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Superfund Technical Assessment and Response Team 3 - Region 8

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PHASE II ENGINEERING EVALUATION/COST ANALYSIS

STANDARD MINE SITE
Crested Butte, Gunnison County, Colorado

TDD No. 0509-08

FINAL

JULY 2, 2007

URS
OPERATING SERVICES, INC.

In association with:
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LT Environmental, Inc.
TechLaw, Inc.
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Dear Ms. Andrews:

Attached are the requested copies of the final Phase II Engineering Evaluation/Cost Analysis for the Standard Mine site in Crested Butte, Gunnison County, Colorado. This document is submitted for your review and approval.

If you have any questions, please call me at 303-291-8215.

Best Regards,

URS OPERATING SERVICES, INC.

Jerry Goedert, P.E.
Project Manager

cc: Charles W. Baker/UOS (w/o attachment)

PHASE II ENGINEERING EVALUATION/COST ANALYSIS

STANDARD MINE
Crested Butte, Gunnison County, Colorado

EPA Contract No. EP-W-05-050
TDD No. 0509-08

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PHASE II ENGINEERING EVALUATION/COST ANALYSIS
STANDARD MINE
Crested Butte, Gunnison County, Colorado

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Appendix A GIS Viewshed Analysis

ACRONYMS

µg/L	micrograms per Liter
ABA	Acid Base Accounting
ac	Acute
AMD	Acid Mine Drainage
ARAR	Applicable or Relevant and Appropriate Requirements
BERA	Baseline Ecological Risk Assessment
bgs	Below ground surface
CDPHE	Colorado Department of Public Health and Environment
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cfs	Cubic feet per second
ch	Chronic
cy	Cubic yards
DEM	Digital elevation model
DRMS	Colorado Division of Reclamation, Mining, and Safety
EE/CA	Engineering Evaluation/Cost Analysis
EPA	U.S. Environmental Protection Agency
EZD	Evaporative Zone Depth
FDR	Forest Development Road
FS 2	USFS Site 2
GIS	Geographic Information System
gpm	Gallons per minute
GPS	Global Positioning System
HEC-HMS	Hydrologic Engineering Center – Hydrologic Modeling System
HELP	Hydrologic
HELP	Hydrologic Evaluation of Landfill Performance
HQ	Hazard Quotient
LAI	Leaf Area Index
LIDAR	Light Detection and Ranging
mg/kg	milligrams per kilogram
mg/L	Milligrams per liter
MRE	Mean resolution element
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NOAA	National Oceanic and Atmospheric Association
NPDES	National Pollutant discharge Elimination System
NPL	National Priorities List
O&M	Operations and Maintenance
pcf	Pounds per cubic foot
ppm	parts per million
psf	Pounds per square foot
RAOs	Removal Action Objectives
RBCs	Risk-Based Concentrations
RCRA	Resource Conservation and Recovery Act
RI/FS	Remedial Investigation / Feasibility Study
SAIC	Science Applications International Corporation

SCS	Soil Conservation Survey
SI	Site Inspection
SLERA	Screening Level Ecological Risk Assessment
SPLP	Synthetic Precipitation Leaching Procedure
TCLP	Toxicity Characteristics Leaching Procedure
UD	University of Delaware
UOS	URS Operating Services, Inc.
USACE	U.S. Army Corps of Engineers
USFS	U.S. Forest Service
XRF	X-Ray Fluorescence Spectrometer

1.0 INTRODUCTION

This Phase II Engineering Evaluation/Cost Analysis (EE/CA) for the Standard Mine Site was prepared by URS Operating Services, Inc. (UOS) under Technical Direction Document (TDD) No. 0509-08 in accordance with the EPA guidance document entitled "Guidance on Conducting Non-Time Critical Removal Actions Under CERCLA." The purpose of the Phase II EE/CA is to evaluate four potential repository capping alternatives and two potential repository locations to accept approximately 80,000 cubic yards (cy) of site wastes.

Based on prior evaluations including the 2002 EE/CA prepared for the U.S. Forest Service (USFS), previous sampling results, and stakeholder input, the U.S. Environmental Protection Agency (EPA) determined that mine wastes located at Level 1, 2, and 3 should be relocated from close proximity to Elk Creek and its tributaries and placed into an on-site repository (Figures 1 and 2). The draft Phase I EE/CA issued November 9, 2006, and Final Phase I EE/CA issued April 20, 2007, evaluated ten potential repository sites. Based on the Phase I evaluation and stakeholder input, EPA determined that two potential repository sites known as USFS Site 2 (FS 2) and Area 245, would be subjected to a more in-depth evaluation (Figure 3).

EPA response activities at the site will address human health and environmental impacts associated with impacts from historic mining that occurred from the late 1800s to as recent as 1964. Waste rock piles and a tailing impoundment are located adjacent to Elk Creek. The town of Crested Butte's drinking water supply is obtained in part from Coal Creek, of which Elk Creek is a tributary. The impacts in Elk Creek and Coal Creek include elevated concentrations of the metals cadmium, copper, manganese, and zinc in water and sediment. The impacts derive from metal leaching from mine waste and overland erosion of mine wastes into Elk Creek.

1.1 PURPOSE

The purpose of this Phase II EE/CA is to conclude the development and evaluation of potential removal alternatives and present EPA's preferred alternative for the cleanup of mining wastes associated with historic waste rock dumps and the tailing impoundment located adjacent to Elk Creek and within drainages near Elk Creek. This EE/CA was developed using the "non-time-critical" process outlined in the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended in 1986 (U.S. Environmental Protection Agency (EPA)

1986), and the updated National Oil and Hazardous Substances Pollution Contingency Plan (NCP). A removal action is implemented by the lead agency to respond to "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..." (EPA 1993).

A removal action is selected when one of the following criteria, as identified in Section 300.415(b)(2)(i-viii) of the NCP, is satisfied:

- Actual or potential exposure to nearby populations, animals, or the food chain from hazardous substances, pollutants, or contaminants;
- Actual or potential contamination of drinking water supplies or sensitive ecosystems;
- Hazardous substances in drums, barrels, tanks, or other bulk contaminants in soils largely at or near the surface that may migrate;
- Weather conditions that may promote migration of hazardous substances;
- Threat of fire or explosion;
- Availability of other appropriate federal or state response mechanisms to respond to the release; and
- Other situations or factors that may pose threats to public health, welfare, or the environment.

Removal actions are categorized in three ways: emergency, time-critical, and non-time-critical, based on the type of situation, the urgency and threat of release or potential release, and the subsequent time frame in which the action must be initiated. Emergency and time-critical removal actions are responses to releases requiring action within six months; non-time-critical removal actions are responses to releases for which actions can start later than six months after the determination that a response is necessary.

EPA has determined that site conditions dictate that a non-time-critical removal be performed at the Standard Mine site based on the threat to human health and environment. Removal actions contemplated in this EE/CA are both appropriate and consistent with the anticipated remedial actions. Work to evaluate remaining site contamination including the Level 1 adit discharge and mine waste dumps, not part of this project, will be conducted by the EPA Remedial Program using the Remedial Investigation/Feasibility Study (RI/FS) process.

1.2 REPORT ORGANIZATION

This EE/CA is organized into seven sections. Following this introductory section, the history of the site and descriptions of site geology, hydrogeology, climate, and characterization of the site are presented in Section 2. Section 3 summarizes ecological risks associated with the site. Section 4 outlines the removal action scope, and removal action objectives (RAOs) for the site. The RAOs were developed by EPA and were identified based on both "applicable or relevant and appropriate requirements" (ARARs), the results of the risk evaluation, and stakeholder input.

Section 5 identifies and analyzes repository cover alternatives using the NCP evaluation criteria. Section 6 presents a detailed analysis of two potential repository locations using the NCP evaluation criteria. Section 7 compares the removal alternatives against the three primary criteria, effectiveness, implementability, and cost and presents EPA's preferred alternative.

2.0 SITE BACKGROUND AND PHYSICAL SETTING

2.1 SITE LOCATION AND DESCRIPTION

The Standard Mine site is located in the Ruby Mining District in the Ruby-Anthracite Range of west central Colorado at an elevation of approximately 11,000 to 11,600 feet above mean sea level. It is located approximately thirty miles northwest of Gunnison, Colorado, and five miles west of Crested Butte, Colorado (Figure 1). The site is in Section 35, T. 13 S., R. 87 W. at the 6th Principal Meridian, in Gunnison County, Colorado. Site coordinates are latitude 38° 52' 45.0" north, longitude 107° 04' 26.0" west. The Ruby Mining District spans both sides of Scarp Ridge, an east-southeast trending ridge on the southeast flank of the Ruby Ridge. The Ruby Ridge is a high, north-south-trending ridge that connects the Elk Range to the north-northeast with the West

Elk Mountains to the south-southwest (Science Applications International Corporation (SAIC) 2002).

The Standard Mine was privately owned and operated. The site is within the boundaries of the Gunnison National Forest but is located on public and private land. The site can be accessed by traveling west from Crested Butte approximately 1.7 miles on County Road 12 (Kebler Pass Road), exiting onto private property owned by U.S. Energy Corporation, traveling two miles to Forest Development Road (FDR) 732 and traveling 2.7 miles to the site. Access is restricted to federal and state personnel and their contractors.

The site area drains into Elk Creek, which flows southeast to Coal Creek. Coal Creek flows east toward the Crested Butte municipal water intake and continues toward the town of Crested Butte and the Slate River.

Approximately ten acres of land were disturbed by past mining activities at the site (Figure 2). A tailing pond with dimensions of approximately 200 feet by 100 feet (0.5 acre) is located in the Elk Creek drainage approximately 400 feet southwest and downgradient from the Level 1 adit (Figure 2). The tailing dam has a notched spillway located so that overflow from the tailing pond would flow directly into Elk Creek. Four springs discharge from the toe of the tailing impoundment dam (SAIC 2002).

Waste rock pile and mill tailing volume estimates were previously calculated for 10 sub-areas at five mine levels and totaled 82,800 cy (SAIC 2002). This estimate has been revised using updated data as discussed in Section 2.6.7. There is evidence of erosion along the flanks of the waste rock piles and seepage at the toes. Several sulfide minerals including sphalerite, bornite, galena, chalcopyrite, marcasite, and pyrite have been reported at the mine waste rock piles (SAIC 2002). Elk Creek flows through and cuts the flank of one of the smaller waste rock piles. During the 2000 SAIC site visit, a flow estimate of 10 gallons per minute (gpm) was made for water flowing from the Level 1 adit.

The remains of the mill including concrete footings and stem walls are located adjacent to the waste rock piles.

2.2 SITE HISTORY

The mining claims associated with the Standard Mine Site were patented in the late 1800s and early 1900s. Most of the mines and prospects in the area were worked in the 1870s and 1880s. During the early history the mine in Upper Elk Basin was known as the Micawber Mine. The name changed to Standard Mine in 1957 after being purchased by the Standard Uranium Corporation (Colorado Geological Survey (CGS) 2005). Although production from the Micawber/Standard and other mines in the area has been intermittent since the early 1900s, the Standard Mine was one of two mines in the area still operating in 1964 (SAIC 2002).

Mining operations began at the Macawber Mine in approximately 1881 by the Douglas County Mining Company. During 1931 and 1932, 2,400 tons of silver, lead, zinc, and copper ore were removed from the mine by the Slate River Mining Company. Based on current nomenclature, Levels 2 through 5 were developed prior to 1957. Level 1 is installed at the lowest elevation and was developed in 1957 to undercut the Micawber Mine workings and serve as a haulage tunnel. The main years of operation and production at the Micawber/Standard Mine were from 1951 to 1966. A mill was built at the site in the late 1950s, but reportedly operated for only a short time (SAIC 2002).

The current owner, Standard Metals Corporation (90 Park Avenue, Suite 1720, New York City, New York 10016), came into possession of the Macawber Mine in 1957 through the purchase of the Newmar Mining Company, the apparent parent company of the Slate River Mining Company. Subsequently the operation was renamed the Standard Mine. Standard Metals Corporation was reported to be the owner and operator of the Standard Mine during the main years of production (SAIC 2002).

2.3 SITE CHARACTERIZATION

2.3.1 Physical Geography

The Ruby Mining District is located in the Central Rocky Mountain province of Colorado (Colorado Geological Survey 1972). Elevations within the area range from a low of 8,900 feet above sea level at the town of Crested Butte, at the eastern edge of the district, to a high of 13,000 feet above sea level along the Ruby Range at the western edge of the

district (U.S. Geological Survey (USGS); 1961a; USGS 1961b). The terrain is mountainous with incised stream valleys with steep slopes. Vegetation ranges from lush willow shrub and scrub brush undergrowth in stream bottoms through aspen, fir, and spruce forests on the mountain slopes to treeless alpine tundra vegetation on the ridge tops more than 12,800 feet above sea level (UOS 1999).

2.3.2 Generalized Regional Geology

The geology of Gunnison County and the Ruby Mining District is complicated involving several periods of intrusion, structural deformation, and mineralization.

The western boundary of the Ruby Mining District is defined by the Ruby Range on which occur a series of north-trending Tertiary dikes. East of the Ruby Range along Scarp Ridge are early Tertiary Age sedimentary rocks of the Wasatch and Ohio Creek formations (State of Colorado 1960). The Wasatch and Ohio Creek formations are composed of varicolored claystone, mudstone, sandstone, and conglomerate, and dip to the south along the south side of Scarp Ridge approximately 14 to 17 degrees forming a dip slope (USGS 1979). The Wasatch and Ohio Creek formations may be as much as 2,200 feet thick in the area (USGS 1980). The eastern boundary of the Ruby Mining District is covered by the sedimentary rocks of the Upper Cretaceous Mesa Verde formation (USGS 1979).

The Ruby Mining District was the scene of middle and late Cenozoic epizonal plutonic activity. During the late Cenozoic tectonic activity, regional crustal extension and local structural reaction to plutonic emplacement created a series of fractures and faults that were mineralized (USGS 1969). The mineralized material consists of quartz-arsenopyrite-pyrargyrite-prousite-calcite-rhodochrosite-tetrahedrite-galena-argentite-pyrite-chalcopyrite-sphalerite veins that have produced silver, zinc, lead, copper, and gold ores. The three largest producing mines in the Ruby Mining District are the Forest Queen Mine, the Standard (Micawber) Mine, and the Keystone Mine (USGS 1987).

Several landslides, slumps, and debris flows are visible in the region and are indicative of the steepness of slopes and instability of unconsolidated sediments. Landslides typically

occur when sediments contained on steep slopes become loaded and lubricated with water and eventually give way to the forces of gravity.

2.3.3 Mine Site Geology

The Standard Mine Site is situated in a high mountain valley on the southerly flank of Scarp Ridge, which extends easterly from the Ruby Range. The primary mine features consist of seven underground mine workings located in Elk Basin. The seven workings include six adits and the remnants of a twin compartment shaft. Two of the adits provide access to the mine workings that are open essentially for their mined length. These are at levels 4 (referred to as level 3 by the Colorado Division of Reclamation, Mining, and Safety (DRMS)) and 5 (Figure 2). The level 1 adit is caved closed less than one hundred feet from the portal. The level 2, 98, and 99 adits are closed at the portal due to collapse. The twin compartment shaft is also caved closed at a depth of approximately 15 feet. Levels 98, 99, and 5 are not connected to the Standard/Micawber Mine workings. (Colorado Division of Reclamation, Mining, and Safety (DRMS) 2007).

