation of the repository has expired, it is currently being renegotiated and the new agreement is anticipated to allow mine waste from the LOB site to be placed in the repository.

Alternative 3 uses proven technologies that are reliable, relatively simple, and would not require long-term maintenance following the establishment of vegetation in disturbed areas. The area has a short construction season due to heavy winter snows; however, the construction activities proposed under this alternative could be easily implemented in single construction season through advanced planning.

8.5.7 Cost

As shown in **Table 12**, the total estimated cost to implement Alternative 3 is $433,500. No future costs are included in this estimate. It was assumed that no future monitoring or maintenance costs would be incurred after the mine waste is removed from the LOB site and placed in the Luttrell Repository. Detailed cost estimates for all three alternatives under evaluation are provided in **Appendix C**.

9.0 COMPARATIVE ANALYSIS OF ALTERNATIVES

This section compares the reclamation alternatives developed in **Section 7.0** and evaluated in detail in **Section 8.0**. Comparative analyses were performed for the alternatives using threshold and primary balancing criteria.

As discussed in **Section 8.1**, threshold criteria include:

- Overall protection of human health and the environment; and
- Compliance with ARARs.

Primary balance criteria include the following:

- Long-term effectiveness and cost;
- Reduction in toxicity, mobility, or volume through treatment;
- Short-term effectiveness;
- Implementability; and
- Cost.

Costs for each reclamation alternative were estimated for comparative purposes only since many design details that would affect costs are preliminary. Actual costs for selected alternatives may range from 30 percent lower to 50 percent higher than the comparative costs estimated in this Expanded EE/CA. Summaries of the alternative cost comparisons are provided in **Table 12**. The results of the comparative analysis of the three alternatives under consideration are summarized in **Table 11**.

9.1 THRESHOLD CRITERIA

Alternative 1 (no action) would do nothing to mitigate current and future risks to human health and the environment associated with mine waste and impacted soil / sediment, and therefore would not be protective of human health and the environment. Under this alternative, the LOB site would be left in its existing condition. The no action alternative would not reduce concentrations of COCs in Telegraph Creek and would not meet state or federal contaminant-specific ARARs applicable to surface water at the LOB site.

Alternative 2 (excavation and disposal in an off-site repository) would significantly reduce risks to human health and the environment through removal of mine waste, soil, and sediment containing COCs at concentrations above cleanup goals for disposal in an off-site repository. The design of the repository would include a cover system that would limit the infiltration of meteoric water through the mine waste to underlying groundwater. Removal of mine waste and impacted media from the LOB site would eliminate a source of metals impacts to surface water and sediment in Telegraph Creek. However, this alternative may not fully achieve surface water quality ARARs alone because it does not address the discharge from the Lilly adit. Alternative 2 would comply with location- and action-specific ARARs (see **Table B-1; Appendix B**).

Alternative 3 (excavation and disposal in the Luttrell Repository) is rated equally to Alternative 2 for achieving threshold criteria. This alternative consists of the removal of mine waste, soil and sediment containing COCs at concentrations that exceed cleanup goals for disposal in the Luttrell Repository. Removal of impacted media from the site would eliminate the potential exposure of human and ecological receptors to mine waste through direct contact. The response would also eliminate of source of metals impacts to Telegraph Creek. Similar to Alternative 2, this alternative does not address the discharge from the Lilly adit and may not fully achieve surface water quality ARARs as a result. The alternative would comply with location- and action-specific ARARs.

9.2 Primary Balancing Criteria

As shown in **Table 11**, Alternative 1 (no action) does not satisfy any of the primary balancing criteria:

- It does not provide long-term effectiveness or permanence;
- It provides no reduction in toxicity, mobility, or volume of contaminants through treatment;
- It is not effective in the short-term;
- No actions would be implemented; and
- There would be no costs associated with the alternative.

Therefore, Alternative 1 was not considered further during the comparative analysis.

The long-term effectiveness and permanence of Alternatives 2 and 3 rank relatively equally. Under both alternatives, mine waste, soil, and sediment containing COCs at concentrations above cleanup goals would be removed from the LOB site. The cover system for the off-site repository would be designed to minimize infiltration of meteoric water into the underlying mine waste. The temporary liner (20-mil polyethylene) placed over the mine waste in the Luttrell Repository at the end of each operating season would also minimize infiltration of meteoric water through the materials in the repository until the final cover system is placed. No long term monitoring or maintenance would be required for Alternative 2 once vegetation is established at the repository site and areas disturbed by excavation activities at the mine site. A long-term monitoring and maintenance program is currently in place for the Luttrell Repository and would continue in the event that Alternative 3 is selected for implementation.

Alternative 2 and 3 also rank equally in terms of reducing the mobility of contaminants through the removal of mine waste, soil, and sediment with elevated metals concentrations from the site for placement whether in an off-site repository (Alternative 2) or in the Luttrell Repository. Metals would no longer be susceptible to mobilization due to infiltration of meteoric water through the waste rock piles, erosion into Telegraph Creek, sediment mobility in Telegraph Creek, wind erosion, or human disturbance. However, there would be no reduction in the toxicity or volume of contaminants by implementing either alternative.

Neither Alternative 2 nor 3 would not create significant short-term risks to human health or the environment. There would be some risk associated with hauling mine waste off-site for disposal over narrow unpaved roads. However, the risk of releases due to accidents or spills of materials from haul trucks would be reduced by limiting the speed of the haul trucks, careful route planning, and covering the haul trucks on site after loading. The estimated haul distances are roughly equal for both alternatives, depending on the location of the off-site repository in Alternative 2 (approximately 7.6 miles for Alternative 2 and approximately 6.6 miles for Alternative 3). There are also some limited risks associated with construction activities for both alternatives. However, these risks would be effectively managed through the implementation of appropriate engineering and administrative controls. Construction would be completed in a single construction season and is anticipated to take less than 90 days to complete. Therefore, Alternatives 2 and 3 are also ranked equally in terms of short-term effectiveness.

Implementation of both Alternative 2 and 3 is technically and administratively feasible. However, the implementability of Alternative 2 is reduced by the limited availability of privately-owned land in proximity to the LOB site that meets repository siting criteria. Considerable uncertainty also exists regarding whether the privately-owned land that does meet repository siting criteria can be purchased or whether a long-term agreement can be reached with the existing property owner. It was assumed that it would be necessary to construct the off-site repository on privately-owned land due to uncertainty associated with whether a repository could be constructed on land administered by the USDA-FS. Although the existing agreement between the DEQ, USDA-FS, and USEPA for the operation of the Luttrell Repository (Alternative 3) has expired, it is currently being renegotiated and the new agreement is anticipated to allow mine waste from the LOB site to be placed in the repository. Therefore, Alternative 2 is ranked lower in terms of implementability than Alternative 3.

The estimated costs to implement Alternatives 2 and 3 are $901,800 and $433,500, respectively (**Table 12**). Construction and materials costs associated with Alternative 2 would be higher than Alternative 3 for the following reasons:

- The costs associated with purchasing land for the off-site repository or obtaining a long-term agreement with an existing land owner for construction of the repository.
- The slightly longer haul distance associated with Alternative 2 (approximately 7.6 miles versus 6.6 miles for Alternative 3).
- Materials and construction costs associated with constructing the off-site repository (including the cover system) that would not be incurred by using the existing Luttrell Repository (Alternative 3). It was assumed that there would be no tipping fees for disposal of mine waste in the Luttrell Repository.

Detailed cost estimates for these alternatives are provided in **Appendix C**.

10.0 PREFERRED ALTERNATIVE

Based on the results of the detailed and comparative analyses of the three reclamation alternatives considered for the LOB site, Alternative 3 is the preferred alternative. As described in **Section 8.5**, this alternative consists of the excavation and removal of approximately 4,415 cubic yards of mine waste, soil, and sediment containing metals concentrations above cleanup goals for disposal in the Luttrell Repository. Following removal of the impacted media, the site would be regraded to match existing undisturbed site slopes. Growth media would be spread over the disturbed areas and seeded to encourage revegetation. Approximately 300 linear feet of Telegraph Creek would be reconstructed and graded to provide a slope consistent with upstream and downstream portions of the creek that have not been affected by mining activities.

Alternative 3 provides the same level of protection as Alternative 2, but is less costly. In addition, Alternative 3 would be easier to implement because there is no requirement to either purchase land or obtain a long-term agreement with an existing property owner for the construction of a repository. The proposed reclamation activities included in Alternative 3 would achieve project goals of minimizing the potential exposure of human and ecological receptors to contaminants associated with mine waste at the LOB site and reducing the mobility of contaminants. Additional benefits for implementing Alternative 3 include the following:

- The action will reduce the amount of pollutants that could enter Telegraph Creek and would directly contribute toward fulfilling DEQ's TMDL goals for sediment and metals reduction in Upper Telegraph Creek.
- The removal action which involves revegetation and naturalization of the LOB site would help restore long-term wildlife habitat, including habitat for species of concern (Clark's Nutcracker, Wolverine) and potentially for grizzly bear, lynx and snowshoe hare.
- In the long-term the action would restore Telegraph Creek to a functioning stream and result in a naturalized riparian/wetland system, providing secure habitat for wild fish at all stages of life history.
- The action would reduce the potential for human exposure to arsenic, cadmium, copper, lead and zinc, whether through recreation or other land uses.

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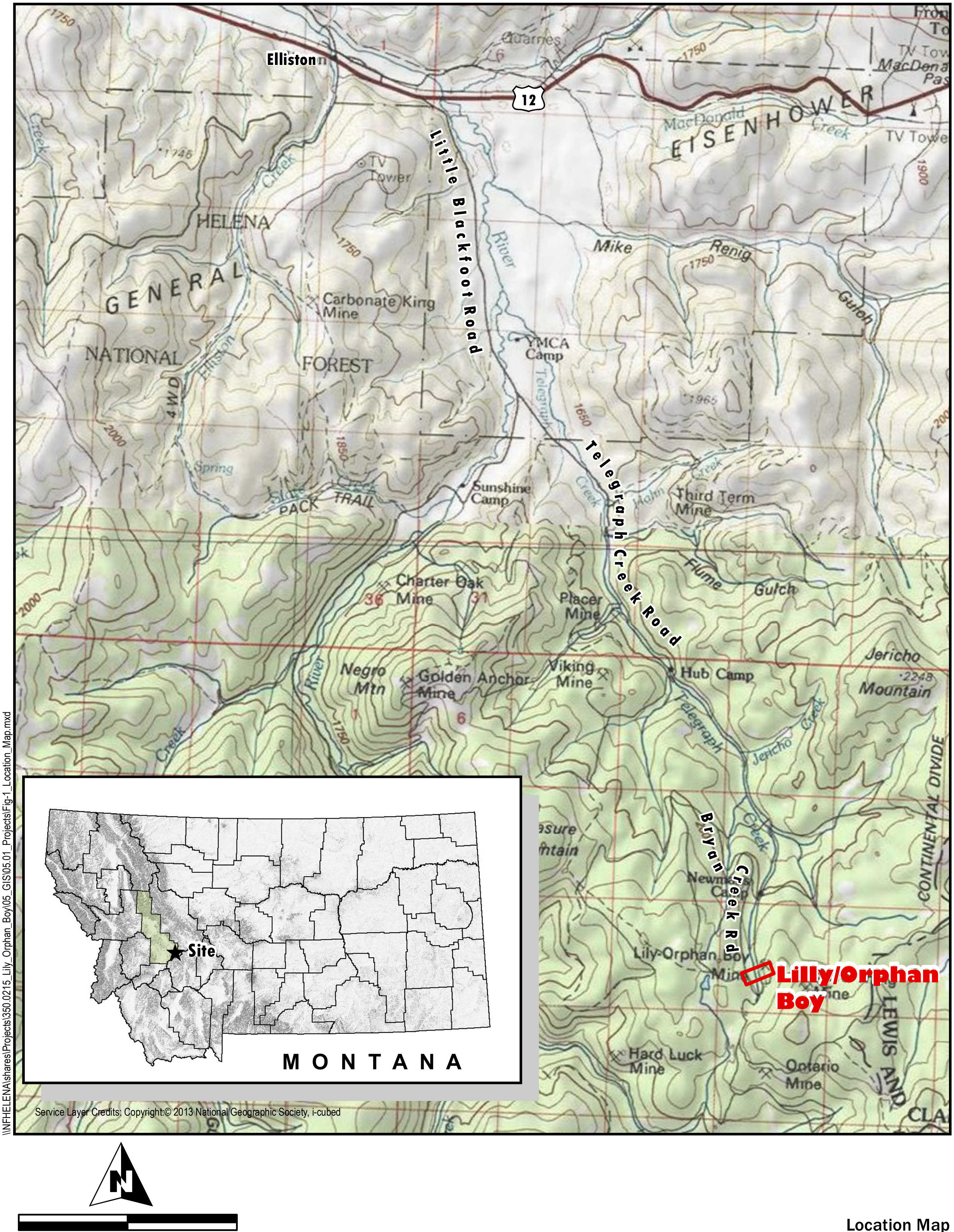
FIGURES



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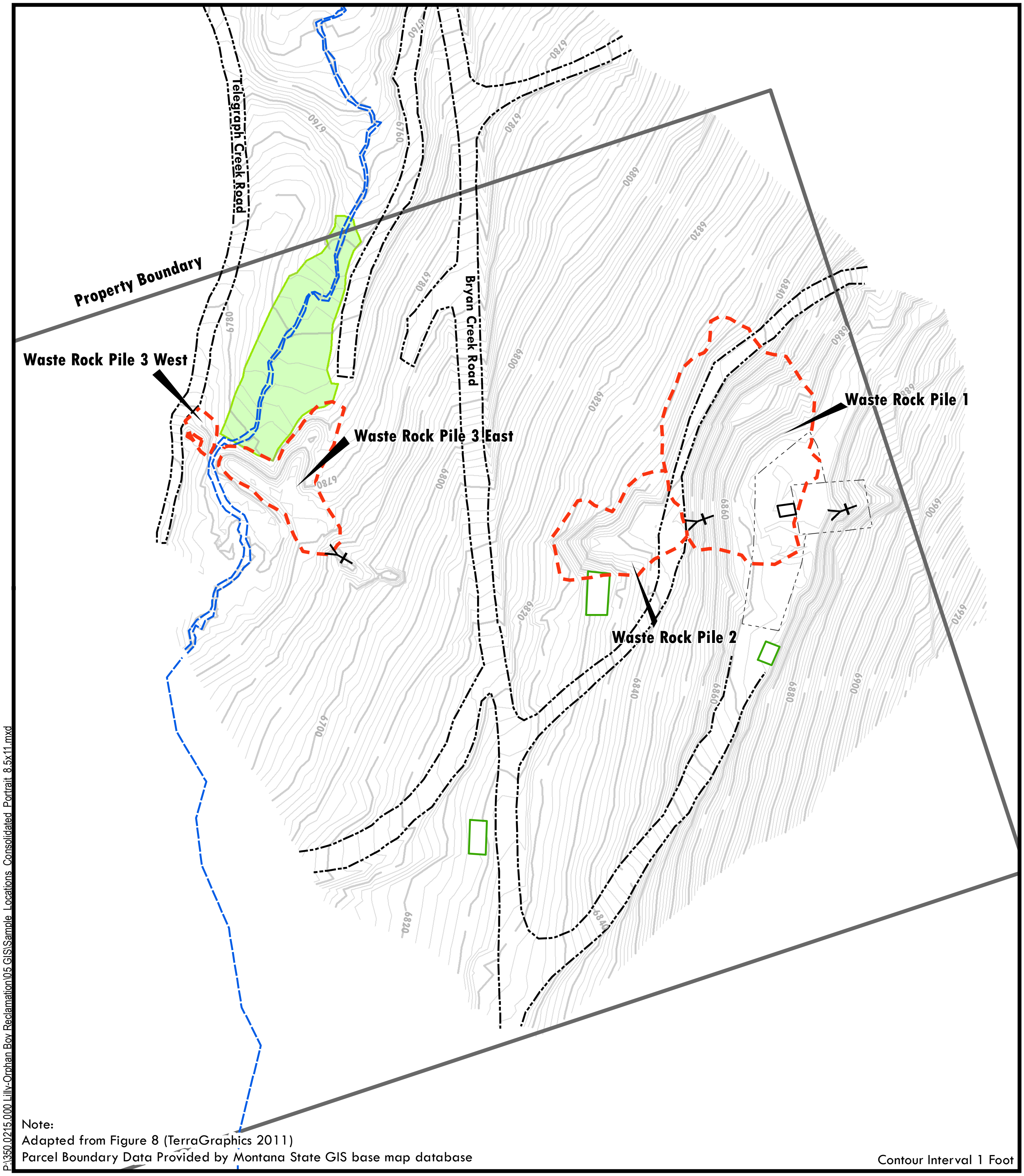
NewFields

Location Map
Lilly/Orphan Boy Mine
Powell County, Montana
FIGURE 1



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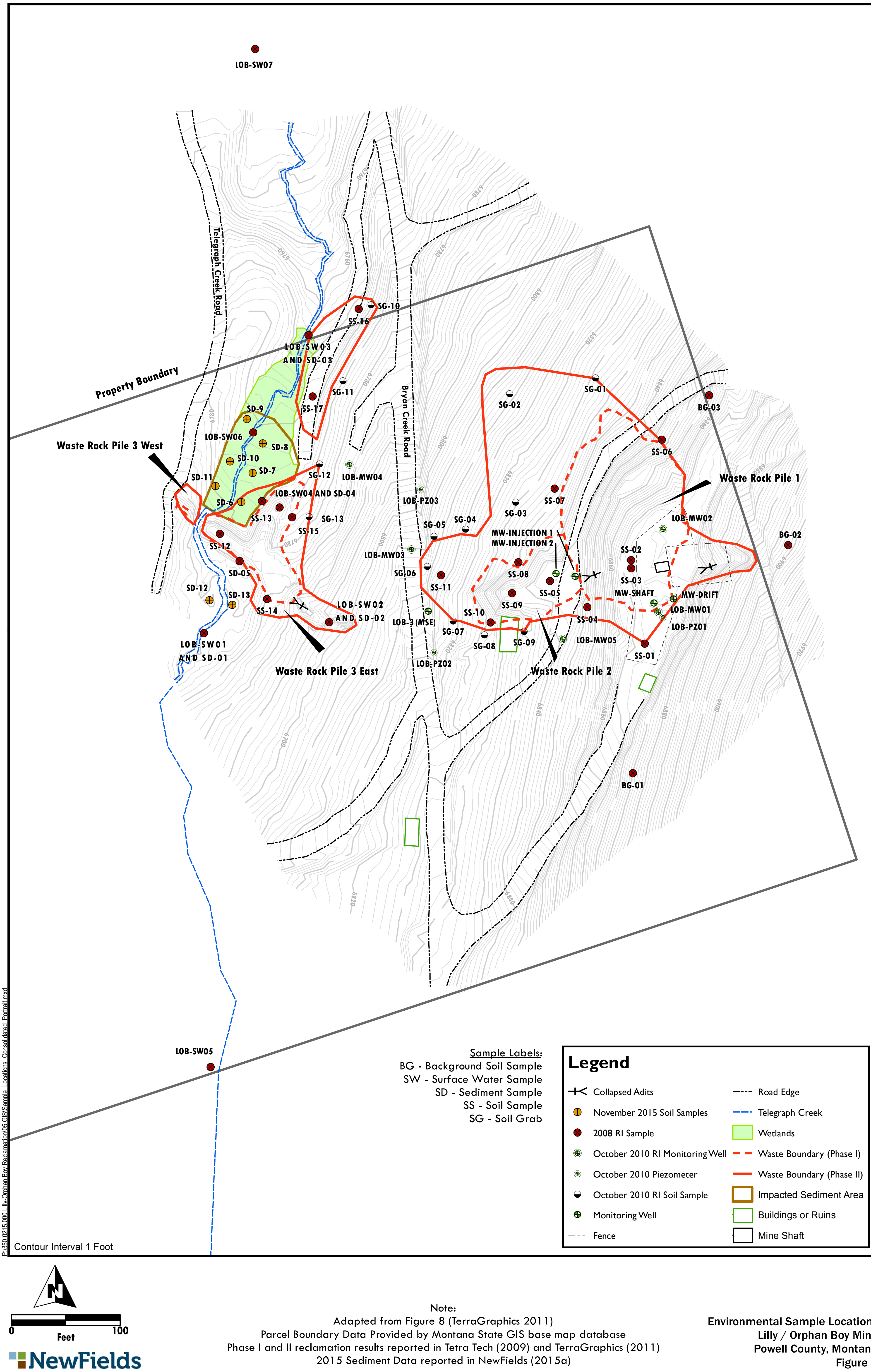
- Collapsed Adit
- Fence
- Road Edge
- Telegraph Creek
- Wetlands
- Waste Rock Boundary
- Buildings or Ruins
- Mine Shaft

NewFields

Site Map
Lilly / Orphan Boy Mine
Powell County, Montana
Figure 2

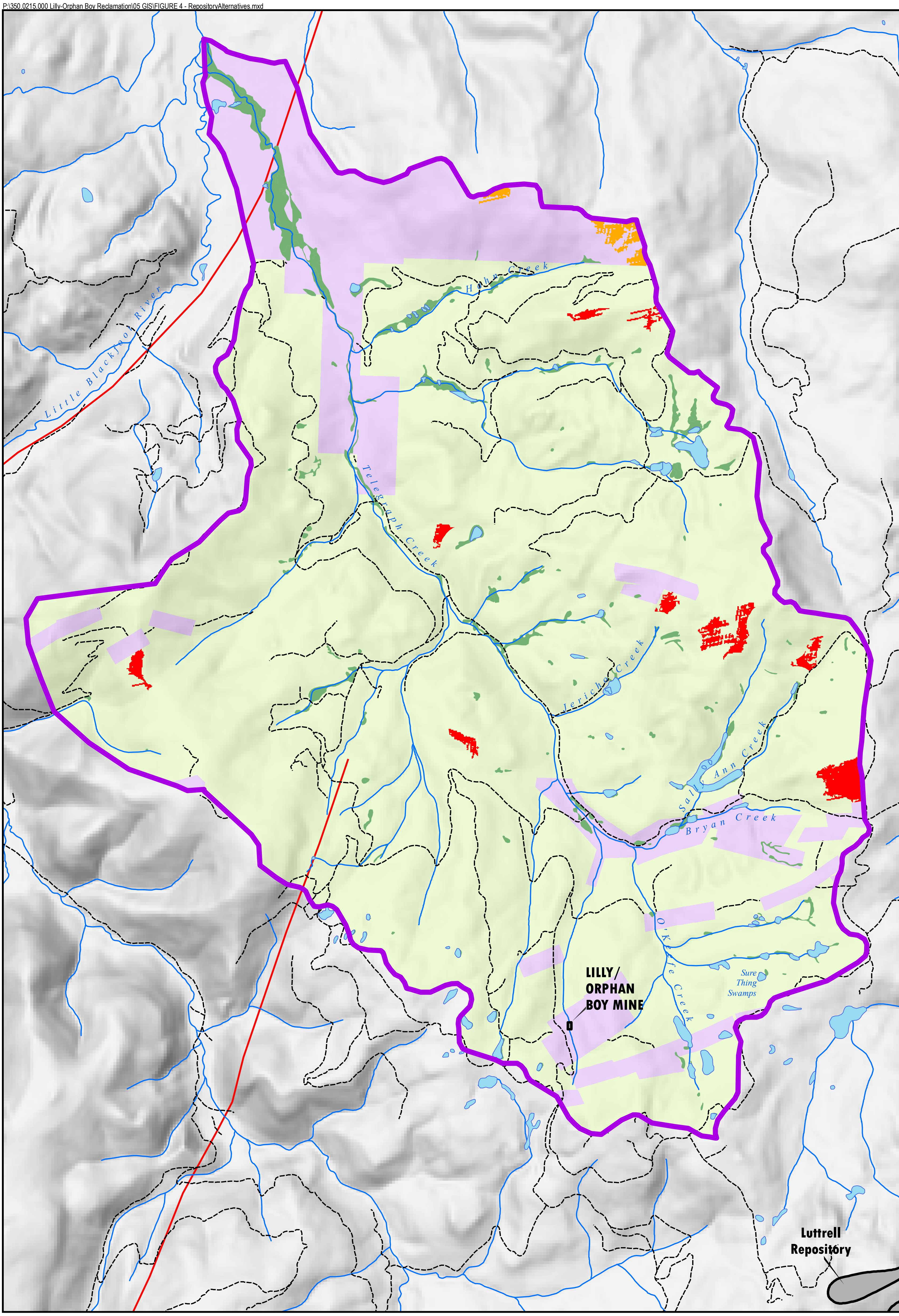


Note:
Adapted from Figure 8 (TerraGraphics 2011)
Parcel Boundary Data Provided by Montana State GIS base map database
Phase I and II reclamation results reported in Tetra Tech (2009) and TerraGraphics (2011)
2015 Sediment Data reported in NewFields (2015a)

NewFields

Environmental Sample Locations
Lilly / Orphan Boy Mine
Powell County, Montana
Figure 3

P:\350.0215.000 Lilly-Orphan Boy Reclamation\05 GIS\FIGURE 4 - RepositoryAlternatives.mxd