The series of six mine workings (Levels 1-5 and 99) are located along a fault trace and, according to Gaskill *et al* (1967), the fault trace is a normal fault that has thrust the underlying Tertiary aged Ohio Creek Formation into horizontal contact with the overlying Tertiary aged Wasatch Formation. The Ohio Creek Formation is an approximately 400-feet-thick collection of three units that include a light grey to white friable medium-grained feldspathic conglomeritic sandstone (upper unit), interbedded sandstone, siltstone, shale, and carbonaceous shale (middle unit), and very thick and massive beds of light grey to white feldspathic sandstone that locally contains pebble lenses (lower unit). The Wasatch Formation is an approximately 1,700-foot-thick assemblage of varicolored fine to very coarse-grained lenticular and evenly bedded sandstone, siltstone, and mudstone. The Wasatch is generally metamorphosed to quartzite, argillite, and silty argillaceous hornfels and conglomerates that are well cemented. As a result, the Ohio Creek Formation is exposed to the north/northwest of the Standard Mine portals, while the Wasatch Formation is found to the south/southeast of the portals (DRMS 2007).

Observations made within the mine and on the ground surface indicate that a generally distinct lithologic change can be observed on either side of the fault trace. Lithology on the up-thrown side of the fault trace tends to preferentially exhibit siltstones, mudstones, or other relatively fine-grained materials interspersed with pebbly conglomeratic sequences. The down-thrown side of the fault appears to be more predominantly a silicified siltstone and sandstone complex (DRMS 2007).

2.3.4 Generalized Regional Hydrogeology

There are no extensive aquifer systems associated with the Ruby Mining District. Groundwater location and movement is controlled by fracture systems in the igneous and fine-grained sedimentary rocks of the mining district. Small to medium-sized isolated groundwater aquifers containing groundwater of variable quality are presumed to be present in the coarser-grained layers of the Wasatch and Ohio Creek formations but there is no record of wells in much of the mining district to provide consistent lithologic, water quality, or aquifer yield data. It is possible that groundwater is discharged into Coal Creek and its tributaries by general stream bed discharge or through multiple springs or seeps (USGS 1980).

There are several abandoned mine shafts and adits discharging groundwater from underground workings into the surface water streams. There is a history of mines in the Ruby Mining District being abandoned because of flooding (USGS 1967).

Groundwater would also be expected to be present in the alluvium and colluvium found in basins and stream valleys. No direct observations have been made to determine alluvium and colluvium depth, but it could be expected to be 10 to 20 feet thick, where present. There is probably a shallow alluvial water table aquifer present in the Lake Irwin area and along Coal Creek Valley.

2.3.5 Mine Site Hydrogeology

Due to the differing lithologies of the Ohio Creek Formation and the Wasatch Formations, groundwater movement through each formation will differ. The down-thrown side of the fault at the mine site incorporates the Wasatch Formation, which is

much less massive in thickness than the up-thrown Ohio Creek Formation, and exhibits more distinct jointing and bedding. This formation is more fine grained and appears to act as a barrier to groundwater movement. In fact, water was observed to enter mine workings at several locations on various mine levels, and each observation indicated water originating from the up-thrown fault block, i.e., Ohio Creek Formation. No in-flow of water was observed from the down-thrown block (Wasatch Formation) at either level 4 or 5 (DRMS 2007). The fault zone acts as a conduit for meteoric water to be transported downward.

Level 1 adit water discharge flowrates were not measured during the 1999 EPA Site Assessment. In 2005-6 a portable flume was used and flowrate measurements have ranged from 5 to 36 gpm (UOS 2006). A permanent flume was installed in January 2007. Flowrates ranging from 1 to 30 gpm have been recorded since the installation of the flume.

2.3.6 Meteorology

The Standard Mine site is located in a semiarid climate zone. Most of the annual precipitation falls as snow. The mean annual precipitation, as totaled from the University of Delaware (UD) database, is 11.7 inches (University of Delaware (UD) Center for climate Research, Department of Geography 1986). The net annual precipitation, as calculated from precipitation and evapotranspiration data obtained from the University of Delaware (UD), is 3.7 inches. The 2-year, 24-hour rainfall event for this area is 1.5 inches (Dunne and Leopold 1978).

2.4 NPL STATUS

This site is currently a National Priorities List (NPL) site; it was listed in the Federal Register on September 4, 2005. The listing was based on the threat to the Crested Butte drinking water source. However the threat to ecological receptors was also noted in the listing package. An RI/FS is in progress and will address remaining site contamination.

2.5 2006 REMOVAL

EPA performed removal assessment work in October 2005. Based on the imminent threat to the Crested Butte drinking water supply presented by site conditions, EPA conducted a time-critical removal in 2006. From June to September 2006 EPA performed the following work activities to provide short-term reductions in threats to human health and the environment presented by the site and to facilitate removal goals (UOS 2006b):

- Improvements were made to FDR 732 including rolling dip and culvert installation;
- Large concrete blocks were installed adjacent to Elk Creek through Level 1;
- Ditches were installed to collect and transport surface water runoff around site wastes;
- Surface water in the tailing pond was treated and discharged into Elk Creek;
- A PVC liner was placed on the tailing pond surface to limit surface water and tailings interaction;
- Trenches and test pits were installed at several potential repository sites; and
- Former mine structures were removed including the remains of a miner's quarters building, a trestle with rails, and a corrugated metal shed that covers the rails leading to the waste rock piles.

An ore bin and inactive power lines and poles remain. Two adits (Levels 4 and 5) are intact and accessible. The main portal, Level 1, originally accessed a total of about 8,400 feet of drifts on six operating levels (SAIC 2002). However, during the 2006 field season, the Level 1 adit was found blocked, approximately 80 feet from the portal (DRMS 2007).

2.6 PREVIOUS REPORTS

2.6.1 EPA 1999 Expanded Site Inspection

EPA conducted an expanded Site Inspection (SI) in two phases in June (Phase I) and September (Phase II) 1999. The SI concluded that cadmium, copper, lead, and zinc concentrations were at elevated levels above background in Elk Creek immediately below the Standard Mine, and continued to be present at elevated levels at the Crested Butte municipal intake, through the town of Crested Butte, and to the last sampling station on Coal Creek immediately before its confluence with the Slate River, for a total distance of approximately 7.5 miles. Waste rock sample results revealed levels of antimony, arsenic, cadmium, copper, lead, selenium, silver, and zinc that were above background samples from non-mineralized areas. Of those metals, zinc (600 milligrams per kilogram (mg/kg) to 21,000 mg/kg) and lead (3,000 mg/kg to 16,000 mg/kg) had the highest concentrations (UOS 1999).

2.6.2 USFS 2002 EE/CA

An EE/CA prepared by SAIC in 2002 for the USFS, Rocky Mountain Region, used data collected during the 1999 EPA expanded SI.

The issues identified by the USFS were:

- Safety hazards associated with open mine shafts and adits; and
- Degraded water quality associated with waste rock piles and acid mine drainage (AMD) from the Level 1 adit.

Twenty-one removal alternatives were evaluated including limited actions such as administrative controls and run-on/runoff controls to capping waste materials in place. Capping the waste in place was not included for further consideration because of poor technical feasibility and implementability. The five removal alternatives that were retained for further consideration were:

1. Adit and shaft closure;

2. Excavation, consolidation, and disposal of mill tailings in an on-site cell;

3. Excavation, consolidation, and disposal into an on-site cell of the portion of mill tailings and waste rock material that are located in close proximity to Elk Creek;

4. Treatment of AMD from the Level 1 adit using a bioreactor; and

5. Excavation and disposal in a permitted off-site facility.

The USFS report concluded that further evaluation was needed prior to selecting a removal alternative.

2.6.3 2004 Colorado Geologic Survey Report

The Colorado Geological Survey conducted an investigation of the area under USFS direction in August 2004. A draft report of the investigation presents a detailed history of mining activities and reports on the collection and analytical results of waste rock and adit discharge water samples (CGS 2005).

2.6.4 EPA 2005 Removal Assessment

In October 2005 EPA conducted a removal assessment at the Standard Mine site and accomplished the following objectives:

- Collection and metals analyses of near surface waste rock and tailing samples;

- Collection and analyses of three adit discharge water samples and flow rate measurement;

- Collection of Global Positioning System (GPS) data for the site waste rock piles and tailing pond for the purpose of waste rock and tailing volume estimation; and

- Inspection of the tailing dam.

Thirteen composite waste rock/tailing sediment samples, 0 to 12 inches below ground surface (bgs), were collected from seven mine waste levels. The samples were analyzed for metal concentrations using an X-Ray Fluorescence Spectrometer (XRF) (Table 2-1). Waste rock/tailing sediment sample metal concentrations were compared to EPA Region 3 Risk-Based Concentrations (RBCs) and revealed that all except the tailing pond sample exceeded the lead RBC of 750 mg/kg. Sample lead concentrations ranged from 2,500 mg/kg (Level 1 southwest pile) to 38,000 mg/kg (Level 3). Zinc concentrations, although not above the RBC (310,000 mg/kg) were as much as 1,300 times background soil concentrations. Zinc concentrations ranged from 610 mg/kg (Level 1 southwest pile) to 11,000 mg/kg (Level 1 north pile).

TABLE 2-1
Waste Rock and Tailings Samples – XRF Inorganic Analytical Results
(Concentrations in mg/Kg)

Sample ID	EPA Region 3 Risk Based Concentrations (April 7, 2005) (mg/kg)	SM-WR-01	SM-WR-02	SM-WR-03	SM-WR-03D	SM-WR-04	SM-WR-05	SM-WR-06	SM-WR-07	SM-WR-08	SM-WR-09	SM-WR-10	SM-WR-11	SM-WR-12	SM-WR-13
Sample Location	Industrial Soil Standards	Level 99A WR 0-12"	Level 99B WR 0-12"	Level 98 A WR 0-12"	Level 5A WR 0-12"	Level 5B WR 0-12"	Level 4 WR 0-12"	Level 3 WR 0-12"	Level 2 WR 0-12"	Mill Site WR 0-12"	Northeast WR 0-12"	North WR 0-12"	Southwest WR 0-12"	Tailing Pond 0-12"	West WR 0-12"
Arsenic[2]	1.9 C	2,300 U	880 U	800 U	760 U	160 U	6,100 U	3,800 U	770 U	580 U	1,900 U	1,500 U	250 U	460	460 U
Chromium*	1,500,000 N	200 U	200 U	400 J	200 U	260 J	200 U	200 U	200 U	200 U	200 U	200 U	200 U	200 U	200 U
Cobalt	20,000 N	300 U	300 U	300 U	300 U	300 U	300 U	300 U	300 U	300 U	300 U	300 U	300 U	300 U	300 U
Copper	41,000 N	1,500	200 J	630	570	280	6,700	1,900	580	310	1,100	690	190 J	63 U	280
Iron	310,000 N	180,000	70,000	190,000	180,000	100,000	230,000	86,000	73,000	65,000	160,000	130,000	100,000	80,000	82,000
Lead	750 [1]	23,000	8,700	8,000	7,600	1,500	61,000	38,000	7,700	5,800	19,000	15,000	2,500	470	4,600
Manganese	20,000 N	2,400	3,300	4,400	4,800	10,000	1,000	390 J	6,700	630	4,000	9,300	2,000	820	7,000
Mercury	NL	5 U	5.3 J	5 U	5 U	6.9 J	5 U	5 U	5 U	5 U	12 J	5 U	5 U	5 U	5 U
Molybdenum	NL	5.7 U	5.7 U	5.7 U	5.7 U	5.7 U	5.7 U	5.7 U	5.7 U	5.7 U	5.7 U	5.7 U	5.7 U	5.7 U	5.7 U
Nickel	20,000 N	81 U	81 U	99 J	100 J	81 U	96 J	81 U	81 U	81 U	81 U	180 J	81 U	81 U	81 U
Rubidium	NL	210	290	220	210	260	200	250	160	150	210	190	150	76	170
Selenium	5,100 N	55	8.4 U	47	57	13 J	190	69	21 J	8.4 U	51	39	13 J	13 J	12 J
Strontium	NL	93	230	86	79	42 J	48 J	140	44 J	130	65	61	58	17 U	46 J
Zinc	310,000 N	650	410	1,200	1,300	1,800	2,400	810	3,200	660	4,700	11,000	610	820	4,800
Zirconium	NL	410	640	300	240	320	340	460	180	400	270	240	330	130	300

Qualifiers
U The material was analyzed for, but was not detected above the level of the associated value. The associated value is either the sample quantitation limit or the sample detection limit.
J The associated numerical value is an estimated quantity because the Quality Control criteria were not met.

1 Region 9 (October 1, 2002 (Direct Contact Exposure Pathways) http://www.epa.gov/Region9/waste/sfund/prg/index.htm
2 Detection levels are above the Industrial Soil Standards. Analyte may be present in excess of these values.

C Carcinogenic effects
N Noncarcinogenic effect
NL Not Listed
* The EPA Region 3 RBCs benchmarks for chromium in Soil - Industrial and Residential are for Chromium III.
Result exceeds the Region 3 Risk Based Concentration

Region 3 Risk Based Concentration Tables http://www.epa.gov/reg3hwmd/risk/human/rbc/rbc1005.pdf

TABLE 2-2
Waste Rock and Tailings Samples
SPLP Analytical Results
(Concentrations in milligrams per liter (mg/L))

Sample ID		SM-WR-01	SM-WR-02	SM-WR-03	SM-WR-04	SM-WR-05	SM-WR-06	SM-WR-07	SM-WR-08	SM-WR-09	SM-WR-10	SM-WR-11	SM-WR-12	SM-WR-13
SPLP Metals	**TCLP Standards****	**Level 99A WR 0-12"**	**Level 99B WR 0-12"**	**Level 98 A WR 0-12"**	**Level 5A WR 0-12"**	**Level 5B WR 0-12"**	**Level 4 WR 0-12"**	**Level 3 WR 0-12"**	**Level 2 WR 0-12"**	**Mill Site WR 0-12"**	**Northeast WR 0-12"**	**North WR 0-12"**	**Tailing Pond 0-12"**	**West WR 0-12"**
Arsenic	5.0	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Barium	100	0.16	0.05 U	0.14	0.05 U	0.05 U	0.05 U	0.05 U	0.098	0.11	0.05 U	0.05 U	0.05 U	0.05 U
Cadmium	1.0	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.078	0.05 U	0.14	0.33	0.05 U	0.05 U
Chromium	5.0	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U
Copper*		0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.13	0.05 U	0.05 U	0.068	1.1	0.05 U	0.05 U	0.05 U
Lead	5.0	**14**	0.1 U	**11**	**8.7**	0.1 U	**17**	**12**	0.29	**11**	**7.3**	1.8	0.15	0.1 U
Selenium	1.0	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Silver	5.0	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Zinc*		0.21	0.064	1.1	3.1	0.091	1.7	0.99	7.1	1.4	22	53	0.3	1.9

SPLP - Synthetic Precipitation Leaching Procedure
Bold - Exceeds *TCLP* Standard
* Copper and Zinc results were requested in addition to the typical SPLP metals
** TCLP (Toxicity Characteristic Leachate Procedure) Standards (mg/L) Reference: 40 CFR Section 261.2

The samples were also analyzed for Synthetic Precipitation Leaching Procedure (SPLP) (EPA Test Method 1312) in order to determine metals leaching properties (Table 2-2). This test was selected because it is a less aggressive procedure than the Toxicity Characteristics Leaching Procedure (TCLP) test (EPA Method 1311) which is used to determine if a material is a Resource Conservation and Recovery Act (RCRA) hazardous waste. The SPLP test is believed to provide a more realistic representation of leaching properties for materials exposed to natural environmental conditions as opposed to conditions in a landfill that the TCLP test was designed to simulate. Although TCLP standards are not applicable to SPLP results, they are presented in the table to provide a frame of reference for the SPLP results.