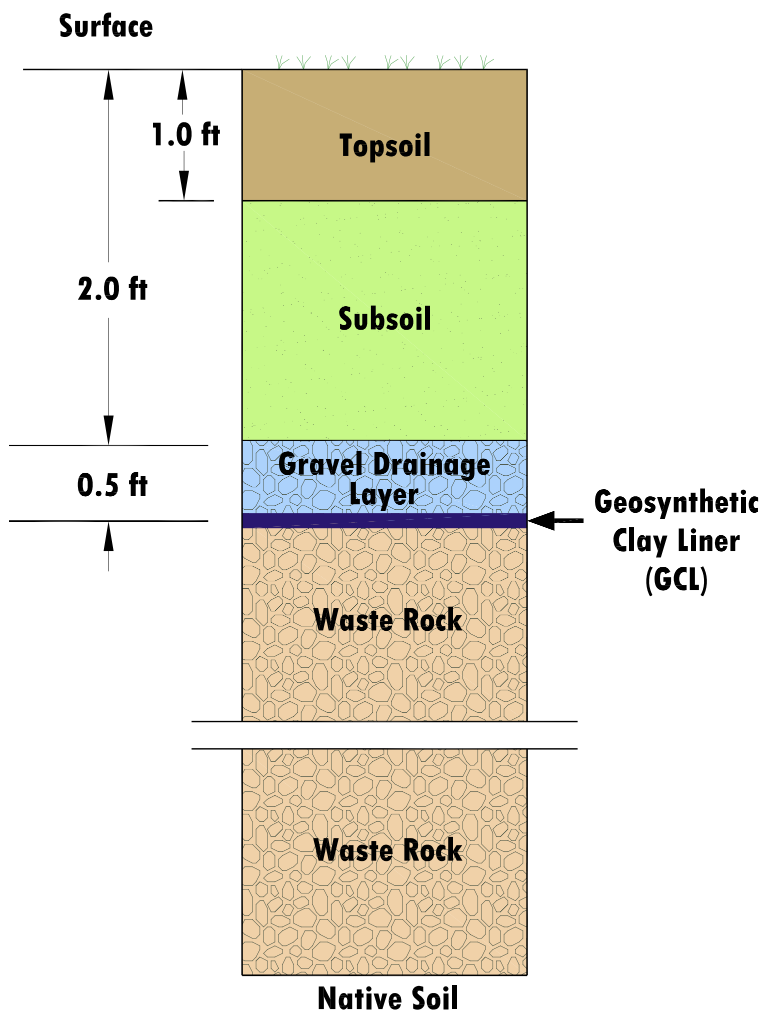
0 Feet 3,000

NewFields

Potential Repository Area

- National Forest System Roads
- Stream/Creek
- Fault
- Pond/Lake
- Study Area Boundary
- Wetland
- Private Land
- USDA Forest Service Land
- Private Land
- USDA Forest Service Land

Alternatives for Off-Site Repository Locations and Luttrell Repository
Lilly/Orphan Boy Mine
Powell County, Montana
FIGURE 4



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Conceptual Off-Site Repository Design - Cross-Section
Lilly/Orphan Boy Mine Site
Expanded Engineering Evaluation/Cost Analysis
FIGURE 5

NewFields

Tables

TABLE 1

Summary of Montana Natural Heritage Program's Species of Concern Data Report

Lilly/Orphan Boy Mine Site

Species of Concern	Common Name	Description	Natural Heritage Ranks		Federal Agency Status		
			State	Global	U.S. Fish & Widlife Service	U.S. Forest Service	U.S. Bureau of Land Management
Nucifraga columbiana	Clark's Nutcracker	Bird	S3	G5			
Oncorhynchus clarkii lewisi	Westslope Cutthroat Trout	Fish	S2	G4T3		SENSITIVE	SENSITIVE
Gulo gulo	Wolverine	Mammal	S3	G4		SENSITIVE	SENSITIVE

Source:

Montana Natural Heritage Program, Species of Concern Data Report, prepared for Montana DEQ, December 11, 2015.

Notes:

Natural Heritage Rank Definitions

G2/S2 At risk because of very limited and/or declining numbers, range, and/or habitat, making it vulnerable to global extinction or extirpation in the state.

G3/S3 Potentially at risk because of limited and/or declining numbers, range, and/or habitat, even though it may be abundant in some areas.

G4/S4 Uncommon but not rare (although it may be rare in parts of its range), and usually widespread. Apparently not vulnerable in most of its range, but possibly cause for long-term concern.

G5/S5 Common, widespread, and abundant (although it may be rare in parts of its range). Not vulnerable in most of its range.

Federal Status Designations

U.S. FOREST SERVICE

The U.S. Forest Service Manual (2670.22) defines the status of Sensitive species on Forest Service lands. The Regional Forester (Northern Region) designates Sensitive species on National Forests in Montana. This designation applies only on USFS-administered lands.

SENSITIVE Any species for which the Regional Forester has determined there is a concern for population viability within the state, as evidenced by a significant current or predicted downward trend in populations or habitat.

U.S. BUREAU OF LAND MANAGEMENT

The BLM 6840 Manual defines the status of species on Bureau of Land Management lands. They apply only on BLM-administered lands.

SENSITIVE species that are proven imperiled in at least part of their ranges and are documented to occur on BLM lands.

TABLE 2
Summary of Soil and Mine Waste Results
Lilly/Orphan Boy Mine Site

Sample ID	Collection Date	Media	Sample Depth (inches)	Aluminum (mg/kg)	Antimony (mg/kg)	Arsenic (mg/kg)	Barium (mg/kg)	Cadmium (mg/kg)	Chromium (mg/kg)	Copper (mg/kg)	Iron (mg/kg)	Lead (mg/kg)	Manganese (mg/kg)	Mercury (mg/kg)	Nickel (mg/kg)	Silver (mg/kg)	Zinc (mg/kg)
SS-01	10/9/2008	Soil	0 - 3	---	5 UJ	140	68	1 U	5 U	29	11,900	117	579	0.5 U	5 U	5 U	123
SS-02	10/9/2008	Soil	0 - 3	---	117	**6,420**	70	6	5 U	116	33,300	**7,840**	764	0.5 U	0.5 U	43	322
SS-03	10/9/2008	Soil	0 - 3	---	**972**	**36,600**	17	15	5 U	267	66,900	**43,800**	13	0.5 U	0.5 U	302	1,250
SS-04	10/9/2008	Soil	0 - 3	---	14	**444**	44	3	5 U	45	14,200	501	838	0.5 U	0.5 U	5 U	241
SS-05	10/9/2008	Soil	0 - 3	---	21	**1,370**	78	3	6	60	15,800	1,190	234	0.5 U	0.5 U	5 U	143
SS-06	10/9/2008	Soil	0 - 3	---	5UJ	188	46	2	5	29	11,800	244	389	0.5 U	0.5 U	5 U	186
SS-07	10/9/2008	Soil	0 - 3	---	21	**11,600**	36	3	5 U	48	28,600	**2,300**	164	0.5 U	0.5 U	8	218
SS-08	10/9/2008	Soil	0 - 3	---	5UJ	**793**	31	3	5 U	61	15,200	608	202	0.5 U	0.5 U	5 U	254
SS-09	10/9/2008	Soil	0 - 3	---	95	**8,180**	31	4	5 U	91	19,300	**19,900**	9	0.5 U	0.5 U	97	220
SS-10	10/9/2008	Soil	0 - 3	---	23	**734**	40	1 U	5 U	75	12,400	909	247	0.5 U	0.5 U	5 U	137
SS-11	10/9/2008	Soil	0 - 3	---	19	**6,640**	33	1	5 U	58	27,000	622	624	0.5 U	0.5 U	5 U	172
SS-12	10/9/2008	Soil	0 - 3	---	30	**5,060**	43	4	5 U	107	34,900	**6,040**	22	0.5 U	0.5 U	6	386
SS-13	10/9/2008	Soil	0 - 3	---	456	**74,100**	7	35	5 U	94	171,000	**7,440**	<5	0.5 U	0.5 U	66	453
SS-14	10/9/2008	Soil	0 - 3	---	31	**5,120**	81	7	5 U	103	24,100	1,610	277	0.5 U	5 U	7	757
SS-15	10/9/2008	Soil	0 - 3	---	15	**31,200**	54	3	5 U	38	185,000	1,320	44	0.5 U	11	5 U	129
SS-16	10/27/2008	Soil	0 - 3	---	12	**725**	34	1 U	5 U	28	9,910	534	197	0.5 U	5 U	5 U	142
SS-17	10/27/2008	Soil	0 - 3	---	5 UJ	**641**	24	1	5 U	78	16,800	834	130	0.5 U	5 U	5 U	326
BG-01	10/9/2008	Soil	0 - 3	---	5 UJ	21	94	2	7	45	9,990	35	759	0.5 U	9	5 U	120
BG-02	10/9/2008	Soil	0 - 3	---	5 UJ	159	79	2	8	47	15,800	228	1,240	0.5 U	6	5 U	205
BG-03	10/9/2008	Soil	0 - 3	---	5 UJ	57	74	1 U	9	26	16,000	42	259	0.5 U	8	5 U	160
SG-01	10/4/2010	Soil	0 - 3	14,900	---	230	---	5	---	31	16,100	142	467	---	---	---	257
SG-02	10/4/2010	Soil	0 - 3	4,550	---	**6,470**	---	103	---	48	27,400	1,300	582	---	---	---	158
SG-03	10/4/2010	Soil	0 - 3	23,500	---	**439**	---	8	---	21	19,000	607	165	---	---	---	550
SG-04	10/4/2010	Soil	0 - 3	15,500	---	204	---	5	---	29	16,400	137	170	---	---	---	378
SG-05	10/4/2010	Soil	0 - 3	11,600	---	197	---	7	---	271	12,400	127	593	---	---	---	315
SG-06	10/4/2010	Soil	0 - 3	8,720	---	**1,090**	---	17	---	52	16,000	188	342	---	---	---	218
SG-07	10/4/2010	Soil	0 - 3	8,760	---	229	---	6	---	44	12,600	139	762	---	---	---	179
SG-08	10/4/2010	Soil	0 - 3	10,400	---	61	---	1	---	24	14,200	51	493	---	---	---	84
SG-09	10/4/2010	Soil	0 - 3	9,580	---	49	---	1	---	26	13,100	32	499	---	---	---	95
SG-10	10/4/2010	Soil	0 - 3	9,460	---	**362**	---	7	---	76	15,600	130	173	---	---	---	268
SG-11	10/4/2010	Soil	0 - 3	5,760	---	133	---	3	---	24	12,200	50	385	---	---	---	121
SG-12	10/4/2010	Soil	0 - 3	10,100	---	138	---	4	---	27	12,800	54	373	---	---	---	274
SG-13	10/4/2010	Soil	0 - 3	8,220	---	**421**	---	13	---	156	14,300	97	465	---	---	---	371
Recreational Cleanup Guideline				**---**	**586**	**323**	**103,000**	**1,750**	**1,470,000**	**54,200**	**---**	**2,200**	**7,330**	**440**	**29,300**	**---**	**440,000**

Notes:

[shaded box] - Exceeds Recreational Cleanup Guideline based on a 50-day gold panner/rock hound exposure scenario (Tetra Tech 2004).

< - Not detected. Reporting limit shown.

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

UJ - Analyte was not detected, but is considered estimated for quality control reasons.

--- - Sample not analyzed, or Recreational Cleanup Guideline not available.

mg/kg - Milligrams per kilogram

1993 Data obtained from Pioneer (1994)

2008 data obtained from Tetra Tech (2009)

2010 data obtained from TerraGraphics (2011)

TABLE 3
Summary of Sediment Results
Lilly/Orphan Boy Mine Site

Sample Location	Sample Date	Antimony mg/kg	Arsenic mg/kg	Barium mg/kg	Cadmium mg/kg	Chromium mg/kg	Copper mg/kg	Iron mg/kg	Lead mg/kg	Manganese mg/kg	Zinc mg/kg
SE-1	6/28/1993	15 UJ	**4,450**	283	**38**	4.1 U	**440**	61,800	**550**	**14,200**	**1,200**
SE-2	6/28/1993	4 UJ	**104**	63	0.5 U	3.5	12	18,300	65	**1,570**	164
SD-01	10/9/2008	5 UJ	**327**	80	1	---	9	24,600	34	**1,670**	362
SD-02	10/9/2008	11	**19,300**	6	4	---	27	113,000	**298**	29	140
SD-03	10/9/2008	5 U	**294**	48	**21**	---	52	11,300	50	**5,930**	**823**
SD-04	10/9/2008	31	**24,400**	5 U	**13**	---	42	106,000	**562**	55	**554**
SD-05	10/9/2008	5 U	**160**	47	6	---	14	12,300	13	768	**967**
SD-06-18	11/16/2015	10	**818**	262	3	---	116	50,300	152	**3,440**	**1,130**
SD-07-24	11/16/2015	6	**352**	278	**9**	---	79	31,700	110	914	**1,070**
SD-08-18	11/16/2015	4	**563**	202	**75**	---	121	19,900	**949**	**1,780**	**4,420**
SD-09-18	11/16/2015	4	**237**	266	**27**	---	77	32,700	132	**5,130**	**1,310**
SD-10-12	11/16/2015	5	**1,010**	99	**34**	---	98	10,700	**1,580**	630	**1,720**
SD-11-24	11/16/2015	8	**886**	80	**20**	---	105	19,100	**2,390**	**2,760**	**1,300**
SD-12-24	11/16/2015	3	**129**	168	3	---	33	22,600	127	886	442
SD-13-16	11/16/2015	1 U	**58**	112	2	---	26	19,800	41	1,020	335
Washington Freshwater Sediment PAET		**35**	**19**	**---**	**8**	**70**	**340**	**---**	**240**	**1,400**	**500**
Recreational Cleanup Guideline		**586**	**323**	**103,000**	**1,750**	**2,200,000**	**54,200**	**---**	**2,200**	**7,330**	**440,000**
Mean Upstream Concentration[a]		**2**	**156**	**94**	**3**	**---**	**19**	**19,520**	**56**	**1,183**	**454**

Notes:

a Mean of five upstream sediment sample results (samples SE-2, SD-01, SD-05, SD-12-24, and SD-13-16)

[blue shading] - Exceeds Washington State Freshwater Sediment Quality Probable Apparent Effects Thresholds (PAET) screening values (Washington State Department of Ecology, 1997).

[tan shading] - Exceeds Recreational Cleanup Guideline based on a 50-day gold panner/rock hound exposure scenario (Tetra Tech 2004) AND Washington State Freshwater Sediment Quality PAET.

J - estimate
U - the compound was analyzed for, but not detected.
UJ - Analyte was not detected, but is considered estimated for quality control reasons.
--- - Sample not analyzed, or Recreational Cleanup Guideline or PAET not available.
mg/kg - Milligrams per kilogram

1993 data obtained from Pioneer (1994)
2008 data obtained from Tetra Tech (2009)
2015 data obtained from NewFields (2015a)

TABLE 4
Summary of Surface Water Results
Lilly/Orphan Boy Mine Site

Sample ID	Collection Date	Aluminum, dissolved (mg/L)	Antimony (mg/L)	Arsenic (mg/L)	Barium (mg/L)	Cadmium (mg/L)	Chromium (mg/L)	Copper (mg/L)	Iron (mg/L)	Lead (mg/L)	Manganese (mg/L)	Mercury (mg/L)	Nickel (mg/L)	Silver (mg/L)	Zinc (mg/L)	pH	Hardness
SW-1	1993	---	0.0183 U	0.0205	0.0157	0.0073 J	0.00793	0.0117	1.9	0.00477	0.226	---	0.011	---	0.635	---	---
SW-2	1993	---	0.0183 U	0.0043	0.00887	0.00255 J	0.007	0.00157	0.552	0.00138	0.0415	---	0.00878 U	---	0.0234	---	---
GW-1	1993	---	0.037	0.881	0.0145	0.342 J	.005 U	0.62	19.2	0.398	5.41	U	0.0326	---	22.5	---	---
LOB-SW01	10/9/2008	---	0.005 U	0.005 U	0.1 U	0.001 U	0.01 U	0.01 U	0.37	0.01 U	0.18	0.001 U	0.01 U	0.005 U	0.03	---	---
LOB-SW01	9/29/10	0.062	---	0.003 U	---	0.00008 U	---	0.0014	0.5 J+	0.0005 U	0.14	---	---	---	0.022 J+	7	16.9
LOB-SW01	12/6/10	0.089	---	0.003 U	---	0.00008	---	0.0012	0.63	0.0005 U	0.19	---	---	---	0.08 J+	7	17.8
LOB-SW02	10/9/2008	---	0.005 U	0.874	0.1 U	0.163	0.01 U	0.04	29.6	0.07	5.64	0.001 U	0.03	0.005 U	17.7	---	---
LOB-SW03	10/9/2008	---	0.005 U	0.014	0.1 U	0.003	0.01 U	0.01 U	0.61	0.01 U	0.74	0.001 U	0.01 U	0.005 U	0.61	---	---
LOB-SW03	9/29/10	0.13	---	0.015	---	0.0018	---	0.0036	0.71 J+	0.0021	0.46	---	---	---	0.38	6.6	22.9
LOB-SW03	10/13/10	0.11 J-	---	0.024	---	0.0018	---	0.0033	1.3	0.0033	0.53	---	---	---	0.31	6.7	21.9
LOB-SW03	10/15/10	0.11	---	0.029	---	0.0033	---	0.0032	1.3	0.0028	0.68	---	---	---	0.52	6.5	33.5
LOB-SW03	10/17/10	0.16	---	0.015	---	0.003	---	0.0039	0.72	0.0026	0.55	---	---	---	0.44	6.5	23.4
LOB-SW03	10/18/10	0.17	---	0.019	---	0.0054 J+	---	0.006	1.1	0.004	0.66	---	---	---	0.6	6.3	26.1
LOB-SW03	10/19/10	0.056	---	0.026	---	0.0093	---	0.01	1.3	0.0065	1	---	---	---	1.3	6.2	35.5
LOB-SW03	10/20/10	0.067	---	0.027	---	0.0074	---	0.0075	1.1	0.005	0.82	---	---	---	0.9	6.4	31.3
LOB-SW03	10/21/10	0.054	---	0.032	---	0.011	---	0.012	1.3	0.0069	1.1	---	---	---	1.4	6.3	35.8
LOB-SW03	10/22/10	0.13	---	0.019	---	0.0063	---	0.0074	0.83	0.0038	0.67	---	---	---	0.72	6.3	28.9
LOB-SW03	12/6/10	0.054	---	0.026	---	0.00049	---	0.0015	1.7	0.0037	0.54	---	---	---	0.092 J+	7	18.1
LOB-SW04	10/9/2008	---	0.005 U	0.854	0.1 U	0.067	0.01 U	0.1	8.28	0.05	5.25	0.001 U	0.02	0.005 U	9.31	---	---
LOB-SW05	9/29/10	0.063	---	0.0035	---	0.00008 U	---	0.0012	0.19 J+	0.0005 U	0.085	---	---	---	0.016 J+	7.1	16.4
LOB-SW05	10/7/10	0.046 J-	---	0.0035	---	0.00008 U	---	0.001 U	0.2	0.0005 U	0.092	---	---	---	0.015 J+	6.9	17.6
LOB-SW05	12/6/10	0.046	---	0.0094	---	0.00028 U	---	0.0019	0.91	0.0011 U	0.15	---	---	---	0.083 J+	7.2	17.8
LOB-SW06	9/29/10	0.063	---	0.012	---	0.00041	---	0.0015	0.65 J+	0.00069	0.29	---	---	---	0.12	7	20.5
LOB-SW06	12/6/10	0.072	---	0.027	---	0.00046	---	0.0018	1.8	0.0056	0.59	---	---	---	0.084 J+	7.2	31.9
LOB-SW07	10/1/10	0.086	---	0.014	---	0.0025	---	0.0038	0.54 J+	0.0013	0.46	---	---	---	0.48	6.2	24.1
LOB-SW07	10/7/10	0.094	---	0.014	---	0.0031	---	0.0038	0.47	0.0013	0.52	---	---	---	0.56	6.6	28.6
LOB-SW07	10/13/10	0.11	---	0.015	---	0.0029	---	0.0042	0.68	0.0014	0.5	---	---	---	0.47	6.6	24.9
LOB-SW07	10/15/10	0.11	---	0.017	---	0.0042	---	0.0046	0.68	0.0015	0.58	---	---	---	0.63	6.6	34.7
LOB-SW07	10/17/10	0.14	---	0.012	---	0.0041	---	0.0051	0.47	0.0013	0.56	---	---	---	0.63	6.6	30.5
LOB-SW07	10/18/10	0.11	---	0.014	---	0.0057 J+	---	0.0061	0.69	0.0019	0.65	---	---	---	0.77	6.2	31.6
LOB-SW07	10/19/10	0.03 U	---	0.021	---	0.0082	---	0.0083	0.84	0.0029	0.85	---	---	---	1.2	6.4	37.6
LOB-SW07	10/21/10	0.03 U	---	0.018	---	0.0075	---	0.0073	0.75	0.0024	0.79	---	---	---	1.1	6.4	38.6
LOB-SW07	10/21/10	0.1	---	0.017	---	0.0062	---	0.0069	0.73	0.0027	0.63	---	---	---	0.88	6.5	33
LOB-SW07	10/22/10	0.11	---	0.013	---	0.0059	---	0.0063	0.51	0.0017	0.63	---	---	---	0.86	6.3	34.1
Surface Water Standards and Guidelines	**Acute***	**0.75**	**---**	**0.34**	**---**	**0.00052 [a]**	**0.579 [a,b]**	**0.00379 [a]**	**--**	**0.014 [a]**	**--**	**0.0017**	**0.145 [a]**	**0.00037 [a]**	**0.037 [a]**	**6.5-8.5**	**---**
	Chronic*	0.087	---	0.15	---	0.000097 [a]	0.0277 [a,b]	0.00285 [a]	1.0	0.00055 [a]	--	0.00091	0.0161 [a]	---	0.037 [a]	6.5-8.5	---
	Human Health*	---	0.0056	0.01	1.0	0.005	0.1	1.3	0.3 (aesthetic)	0.015	0.05 (aesthetic)	0.00005	0.1	0.1	2.0	6.5-8.5	---
	Recreational Cleanup Guideline**	---	0.117	0.0876	204	0.146	438 [b]	10.8	---	0.127	40	0.0876	5.89	---	87.9	---	---

Notes:

(shaded) - Exceeds DEQ-7 acute aquatic life numeric water quality standards (DEQ 2012).
* DEQ-7 chronic aquatic life and human health standards are provided for reference (Circular DEQ-7, 2012).
** Recreational Cleanup Guideline based on a 50-day gold panner/rock hound exposure scenario (Tetra Tech 2004).
a - Hardness dependent standard. Listed value based on hardness value of 25 mg/L.
b - Standard for Chromium (III).
U the constituent was analyzed for, but not detected.
J - estimate

J+ - high estimate
--- - Sample not analyzed, or Surface Water Standards/Guideline not available.
mg/L - Milligrams per Liter
1993 Data obtained from Pioneer (1994)
2008 data obtained from Tetra Tech (2009)
2010 data obtained from TerraGraphics (2011)

TABLE 5
Summary of Groundwater Results
Lilly/Orphan Boy Mine Site

Sample Location (Alias)	Sample Date	Aluminum mg/L	Arsenic mg/L	Cadmium mg/L	Copper mg/L	Iron mg/L	Lead mg/L	Manganese mg/L	Nickel mg/L	Zinc mg/L
LOB-GW-01 (MW-Shaft)	10/9/08	---	0.131	0.001	< 0.01	1.68	< 0.01	2.05	< 0.01	0.78
LOB-GW-02 (MW-Injection 2)	10/9/08	---	0.236	< 0.001	< 0.01	52.5	< 0.01	1.64	< 0.01	0.02
LOB-GW-03 (LOB-3 (MSE))	10/9/08	---	0.138	0.065	0.14	13.6	0.08	3.3	0.01	9.45
LOB-MW01	9/29/10	0.64	0.019	0.00064	0.012	2.3 J+	0.02	1.4	---	0.47
LOB-MW02	9/27/10	0.79	0.083	0.0074	0.0059	27 J+	0.056	12.5	---	11.7
LOB-MW03	9/29/10	0.61	0.069	0.11	0.011	0.76 J+	0.014	0.49	---	15.3
LOB-MW04	9/29/10	0.29	0.0032	0.016	0.0078	0.22 J+	0.0014	0.37	---	13.3
LOB-MW05	9/29/10	2.5	0.0064	0.00015	0.0057	2.4 J+	0.01	0.63	---	0.054
DEQ-7 Human Health Standard for Groundwater		**---**	**0.01**	**0.005**	**1**	**0.3[a]**	**0.015**	**0.050[a]**	**0.1**	**2**

Notes:

[shaded box] - Exceeds Circular DEQ-7 Human Health Standard for Groundwater (DEQ 2012).