The SPLP results showed that zinc and lead were the most common metals with detections. The highest zinc and lead detections were 53 milligrams per liter (mg/L) (Level 1 north pile) and 17 mg/L (Level 4). Based on the total metal and SPLP results, zinc is approximately 10 times more leachable than lead. The higher leachability of zinc is also apparent in Elk Creek samples as discussed in Section 2.6.6.

The flow rates of three adits (Level 1, Level 5, and Level 98) with draining water were measured and samples collected. Flow rates, ranging from 2.7 to 5 gpm, were recorded. Level 1 water had by far the highest metal concentrations. Level 1 water samples exceeded the Coal Creek stream standards for cadmium, copper, iron, lead, manganese, and zinc.

A summary of dam stability inspection findings are presented in Section 4.3.

2.6.5 Wetland and Threatened and Endangered Species Assessment 2006

EPA conducted a wetland and threatened and endangered species assessment during July 2006. The report of this assessment was included in the Phase I EE/CA Report. Six wetland areas totaling slightly over 1 acre within the 26-acre study site were identified and their characteristics documented and described. Wetlands were delineated at Levels 1, 2, 5, and 98. Thirty-two plant species were identified in the wetlands. Three species were found in all six wetlands (White marsh marigold, tufted hairgrass, and arrowleaf

ragwort). Forty-three plant species, some of which are the same, were identified in the wetland perimeter. Two species were identified in the perimeter of all six wetlands (Engelmann spruce and yellow avalanche-lily).

Based on field evaluation, 51 of the nearly 100 threatened and endangered species listed as possibly occurring in Gunnison County and/or the greater Gunnison National Forest have potential habitat in or near the study area. These include 12 bird species, seven mammal species, two amphibian species, two invertebrate species, and 28 plant species. No threatened and endangered species have been observed at the site.

The report provides numerous recommendations for minimizing potential impacts to wetlands and threatened and endangered species.

2.6.6 EPA and Coal Creek Watershed Coalition Sampling Events

Beginning in June 2005, EPA and the Coal Creek Watershed Coalition have conducted sampling events of Elk Creek and Coal Creek and Standard Mine as well as other watershed locations. Approximately 17 locations have been sampled, twice in 2005 and four times in 2006. Samples were analyzed for total and dissolved metals. The 2006 results showed that metals concentrations increased in Elk Creek between the upper (Elk 29) and lower (Elk 10) portions of Level 1 (Table 2-3). The largest exceedances of state of Colorado stream standards were for zinc (3,700 percent) and cadmium (1,700 percent).

Besides impacts due to leaching from and erosion of waste rock the metal load increase observed in this stretch of Elk Creek was also a result of discharge from the Level 1 adit.

TABLE 2-3
Dissolved Metal Concentrations in Elk Creek at the Elk 10 and Elk 29 Sample Locations

	2007 Segment 11 Acute Stream Standard*	Elk 10 Immediately downstream of Level 1			Elk 29 Immediately upstream of Level 1		
		6/20/2006	7/19/2006	9/13/2006	6/20/2006	7/19/2006	9/13/2006
Analyte	(µg/L)	Sample Results (µg/L)			Sample Results (µg/L)		
Cadmium	1.7	17	29	43	0.75 J	1	1.1
Copper	13.4	44	28	47	1.1 J	2.8	1.4 J
Lead	65	66	33	44	4.6	2.3	1
Manganese	2,990	810	1,500	2,300	1 U	2.1 J	1 U
Zinc	143	3,100	4,600	8,200	150	150	210

* Using a hardness of 100 mg/L.
U The material was analyzed for, but was not detected above the level of the associated value.
J The associated numerical value is an estimated quantity because the Quality Control criteria were not met.
µg/L Micrograms per liter.

2.6.7 Waste Volume Estimate

Mine waste volume estimates were calculated using Light Detection and Ranging (LIDAR) data and high-resolution photography collected in 2006. At each mine level, waste rock piles/tailings were separated into visually distinguishable masses and labeled (e.g., Level 1, North Pile) (Figure 2). Waste piles for Level 1 were the same as the previous SAIC designations (northeast, north, west, mill site, and tailing pond).

A two-foot digital elevation model (DEM) was created from LIDAR data. This was done by interpolating LIDAR point data in a Geographic Information System (GIS) into a two-foot mean resolution element (MRE) raster dataset.

Work has not been performed to determine the exact depth of contaminated material associated with each pile. Therefore a method to approximate the elevation of the native soil/waste material contact was necessary. For each waste rock pile, the volume was calculated by taking the average elevation around the base of the waste rock pile (calculated from the DEM). Then, elevations from the top of the pile were measured. To derive waste pile volumes, a roughly paraboloidal form (similar to the shape of a gum-drop) was assumed for each pile. A one-foot over excavation was assumed. Using a volume equation for paraboloids and elevations taken from the top of each waste pile, the

likely estimated waste rock volume was calculated. Volumetric expansion of material due to excavation is not considered for these calculations. Calculated waste volumes are presented below in Table 2-4. For the purposes of this report, the repository will be designed to hold 115 percent of the volume estimate presented here or 80,000 cubic yards. However, both repository locations under consideration have the potential to accept significantly more waste, if needed.

TABLE 2-4
Waste Volume Estimates
Prepared March 2007

Level	Pile Designation	Volume (cubic yards)
1	Northeast Pile	12,000
1	Waste Pile North	7,000
1	West Pile	15,000
1	Mill Site Area	1,000
1	Tailing Pond	16,000
2	A	8,000
3	A	9,000
	Total	**68,000**

3.0 BASELINE ECOLOGICAL RISK ASSESSMENT

3.1 INTRODUCTION

EPA performed a Baseline Ecological Risk Assessment (BERA) to describe the likelihood, nature, and extent of adverse effects to ecological receptors from exposure to contaminants released to the environment as a result of past or present mining activities at the site. This information, along with other relevant information, is used by risk managers to decide whether remedial actions are needed to protect the environment from site-related releases. The BERA report is a draft at the time of this EE/CA preparation. Changes to the final BERA report, if any, that affect this EE/CA will be reflected in the final EE/CA report.

3.2 SITE DESCRIPTION

The Standard Mine site is located in heavily forested mountainous terrain about 10 miles west of the community of Crested Butte. The site is drained by Elk Creek, which flows primarily south

from the site until it joins Coal Creek, which flows eastward toward Crested Butte. Both Elk Creek and Coal Creek are habitat for a variety of aquatic species, including coldwater fish (primarily brook trout) and a variety of benthic macro invertebrates. Vegetation in the vicinity of the site ranges from lush willow and scrub undergrowth in the stream bottoms through aspen, fir, and spruce forests on the mountain slopes to treeless alpine tundra vegetation on the ridge tops. The area is suitable habitat for a wide variety of birds and mammals.

3.3 BASIS FOR CONCERN

Mining activities often result in soil contamination with several types of solid wastes (tailings, ore, and waste rock) that contain elevated levels of a number of metals. In addition, mine adits often serve as a pathway for release of contaminated water into area streams. At this site, there is clear evidence for the presence of tailings and other solid wastes at and around the site, and the main adit at the site has been observed to discharge contaminated water into Elk Creek.

3.4 SCREENING LEVEL ECOLOGICAL RISK ASSESSMENT

Characterization of ecological risks at the site began with the preparation of a screening level ecological risk assessment (SLERA). The purpose of the SLERA was to formulate an initial conceptual model that characterized ecological exposure scenarios of potential concern, to determine which, if any, exposure scenarios may be excluded from further assessment, and to identify data gaps that limit confidence in the initial risk characterization. The SLERA identified the following exposure pathways as the primary means by which ecological receptors might be impacted by contaminants released from the site into the environment:

- Direct contact of fish and benthic invertebrates with surface water;
- Direct contact of benthic invertebrates with sediment;
- Direct contact of terrestrial plants and soil invertebrates with on-site soil; and
- Ingestion of on-site soil, surface water, and food items by birds and mammals.

Each of these exposure pathways was evaluated in the SLERA using the data that were available at that time, and using simplified and conservative approaches. The SLERA found that none of the exposure scenarios listed above could be excluded from further evaluation except for ingestion of on-site water by birds and mammals.

3.5 APPROACH USED IN THE BERA

Based on the results of the SLERA, the BERA performed a more detailed assessment of each of the exposures scenarios that were retained, using new data that were collected by EPA to support the assessment. Whenever possible, the assessment considered the findings from three alternate approaches for risk characterization:

- Hazard Quotients (HQs);
- Site-specific toxicity tests; and
- Observations of population and community demographics.

Because each of these approaches has advantages and limitations, final conclusions were based on a weight of evidence consideration of all of the available data.

3.6 RISK EVALUATION FOR AQUATIC RECEPTORS

Aquatic receptors living in Elk Creek and Coal Creek may be exposed to site-related contaminants through two main pathways:

- Direct contact with chemicals in surface water. This pathway is applicable to fish and to benthic organisms that reside in the uppermost portion of the sediment substrate or the water column.

- Direct contact with chemicals in sediment. This pathway is most applicable to benthic invertebrate species that live within the sediment substrate.

The findings for each of these media are summarized below.

3.6.1 Evaluations of Risks to Aquatic Receptors from Surface Water

Three lines of evidence were evaluated to assess the potential effects of contaminated surface water on aquatic receptors.

- The Hazard Quotient (HQ) approach identified numerous chemicals (cadmium, copper, lead, manganese, and zinc) that yielded HQ values in a range of potential

concern. Highest values were observed in Elk Creek. For Coal Creek immediately downstream of the confluence with Elk Creek, HQ values were lower than in Elk Creek, but several chemicals continued to be above a level of concern for acute and/or chronic exposures.

- Site specific surface water toxicity tests performed using rainbow trout fry showed high mortality (60 percent to 100 percent) for waters collected from Elk Creek. The highest mortality (100 percent) was observed at the upstream stations closest to the mine, and there was a tendency for a slight decrease in mortality with increasing distance from Standard Mine. Fish exposed to water from Coal Creek immediately downstream of the confluence with Elk Creek showed low mortality, and this level of mortality was not different than that observed in Coal Creek just upstream of Elk Creek. This suggests that waters from Elk Creek are sufficiently diluted by Coal Creek and that site-related contaminants have only a minimal impact on the survival of fish in Coal Creek.

- Fish surveys performed along Elk Creek indicate that some fish are present at the mouth of the creek (possibly immigrants from Coal Creek), but that there are no fish present at stations above the mouth. This observation supports the conclusion that water in Elk Creek is toxic to fish. Fish density and biomass appear to be generally similar in Coal Creek above and below the confluence with Elk Creek. This suggests that fish in Coal Creek are not strongly impacted by releases from Elk Creek.

Based on these three lines of evidence, the conclusions regarding risks to aquatic receptors from contaminants in surface water are as follows:

- Mining-related releases from Standard Mine into surface water are substantially toxic to fish in Elk Creek.

- Water discharged from Elk Creek into Coal Creek elevates concentrations of metals in Coal Creek but this appears to have only minimal to moderate toxicity to fish.

3.6.2 Evaluations of Risks to Benthic Invertebrates from Sediment

Four lines of evidence were evaluated to assess the potential effects of contaminated sediments on benthic macro invertebrates.

- An HQ approach based on measurements of metals in bulk sediment in Elk Creek identified a number of chemicals with HQ values in a range of concern, including cadmium, copper, lead, silver, and zinc. For Coal Creek immediately downstream of the confluence with Elk Creek, HQ values were lower than in Elk Creek, but a number of chemicals had HQ values that remained in a range of concern.

- An HQ approach based on measurements of metals in sediment pore water in Elk Creek identified a number of chemicals with HQ values in a range of concern, especially cadmium and zinc. In Coal Creek just downstream of the confluence with Elk Creek, pore water-based HQ values remained elevated for most chemicals, but the magnitude of the exceedences was generally low.

- Site-specific sediment toxicity tests using a small freshwater crustacean (*Hyalella azteca*) revealed very high (98 percent to 100 percent) mortality for all Elk Creek locations tested. Toxicity test results for Coal Creek immediately downstream of the confluence with Elk Creek showed low mortality that was similar to that seen in Coal Creek upstream of Elk Creek, suggesting that sediments from Elk Creek are not having a clear effect on benthic invertebrates in Coal Creek.

- Benthic macroinvertebrates surveys performed by EPA in 2005 and 2006 reveal decreased density and diversity of organisms in Elk Creek compared to a reference station, especially in the upper reaches of Elk Creek just below the mine. When the benthic community data are adjusted for habitat factors, observations in Elk Creek indicate that the benthic communities are of lower quality than expected based on habitat factors alone, indicating a probable effect of water and/or sediment contamination from Standard Mine. For Coal Creek, the results suggest a slight impairment to the benthic community, but less than in Elk Creek.

Based on these multiple lines of evidence, it is concluded sediments in Elk Creek are likely to have significant adverse effects on benthic organisms residing in the sediment, but that hazards are lower and of lesser concern in Coal Creek.

3.7 RISK EVALUATION FOR PLANTS AND SOIL INVERTEBRATES

The plant and soil invertebrate community are important components of any ecosystem because they provide a significant portion of the energy, organic matter, and nutrient inputs for terrestrial systems as well as providing habitat and forage for a variety of wildlife species. Terrestrial plants and soil invertebrates are good indicators of soil condition because they reside directly in the soil and are not mobile.

EPA collected an extensive set of soil samples from the Standard Mine site, and these samples were used to assess risks to plants and soil invertebrates using the HQ approach. Site-specific toxicity tests and community surveys are not available.

Based on the HQ approach, there are a number of metals in on-site soils that are of potential concern for plants and/or soil invertebrates, including aluminum, arsenic, cadmium, chromium, copper, lead, iron, manganese, selenium, silver, vanadium, and zinc. Based on very limited data, levels of some of these chemicals (aluminum, chromium, iron, and vanadium) may not be different from background.