[a] - Secondary Maximum Contaminant Levels have been established by EPA for iron and manganese (0.3 and 0.05 mg/L, respectively) in public drinking water supplies, but are not listed in DEQ-7

J+ - high estimate

--- Sample not analyzed, or DEQ-7 Human Health Standards not available.

mg/L - Milligrams per Liter

2008 data obtained from Tetra Tech (2009)

2010 data obtained from TerraGraphics (2011)

TABLE 6
Human Health Reference Concentrations
Lilly/Orphan Boy Mine Site

Constituent	Mine Waste / Soil (mg/kg)	Surface Water (mg/L)
Antimony	586	0.117
Arsenic	323	0.01
Barium	103,000	1.0
Cadmium	1,750	0.005
Chromium	1,470,000	0.1
Copper	54,200	1.3
Lead	2,200	0.015
Manganese	7,330	---
Mercury	440	0.00005
Nickel	29,300	0.1
Silver		0.1
Zinc	440,000	2.0

Notes:

mg/kg - milligrams per kilogram

mg/L - milligrams per liter

Reference:

[1] Tetra Tech, Inc. 2004. User's Guide: Risk-Based Cleanup Guidelines for Abandoned Mine Sites. Prepared for the Montana Department of Environmental Quality, Mine Waste Cleanup Bureau/Abandoned Mines Section. July.

TABLE 7
Reference Concentrations for Aquatic Life
Lilly/Orphan Boy Mine Site

Constituent	Surface Water [1] (mg/L)		Sediment [2] (mg/kg)
	Acute	Chronic	
Aluminum	0.75	0.087	---
Antimony	---	---	35
Arsenic	0.34	0.15	19
Barium	---	---	---
Cadmium	0.00052 [a]	0.000097 [a]	7.6
Chromium	0.579 [a,b]	0.0277 [a,b]	70
Copper	0.00379 [a]	0.00285 [a]	340
Iron	--	1.0	---
Lead	0.014 [a]	0.00055 [a]	240
Manganese	--	--	1400
Mercury	0.0017	0.00091	0.22
Nickel	0.145 [a]	0.0161 [a]	39
Silver	0.00037 [a]	---	3.9
Zinc	0.037 [a]	0.037 [a]	500

Notes:

mg/L - milligrams per liter

mg/kg - milligrams per kilogram

References

[1] Montana Department of Environmental Quality, 2012. Circular DEQ-7 Montana Numeric Water Quality Standards. October.

[2] Washington State Department of Ecology (WDOE), 1997. Creation and Analysis of Freshwater Sediment Quality Values in Washington State. July.

TABLE 8
ARAR-BASED RECLAMATION GOALS FOR SURFACE WATER AND GROUNDWATER
Lilly/Orphan Boy Mine Site

Media	Arsenic (mg/L)	Cadmium (mg/L)	Copper (mg/L)	Lead (mg/L)	Zinc (mg/L)
Surface Water	0.01 [a]	0.000097 [b, c]	0.00285 [b, c]	0.00055 [b, c]	0.037 [b, c]
Groundwater [d]	0.01	0.005	1	0.015	2

Notes:

[a] DEQ-7 Human Health Standard for Surface Water (Circular DEQ-7, 2012).

[b] DEQ-7 Chronic Aquatic Life Standard for Surface Water (Circular DEQ-7, 2012).

[c] Hardness dependent standard. Listed value based on a hardness value of 25 mg/L.

[d] Project does not address groundwater at the site. DEQ-7 Human Health Standard for Groundwater (Circular DEQ-7, 2012) provide for reference only.

TABLE 9
RISK-BASED RECLAMATION GOALS FOR SOIL AND SEDIMENT
Lilly/Orphan Boy Mine Site

Media	Arsenic (mg/kg)	Cadmium (mg/kg)	Copper (mg/kg)	Lead (mg/kg)	Zinc (mg/kg)
Soil [a]	323	1,750	54,200	2,200	440,000
Sediment [b]	19	7.6	340	240	500

Notes:

[a] Recreational Cleanup Guideline based on a 50-day gold panner/rock hound exposure scenario (Tetra Tech 2004).

[b] Probable Apparent Effects Thresholds (PAET; Washington State Department of Ecology, 1997).

TABLE 10

RECLAMATION TECHNOLOGY SCREENING SUMMARY

LILLY/ORPHAN BOY MINE SITE

General Reclamation Action	Reclamation Technology	Process Option	Description	Initial Screening Result
No Action	None	Not Applicable	No action taken to address site conditions.	Retained as a baseline for comparison to other reclamation actions.
Institutional Controls	Access Restrictions	Physical barriers / signs	Install fences around mine waste / impacted soil and warning signs to restrict access.	Not effective as a stand-alone response. Retained for consideration as a potential component of overall response action.
		Deed restrictions	Legal restriction to control current and future land use.	Not effective as a stand-alone response. Retained for consideration as a potential component of overall response action.
Engineering Controls	Containment	Simple Soil Cover	Mine waste covered by monolithic layer of growth media or a layer of coarse-grained material (as a capillary break) and then overlain with growth media; growth media revegetated to promote evapotranspiration and reduce both infiltration and erosion.	Prevents direct contact with waste materials. Would require mine waste in direct contact with Telegraph Creek to be excavated and placed on site. Cover materials would need to be imported to the site and extensive grading of mine waste would be required prior to cover placement. Would require maintenance and weed control until vegetation is established. Vegetated cover would not reduce infiltration during spring runoff when plants are dormant. Not retained because site slopes, aspects, and proximity to surface water make the LOB mine site unsuitable for on-site containment.
		Composite Cover	Mine waste covered by compacted clay layer or geomembrane liner overlain by a layer of growth media. Revegetate growth media to promote evapotranspiration and reduce both infiltration and erosion.	Prevents direct contact with waste materials and effectively controls infiltration. Would require mine waste in direct contact with Telegraph Creek to be excavated and placed on site. Growth media and other soil cover materials would need to be imported to the site and regrading of mine waste would be required prior to cover placement. Not retained because site slopes, aspects, and proximity to surface water make the LOB mine site unsuitable for on-site containment.
	Surface Controls	Grading	Reshape and reduce slopes of mine waste to control storm water run-on/runoff, prevent erosion, and reduce infiltration.	Readily implementable. Periodic maintenance may be necessary to repair erosion that occurs following remedial action. Retained for further evaluation through inclusion with other response action alternatives.
		Revegetation	Seeding of mine waste to reduce infiltration and control erosion.	Addition of soil amendments would be necessary to establish vegetation due to the absence of organic materials. Mulching, chemical stabilization, weed control and fertilization will likely be necessary. Periodic maintenance may be necessary until a self-sustaining plant community is established. Readily implementable. Effectively controls erosion of mine waste. Retained for further evaluation since revegetation would be required with other response actions.
		Erosion Controls	Construction of run-on/runoff diversion channels to direct storm water runoff away from mine waste. Placement of erosion resistant materials (e.g., mulch or fiber mats) to reduce erosion of mine waste.	Readily implementable. Effective at reducing infiltration and controlling erosion of mine waste. Retained for further evaluation since other response action alternatives would require erosion control.
Excavation and Disposal	On-site Disposal	Repository with Composite or Simple Soil Cover	Excavate mine waste and impacted soil / sediment. Place in an on-site repository with either a composite or simple soil cover. Regrade and revegetate excavation areas to control erosion. Reconstruct portions of Telegraph Creek affected by excavation.	Not retained because the parcel containing the LOB mine site is not suitable for construction of an on-site repository due to site slopes, aspect, and proximity to surface water.
	Off-site Disposal	Off-site Repository	Excavate mine waste and impacted soil / sediment. Load, haul, and place material in an off-site repository constructed with either a composite or simple soil cover. Regrade and revegetate excavation areas to control erosion. Reconstruct portions of Telegraph Creek affected by excavation.	Implementable. Potential off-site repository locations identified in Telegraph Creek watershed during a preliminary siting evaluation. Prevents direct contact with mine waste and removes a source of impacts to Telegraph Creek. Retained for further evaluation.

TABLE 10

RECLAMATION TECHNOLOGY SCREENING SUMMARY

LILLY/ORPHAN BOY MINE SITE

General Reclamation Action	Reclamation Technology	Process Option	Description	Initial Screening Result
Excavation and Disposal, cont.	Off-site Disposal, cont.	Luttrell Repository	Excavate mine waste and impacted soil / sediment. Load and haul material for placement in the Luttrell Repository. Regrade and revegetate excavation areas to control erosion. Reconstruct portions of Telegraph Creek affected by excavation.	Implementable. DEQ/MWCB currently (January 2016) negotiating new operational agreement with USEPA and USDA-FS that would allow the repository to accept waste from the LOB mine site. Prevents direct contact with mine waste and removes a source of impacts to Telegraph Creek. Retained for further evaluation.
		RCRA Class C Landfill	Excavate mine waste and impacted soil /sediment for disposal in a hazardous waste landfill. Regrade and revegetate excavation areas to control erosion. Reconstruct portions of Telegraph Creek affected by excavation.	Readily implementable. Prevents direct contact with mine waste and removes one source of contaminants. Disposal fees and transportation costs would be cost prohibitive compared to other disposal options (e.g., off-site repository, Luttrell Repository, etc.). Not retained for further evaluation.
In-Situ Treatment	Fixation/Stabilization	Portland Cement / Pozzolans	Mine waste would be mixed in-situ with Portland cement or other pozzolan(s) to solidify the waste and prevent or reduce leaching of contaminants to surface water. Revegetate treated mine waste to control erosion.	Extensive treatability and leaching tests required. Potentially implementable but cost prohibitive. Not retained for further evaluation.
		Phosphate	In-situ mixing of mine waste with phosphate to reduce leachable concentrations of metals. Revegetate treated mine waste to control erosion.	Demonstrated technology at similar mine sites, although limited data is available regarding long-term effectiveness. Extensive treatability and leaching tests required. Reapplication and maintenance may be required. Not retained for further evaluation.
Ex-Situ Treatment	Reprocessing	Milling and Smelting	Excavate and transport mine waste to operating mill and/or smelter for minerals extraction. Regrade/revegetate excavation areas. Reconstruct sections of Telegraph Creek affected by excavation.	Not readily implementable because elevated (non-ore) metals concentration in mine waste make it unacceptable to the nearest mill (GSM), potentially low concentrations of recoverable metals, and high costs relative to other response actions. Not retained for further evaluation.
	Re-Use	Paving	Excavate and use mine waste as aggregate in asphalt or concrete pavement. Regrade and revegetate excavation areas to control erosion. Reconstruct portions of Telegraph Creek affected by excavation.	Not retained for further consideration due to potential liability concerns associated with using contaminated materials at off-site locations.
	Physical / Chemical Treatment	Soil Washing	Separate hazardous constituents from excavated mine waste through dissolution, physical separation, and precipitation. Regrade/revegetate excavation areas. Reconstruct sections of Telegraph Creek affected by excavation.	Testing required to verify effectiveness. Wastes generated would require additional treatment and/or disposal. Not retained for further evaluation due to high associated cost relative to other response actions.
		Acid Extraction	Application of acidic solution to excavated mine waste in mixing tank to extract metals from media. Regrade/revegetate excavation areas. Reconstruct sections of Telegraph Creek affected by excavation.	Testing required to verify effectiveness. Wastes generated would require additional treatment and/or disposal. Not retained for further evaluation due to high associated cost relative to other response actions.

Notes:

Shading indicates reclamation technology or process option retained for inclusion in reclamation alternatives.
LOB = Lilly/Orphan Boy Mine Site.
DEQ MWCB = Montana Department of Environmental Quality, Mine Waste Cleanup Bureau.
USEPA = U.S. Environmental Protection Agency.
USDA-FS = U.S. Department of Agriculture, Forest Service.
GSM = Golden Sunlight Mine, Whitehall, Montana vicinity.

TABLE 11

COMPARATIVE ANALYSIS OF RECLAMATION ALTERNATIVES

LILLY/ORPHAN BOY MINE SITE

Assessment Criteria	Alternative 1: No Action	Alternative 2: Excavation and Disposal in Off-site Repository	Alternative 3: Excavation and Disposal in Luttrell Repository
Threshold Criteria			
Overall Protection of Human Health and the Environment	Provides no protection of human health and the environment.	Significantly reduces risk to human health and the environment. Achieves cleanup goals and project reclamation goals.	Significantly reduces risk to human health and the environment. Achieves cleanup goals and project reclamation goals.
Compliance with ARARs • Contaminant Specific	• Does not comply with ARARs.	• Action may not achieve surface water and groundwater quality ARARs because the discharge from the Lilly adit and groundwater are not included in the project scope.	• Action may not achieve surface water and groundwater quality ARARs because the discharge from the Lilly adit and groundwater are not included in the project scope.
• Location Specific	• Does not comply with ARARs.	• Complies with ARARs.	• Complies with ARARs
• Action Specific	• Does not comply with ARARs.	• Complies with ARARs.	• Complies with ARARs.
Primary Balancing Criteria			
Long-term effectiveness and permanence	Not effective. No action would be taken to reduce risks to human health and the environment. No administrative or engineering controls would be implemented at the site.	Provides long-term effectiveness and permanence because mine waste would be permanently removed from the LOB mine site. The repository cover would isolate the waste from human and ecological receptors. No long-term monitoring or maintenance would be required once vegetation is fully established on the repository site. Ranks equally with Alternative 3.	Provides long-term effectiveness and permanence because mine waste be permanently removed from the LOB mine site. The temporary cover placed at the end of each operating season at the repository would limit infiltration until the final cover system is placed. A long-term monitoring and maintenance program is in place for the Luttrell Repository. Ranks equally with Alternative 2.
Reduction in toxicity, mobility, and volume through treatment	Provides no reduction in toxicity, mobility, and volume of mine waste and impacted soil / sediment.	Reduces contaminant mobility through placement of mine waste and impacted sediment / soil in an off-site repository. Provides no reduction in the toxicity or volume of contaminants. Ranks equally with Alternative 3.	Reduces contaminant mobility through placement of mine waste and impacted sediment / soil in the Luttrell Repository. Provides no reduction in the toxicity or volume of contaminants. Ranks equally with Alternative 2.
Short-term effectiveness	No short-term risks would be created because no actions would be implemented.	Limited short-term environmental risks. Potential risks associated with release/spills of materials during hauling would be mitigated through reduced speed and by covering trucks. Construction risks would be mitigated through administrative and engineering controls. Ranks equally with Alternative 2.	Limited short-term environmental risks. Potential risks associated with release/spills of materials during hauling would be mitigated through reduced speed and by covering trucks. Construction risks would be mitigated through administrative and engineering controls. Ranks equally with Alternative 2.
Implementability	No actions would be implemented.	Implementation is technically and administratively feasible. Limited availability of suitable repository sites and uncertainty regarding the ability to purchase or obtain long-term agreement for repository affect implementability of this alternative.	Assuming the interagency agreement is finalized for taking LOB mine waste to the Luttrell Repository, Alternative 3 ranks highest for implementability. Labor, equipment, and materials are locally available.
Cost	$0	$897,300	$429,000

__Notes__:

ARARs = Applicable or Relevant and Appropriate Requirements
LOB = Lilly/Orphan Boy Mine Site

TABLE 12
Reclamation Alternative Cost Comparison
Lilly/Orphan Boy Mine Site

Item	Alternative 1: No action	Alternation 2: Off-Site Repository	Alternative 3: Luttrell Repository
Purchase repository site	$ -	$ 100,000	$ -
Stream Diversion	$ -	$ 7,000	$ 7,000
Mine Waste Removal	$ -	$ 216,700	$ 216,700
Repository Construction	$ -	$ 190,200	$ -
Lilly Adit Improvements	$ -	$ 20,000	$ 20,000
Subtotal	*$ -*	*$ 533,900*	*$ 243,700*
Mobilization & Site Prep	$ -	$ 83,100	$ 48,800
Wetland Delineation/ Pre-Construction Notice	$ -	$ 4,500	$ 4,500
Project Management/ Administrative Costs (6%)	$ -	$ 26,000	$ 14,600
Engineering and Design (15%)	$ -	$ 65,100	$ 36,600
Construction Management (10%)	$ -	$ 43,400	$ 24,400
Contingency (25%)	$ -	$ 133,500	$ 60,900
O&M[1] Net Present Value	$ -	$ 12,300	$ -
TOTAL	$ -	$ 901,800	$ 433,500

Notes:

[1] Operation and maintenance

Refer to Appendix C for a detailed breakdown of reclamation action alternative costs

APPENDIX A

Preliminary Repository Siting Evaluation

MEMORANDUM

DATE:	January 6, 2016	**PROJECT NO.**	350.0215
TO:	Rob Roberts, Trout Unlimited		
FROM:	Shane Fox K. Bill Clark		
SUBJECT:	Preliminary Repository Siting Evaluation Lilly/Orphan Boy Mine, Telegraph Creek Watershed, Elliston, Montana Vicinity		

NewFields Companies, LLC (NewFields) completed a preliminary repository siting evaluation for the Lilly/Orphan Boy mine site using ArcGIS. Work was completed to fulfill Task 2 of the Contract for Services between Trout Unlimited and NewFields, dated September 14, 2015. The study area generally consists of the Telegraph Creek watershed with a slight extension on the west side. Trout Unlimited requested that the area around the Tramway Creek Mining Complex in Section 6, Township 8 North, Range 6 West be evaluated for a potential repository during the GIS analysis.

SITING CRITERIA

Specific repository siting criteria for the GIS analysis were established for key resources, as presented in the following chart.

RESOURCE	SITING CRITERIA
Surficial Geologic Materials	Repository cannot be located in mapped alluvial material
Mapped Faults	Greater than 500 feet from any mapped fault
Streams, Lakes and Ponds	Greater than 500 feet from flowing or ponded water
Wetlands	Greater than 500 feet from mapped wetlands
Depth to Groundwater	Greater than 20 feet
Existing Roads	Sites accessible by existing roads are preferred
Slope	Less than 20 percent
Aspect	Compass direction from 157 to 248 degrees, clockwise from north
Site size	Minimum of 5 acres
Land Ownership	USDA-Forest Service administered land preferred over private land

DATA SOURCES

A variety of publically available data sources were accessed to obtain resource data layers. The following identifies data sources along with descriptions posted on their various websites.

Geology/Faults

Surficial geology and information on faults was obtained from the following Montana Bureau of Mines and Geology publication accessed at http://www.mbmg.mtech.edu:

> Lewis, R.S., 1998, Geologic map of the Butte 1º x 2º quadrangle, southwestern Montana: Montana Bureau of Mines and Geology Open-File Report 363, 16 p., 1 sheet, scale 1:250,000.

Rivers/Streams/Lakes

Surface water data was obtained from the Montana Hydrography Framework; data were accessed at http://mslapps.mt.gov/Geographic_Information/Applications/DigitalAtlas/Default. The data are described as follows:

> "The National Hydrography Dataset (NHD) is a feature-based database that interconnects and uniquely identifies the stream segments or reaches that make up the nation's surface water drainage system. NHD data was originally developed at 1:100,000-scale and exists at that scale for the whole country. This high-resolution NHD, generally developed at 1:24,000/1:12,000 scale, adds detail to the original 1:100,000-scale NHD."

Wetlands

Wetland information was obtained from the Montana Wetland and Riparian Framework (http://mslapps.mt.gov/Geographic_Information/Applications/DigitalAtlas/Default). The following is a description of the framework:

> "The Montana Wetland and Riparian Framework represents the extent, type, and approximate location of wetlands, riparian areas, and deepwater habitats in Montana. The Montana Wetland and Riparian Framework consists of features that were manually digitized at a scale of 1:4,500 or 1:5,000 from orthorectified digital color-infrared aerial imagery collected during the summers of 2005, 2006, 2009, 2011, and 2013 by the National Agricultural Imagery Program (NAIP). These data are intended for use in publications at a scale of 1:12,000 or smaller. This layer consists of one feature dataset: NHP_Layers. The NHP_Layers feature dataset contains the digital wetland and riparian mapping and consists of the feature class WetRip. This feature class consists of data that have undergone three rounds of internal quality assurance/quality control procedures by the Montana Natural Heritage Program."

Depth to Groundwater

Information on depth to groundwater in the study area was found at the Montana Bureau of Mines and Geology (MBMG) and was accessed from the Montana Natural Resources Information System (NRIS) at http://mslapps.mt.gov/Geographic_Information/Data/DataList/datalist_Details?did=%7BB40FCBD4-DA34-483A-A8C9-F9C1E95F7A21%7D According to MBMG:

> "The Ground Water Information Center (GWIC) at the Montana Bureau of Mines and Geology is the central repository for information on the ground-water resources of Montana. The data include well-completion reports from drillers, measurements of well performance and water quality based on site visits, water-level measurements at various wells for periods of up to 60 years, and water-quality reports for thousands of samples. The databases at GWIC are continually updated with new data from driller's logs, MBMG research projects, and research projects from other agencies."

Existing Roads

Information to locate existing roads was obtained from the US Department of Agriculture Forest Service, at http://data.fs.usda.gov/geodata/. Due to the limited road network in the study area, road information was not specifically included in the analysis; however, existing roads are identified on the map resulting from the GIS analysis (see below).

Slope and Aspect

Digital elevation data from the US Geological Survey (USGS) used to evaluate slope and aspect, and were obtained at http://viewer.nationalmap.gov/basic/. The following description of the data source is provided:

> "USGS National Elevation Dataset (NED) is 1/3 arc-second resolution. The National Elevation Dataset (NED) serves the elevation layer of The National Map, and provides basic elevation information for earth science studies and mapping applications in the United States. Scientists and resource managers use NED data for global change research, hydrologic modeling, resource monitoring, mapping and visualization, and many other applications. The NED is an elevation dataset that consists of seamless layers and a high resolution layer. Each of these layers are composed of the best available raster elevation data of the conterminous United States, Alaska, Hawaii, territorial islands, Mexico and Canada. The NED is updated continually as new data become available. All NED data are in the public domain. The NED are derived from diverse source data that are processed to a common coordinate system and unit of vertical measure. These data are distributed in geographic coordinates in units of decimal degrees, and in conformance with the North American Datum of 1983 (NAD 83). All elevation values are in meters and, over the continental United States, are referenced to the North American Vertical Datum of 1988 (NAVD 88). The vertical reference will vary in other areas."

Land Ownership

Land ownership information was obtained from the Montana Cadastral Framework (http://mslapps.mt.gov/Geographic_Information/Applications/DigitalAtlas/Default). The database is described as follows:

"The Montana Cadastral Database is comprised of taxable parcels (fee land) and public land (exempt property). It is not broken down into individual lots, for instance lots 4 & 5, Forest Grove Subdivision may comprise one taxable parcel and the Lot line between lots 4 & 5 is not contained in this database. The database encompasses all the area within Montana. At this time, the Data is in an ArcSde/Oracle geodatabase. Each county is available for download as a single ArcGIS personal geodatabase or shapefile. The data is maintained by the Montana Department of Revenue (DOR) or in cases of Silver Bow, Cascade, Missoula, Lake, Flathead and Yellowstone counties that are maintained by the individual counties. The data is integrated by Montana State Library Geographic Information Services staff. Each parcel contains an attribute called ParcelID (geocode) that is the parcel identifier. It relates to the geocode in the DOR's Orion database (Computer Assisted Mass Appraisal data - CAMA). Most of the ancillary attribute information is held in this database. Information such as owner name, legal description, and appraised value as well as structural and agricultural data are available within CAMA. SQL Server Express 2000 R2 database files of individual county CAMA data are available for download at the project website listed above. In addition, a SQL Server Express database of selected attributes is available for the entire state. Parcel data is built upon the USDI Bureau of Land Management's (BLM) Geographic Coordinate Database (GCDB). The GCDB is a complex measurement management system that uses a least squares adjustment of existing survey data to come up with a digital representation of the Public Land Survey System (PLSS). For more information on GCDB you should proceed to the Montana/North Dakota BLM website at http://www.blm.gov/mt/st/en/res/public_room/cadastral_survey/gcdb.html. Accuracy varies between townships and it is important to note that the accuracy of the parcel data can't be any more accurate than the GCDB."

RESULTS

NewFields GIS analysts assembled the publically available data identified above to complete the analysis. Data layers for the resources identified in the chart above were simultaneously analyzed using ArcGIS to identify sites that met the criteria assigned to each resource. Because only a few of the potential repository locations were accessible by existing roads, the "existing roads" criteria was dropped from further consideration. Locations that met all criteria are shown on **Figure 1** (**Attachment A**) and are differentiated between those located on USDA Forest Service lands (red) and those located on private land (orange).

With a few exceptions, most of the potential repository sites on USDA-Forest Service lands and all potential repository sites on private land are located near the Telegraph Creek watershed boundary. The potential repository site nearest the Lilly/Orphan Boy mine is located approximately 1.8 miles north of the mine. Only a few potential repository sites are adjacent to existing roads.