These predictions of risk to plants and soil invertebrates must be interpreted with caution, for two reasons. First, data on the concentrations of metals in soil that cause toxicity to plants and soil invertebrates are usually based on laboratory studies in which soluble forms of test metals are added to test soils. Thus, these values do not account for occurrence of metals in mineral forms that are largely insoluble and do not contribute as much toxicity as soluble forms. Second, because only one line of evidence is available, other lines of evidence (site-specific toxicity tests and/or community surveys) would be needed to further clarify the actual risks from site-related contaminants to plants and soil invertebrates.

3.8 RISK EVALUATION FOR BIRDS AND MAMMALS

Birds and mammals that reside on or near the Standard Mine site may be exposed by three pathways: 1) ingestion of contaminated food items, 2) incidental ingestion of soil or sediment while feeding, and 3) ingestion of on-site surface waters.

Only one line of evidence (the HQ approach) is available for assessment of risks to birds and mammals from these pathways. This approach was used to assess risks to a number of different receptors, each selected to represent a feeding guild that might occur at the site (Table 3-1). This included:

TABLE 3-1
Representative Species

Feeding Guild	Representative Avian Species	Representative Mammalian Species
Aerial and/or Terrestrial Insectivores	Cliff Swallow Northern Flicker	Big Brown Bat Masked Shrew
Aquatic Insectivores	American Dipper	
Herbivores	Greater-Sage Grouse	Mule Deer
Omnivores	American Robin	Deer Mouse
Piscivores	Belted Kingfisher	
Carnivores	Red-tailed Hawk	Red Fox Lynx

As noted above, EPA collected an extensive data set for on-site soils, and also collected and analyzed a number of samples of plants, benthic invertebrates and fish for use in estimating dietary exposure of various receptors. Data on contaminant levels in tissues were not collected for soil invertebrates or small mammals, so tissue concentrations for these food categories were estimated using mathematical models.

In this case, two different types of HQ values were calculated. The first type is based on the No-Observed-Adverse-Effect-Level (NOAEL), which is an estimate of the highest daily dose of a chemical that may be ingested without any unacceptable adverse effect occurring. The second type is based on the Lowest-Observed-Adverse-Effect-Level (LOAEL), which is an estimate of the lowest ingested daily dose that is likely to result in an observable adverse effect. If an HQ is below 1 based on the NOAEL TRV, it is believed that risks are minimal. If the HQ is above 1

based on the LOAEL TRV, it is considered likely that some adverse effects will occur. If the HQ is above 1 based on the NOAEL and below 1 based on the LOAEL, it is considered that adverse effects are possible, but they are likely to be minor in extent and/or severity.

Many receptors (cliff swallow, dipper, sage grouse, kingfisher, red-tailed hawk, mule deer, fox, lynx, and bat) have no significant HQ exceedences based on either the NOAEL- or LOAELbased TRV. This indicates that risk to these receptors from site-related contaminants is likely to be minimal. There are four receptors (robin, flicker, shrew, and mouse) that have NOAEL-based HQ values above 1 for multiple chemicals. These elevated HQ values are attributable to intake of contaminants is soil and/or diet (terrestrial invertebrates), with no significant contribution from surface water. However, in nearly all cases, LOAEL-based HQ values did not exceed 1. These results indicate that the magnitude and/or severity of any adverse effects on these four receptors is likely to be low to moderate.

These conclusions regarding risks to birds and mammals must be interpreted with caution, since calculations of exposure require a number of assumptions and approximations, and toxicity data are limited for many of the receptor types included in the assessment. In particular, HQ values may be overestimated for receptors with a high intake of soil and/or a high dietary intake of terrestrial invertebrates (e.g., robin, flicker, shrew and mouse), since conservative assumptions were employed in estimating intake and absorption from these pathways. In addition, because only one line of evidence is available, other lines of evidence (site-specific toxicity tests and/or community surveys) would be needed to further clarify the actual risks from site-related contaminants to birds and mammals.

4.0 REMOVAL ACTION OBJECTIVES, ARARS, AND SCOPE

4.1 REMOVAL ACTION OBJECTIVES

Based on the results of the Ecological Risk Evaluation the following Removal Action Objectives (ROAs) have been identified:

1. Reduce human and ecological exposure to metals by reducing metals loading from site soils and tailings.

2. Reduce metals loading and risk to aquatic life in Elk Creek from surface water runoff and leaching from waste rock piles and tailings into Elk Creek.

3. Reduce erosion of tailings and waste rock to Elk Creek, Coal Creek and the Crested Butte drinking water supply.

4. Eliminate the threat of a catastrophic failure of the tailings impoundment by removing the material/structure.

4.2 ARARS

Section 121(d)(2) of CERCLA of 1980, 42 USC 9621(d)(2), requires that cleanup actions conducted under CERCLA achieve a level or standard of control that at least attains "any standard, requirement, criteria, or limitation under any federal environmental law...or any (more stringent) promulgated standard, requirement, criteria or limitation under a state environment or facility siting law...(which) is legally applicable to the hazardous substance of concern or is relevant and appropriate under the circumstance of the release of such hazardous substance or pollutant, or contaminant..." The standards, requirements, criteria, or limitations identified pursuant to this section are commonly referred to as "applicable or relevant and appropriate requirements (ARARs)" (EPA 1986)

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

ARARs are divided into contaminant-specific, location-specific, and action-specific requirements. Contaminant-specific requirements govern the release of materials possessing certain chemical or physical characteristics, or containing specific chemical compounds into the environment. Contaminant-specific ARARs generally set human or environment risk-based criteria and protocol which, when applied to site-specific conditions, result in the establishment of

numerical action values. These values establish the acceptable amount or concentration of a chemical that may be found in, or discharged to, the ambient environment.

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

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

As provided by Section 121 of CERCLA, 42 USC 9621, only those state standards that are more stringent than any federal standard and that have been identified by the state in a timely manner are appropriately included as ARARs. Some state standards that are potentially duplicative of federal standards may be identified to ensure their timely identification and consideration in the event that these standards are not identified or retained in the federal ARARs.

The Colorado Department of Public Health and Environment (CDPHE) submitted potential state and federal ARARs for mine removal sites to EPA. Each list contains in excess of 80 ARARs. These lists were reviewed and only regulations that are applicable or relevant and appropriate are presented in this report. The retained ARARs are presented in Table 4-1.

4.2.1 ARARs for Standard Mine

The Colorado Noise Abatement Act regulates the maximum permissible noise levels for specific time periods and land use zones. The Removal Action will comply with this regulation by performing work during time periods in which the noise generated by equipment performing the removal actions is permissible.

Colorado Water Quality Regulations (5 CCR 1002) regulate discharge of substances into state waters. Portions of this regulation that are applicable to the Removal Action include stream standards, anti-degradation requirements, and stormwater discharge prevention.

This Removal Action is intended to reduce or eliminate discharge of site contaminants and sediment to state waters that currently occurs due to erosion and leaching of mine waste located at the site; therefore, implementation of the Removal Action complies with these regulations. The Removal Action will be conducted in a manner to also comply with the regulations during construction. During the Removal Action, measures to reduce discharge of site contaminants to Elk Creek will be implemented. Measures that may be employed include channelization or piping of site waters around removal locations, stormwater controls (to be included in a site-specific Stormwater Management Plan), and other best construction practices.

Colorado Solid Waste Regulations (6 CCR 1007-2) were considered for the Standard Mine Removal Action. Hazardous waste regulations do not apply. The Removal Action includes construction of an on-site mine waste repository and excavation and transportation of site mine wastes to the repository. Additionally, Federal Solid Waste Regulations were also considered. In order to meet the intent of these regulations:

- The repository will be sited such that it will not restrict the flow of base flood, reduce the temporary water storage capacity of the floodplain, or result in a washout of solid waste, so as to pose a hazard to human life, wildlife, or land or water resources. The repository will be sited outside of the floodplain and in a location to minimize impact to human health and the environment.

- No endangered or threatened species of plants, fish, or wildlife, or critical habitat of endangered or threatened species are known to exist in the area where the removal action is to occur or where the repository will be sited. A survey of site species is currently underway.

- The facility will not cause a discharge of pollutants into waters of the United States that is in violation of the requirements of the National Pollutant Discharge Elimination System (NPDES).

- The repository will not discharge dredged or fill material to waters of the state that is in violation of the requirements under section 404 of the Clean Water Act.
- The repository will be located as not to cause non-point source pollution of state

waters. The Removal Action will reduce, not increase, non-point source loading of contaminants to the waters of the state.

- The repository will not result in a point source discharge to waters of the state.

- The Removal Action will not adversely impact a protected groundwater aquifer or drinking water source.

- The Removal Action will be performed in a manner that will not result in a discharge of dredged or fill material to waters of the state.

- Materials placed in the repository will not increase the populations of disease vectors such as rodents, flies, or mosquitos.

- Public safety requirements will be met by covering the repository so the public is not exposed to potential health and safety hazards. Site access will be restricted during the Removal Action.

- An environmental covenant, or similar instrument, will be implemented between the State with the USFS to insure that the repository and repository cover will remain in tact in perpetuity.

The Fish and Wildlife Coordination Act requires coordination with federal and state agencies on activities affecting/modifying streams or rivers if the activity has a negeative impact on fish or wildlife. The trustees will be be given the opportunity to provide input regarding the Removal Action. The USFS has participated in Removal Action planning. The Endangered Species Act requires protection of species identified as threatened or endangered. No endangered or threatened species of plants, fish, or wildlife, or critical habitat of endangered or threatened species as identified in 50 CFR part 17 are known to exist in the area where the removal action is to occur or where the repository will be sited. A site survey to identify species that may require protection is being planned to ensure that preliminary indications are accurate.

Protection of floodplains regulations regulate actions that will occur in a floodplain.

Actions must avoid adverse effects, minimize potential harm, and restore and preserve natural and beneficial values. The Removal Action will occurr adjacent to waters of the U.S.; however, the result of the removal action will reduce adverse effects of the existing mine waste and restore natural and beneficial uses. Work will be performed in a manner to minimize the short-term impacts of the Removal Action.

Applicable to this removal action are regulations governing discharges of treated water to surface waters of the State. It is anticipated this Removal Action will include treatment and discharge of a small volume of water removed from subsurface tailings material to Elk Creek. Raising the pH of the water causes the dissolved metals to precipiate. To the extent practicable EPA will comply with these regulations.

TABLE 4-1
Retained Applicable and Relevant and Appropriate Requirements

REGULATION	CITATION	COMMENTS	TYPE OF ARAR	RATIONALE
Colorado Water Quality Control Regulations 5 CCR 1002	5 CCR 1002-31	Substances which form harmful surface material or detrimental bottom deposit, create a nuisance or harm beneficial use, are toxic to humans, produce predominance of undesirable aquatic life, or cause film or shoreline deposit, shall not be introduced into state waters. Basic standards, anti-degradation rule, implementation process, and system for classifying surface water, assigning water quality standards and review of classifications and standards.	Chemical-Specific	Relevant and Appropriate for Anti-degradation standard. The Removal Action will be implemented such that no further degradation to the ambient water quality of Elk Creek and/or Coal Creek occurs. Measures such as sediment controls and other best management practices will be implemented to ensure the removal action will not result in increased sedimentation to downstream areas.
	5 CCR 1002 - 35	Colorado Classification and Numeric Standards for the Upper Gunnison River Basin, River segments 11 and 12 as amended January 1, 2007.	Chemical-Specific	Applicable for current numeric standards for Elk Creek and Coal Creek immediately downstream of the Elk Creek confluence (Segment 11), and for Coal Creek immediately downstream of the Crested Butte Water Supply intake (Segment 12). There are temporary modifications for cadmium, chronic (2.3 µg/L) and zinc, chronic (518 µg/L). Modifications are effective until 12/31/2011. After that date, the modification may be deleted or renewed.
	5 CCR 1002-61	Implementation of the Colorado Water Quality Control Act, and applies to operations discharging to waters of the state from a point source.	Action-Specific	Applicable for water discharges. The Removal Action will likely be treating water removed from the subsurface tailings material and discharging to Elk Creek; this work will be done in accordance with this regulation to the extent practicable.
	5 CCR 1002-62	Stormwater Discharge Regulations - Regulates discharge of stormwater during construction.	Action-Specific	Applicable. Implementation of best management practices for sediment control will be performed to comply with the intent of this regulation.
Colorado Noise Abatement Statute	CRS 25-12-103	Provides limits for noise based on time periods and zones.	Action-specific	Applicable
Colorado Solid Waste Disposal Sites and Facilities Act	6 CCR 1007-2	Regulations applicable to solid waste disposal units.	Action-specific	Part B Section 3 is TBC, all other parts are Not Applicable (NA).
Fish and Wildlife Coordination Act	40 CFR Section 6.302(g)	Requires coordination with federal and state agencies to provide protection of fish and wildlife.	Location-specific	Applicable. The U.S. Fish and Wildlife Service, U.S. Forest Service, and other trustees have participated in planning and/or commented on plans for the Removal Action.

TABLE 4-1
Retained Applicable and Relevant and Appropriate Requirements

REGULATION	CITATION	COMMENTS	TYPE OF ARAR	RATIONALE
Endangered Species Act	50 CFR Parts 17 and 402 40 CFR Section 6.302(b)	Regulates the protection of threatened and endangered species.	Location-specific	Threatened and endangered species have not been identified at this site; however, a survey will be conducted to support this conclusion.
Colorado Wildlife, Non-game, Endangered and Threatened Species Act	CRS 33-2-101 to 108	Regulates non-game wildlife and threatened and endangered species	Location-specific	Relevant and appropriate for activities that affect the habitat of game and non-game species. These species have not been identified on the Standard Mine site; however, a survey will be conducted to support this conclusion.
Executive Orders No 11988 and 11990	40 CFR Section 6.302 and Appendix A	Regulates construction in floodplains and minimizes allowable impacts to wetlands.	Location-specific	TBC – the repository was sited such that it was not located in a floodplain.
Colorado Water Quality Control Regulations 5 CCR 1002	5 CCR 1002-31	Substances which form harmful surface material or detrimental bottom deposit, create a nuisance or harm beneficial use, are toxic to humans, produce predominance of undesirable aquatic life, or cause film or shoreline deposit, shall not be introduced into state waters. Basic standards, anti-degradation rule, implementation process, and system for classifying surface water, assigning water quality standards and review of classifications and standards.	Chemical-Specific	Relevant and Appropriate for Anti-degradation standard. The Removal Action will be implemented such that no further degradation to the ambient water quality of Elk Creek and/or Coal Creek occurs. Measures such as sediment controls and other best management practices will be implemented to ensure the removal action will not result in increased sedimentation to downstream areas.
	5 CCR 1002 - 35	Colorado Classification and Numeric Standards for the Upper Gunnison River Basin, River segments 11 and 12 as amended January 1, 2007.	Chemical-Specific	Applicable for current numeric standards for Elk Creek and Coal Creek immediately downstream of the Elk Creek confluence (Segment 11), and for Coal Creek immediately downstream of the Crested Butte Water Supply intake (Segment 12) . There are temporary modifications for cadmium, chronic (2.3 µg/L) and zinc, chronic (518 µg/L). Modifications are effective until 12/31/2011. After that date, the modification may be deleted or renewed.