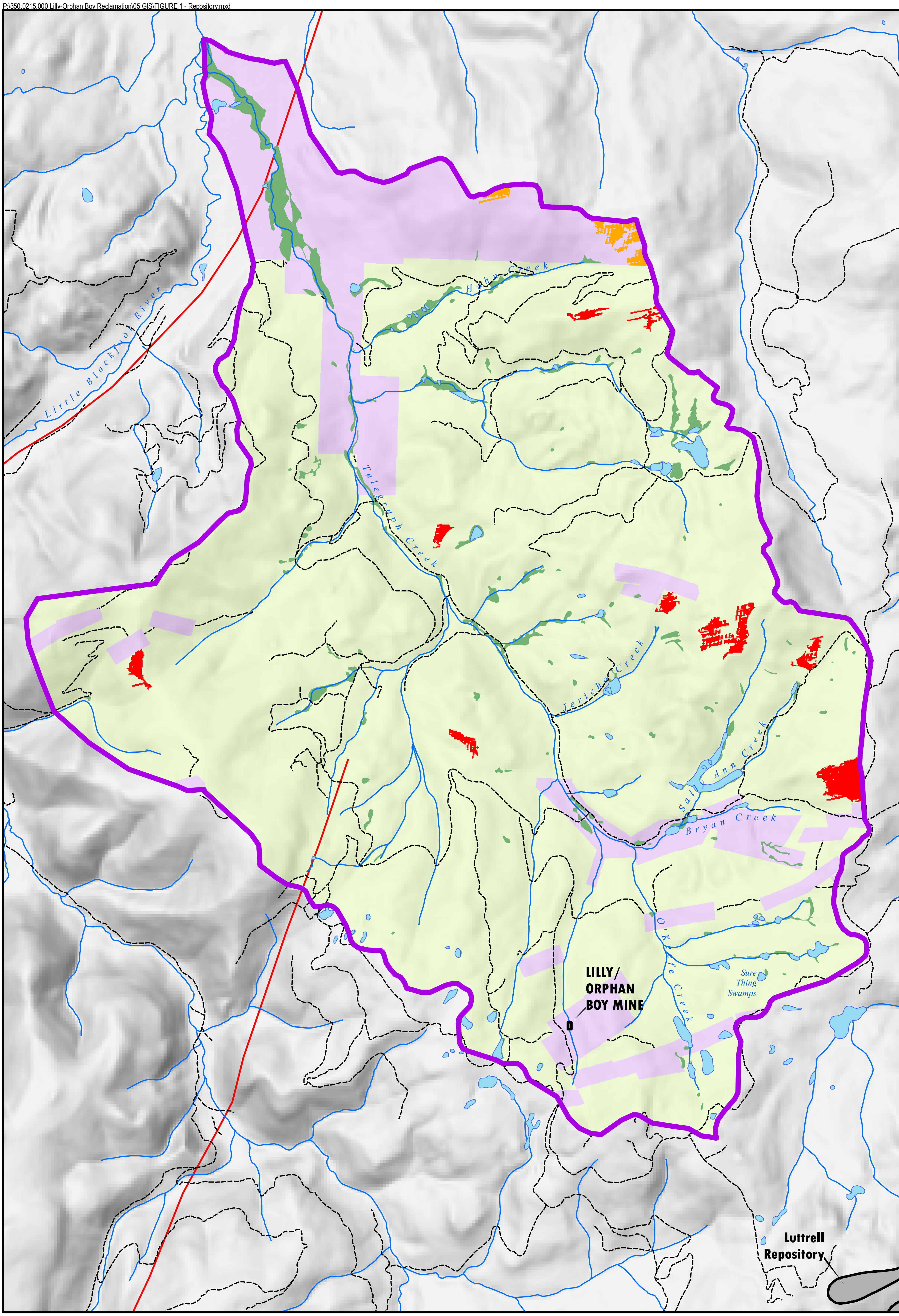
ATTACHMENTS:

Attachment A Figure

Attachment A

Figure

P:\350.0215.000 Lilly-Orphan Boy Reclamation\05 GIS\FIGURE 1 - Repository.mxd



0 Feet 3,000

Areas Passing All Criteria

- National Forest System Roads
- Steam/Creek
- Fault
- Pond/Lake
- Study Area Boundary
- Wetland
- Private Land
- USDA Forest Service Land
- Private Land
- USDA Forest Service Land

NewFields

Repository Siting Evaluation
Lilly/Orphan Boy Mine
Powell County, Montana
FIGURE 1

Appendix B

Applicable or Relevant and Appropriate Requirements (ARARs)

TABLE B-1
Preliminary Identification of
Applicable or Relevant and Appropriate Requirements (ARARs)
Lilly/Orphan Boy Mine

Standard, Requirement, Criteria or Limitation	Citation	Description	ARAR Status
FEDERAL: CONTAMINANT-SPECIFIC			
Safe Drinking Water Act	40 USC § 300		Relevant and appropriate. Although surface water and groundwater are not currently used for drinking water at the site, the potential for future use exists.
National Primary Drinking Water Regulation	40 CFR Part 141	Establishes health-based standards (MCLs) for public water systems	
National Secondary Drinking Water Regulation	40 CFR Part 143	Establishes welfare-based standards (secondary MCLs) for public water systems.	
Clean Water Act	33 USC § 1251-13871	Ch. 26 Water Pollution Prevention and Control	Applicable
Water Quality Standards	40 CFR Part 131 Quality Criteria for Water	Sets criteria for water quality based on toxicity to aquatic organisms and human health.	
National Ambient Air Quality Standards	40 CFR 50.16, 50.12	Establish standards for PM-10 and lead emissions to air.	Applicable
STATE: CONTAMINANT SPECIFIC			
Groundwater Protection	ARM 17.30.1005, 1006, 1011	Identifies groundwater classes, assigns beneficial uses, and establishes groundwater standards, including non-degradation requirements	Applicable Removal of waste rock, and contaminated materials will reduce the loading of contaminants to groundwater and reduce further degradation of groundwater
Montana Water Quality	ARM 17.30.637	Establishes water quality criteria for discharges to surface water	
	MCA 75-5-101 et seq., MCA 75-5-605 et seq., MCA 75-5-303 et seq., ARM 17.30.705."	Establishes requirements to protect, maintain and improve the quality of surface water and groundwater	Applicable

TABLE B-1 Preliminary Identification of Applicable or Relevant and Appropriate Requirements (ARARs) Lilly/Orphan Boy Mine			
Standard, Requirement, Criteria or Limitation	**Citation**	**Description**	**ARAR Status**
Montana Ambient Air Quality	ARM17.8. 220, -221, -222, -223	Establishing monitoring requirements for ambient air quality standards, including limits for lead emissions (ARM 17.8.222), settled particulate matter, and PM-10 concentration in ambient air (ARM 17.8.223).	Applicable
FEDERAL: LOCATION-SPECIFIC			
National Historic Preservation Act	16 USC § 470; 36 CFR Part 800; 40 CFR part 6.301(b)	Requires Federal agencies to take into account the effect of any Federally-assisted undertaking or licensing on any district, site, building, structure, or object that is included in or eligible for inclusion in the National Register of Historic Places and to minimize harm to any National Historic Landmark adversely or directly affected by an undertaking.	Applicable
Archaeological and Historic Preservation Act	USC Title 54, Subtitle III; 40 CFR 6.301 (c)	Establishes procedures to provide for preservation of historical and archaeological data which might be destroyed through alteration of terrain as a result of a Federal construction project or a Federally licensed activity or program.	Applicable
Historic Sites, Buildings, and Antiquities Act	36 CFR § 62.6(d)	Requires Federal agencies to consider the existence and location of landmarks on the National Registry of Natural Landmarks to avoid undesirable impacts on such landmarks.	Applicable
Protection of Wetlands Order	40 CFR Part 6, Appendix A, and Executive Order No. 11990	Avoid adverse impacts to wetlands.	Applicable
Migratory Bird Treaty Act	16 USC § 703 et seq.	Establishes a Federal responsibility for the protection of international migratory bird resource.	Applicable
Fish and Wildlife Coordination Act	16 USC § 661 et seq.; 40 CFR Part 6.302(g)	Requires consultation when Federal department or agency proposes or authorizes any modification or any stream or other water body and adequate provision for protection for protection of fish and wildlife resources.	Applicable

TABLE B-1
Preliminary Identification of
Applicable or Relevant and Appropriate Requirements (ARARs)
Lilly/Orphan Boy Mine

Standard, Requirement, Criteria or Limitation	Citation	Description	ARAR Status
Floodplain Management Order	40 CFR 6.302(b), and Executive Order No. 11988	Requires Federal agencies to evaluate the potential effects of actions they may make in a floodplain to avoid the adverse impacts associated with direct and indirect development of a floodplain, to the extent possible.	Applicable
Bald Eagle Protection Act	16 USC § 668 et seq.	Establishes a federal responsibility for protection of bald and golden eagles. Requires consultations with the USFWS.	Applicable
Endangered Species Act	16 USC §§ 1531-1543; 40 CFR Part 6.302(h); 50 CFR Part 402	Requires action to conserve endangered species within critical habitat upon which species depend. Includes consultation with US Department of Interior.	Applicable
Clean Water Act	33 USC §1251 et seq., 33 CFR 330	Regulates discharge or dredged or fill materials into waters of the United Sates.	Applicable. Consultation with USACE will be required regarding wastes removed from Telegraph Creek and channel reconstruction.
Resource Conservation and Recovery Act	40 CFR Part 264.18(a) and (b)	Provides seismic and floodplain restrictions on location waste management units.	Relevant and Appropriate
American Indian Religious Freedom Act	42 USC §1996, et seq	Requires reclamation activities to consider and protect Indian religious freedom.	Applicable
Native American Graves Protection and Repatriation Act	25 USC § 3001, et seq	Prioritizes ownership or control over Native American cultural items excavated or discovered on Federal or tribal lands.	Relevant and appropriate
STATE: LOCATION-SPECIFIC			
Montana Antiquities Act	22-3-421, et seq. MCA	Address the responsibilities of State agencies regarding historic and prehistoric sites.	Relevant and appropriate
Montana Human Skeletal Remains and Burial Site Protection Act	22-3-801 MCA	Establishes requirements for the protection of human skeletal remains and burial requirements.	Applicable
Montana Floodplain and Floodway Management Act	76-5-401 et seq., MCA, ARM 36.15.601, et seq.	Specifies the types of uses/structures that are allowed or prohibited in designated 100-year floodway and floodplain. Solid and hazardous was disposal are prohibited in the floodway or the floodplain.	Applicable

TABLE B-1 Preliminary Identification of Applicable or Relevant and Appropriate Requirements (ARARs) Lilly/Orphan Boy Mine			
Standard, Requirement, Criteria or Limitation	**Citation**	**Description**	**ARAR Status**
Montana Stream Protection Requirements	75-7-101 et seq., MCA, 87-5-502 and 504 MCA, ARM 36.2.401, et seq.	Establishes requirements for actions that would alter or affect a streambed or its banks. Reclamation projects must be designed and constructed to minimize adverse impacts to the stream.	Applicable
Montana Solid Waste Management Act	75-10-206 and 75-10-212 MCA, ARM 17.50.523, ARM 17.50.1009(1)(c), ARM 17.50.1204, ARM 17.50.1109, ARM 17.50.1403, ARM 17.50.1404	Sets requirements for the location of solid waste management facilities. Facilities must be located outside the 100-year floodplain and must be located to prevent impacts to groundwater, surface water, and private water supply systems.	Applicable
Endangered Species and Wildlife act	85-5-106, -107, and -111 MCA	Establishes protections for endangered species.	Applicable
FEDERAL: ACTION-SPECIFIC			
Clean Water Act	33 USC 1342		Applicable (substantive provisions only)
National Pollutant Discharge Elimination System (NPDES)	40 CFR Parts 121, 122, 125	Requires permits for the discharge of pollutants from a point source into waters of the United States.	Relevant and appropriate
Clean Air Act			
National Primary and Secondary Ambient Air Quality Standards	40 CFR Part 50.12	Air quality levels that protect public health.	Applicable
Surface Mining Control and Reclamation Act	30 USC 1201-1326	Reclamation requirements for coal and certain non-coal mining.	Relevant and Appropriate

TABLE B-1 **Preliminary Identification of** **Applicable or Relevant and Appropriate Requirements (ARARs)** **Lilly/Orphan Boy Mine**			
Standard, Requirement, Criteria or Limitation	**Citation**	**Description**	**ARAR Status**
Resources Conservation and Recovery Act	42 USC 6921, et seq.	Defines those solid wastes that are subject to regulation as hazardous wastes under 40 CFR Parts 262-265 and parts 124, 270, and 271	Relevant and appropriate However, pursuant to the Bevill Amendment, solid waste from extraction of ore and minerals are exempt from hazardous waste requirements and are subject only to requirements applicable to solid waste.
	40 CFR Part 257.3	Governs waste handling and disposal	Relevant and appropriate
	40 CFR Part 264.310	Provisions regarding run-on and run-off controls.	Relevant and appropriate
Occupational Safety and Health Act Hazardous Waste Operations and Emergency Response	29 CFR 1910.120	Defines standards for employee protection during initial site characterization and analysis, monitoring activities, material handling activities, training, and emergency response.	To Be Considered
STATE: ACTION-SPECIFIC			
Montana Pollutant Discharge Elimination System (MPDES)	ARM 17.30.1342-1344, and .1203	Establishes requirements for MPDES and NPDES permits, including technology-based treatment requirements	Applicable
Montana Water Quality Act and Regulations	75-5-303, and -605 MCA; ARM 17.30.637, .705, and 1011	Prohibits the pollution of state waters and establishes provisions that existing uses and levels of water quality of state water must be protected and maintained.	Applicable
Storm Water Runoff Control Requirements	ARM 17.24.633 and 17.30.1341	Surface drainage from disturbed areas must be treated by the best technology currently available and requires compliance with the MPDES General Permit for Construction Activities.	Applicable