4.3 REMOVAL ACTION SCOPE

EPA determined that the waste rock and tailings present at Levels 1, 2, and 3 require removal because of the instability of the tailing dam and surface erosion and leaching of waste rock into Elk Creek or into drainages that may discharge into Elk Creek. The stability issues associated with the tailing dam were documented in the 2005 Inspection Report and are as follows (UOS 2006a):

1) Inadequate spillway;
2) Location in the Elk Creek drainage;
3) Inadequate freeboard;
4) High phreatic surface;
5) Unknown internal geometry;
6) Nonexistent design/construction documentation;
7) No instrumentation (piezometers, movement monuments; and
8) No inspection records.

Metal concentrations and metal leaching properties of the tailings waste rock were evaluated during the October 2005 EPA sampling event. Composite surface samples were collected from waste rock units and subjected to SPLP analysis. Results presented in Section 2 indicate that measurable quantities of zinc, cadmium, copper, and lead leach from the waste rock. Evidence of erosion of waste material into Elk Creek is visually apparent and was confirmed during EPA sampling of Elk Creek sediment.

EPA determined that waste rock piles and tailings at Levels 1, 2, and 3 will be addressed because of their proximity to Elk Creek and drainages near Elk Creek. Waste rock piles at Levels 4, 5, 98, and 99 are located near sensitive wetland areas. EPA determined that access road improvement to these areas and waste excavation and hauling would result in greater environmental disturbance than is believed warranted given the size and location of the piles. Wastes present at Levels 4, 5, 98, and 99 will be addressed as part of the RI/FS process.

As described in the 2002 EE/CA prepared for USFS (mentioned in Section 2.6), the construction of an on-site cell for waste materials was determined to be the most feasible, implementable, and cost-effective alternative for addressing the impacts from mine wastes. EPA concurred with this

conclusion and proceeded with an evaluation of potential repository sites in a Phase I EE/CA for the Standard Mine site (URS Corporation (URS) 2007). EPA considered consolidating the tailings and waste rock into a repository at Level 1. This alternative would offer the advantage of 1) short haul distance; 2) minimal disturbance of additional site land; and 3) potential cost savings. The disadvantages of this location documented in the Phase I EE/CA involve 1) the presence of numerous springs and wet areas in the prospective repository area, and 2) the small area available. It is based on this information/data that EPA has determined that the construction of a repository at Level 1 was not feasible.

Nine additional sites were evaluated in the Phase I EE/CA. These sites were identified as follows:

Area 69, Area 99, Area 225, Area 245, Area 361, Standard Mine Level 2, USFS Site 1, USFS Site 2, and the Lucky Jack Tailing Impoundment. EPA considered input provided by the stakeholders, including nearby landowners, the Standard Mine Advisory Group, USFS, and CDPHE; information from all parties was considered throughout the EE/CA process. EPA determined that the Area 245 and USFS Site 2 locations merited further evaluation. Capping alternatives and these two potential repository locations are evaluated in Sections 5 and 6.

Based on the discussion above, the scope of the removal action will include the following:

- Preparation of the selected repository site including tree removal, grading, and run-on/ runoff control;
- Improvement of the haul roads as necessary;
- Preparation of the subsurface tailing impoundment by drying and/or mixing with other waste material;
- Excavation and transportation of tailings and waste rock to the repository;
- Placement of waste materials into the repository according to the engineering design using a 3H:1V slope (slope being identified by the abbreviation 3H:1V is defined as a

slope with a 33 percent grade or one that has a change in grade of three feet horizontal for every vertical foot.);

- Development of a source of cover soil at the USFS Site 1 location;
- Placement of cap materials on the tailings and waste rock;
- Grading of Levels 1, 2, and 3 excavated areas so that erosion is minimized; and
- Reclamation of the excavated areas. This work has not has not yet been scoped/designed but will generally include revegetation of the excavated areas and stream restoration and will be coordinated with the Federal Land Manager and the state. This work may begin in 2007 and be finished in 2008 depending on the removal progress.

4.4 REMOVAL SCHEDULE

EPA plans to commence removal work as soon as practical during the 2007 field season. Road conditions and how much snow has melted are factors that determine when the site is accessible and work will begin. Because the 2006-07 winter was relatively mild, it is anticipated that mobilization will occur by the middle of June and that the 2007 field season scope of work will be completed by the end of September. EPA's removal contractor will prepare a detailed work schedule prior to the start of work. Depending on when excavation is completed, revegetation work may occur in 2008.

5.0 COVER ALTERNATIVES

This Section presents and discusses cover alternatives selected for the Standard Mine Waste Rock Repository and provides an evaluation of the repository cover alternatives. The evaluation of the cover alternatives considers the effectiveness of the cover to protect human health and environment, the ability to implement and construct the cover alternative, and the cost to construct the cover, and the cost of long-term operations and maintenance for the cover after construction. Costs to excavate and haul waste to the repository and to perform reclamation activities are not considered in this section. Based on the evaluation of the cover alternatives a preferred alternative is selected.

5.1 SELECTION CRITERIA

The cover alternatives selected were based on the following:

- Availability of construction materials;
- Relative proximity of construction materials;
- Ability to construct the cover;
- Construction complexity;
- Performance of the cover alternatives;
- Time to construct the cover;
- Disturbance to surrounding terrain;
- Long-term operations and maintenance of the final cover;
- Visual aesthetics; and
- Technical feasibility.

Four alternatives were evaluated to provide a range of cover alternatives that could be constructed utilizing locally available construction materials and synthetic construction materials. A description of these cover alternatives is included in Section 5.2.

5.2 DESCRIPTION OF ALTERNATIVES

Four cover alternatives were selected for the closure of the repository. These alternatives were identified and developed to provide a basis for comparison of the effectiveness, implementability, and cost to construct, operate, and maintain each of the cover alternatives. The four cover alternatives selected for consideration and evaluation are presented on Figure 4 and summarized below.

- Alternative 1 – Soil Cover with Vegetation: This cover alternative consists of a 12-inch-thick compacted soil cover, overlain by a 6-inch-thick layer of amended soil growth medium, for a total cover thickness of 18 inches. The compacted soil cover would be constructed with material taken from the USFS Site 1, screened to remove particles greater than three inches in diameter. The growth medium would consist of material stripped from the repository

location prior to construction and augmented with screened material from USFS Site 1, if necessary. The growth medium would be amended with soil amendments (organic and inorganic) to assist in the establishment of vegetation and would be vegetated with native grasses. Cross-slope channels would be constructed into the cover to reduce the impacts due to erosion and to carry water off the soil cover. The cross-slope channels would be lined with riprap to reduce the potential for erosion from concentrated flows within the channel.

- Alternative 2 – Soil Cover with Riprap: This cover alternative consists of a 12-inch-thick compacted soil cover, overlain by a 12-inch-thick layer of riprap, for a total cover thickness of 24 inches. The compacted soil cover would be constructed with material taken from USFS Site 1, screened to remove particles greater than three inches in diameter. The riprap would be constructed from oversized material stripped from the repository location prior to construction, oversized material screened out of the soil cover material, and augmented with riprap material from Area 99, if necessary.

- Alternative 3 – Geomembrane Cover with Vegetation: This cover alternative consists of a 12-inch-thick compacted soil cover, overlain by a 60-mil geomembrane, overlain by a geonet drainage blanket with geotextile on two sides, overlain by a 12-inch-thick protective soil cover, overlain by a 6-inch-thick layer of amended soil growth medium, for a total cover thickness of 30 inches. The compacted soil cover would be constructed with material taken from the USFS Site 1, screened to remove particles greater than three inches. The geomembrane and geonet drainage blanket would be purchased from a geosynthetic manufacturer and delivered to the site for placement. The protective soil would consist of material taken from USFS Site 1, screened to remove particles greater than 6 inches. The growth medium would consist of material stripped from the repository location prior to construction and augmented with screened material from USFS Site 1, if necessary. The growth medium would be amended with soil amendments (organic and inorganic) to assist in the establishment of vegetation and would be vegetated with native grasses. Cross-slope channels would be constructed into the cover to reduce the effects of erosion and to carry water off the soil cover. The cross-slope channels would be lined with riprap to reduce the potential for erosion from concentrated flows within the channel.

- Alternative 4 – Geomembrane Cover with Riprap: This cover alternative consists of a 12-inch-thick compacted soil cover, overlain by a 60-mil geomembrane, overlain by a geonet

drainage blanket with geotextile on two sides, overlain by a 12-inch-thick protective soil, overlain by a 12-inch layer of riprap, for a total cover thickness of 36 inches. The compacted soil cover would be constructed with material taken from USFS Site 1, screened to remove particles greater than three inches. The geomembrane and geonet drainage blanket would be purchased from a geosynthetic manufacturer and delivered to the site for placement. The protective soil would consist of material taken from USFS Site 1, screened to remove particles greater than six inches. The riprap would be constructed from oversized material stripped from the repository location prior to construction, oversized material screened out of the soil cover material, and augmented with riprap material from Area 99.

5.3 COVER THICKNESS CONSIDERATIONS

For Alternatives 1 and 3, the thickness of the compacted soil cover was selected based on the cost of construction versus the relative level of protection against vertical infiltration gained by constructing a compacted soil cover with a greater thickness. A compacted soil cover with a thickness of 36 inches could have an estimated cost of approximately three times that of the 12-inch compacted soil cover. However, the level of protection, measured by the volumetric rate of infiltration, would have decreased only a small amount. The estimated cost of constructing a compacted soil cover greater than 12 inches out-weighs the benefit one might expect to receive from a layer of material with a greater thickness. The 12-inch compacted soil cover does not pose constructability issues and can be constructed in a single construction season.

For Alternatives 1 and 3, the depth of the growth medium was selected based on the depth of the existing growth medium encountered during test investigation and the approximate depth of root penetration in the vicinity of the potential repositories (URS 2007).

For Alternatives 3 and 4, the compacted soil cover acts as a barrier and a smooth base for the deployment of the geomembrane. The 12-inch thickness was selected based on the potential protrusion height of the graded waste rock. One of the functions of the compacted soil cover is to protect the geomembrane from puncture by the waste rock. The actual depth of the compacted soil cover may vary by location, depending on the actual shape and protrusion height of the waste rock. The minimum thickness of the compacted soil cover was estimated to be 12 inches.

For Alternatives 3 and 4, the thickness of the protective soil cover was selected based primarily on the constructability and the relative level of protection of the geosynthetics offered by a layer of material with a greater thickness. Thicknesses less than 12 inches are generally more difficult

to construct and provide a reduced level of protection to the geosynthetics. The estimated cost of constructing a protective soil layer greater than 12 inches out-weighs the benefit one might expect to receive from a layer of material with a greater thickness.

For Alternatives 2 and 4, the thickness of the riprap cover was selected based on the cost of construction versus the relative level of protection against erosion gained by constructing the riprap with a greater thickness. A riprap thickness of 24 inches could have an estimated cost of approximately two times that of the 12-inch riprap cover. However, the level of protection, measured by the volumetric rate of soil loss and potential erosion, would have decreased only a small amount. The estimated cost of constructing a riprap finish greater than 12 inches out-weighs the benefit one might expect to receive from a layer of material with a greater thickness. The actual depth of the riprap may vary by location, depending on the actual size but the minimum thickness of the riprap was estimated to be 12 inches.

5.4 COVER EVALUATIONS

Infiltration and slope stability analyses were performed to evaluate each of the cover alternatives. The infiltration analyses were conducted to estimate the amount of water (resulting from precipitation) that could percolate through the cover and provide a source of leachate. The stability of the cover was evaluated to confirm that the proposed cover alternatives would be stable and not subject to sliding. The results of these analyses were used to compare the effectiveness and implementability of each of the cover alternatives. The following describes the aforementioned analyses and the results of these evaluations.

Infiltration Analyses (HELP Model Description)

Four different cover alternatives were evaluated using the Hydrologic Evaluation of Landfill Performance (HELP) model developed by the EPA (Schroeder *et al* 1994). The HELP model was designed to evaluate the infiltration potential of typical landfills, and requires input data regarding facility design specifications, soil and waste characteristics, and climatic data. Facility design specifications include facility area, evaporative zone depth, anticipated vegetative cover, and Soil Conservation Survey (SCS) runoff Curve Number. Soil and waste characteristics include repository layer types and material properties consisting of porosity, field capacity, wilting point, and saturated hydraulic conductivity. Climatic information required for the model includes wind speed, relative humidity, precipitation, temperature, and solar radiation values.

The climatic data required for the HELP model may be provided using one of the following methods: 1) historical climatic records for numerous U.S. cities are stored within the HELP model and may be used directly; 2) site-specific information may be input directly into the model if a large historical record of site-specific information is available; and 3) a site-specific climatic record may be synthetically generated from weather patterns stored within the HELP model for numerous U.S. cities, adjusted for site-specific average monthly temperature and precipitation values.

The following sections present climatic, soil, facility design, and cover geometry inputs to the HELP model. Using this input data, the HELP model was used to estimate infiltration through cover Alternatives 1 through 4.

Evaluation

Site-specific climate information (method 2) was used for the HELP infiltration analyses. Precipitation data from Aspen, Colorado, were used in the analyses. The weather data from Aspen were used because no data were available for the Standard Mine site or surrounding area and were assumed to be most similar to the weather conditions at the mine location. A total of five years of weather data were used,. from January 2002 to December 2006. These data include average daily temperatures, daily precipitation, average relative daily humidity, and the start and end of growing seasons based on the average daily temperature. The average wind speed was extrapolated from wind speed data obtained for Aspen, Colorado, and was estimated to be six miles per hour. Solar radiation data were not available for the Standard Mine site or the surrounding area, therefore solar radiation data were synthetically generated using the aforementioned weather data and coefficients for Denver, Colorado, which was the closest geographical location with available data.

The leaf area index (LAI) is the dimensionless ratio of the leaf area of actively transpiring vegetation to the nominal surface area of the land on which the vegetation is growing. The LAI can range from zero (bare ground) to 5 (excellent stand of grass). A leaf area index of 1.0 (poor stand of grass) was chosen for evapotranspiration.

The evaporative zone depth (EZD) is the maximum depth at which water may be removed by evapotranspiration. An EZD of eight inches was used for the vegetative support material in cover

Alternatives 1 and 3. An EZD of one inch was used for the riprap material in cover Alternatives 2 and 4.

The properties for the cover materials are based on laboratory test results of on-site borrow materials obtained from USFS Site 1 and typical values for geosynthetic products (URS 2007). The USFS Site 1 is located west of the FS 732 access road and is not forested (Figure 3). USFS Site 1 samples were collected during 2006 test pit investigations of potential repositories and were analyzed for Atterberg Limits, Proctor Compaction Test, and Sieve Test, the results of which are given in the Final Phase I EE/CA. The resulting material properties used in the HELP infiltration analyses are summarized in Table 5-1.