TABLE B-1 Preliminary Identification of Applicable or Relevant and Appropriate Requirements (ARARs) Lilly/Orphan Boy Mine			
Standard, Requirement, Criteria or Limitation	**Citation**	**Description**	**ARAR Status**
Montana Solid Waste Requirements	75-10-201 et seq., MCA; and ARM 17.50.523, 17.50.1009(1)(c), 17.50.1109, 17.50.1110, 17.50.1111, 17.50.1116, 17.50.1204, 17.50.1403, 17.50.1404	Establishes requirements for management and disposal of solid wastes, including mine wastes that at sites not currently subject to operating permit requirements	Applicable
Montana Strip and Underground Mine Reclamation Act and Montana Metal Mining Act	82-4-201 et seq., and 82-4-301 et seq., MCA; and ARM 17.24.501, 17.24.519, 17.24.631(1), (2), (3)(a) and (b), 17.24.633, 17.24.634, 17.24.637 through 17.24.641, 17.24.643 through 17.24.646, 17.24.701 through 17.24.703, 17.24.711, 17.24.713, 17.24.714, 17.24.716 through 17.24.718, 17.24.721, 17.24.723, 17.24.724, 17.24.726, 17.24.731, and 17.24.751.	Establishes grading, drainage, erosion control, groundwater protection, revegetation, and fish and wildlife protection requirements.	Relevant and appropriate

TABLE B-1
Preliminary Identification of
Applicable or Relevant and Appropriate Requirements (ARARs)
Lilly/Orphan Boy Mine

Standard, Requirement, Criteria or Limitation	Citation	Description	ARAR Status
Montana Ambient Air Quality Regulations	ARM 17.8.304, .308, and .604	Establishes requirements to ensure existing air quality will not be adversely affected	Applicable
	ARM 17.24.761	Specifies measures for controlling fugitive dust	Relevant and appropriate

Appendix C

Estimated Reclamation Action Costs

Engineer's Estimate
Alternative 2: Mine Waste Removal & Disposal at Off-Site Repository
Expanded Engineering Evaluation and Cost Analysis
Lilly/Orphan Boy Mine

Item	Description	Units	Unit Cost	Quantity	Est. Subtotal	Comments
1.0	**Property Purchase**					
1.1	5-acre parcel (no improvements)	LS	$ 100,000	1	$ 100,000	Based on real estate listings in Elliston area
2.0	**Stream Diversion**					
2.1	Diversion berm	EA	$ 2,500	1	$ 2,500	
2.2	Diversion piping, installed	LF	$ 12.50	160	$ 2,000	Diversion piping to begin above area of ponding and continue downstream of Waste Rock Pile 3
2.3	Sedimentation basin	EA	$ 2,500	1	$ 2,500	At discharge of diversion pipe to prevent scouring
				Subtotal	**$ 7,000**	
3.0	**Mine Waste Removal**					
3.1	Access improvement	LS	$ 5,000	1	$ 5,000	Access to Waste Rock Pile 3
3.2	Excavate, load, haul mine waste	CY	29.50	4415	$ 130,243	Waste Rock Pile 1 - 3 and incidental soil
3.3	Rough grading	CY	$4.80	2100	$ 10,080	Post removal of mine waste
3.4	Run-on Diversion	LF	$15.50	600	$ 9,300	Uphill swale / berm to divert run-on away from mine
3.5	Fine grading	SY	$ 2.50	6200	$ 15,500	
3.6	Stream reconstruction	LF	$ 40	160	$ 6,400	Rough grading only. Final reconstruction by others.
3.7	Import / spread topsoil	CY	$ 35	1050	$ 36,750	Assume 6 inches topsoil spread over disturbed area
3.8	Revegetation	SY	$ 0.55	6200	$ 3,410	Broadcast seeding with hydromulch
				Subtotal	**$ 216,700**	
4.0	**Repository Construction**					
4.1	Survey / construction staking	LS	$ 4,500	1	$ 4,500	
4.2	Access improvements	LS	$ 2,500	1	$ 2,500	
4.3	Cut & chip trees	AC	$ 3,500	1.5	$ 5,250	Assumes thin tree cover in repository area
4.4	Clearing & grubbing	AC	$ 7,000	1.5	$ 10,500	
4.5	Strip /stockpile topsoil	BCY	$ 2.25	540	$ 1,215	assumes 4 inches of topsoil present
4.6	Excavate / stockpile subsoil in footprint	BCY	$ 2.50	4840	$ 12,100	assume 3 ft. of subsoil excavated (Means)
4.7	Rough grade subgrade	HR	$ 170	6	$ 1,020	
4.8	Compact subgrade	LS	$ 500	1	$ 500	
4.9	Place and compact mine waste	LCY	$ 5.78	5520	$ 31,906	assumes 25% bulking factor for loose (excavated) waste rock
4.10	Rough grading	LCY	$ 2.62	1600	$ 4,192	top 1-ft interval of mine waste
4.11	Compost, delivered	CY	$ 35.00	1080	$ 37,800	
4.12	Gravel, delivered	CY	$ 32.00	810	$ 25,920	drainage layer
4.13	GCL, installed	SF	$ 0.70	43600	$ 30,520	
4.14	Drainage layer, installed	LCY	$ 2.75	810	$ 2,228	
4.15	Repository cover - soil placement	LCY	$ 2.62	4840	$ 12,681	
4.16	Revegetation	SY	$ 0.53	7260	$ 3,848	
4.17	Runoff / run-on control ditches	LS	$ 3,500	1	$ 3,500	
				Subtotal	**$ 190,200**	

Engineer's Estimate
Alternative 2: Mine Waste Removal & Disposal at Off-Site Repository
Expanded Engineering Evaluation and Cost Analysis
Lilly/Orphan Boy Mine

Item	Description	Units		Unit Cost	Quantity		Est. Subtotal	Comments
5.0	**Adit Discharge**							
5.1	Lilly Adit access improvements / barrier	LS	$	20,000	1	**$**	**20,000**	
SUBTOTAL DIRECT CAPITAL COSTS						**$**	**533,900**	
6.0	**Mobilization and Site Prep**							
6.1	Mobilization	%	$	433,900	12%	$	52,100	
6.2	Construction BMPs	%	$	433,900	6%	$	26,000	
6.2	Demobilization and Cleanup	LS	$	5,000	1	$	5,000	
					Subtotal	**$**	**83,100**	
7.0	**Engineering / Support Costs**							
7.1	Wetland Delineation / Pre-Construction Notice	LS	$	4,500	1	$	4,500	
7.2	Project Management/ Administrative Costs	%	$	433,900	6%	$	26,000	
7.3	Engineering and Design	%	$	433,900	15%	$	65,100	
7.4	Construction Management	%	$	433,900	10%	$	43,400	
					Subtotal	**$**	**139,000**	
8.0	Contingency	%	$	533,900	25%	$	133,500	
TOTAL DESIGN AND CONSTRUCTION COSTS						**$**	**889,500**	

Assumptions

1. Approximately 4,515 cubic yards of mine waste and impacted soil/sediment will be removed.
2. Excavated waste rock will be hauled to an off-site repository (approx. 7.6 miles from the site) constructed on private land.
3. No improvements will be required to the haul route between the site and the off-site repository. Standard (highway) 10 yard dump trucks would be used to haul the waste.
4. It will be necessary to construct an access road on the repository parcel from an existing public road.
5. During removal of Waste Rock Pile 3, access to the Lilly Adit will be improved to facilitate future remediation efforts. A physical barrier will be installed over the adit opening to prevent unauthorized access to the adit.
6. A diversion berm would be installed uphill of the Lilly shaft and above the upper-most adit to direct storm water / snow melt away from the mine workings.

Engineer's Estimate
Annual Maintenance and Operation Costs
Alternative 2: Excavation & Off-Site Disposal
Expanded Engineering Evaluation and Cost Analysis
Lilly/Orphan Boy Mine Site

Year	Annual Monitoring Costs	Annual Maintenance Costs	Total Annual Costs
1	$ 1,000	$ 3,500	$ 4,500
2	$ 1,022	$ -	$ 1,022
3	$ 1,044	$ 1,000	$ 2,044
4	$ 1,067	$ -	$ 1,067
5	$ 1,091	$ 3,500	$ 4,591
Net Present Value of Annual Costs			**$12,300**

5-year nominal discount rate[1]	2.40%
Annual Escalation Rate	2.20%

Source:

[1] U.S. Office of Management and Budget, 2014. Circular A-94 Discount Rates for Cost-Effectiveness, Lease Purchase, and Related Analyses. Rev. Dec. 2014.

Assumptions:

1. Annual repository inspections conducted for 5 years following completion.
2. Repairs required on years 1, 3, and 5 following completion.
3. Repairs include minor erosion repairs (years 1 and 5) and control of invasive weeds (year 3).

Engineer's Estimate
Alternative 3: Mine Waste Removal & Disposal at Luttrell Pit
Expanded Engineering Evaluation and Cost Analysis
Lilly/Orphan Boy Mine

Item	Description	Units		Unit Cost	Quantity		Est. Subtotal	Comments
1.0	**Stream Diversion**							
1.1	Diversion berm	EA	$	2,500	1	$	2,500	
1.2	Diversion piping, installed	LF	$	12.50	160	$	2,000	Diversion piping to begin above area of ponding and continue downstream of Waste Rock Pile 3
1.3	Sedimentation basin	EA	$	2,500	1	$	2,500	At discharge of diversion pipe to prevent scouring
					Subtotal	**$**	**7,000**	
2.0	**Mine Waste Removal**							
2.1	Access improvement	LS	$	5,000	1	$	5,000	Access to Waste Rock Pile 3
2.2	Excavate, load, haul mine waste	CY		29.50	4415	$	130,243	Waste Rock Pile 1 - 3 and impacted soil/sediment
2.3	Rough grading	CY		$4.80	2100	$	10,080	Post removal of mine waste
2.4	Run-on Diversion	LF		$15.50	600	$	9,300	Uphill swale / berm to divert run-on away from mine
2.5	Fine grading	SY	$	2.50	6200	$	15,500	
2.6	Stream reconstruction	LF	$	40	160	$	6,400	Rough grading only. Final reconstruction by others.
2.7	Import / spread topsoil	CY	$	35	1050	$	36,750	Assume 6 inches topsoil spread over disturbed area
2.8	Revegetation	SY	$	0.55	6200	$	3,410	Broadcast seeding with hydromulch
					Subtotal	**$**	**216,700**	
3.0	**Adit Discharge**							
3.1	Lilly Adit access improvements / barrier	LS	$	20,000	1	**$**	**20,000**	
SUBTOTAL DIRECT CAPITAL COSTS						**$**	**243,700**	
4.0	**Mobilization and Site Prep**							
4.1	Mobilization	%	$	243,700	12%	$	29,200	
4.2	Construction BMPs	%	$	243,700	6%	$	14,600	
4.3	Demobilization and Cleanup	LS	$	5,000	1	$	5,000	
					Subtotal	**$**	**48,800**	
5.0	**Engineering / Support Costs**							
5.1	Wetland Delineation / Pre-Construction Notice	LS	$	4,500	1	$	4,500	
5.2	Project Management/ Administrative Costs	%	$	243,700	6%	$	14,600	
5.3	Engineering and Design	%	$	243,700	15%	$	36,600	
5.4	Construction Management	%	$	243,700	10%	$	24,400	
					Subtotal	**$**	**80,100**	
6.0	Contingency	%	$	228,500	25%	$	60,900	
TOTAL DESIGN AND CONSTRUCTION COSTS						**$**	**433,500**	

Engineer's Estimate
Alternative 3: Mine Waste Removal & Disposal at Luttrell Pit
Expanded Engineering Evaluation and Cost Analysis
Lilly/Orphan Boy Mine

Assumptions

1. Approximately 4,515 cubic yards of mine waste and impacted soil/sediment will be removed.
2. Excavated waste rock will be hauled to the Luttrell Pit (approx. 6.6 miles from the site) and stockpiled for future placement in the repository. Haul route to repository identified by Montana Department of Environmental Quality.
3. No tipping fees will be charged for disposal of the mine waste / soil at the Luttrell Pit.
4. No improvements will be required to the haul route between the site and the Luttrell Pit. Standard (highway) 10 yard dump trucks would be used to haul the waste.
5. During removal of Waste Rock Pile 3, access to the Lilly Adit will be improved to facilitate future remediation efforts. A physical barrier will be installed over the adit opening to prevent unauthorized access to the adit.
6. A diversion berm would be installed uphill of the Lilly shaft and above the upper-most adit to direct storm water / snow melt away from the mine workings.