TABLE 5-1
Summary of Material Properties Used in HELP Infiltration Analyses

Material	HELP Default Material Description (USCS Classification when applicable)	Porosity (vol/vol)	Field Capacity (vol/vol)	Wilting Point (vol/vol)	Saturated Hydraulic Conductivity (cm/sec)
Compacted Soil	SC	0.365	0.305	0.202	2.7×10^{-5}
Amended Soil Growth Medium	SM	0.453	0.190	0.085	7.2×10^{-4}
Protective Soil	ML	0.419	0.307	0.180	1.9×10^{-5}
Geonet	Drainage Net (0.5 cm thick)	0.850	0.010	0.005	1.0×10^{1}
HDPE Geomembrane	HDPE	0.000	0.000	0.000	2.0×10^{-13}
Riprap	Gravel	0.397	0.032	0.013	1.0

The following additional information was used to estimate the infiltration through each of the cover alternatives, as appropriate:

- Two different scenarios were evaluated having slope lengths at two percent across the top of the repository of 200 feet and 300 feet, and having side slope lengths at 3H:1V of 300 and 350 feet. These two scenarios represent the maximum slope lengths for the repository if constructed at USFS Site 2 or Area 245, respectively.

- Initial moisture contents were estimated by the HELP model.

- Curve Numbers were estimated by the HELP model with the corresponding slope length, percent of slope, and soil texture at the surface. The case where riprap was modeled at the

surface, the HELP model produced an error. To mitigate the error, the Curve Number was estimated using the HELP model and then input as a user defined Curve Number.

- In order to model the riprap cover effectively, two materials were input to the model to represent the 12 inch riprap layer; a 0.1 inch top vertical percolation layer underlain by an 11.9-inch drainage layer. To satisfy the requirements of the HELP model, the protective layer beneath the riprap was modeled as a barrier layer.

- The evaluation was conducted over a 100-year period using the five-year, average monthly precipitation and temperature for Aspen, Colorado.

Infiltration Estimates

The results of the 100-year infiltration analyses using the HELP model are summarized for the four cover alternatives being evaluated (Tables 5-2 and 5-3). Results of the analyses are given as the average rate of infiltration and the average infiltration as a percent of the precipitation.

TABLE 5-2
Results of HELP Analysis for USFS Site 2: Average Annual Totals for 100 Years

Cover Alternative	Percolation through Cover on 3H:1V side slopes gpm (% of precip.)	Percolation through Cover on 2% top slope gpm (% of precip.)	Average Percolation through the Cover gpm
Soil cover w/vegetation	0.289 (20.2)	0.086 (20.2)	0.375
Soil cover w/riprap	0.476 (33.2)	0.203 (47.9)	0.679
Geomembrane cover w/vegetation	0.000 (0.0)	0.000 (0.0)	0.000
Geomembrane cover w/riprap	0.000 (0.0)	0.000 (0.0)	0.000

TABLE 5-3
Results of HELP Analysis for Area 245: Average Annual Totals for 100 Years

Cover Alternative	Percolation through Cover on 3H:1V side slopes gpm (% of precip.)	Percolation through Cover on 2% top slope gpm (% of precip.)	Average Percolation through the Cover gpm
Soil cover w/vegetation	0.512 (20.2)	0.119 (22.9)	0.631
Soil cover w/riprap	0.886 (33.2)	0.261 (47.9)	1.147
Geomembrane cover w/vegetation	0.000 (0.0)	0.000 (0.0)	0.000
Geomembrane cover w/riprap	0.000 (0.0)	0.000 (0.0)	0.000

Metal Loading

In order to place percolation rates shown above for Alternatives 1 and 2 into context, it is necessary to establish metal concentrations associated with the percolated water and to identify where the water enters Elk Creek. A precise determination of these factors would require a groundwater investigation that would identify contaminant transport downgradient of the repository, including where contaminated water flows and the dilution, dispersion, and attenuation of metals. Because this information is not available, has limited benefit, and would be expensive and time consuming to obtain, this section presents estimates of the effect of water percolating through the repository.

Percolated water exiting the bottom of the repository will contact native fine-grained soils en route to groundwater. The groundwater travels through unconsolidated soils/bedrock and eventually discharges into surface water. The literature suggests that clay-rich soils, such as exists in the vicinity of both potential repository sites, can effectively attenuate dissolved metals present in groundwater (Federal Remediation Technology Roundtable web site http://www.frtr.gov/matrix2/top_page.html). However for the purposes of this evaluation, it is assumed that metals are not attenuated in subsurface soils and that all metal loading exiting the repository enters Elk Creek. This conservative approach provides a worst-case indication of potential metal loading from the repository.

The SPLP results discussed in Section 3 are useful in determining leachate metal concentrations. Using the metal concentrations and percolation rates, metal loads can be calculated and compared with metal loads currently present in Elk Creek. Three metals (cadmium, lead, and zinc) were

reported with SPLP concentrations above laboratory detection levels. Weighted average SPLP concentrations were calculated based on the volume and SPLP results of the Level 1, 2, and 3 waste piles that will be excavated and placed in the repository.

The weighted SPLP results were adjusted to account for the lower acid generation potential of site waste materials compared to that simulated by the SPLP test protocol. Based on Acid Base Accounting data obtained during the 2005 EPA removal assessment, the weighted average pH of the Level 1, 2, and 3 waste piles is 5.9 (UOS 2006a). The pH of SPLP extraction solution is 4.2. Using the relationship of metal sulfide concentrations versus pH (http://www.hoffland.net/src/tks/3.xml), the SPLP results were adjusted to concentrations expected for pH 5.9 extraction solution resulting in weighted average cadmium, lead, and zinc SPLP concentrations of 0.6 µg/L, 66 µg/L, and 220 µg/L, respectively; thereby giving metals concentrations expected to be exiting the repository in leachate water.

In order to precisely determine the effect of percolation through the repository on Elk Creek, the location where the water enters the creek and the metal concentrations and flow rates at that location during various times of the year would be required. For the purposes of this report, the Elk00 sample location near the Elk Creek confluence with Coal Creek and the results from two Elk Creek sampling events conducted in 2006 were used to evaluate the potential metal loads calculated for each cap alternative. The following table outlines the 2006 sampling results and the expected metals load for cap alternatives 1 and 2.

TABLE 5-4
Comparison of Calculated Metal Loads from Percolated Water for Two Repository Cap Alternatives Compared to Meal Loads in Elk Creek at Elk00

	Adjusted SPLP Concentration (µg/L)	Elk00 June 2006 Sampling Metal Concentrations and (Metal Load) (lbs/year)	Elk00 September 2006 Sampling Metal Concentrations and (Metal Load) (lbs/year)	Metal Load (lbs/year)	
				USFS Site 2 Alternative 1 and (2) Cap	Area 245 Alternative 1 and (2) Cap
Flow Rate		624 gpm	581 gpm		
Cadmium	0.6	2.5 (7.0)	3.2 (8.2)	0.0010 (0.0018)	0.0017 (0.0030)
Lead	66	2.7 (7.5)	0.21 (0.54)	0.11 (0.20)	0.18 (0.33)
Zinc	220	520 (1,400)	640 (1,600)	0.36 (0.66)	0.61 (1.1)

The calculations reveal that the cadmium and zinc loads from percolated water would represent less than 0.1 percent of the Elk Creek loads for cap alternatives 1 and 2 at both potential repository locations for both Elk Creek sampling events discussed. Similarly, the percolated water lead load is less than 5 percent of the Elk Creek lead load compared to the June 2006 sampling event for cap alternatives 1 and 2 at both potential repository locations. The Elk00 lead concentration for the September 2006 sampling event was near the detection limit. As a result the projected percolated water lead load ranges from 20 to 37 percent of the Elk Creek load for cap alternative 1 and 54 to 62 percent for cap alternative 2 at USFS Site 2 and Area 245, respectively. Using the later comparison would result in an Elk00 lead concentration of approximately 0.34 μg/L compared to the state of Colorado stream standard of 2.0 μg/L (Colorado Department of Public Health and Environment – Water Quality Control Division (CDPHE) 2007). This leaves the resulting lead concentration at 17 percent of the stream standard as a worst-case scenario of all leachate that is generated at the repository migrating into Elk Creek. Further, as mentioned previously, native clay-rich soils, present at both repository sites, are expected to attenuate a significant portion of metals present in the leachate. The actual metal loads that reach Elk and Coal Creeks are expected to be much smaller than those calculated for this report. These calculations do not include the likely reduction in metal loads in Elk Creek due to the removal of waste materials that will occur as part of this project.

Based on the above evaluation, it is concluded that both cap alternative 1 and 2 can provide substantial human health protection and will serve to reduce the metal loading into Elk Creek from the site. Further, neither alternative should be disqualified from further consideration based on potential metal loading impacts from percolated water.

Other Considerations

Consideration should be given to the potential for leachate generation due to lateral flows. The infiltration of water from the surrounding geology (soil and bedrock) is considered lateral flow. Lateral flow can be generated from snowmelt, precipitation, or other subsurface water sources such as fissures in the bedrock or perched water tables. Lateral flows pose a concern because of their potential to infiltrate the waste rock, creating a source of leachate generation. Because of the variability in lateral flow and the lack of sufficient hydrogeologic data, estimating the quantity and direction of lateral flow can be difficult. This is important for evaluating the effectiveness of the four cover alternatives since the cover, in all cases, will not protect against the infiltration from lateral flows. As indicated on Table 5-2, the estimated infiltration for the geomembrane

cover alternatives (Alternatives 3 and 4) is approximately zero. These estimates do not account for the potential infiltration of water from lateral inflows. A site specific groundwater study would be needed to evaluate lateral flow. These groundwater studies would be time-consuming and expensive and have not been performed. For the purposes of this report, the potential lateral flow component of infiltration would affect each cap alternative equally and will not be evaluated.

Slope Stability Analysis

Sliding stability of the four cover alternatives was evaluated. The factor of safety against sliding for Alternatives 1 through 4 was computed using infinite slope theory for the design slope of 3H:1V (18.4 degrees). Infinite slope analysis assumes the potential failure plane is parallel to the surface of the slope. The factor of safety is computed as the ratio of the available strength to the strength required to maintain stability, and is independent of the slope height and depth, and depends only on the angle of internal friction and the angle of the slope. Two potential failure modes exist: 1) a failure plane through individual strata, or 2) a failure plane at the interface between two materials (soil or synthetic). The analysis considers the angle of internal friction for all of the materials and the interface friction angle between all of the elements that comprise the cover. The interface friction angle between soils can be estimated as the lowest internal friction angle of the two soils in contact. The interface friction angle between soils and synthetics is typically based on laboratory test results or published values for similar materials.

Analysis of the four cover alternatives considered the weakest plane or strata within each cover alternative. Table 5-5 identifies each of the alternatives and the weakest plane or strata as defined by the interface friction angle or the internal friction angle, respectively.

TABLE 5-5
Summary of Infinite Slope Stability Results for Cover Alternatives

Cover Alternative	Weakest Plane or Strata	Friction Angle (degrees)	Calculated Factor of Safety
Alternative 1 – Soil Cover with Vegetation	Compacted Soil – Waste Rock	30	1.73
Alternative 2 – Soil Cover with Riprap	Compacted Soil – Waste Rock	30	1.73
Alternative 3 – Geomembrane Cover with Vegetation	Geotextile – Protective Soil Compacted Soil – Waste Rock	30	1.73
Alternative 4 – Geomembrane Cover with Riprap	Geotextile – Protective Soil Compacted Soil – Waste Rock	30	1.73

A minimum factor of safety of 1.3 is recommended for infinite slope stability analysis. The minimum calculated factor of safety for all of the cover alternatives was 1.73. The critical plane for Alternatives 1 and 2 occurred at the interface between the compacted soil cover and the waste rock, where the interface friction angle was estimated to be 30 degrees. The critical planes for Alternatives 3 and 4 occurred at the interface between the geotextile and the protective soil and between the compacted soil cover and the waste rock, where the interface friction angles were estimated to be 30 degrees.

5.5 ALTERNATIVE 1 – SOIL COVER WITH VEGETATION

This alternative consists of a 12-inch-thick compacted soil cover overlain by a 6-inch-thick layer of amended soil growth medium, for a total cover thickness of 18 inches. Straw mulch will be used as an erosion control measure until vegetation is established.

5.5.1 Effectiveness

Infiltration estimates indicate that Alternative 1 would be an effective alternative in reducing vertical infiltration. This alternative is effective at reducing the overall runoff and drainage through evapotranspiration, and would result in a decrease in the quantity of overland flow. This decrease in overall runoff would occur once the vegetation becomes established. There is uncertainty regarding how readily this cap will be effective at reducing vertical infiltration due to the high mountain environment and the difficulty to achieve appropriate coverage. The following lists the advantages and disadvantages for this cover alternative:

Advantages:

- The vegetated cover will blend with the surrounding terrain; and
- Slightly reduced runoff and drainage due to evapotranspiration.

Disadvantages:

- Potential for leachate generation from vertical and lateral inflows;
- Erosion of the cover from concentrated flows;
- Unpredictability of how soon after construction the vegetative cover can be established in the high mountain climate; and
- The aesthetic nature of the vegetated surface may invite recreational use of the repository that could potentially degrade the overall effectiveness of the cover.

5.5.2 Implementability

Construction of this cover alternative can be implemented. The technical aspects of this cover alternative include the shaping of the waste to accommodate the cross-slope channels and compaction of the soil cover. The location of the soil cover and riprap borrow areas are relatively close and can be accessed from the existing roads.
The construction of this cover alternative can be done with typical construction equipment and experienced labor. There are no specialized skills required for the construction.

Slope stability analysis indicates that this cover alternative is expected to meet the minimum recommended factor of safety against sliding. Infiltration analysis indicates that this cover alternative may not perform as well as the other alternatives, based on the estimated quantity of vertical infiltration.

This cover alternative could experience erosion from concentrated flows resulting in deep crevasses and washouts on the soil cover. As a result, this cover alternative may require more long-term maintenance than the riprap cover alternatives.

The implementation of this alternative will require the negotiation and agreement

of performance standards amoung partnering agencies. Performance standards such as the percentage of coverage and species diversity would dictate the degree to which the cover is effective.

5.5.3 Cost

The estimated capital cost for this alternative includes mobilization and demobilization of equipment; screening, hauling, and placing of the compacted soil cover; hauling and placing of stockpiled topsoil; application of soil amendments; construction of cross-slope channels; drilling and seeding; and operations and maintenance costs. The estimated cost of this alternative is shown on Table 5-6. The estimated capital costs are $83,500 and $148,280 for the USFS Site 2 and Area 245 sites, respectively.

Operations and maintenance (O&M) costs consist of annual inspections and actual repairs/maintenance to the cover and/or run-on/runoff controls. For the purposes of this report it is assumed that O&M costs will continue for 20 years. Although inspections in some form may continue past 20 years, costs incurred this far in the future have little impact on present worth costs. The O&M costs for this alternative are also contingent upon the negotiated performance standards for the cap. If the vegetation on the cap fails to meet the prescribed percentage of cover (only 75% when 80% is the standard) additional work will be required to achieve this standard, obviously resulting in additional costs

Annual Inspections

Annual repository inspections will be performed in conjunction with the inspection of other site remediation activities including the reclaimed Level 1, 2, and 3 areas. Each inspection will include the collection of photographs and written documentation of potential problem areas within the repository including erosion channels and/or areas with sparse vegetation, if present. Run-on and runoff controls will be inspected to determine if they are functioning as planned and to document sloughing of soil or erosion of the soil cap into the channels, if present. A detailed sketch will be prepared using GPS if possible, to map areas within the repository supporting good, medium, or poor vegetation. After returning to the office, the GPS data will be analyzed to quantify the area supporting poor vegetation.

The costs of the annual repository inspection may be spread among several site installations. For the purposes of this evaluation, it is assumed that the annual inspection with one inspector will take three eight-hour days ($80/hr), including one day for travel, one day on site, and one day for planning and follow-up. The inspection cost for the first year after construction including transportation, lodging, and per diem is estimated at $2,600. It is assumed that inspections will be performed annually for 20 years with the cost increased by four percent per year to account for inflation. Annual future costs are discounted at an annual rate of eight percent per year to arrive at present worth costs.

Cover Maintenance

O&M costs associated with this cover alternative are related to the potential erosion of the soil cover. The erosion of the soil cover is dependant on several factors; 1) rainfall intensity, 2) soil erodibility, 3) slope length and gradient, 4) cover management (effects of vegetation), and 5) support practices (vegetation placement). Based on these factors an approximate soil loss can be estimated for the footprint of each repository based on "sheet flow" of the runoff over the soil cover. Although the soil loss from sheet flow is of concern, "concentrated flows" are of more concern because of the potential for erosion resulting in deep crevasses and washouts on the soil cover. The estimate of soil loss from sheet flow does not accurately estimate the gully or stream-channel erosion resulting from concentrated flows on the repository cover. Concentrated flows typically occur when minor imperfections in the soil cover collect and direct flow in a path that is not typical of sheet flow. The location and the intensity of concentrated flows are difficult to quantify; therefore, the amount of erosion resulting from concentrated flows is equally difficult to quantify. It is anticipated that some degree of erosion will occur at either repository location for the following reasons:

- Potential for intense rainfall events;
- Runoff;
- Erodability characteristics of the soil;
- Lack of vegetation;
- Slopes of the repository cover; and
- Overall slope lengths.

Our conceptual design of the repository cover alternatives accounts for the erosion (soil loss) from "sheet flow" based on the influence of the factors listed above. However, of the reasons listed above, the amount of vegetation is the one unpredictable factor that will contribute to the amount of erosion the soil cover will experience as a result of concentrated flows. The vegetation may not become fully established for many years, for the following reasons:

- Short growing season;
- Elevation of the repository locations (10,000 and 11,000 feet above mean sea level);
- Erosion (wind and water); and
- Frost kill.

It was assumed maintenance of the cover will occur on an annual basis until vegetation is fully established. This maintenance may include repair and/or replacement of the soil cover in some areas, removal of sediment from cross-slope and perimeter channels, and re-seeding.

For the purposes of this report it is assumed that one trip to perform repository maintenance will be necessary in the year following the repository construction. It is assumed that 20 percent of the vegetative cover including amendments would require repairs and 50 percent of the cover would require reseeding. The time estimated to complete the task includes one day for mobilization, three days to complete the repairs, and one day for demobilization. The estimated cost for this work is approximately $40,000. The present worth cost of 20 years of annual inspections is estimated to be $34,000. Therefore the estimated total O&M Cost for Alternative 1 is $74,000.

5.6 ALTERNATIVE 2 – SOIL COVER WITH RIPRAP

This alternative consists of a 12-inch-thick compacted soil cover overlain by a 12-inch-thick layer of riprap, for a total cover thickness of 24 inches.

5.6.1 Effectiveness

Infiltration estimates indicate Alternative 2 would be effective in reducing vertical infiltration. This alternative would be slightly less effective at reducing the overall runoff

and drainage due to the lack of vegetation available for evapotranspiration, and would likely result in an increase in the quantity of overland flow. Alternative 2 provides a high degree of performance certainty because once placed the riprap is fully functional. This alternative is effective at reducing the likelihood of erosion causing damage to the cover soil. The following lists the advantages and disadvantages for this cover alternative:

Advantages:

- The riprap surface may inhibit recreational use of the repository that could potentially degrade the overall effectiveness of the cover;
- The protection gained by the riprap could reduce the erosion to the compacted soil cover;
- Riprap provides a high degree of performance certainty; and
- The riprap cover may blend in with the surrounding terrain if used at USFS Site 2.

Disadvantages:

- Potential for leachate generation from vertical and lateral inflows;
- Minor increase in the quantity of runoff and drainage; and
- The riprap cover may not blend in with the surrounding terrain at Area 245.

5.6.2 Implementability

Construction of this cover alternative can be implemented. The technical aspects of this cover alternative include the compaction of the soil cover and the placement of riprap. The location of the soil cover and riprap borrow areas are relatively close and can be accessed from the existing roads.

The construction of this cover alternative can be done with typical construction equipment and experienced labor. There are no specialized skills required for the construction.

Slope stability analysis alternative indicates that this cover alternative is expected to meet the minimum recommended factor of safety against sliding. Infiltration analysis of this

cover alternative indicates that this alternative may not perform as well as geomembrane cover alternatives but better than soil cover alternatives with vegetation, based on the estimated quantity of vertical infiltration.

This cover alternative may not experience the same scale of erosion as that of the soil cover with vegetation, because of the armament provided by the riprap. As a result, this cover alternative may require less long-term maintenance.

5.6.3 Cost

The estimated cost for this alternative includes mobilization and demobilization of equipment; screening, hauling, and placing of the compacted soil cover; hauling and placing the riprap cover; and operations and maintenance costs. For the purposes of this evaluation, it is assumed that for USFS Site 2, 50 percent of the required riprap will be obtained from the adjacent talus slope and 50 percent from Area 99. Area 99 will be the sole riprap source for Area 245. The estimated capital costs are $98,175 and $143,320 for the USFS Site 2 and Area 245 sites, respectively (Table 5-6). There are no additional costs expected for this alternative since there are no performance standards associated with this type of cap.

O&M Costs

The O&M costs associated with this cover alternative are related to minor erosion, sediment deposition in perimeter channels, and the displacement of riprap due to frost heave and/or gulley erosion resulting from concentrated flows on the soil cover. The riprap cover is expected to be less susceptible than Alternative 1 to erosion from concentrated flows. This maintenance may include repair and/or replacement of the riprap cover in some areas, removal of sediment from perimeter channels, and minor repairs to the soil cover.

For the purposes of this report O&M costs will include annual inspections for 20 years as described in Section 5.2.3. In addition, one maintenance/repair mobilization is included in the first year after construction. Repairs will be conducted using one excavator and one front-end loader. The time estimated to complete the task includes one day for mobilization, three days to complete the repairs, and one day for demobilization. The

estimated cost for this work is approximately $14,000. The present worth cost of 20 years of annual inspections is estimated to be $34,000. Therefore the estimated total O&M Cost for Alternative 2 is $48,000. There are no additional O&M expenditures related to performance standards associated with this alternative.

5.7 ALTERNATIVE 3 – GEOMEMBRANE COVER WITH VEGETATION

This alternative consists of a 12-inch-thick compacted soil cover, overlain by a 60-mil geomembrane, overlain by a geonet drainage blanket with geotextile on two sides, overlain by a 12-inch-thick protective soil layer, overlain by a 6-inch-thick layer of amended soil growth medium, for a total cover thickness of 30 inches. Straw mulch will be used as an erosion control measure until vegetation is established.

5.7.1 Effectiveness

Infiltration estimates indicate Alternative 3 would be effective in reducing vertical infiltration and at reducing the overall runoff and drainage through evapotranspiration, and would result in a decrease in the quantity of overland flow. The following lists the advantages and disadvantages for this cover alternative:

Advantages:

- The vegetated cover will blend with the surrounding terrain;
- Slightly reduced runoff and drainage due to evapotranspiration; and
- Relatively low estimate of vertical infiltration.

Disadvantages:

- Potential for leachate generation from lateral inflows;
- Erosion of the cover from concentrated flows; and
- The aesthetic nature of the vegetated surface may invite recreational use of the repository that could potentially degrade the overall effectiveness of the cover.

5.7.2 Implementability

Construction of this cover alternative can be implemented. The technical aspects of this cover alternative include the shaping of the waste to accommodate the cross-slope channels, compaction of the soil cover, and installation of the geosynthetic cover. The location of the soil cover and riprap borrow areas are relatively close and can be accessed from the existing roads. Geosynthetic materials would have to be purchased from an off-site vendor and delivered to the site.

The construction of this cover alternative can be done with typical construction equipment and experienced labor. Specialized skills will be required for the installation of the geosynthetic materials.

Slope stability analysis of this cover alternative indicates this alternative is expected to meet the minimum recommended factor of safety against sliding. Infiltration analysis of this cover alternative indicates that this alternative will perform very well based on the estimated vertical infiltration.

This cover alternative could experience erosion from concentrated flows resulting in deep crevasses and washouts on the soil cover. As a result, this cover alternative may require more long-term maintenance than the riprap cover alternatives

5.7.3 Cost

The estimated cost for this alternative includes mobilization and demobilization equipment; screening, hauling, and placing of the compacted soil cover; placement of geomembrane; placement of geocomposite; hauling and placing of protective soil; hauling and placing stockpiled topsoil; application of soil amendments; construction of cross-slope channels; drilling and seeding; and operations and maintenance costs. The estimated cost of this alternative is shown on Table 5-6. The estimated capital costs are $401,900 and $680,730 for the USFS Site 2 and Area 245 site, respectively.

O&M Costs

The O&M costs associated with this cover alternative are related to the potential erosion of the soil cover and the potential for damage to the geosynthetics resulting from

excessive erosion, exposure to ultra-violet light, and exposure to the elements. Damage to the geosynthetics would likely require a much larger event, more "catastrophic" in nature, and as such, it was assumed maintenance of the cover will occur on an annual basis until vegetation is fully established. This maintenance may include repair and/or replacement of the protective soil cover in some areas, repair and/or replacement of the geomembrane cover in some areas, removal of sediment from cross-slope and perimeter channels, and re-seeding.

As with alternatives 1 and 2 it is assumed that annual inspections (described in Section 5.2.3) will be performed for a period of 20 years following repository construction. For the purposes of this report it is assumed that one trip to perform repository maintenance will be necessary in the year following the repository construction. It is assumed that 20 percent of the vegetative cover including amendments would require repairs and 50 percent of the cover would require reseeding. The time estimated to complete the task includes one day for mobilization, three days to complete the repairs, and one day for demobilization. The estimated cost for this work is approximately $40,000. The present worth cost of 20 years of annual inspections is estimated to be $34,000. Therefore the estimated total O&M Cost for Alternative 1 is $74,000.

5.8 ALTERNATIVE 4 – GEOMEMBRANE COVER WITH RIPRAP

This alternative consists of a 12-inch-thick compacted soil cover, overlain by a 60-mil geomembrane, overlain by a geonet drainage blanket with geotextile on two sides, overlain by a 12-inch-thick protective soil, overlain by a 12-inch-thick layer of riprap, for a total cover thickness of 36 inches.

5.8.1 Effectiveness

Infiltration estimates indicate Alternative 4 would be effective in reducing vertical infiltration and least effective at reducing the overall runoff and drainage because of the lack of vegetation available for evapotranspiration, and would result in an increase in the quantity of overland flow. The following lists the advantages and disadvantages for this cover alternative:

Advantages:

- The riprap surface may inhibit recreational use of the repository that could potentially degrade the overall effectiveness of the cover;
- The protection gained by the riprap may reduce the erosion to the compacted soil cover;
- Relatively low estimate of vertical infiltration;
- Riprap provides a high degree of performance certainty; and
- The riprap cover may blend in with the surrounding terrain if used at USFS Site 2.

Disadvantages:

- Potential for leachate generation from lateral inflows;
- Slight increase in the quantity of runoff and drainage; and
- The riprap cover may not blend with the surrounding terrain at Area 245.

5.8.2 Implementability

Construction of this cover alternative can be implemented. The technical aspects of this cover alternative include the compaction of the soil cover, installation of the geosynthetic cover, and the placement of riprap. The location of the soil cover and riprap borrow areas are relatively close and can be accessed from the existing roads. Geosynthetic materials would have to be purchased from an off-site vendor and delivered to the site.

The construction of this cover alternative can be done with typical construction equipment and experienced labor. Specialized skills will be required for the installation of the geosynthetic materials.

Slope stability analysis indicates that this cover alternative is expected to meet the minimum recommended factor of safety against sliding. Infiltration analysis indicates that this cover alternative will perform very well based on the estimated vertical infiltration.

This cover alternative may not experience the same scale of erosion as that of the soil cover with vegetation because of the armament provided by the riprap. As a result, this cover alternative may require less long-term maintenance.

5.8.3 Cost

The estimated cost for this alternative includes mobilization and demobilization of equipment; screening, hauling, and placing of the compacted soil cover; placement of geomembrane; placement of geocomposite; hauling and placing of protective soil; hauling and placing of the riprap cover; and operations and maintenance costs. For the purposes of this evaluation, it is assumed that for USFS Site 2, 50 percent of the required riprap will be obtained from the adjacent talus slope and 50 percent from Area 99. Area 99 will be the sole riprap source for Area 245. The estimated capital costs are $417,175 and $675,670 for the USFS Site 2 and Area 245 sites, respectively (Table 5-6).

O&M Costs

The O&M costs associated with this cover alternative are related to minor erosion, sediment deposition in perimeter channels, and the displacement of riprap from frost heave and/or gulley erosion resulting from concentrated flows on the soil cover. The riprap cover is expected to be less susceptible that Alternative 3 to erosion from concentrated flows. This maintenance may include repair and/or replacement of the riprap cover in some areas, removal of sediment from perimeter channels, and minor repairs to the soil cover.

For the purposes of this report O&M costs will include annual inspections for 20 years as described in Section 5.2.3. In addition, one maintenance/repair mobilization is included in the first year after construction. Repairs will be conducted using one excavator and one front-end loader. The time estimated to complete the task includes one day for mobilization, three days to complete the repairs, and one day for demobilization. The estimated cost for this work is approximately $14,000. The present worth cost of 20 years of annual inspections is estimated to be $34,000. Therefore the estimated total O&M Cost for Alternative 2 is $48,000.

5.9 COMPARATIVE ANALYSIS OF REPOSITORY COVER ALTERNATIVES

A comparative analysis was performed for the four proposed repository cover alternatives considering the effectiveness, implementability, and cost of each alternative. This section includes the comparative analysis, and a summary of the alternative analysis that is presented on Table 5-7.

5.9.1 Effectiveness

Alternatives 1 and 2 are less effective at reducing vertical infiltration because they provide a soil cover that has a relatively high permeability in comparison to the geomembrane cover types. Sensitivity analysis specific to the permeability of the compacted soil indicates that these alternatives could be more effective at reducing the vertical infiltration if the actual permeability of the compacted soil is less than the estimated permeability. However achieving a lower permeability in the compacted soil may require additional processing or bentonite augmentation. Alternatives 3 and 4 are the most effective at reducing the vertical infiltration because of the relatively low permeability of the geomembrane cover. All four alternatives have the same relative effectiveness at reducing infiltration from lateral inflows. None of the alternatives will eliminate the generation of leachate resulting from infiltration. An evaluation of leachate metal loading for each alternative was presented in Section 5.1.4. The evaluation concluded that the metal loading resulting from each of the alternatives would have potential for creating only a minor impact on Elk Creek.

Alternatives 1 and 3 are effective at reducing the quantity of runoff and drainage because of the benefits of evapotranspiration. Alternatives 2 and 4 are the least effective in reducing the quantity of runoff and drainage because they do not include vegetation. The runoff and drainage need consideration because of the erosive effects associated with increased surface water flows; the need to provide adequately sized surface water collection and diversion channels; and the potential for increased erosion at the point of discharge from the repository that may require long-term maintenance.

Alternatives 1 and 3 may be more aesthetically pleasing than Alternatives 2 and 4 because the vegetated cover may blend in better with the surrounding terrain, specifically at Area 245. Because of their vegetated surface, Alternatives 1 and 3 may invite

recreational use of the repository that could potentially degrade the overall effectiveness of the cover.

5.9.2 Implementability

Each of the four alternatives can be implemented and can be constructed with typical construction equipment. Alternatives 1 and 2 are less technical because the work does not require specialized skills for the construction of the cover. Alternatives 3 and 4 are more technical, primarily because of the installation of the geosynthetic cover. Specialized skills will be required for the construction of the geosynthetic cover.

The cover and riprap borrow locations are relatively close and can be accessed from the existing roads for the construction of all four alternatives. Alternatives 3 and 4 would require the purchase and delivery of geosynthetic products that would need to be accommodated in the construction schedule. Alternatives 1 and 2 could be implemented more efficiently because all of the materials required to construct the cover are locally available.

Alternatives 2 and 4 would likely have better long-term durability than Alternatives 1 and 3 because of the armament provided by the riprap cover. Alternatives 1 and 3 would likely not perform as well and may require more long-term maintenance, primarily because of erosion.

5.9.3 Cost

Alternatives 1 and 2 have lower capital costs than Alternatives 3 and 4. The increased costs for Alternatives 3 and 4 are primarily related to the geosynthetics required to construct these cover alternatives.

Alternatives 2 and 4 have lower O&M costs than Alternatives 1 and 3. The increased costs for Alternatives 1 and 3 are primarily related to the maintenance to the cover resulting from erosion prior to the establishment of vegetation.

Table 5-6 presents a comparison of the costs associated with each of the cover alternatives.

5.9.4 Preferred Cover Alternative

EPA has selected the Alternative 2 cover as the preferred Standard Mine Waste Rock Repository cover alternative because it is the most technically feasible and cost-effective alternative when constructed at either USFS Site 2 or Area 245. Alternative 2 offers adequate protection against vertical infiltration compared to the estimated cost of construction. The metals loading projections presented in Section 5.1.4 show this cap alternative achieves a high degree of protection of human health & environment; the small amount of metal loading present in the leachate is unlikely to impact Elk Creek. The higher degree of performance reliability is particularly important for a remote high elevation repository. It is uncertain how long it might take for a vegetative cover to become established well enough to successfully ward off the effects of large storm events that are common to this site. Moreover, due to the remote location, damage to a vegetated cap could occur and go unnoticed for quite some time. Finally, the riprap on Alternative 2 provides protection from erosion that directly impacts the cost of operations and maintenance. Erosion of the Alternative 1 cover could not only be expensive to correct, but also risk transport of waste materials into the area downgradient of the repository.

TABLE 5-6
Summary of Estimated Construction and Operations and Maintenance Costs for the Four Cover Alternatives

		USFS Site 2									Area 245								
		Unit cost	Soil Cover w/ Vegetation		Soil Cover w/ Riprap		Geomembrane Cover w/ Vegetation		Geomembrane Cover w/ Riprap		Unit cost	Soil Cover w/ Vegetation		Soil Cover w/ Riprap		Geomembrane Cover w/ Vegetation		Geomembrane Cover w/ Riprap	
Description	**Unit**	**Labor & Materials**	**Estimated Quantity**	**Estimated Cost**	**Estimated Quantity**	**Estimated Cost**	**Estimated Quantity**	**Estimated Cost**	**Estimated Quantity**	**Estimated Cost**	**Labor & Materials**	**Estimated Quantity**	**Estimated Cost**	**Estimated Quantity**	**Estimated Cost**	**Estimated Quantity**	**Estimated Cost**	**Estimated Quantity**	**Estimated Cost**
Cover Construction																			
Project General Requirements (10% of Cost)	LS			$7,600		$9,000		$36,500		$38,000			$13,500		$13,000		$ 62,000		$61,400
Screen, Haul and Place Compacted Soil Cover	CY	$6.00	4,350	$26,100	4,350	$26,100	4,350	$26,100	4,350	$26,100	$6.00	7,240	$43,440	7,240	$43,440	7,240	$43,440	7,240	$43,440
Haul and Place Riprap Cover	CY	$14.50			4,350	$63,075			4,350	$63,075	$12.00			7,240	$86,880			7,240	$86,880
Place Geomembrane	SY	$11.30					13,000	$146,900	13,000	$146,900	$11.30					21,700	$245,210	21,700	$245,210
Place Geocomposite Drainage	SY	$9.00					13,000	$117,000	13,000	$117,000	$9.00					21,700	$195,300	21,700	$195,300
Haul and Place Protective Soil	CY	$6.00					4,350	$26,100	4,350	$26,100	$6.00					7,240	$43,440	7,240	$43,440
Haul and Place Stockpiled Topsoil	CY	$5.00	2,200	$11,000			2,200	$11,000			$5.00	3,620	$18,100			3,620	$18,100		
Application of Soil Amendments	SY	$0.50	13,000	$6,500			13,000	$6,000			$0.50	21,700	$10,850			21,700	$10,850		
Construct Cross-Slope Channels	LF	$15.00	680	$10,200			680	$10,200			$15.00	1,700	$25,500			1,700	$25,500		
Drill and Seed (No Trees)	SY	$1.70	13,000	$22,100			13,000	$22,100			$1.70	21,700	$36,890			21,700	$36,890		
Subtotal:				**$83,500**		**$98,175**		**$401,900**		**$417,175**			**$148,280**		**$143,320**		**$680,730**		**$675,670**
Operations and Maintenance (O&M)																			
Total Annual Inspections*				$34,000		$34,000		$34,000		$34,000			$34,000		$34,000		$34,000		$34,000
Year 1 Repairs				$39,000		$14,000		$39,000		$14,000			$39,000		$14,000		$39,000		$14,000
Subtotal:				**$73,000**		**$48,000**		**$73,000**		**$48,000**			**$73,000**		**$48,000**		**$73,000**		**$48,000**
TOTAL				**$156,500**		**$146,175**		**$474,900**		**$465,175**			**$221,280**		**$191,320**		**$753,730**		**$723,670**

* Annual Inspections will cost $2,600/yr and will be performed for 20 years. Present worth costs are calculated assuming an escalation factor of 4%/yr and a discount rate of 8%/yr.

TABLE 5-7
Summary of the Alternatives Analysis for the Four Cover Alternatives

Alternative	Effectiveness		Implementability		Cost	
	Protectiveness	Ability to Achieve RAO	Technical	Availability	Capital	O&M
Alternative 1 – Soil Cover with Vegetation	Would be effective in reducing vertical infiltration. Offers a slight reduction in the overall runoff and drainage through evapotranspiration. Offers less performance predictability due to the nature of establishing a vegetative cover.	Would reduce human and ecological exposure to metals.	Can be implemented. The technical aspects of this cover alternative include the shaping of the waste to accommodate the cross-slope channels and compaction of the soil cover. Can be done with typical construction equipment and experienced labor. There are no specialized skills required for the construction. May require more long-term maintenance than the riprap cover alternatives.	Location of the soil cover and riprap borrow areas are relatively close and can be accessed from the existing roads. Expected to meet the minimum recommended factor of safety against sliding. May not perform as well as the other alternatives, based on the estimated quantity of vertical infiltration.	USFS Site 2 $83,677 Area 245 $148,573	USFS Site 2 $73,000 Area 245 $73,000
Alternative 2 – Soil Cover with Riprap	Would offer a high degree of performance predictability. Would be slightly less effective at reducing the overall runoff and drainage.	Would reduce human and ecological exposure to metals.	Can be implemented. The technical aspects of this cover alternative include the compaction of the soil cover and the placement of riprap. Can be done with typical construction equipment and experienced labor. There are no specialized skills required for the construction May require less long-term maintenance.	Location of the soil cover and riprap borrow areas are relatively close and can be accessed from the existing roads. Expected to meet the minimum recommended factor of safety against sliding. May not perform as well as geomembrane cover alternatives but better than soil cover alternatives with vegetation, based on the estimated quantity of vertical infiltration.	USFS Site 2 $110,207 Area 245 $143,411	USFS Site 2 $48,000 Area 245 $48,000
Alternative 3 – Geomembrane Cover with Vegetation	Would be the most effective in reducing vertical infiltration and at reducing the overall runoff and drainage.	Would reduce human and ecological exposure to metals. Vertical precipitation infiltration through the repository would be prevented.	Can be implemented. The technical aspects of this cover alternative include the shaping of the waste to accommodate the cross-slope channels, compaction of the soil cover, and installation of the geosynthetic cover. Can be done with typical construction equipment and experienced labor. Specialized skills will be required for the installation of the geosynthetic materials. May require more long-term maintenance than the riprap cover alternatives.	Location of the soil cover and riprap borrow areas are relatively close and can be accessed from the existing roads. Geosynthetic materials would have to be purchased from an off-site vendor and delivered to the site. Expected to meet the minimum recommended factor of safety against sliding. May perform very well based on the estimated vertical infiltration.	USFS Site 2 $404,280 Area 245 $681,586	USFS Site 2 $73,000 Area 245 $73,000
Alternative 4 – Geomembrane Cover with Riprap	Would offer greater performance predictability than Alternative 3. Would be the most effective in reducing vertical infiltration Would be least effective at reducing the overall runoff and drainage.	Would reduce human and ecological exposure to metals. Vertical precipitation infiltration through the repository would be prevented.	Can be implemented. The technical aspects of this cover alternative include the compaction of the soil cover, installation of the geosynthetic cover, and the placement of riprap. Can be done with typical construction equipment and experienced labor. Specialized skills will be required for the installation of the geosynthetic materials. May require less long-term maintenance.	Location of the soil cover and riprap borrow areas are relatively close and can be accessed from the existing roads. Geosynthetic materials would have to be purchased from an off-site vendor and delivered to the site. Expected to meet the minimum recommended factor of safety against sliding. may perform very well based on the estimated vertical infiltration	USFS Site 2 $430,810 Area 245 $676,424	USFS Site 2 $48,000 Area 245 $48,000

6.0 IDENTIFICATION AND ANALYSIS OF REPOSITORY DESIGN ALTERNATIVES

This section presents and discusses conceptual designs for a proposed mine waste repository at two alternative sites, Area 245 and USFS Site 2, both of which are located on USFS land. The conceptual designs presented include a soil cover with riprap, as recommended in Section 5.9.4. The conceptual designs for these two alternative sites are evaluated considering the effectiveness of the mine waste repository to protect human health and environment, the ability to implement and construct the repository, and the cost to construct the repository and provide long-term operations and maintenance after construction. Based on the evaluation of each of the proposed repository site conceptual designs, a preferred mine waste repository site is selected.

6.1 GENERAL

6.1.1 Repository Site Alternatives

Two repository site alternatives were selected for consideration, Area 245 and USFS Site 2. The following is a brief description of existing conditions at the two repository locations, as indicated on Figure 5.

Area 245 is located on a relatively flat and south-sloping ridge between Elk Creek and Evans Creek, approximately 1.5 miles southeast of Level 1. Glacial activity is believed to have removed overlying relatively weak rock from the top of this ridge. Bedrock on the ridge is covered with ground moraine, and the moraine supports a thick growth of trees. The ground moraine is generally four to seven feet thick and consists of silty, clayey sand or gravel with cobbles and boulders (URS 2007). There are no naturally occurring drainage features within the Area 245 boundary and the area is considered to be heavily wooded.

USFS Site 2 is located on the east side of Elk Creek Valley, approximately 0.4 mile downgradient of the Level 1 area. The site consists of a depression, roughly oval in shape, approximately 250 feet wide, 400 feet long, and 5 feet to 10 feet deep. The depression contains a cover of ground moraine that is generally 4 feet to 8 feet thick and consists of silty, clayey sand or gravel with cobbles and boulders (URS 2007). The valley slope east of the depression contains a thick cover of talus and a rock glacier

composed of talus. There are no naturally occurring drainage channels within the USFS Site 2 boundary and the area is considered to be somewhat heavily wooded.

6.1.2 Design Criteria

The following design criteria were used to develop conceptual mine waste repository designs for Area 245 and USFS Site 2:

- The repository is to have the capacity to store 80,000 cubic yards of mine waste, consisting of waste rock and tailing from the Standard Mine site.
- Minimize the Repository footprint
- Construct a repository that blends with surrounding topography
- Locally available construction materials will be used whenever possible.
- Final cover is to consist of a soil cover with riprap, as recommended in Section 5.6.4.
- Final cover slope benches and ditches will not be needed because the soil loss and erosion from the riprap final cover will be negligible.
- Runoff from surrounding watershed areas will be diverted around the proposed repository.
- Repository final grades will be no flatter than two percent to promote runoff, and no steeper than 3H:1V to facilitate construction and maintenance.
- The proposed repository will meet or exceed recommended factors of safety for slope stability.
- Surface water control structures will be sized to convey at least the 100-year, 24-hour precipitation event.

- Grading plans will be prepared using the September 2006 topography of Standard Mine and the surrounding area developed by UOS.

6.1.3 Site Constraints

The Standard Mine site and the proposed mine waste repository sites are located about five miles northwest of Crested Butte, Colorado, in the Ruby Range of the Gunnison National Forest, at an elevation of approximately 11,000 feet. Access to the site is via unimproved roads. The elevation, remote location, and access to the Standard Mine site represent significant constraints for the design and construction of the proposed mine waste repository. These constraints are further discussed below.

Equipment Mobilization and Access

Access to the Standard Mine site is currently provided via existing mining roads. These roads are accessed off the north side of Gunnison County Road 12 (CR12), approximately five miles west of the town of Crested Butte. The lower 1.8-mile segment of this route follows a named road, Trappers Way, which is gated just above the CR12 intersection to restrict access through the Lucky Jack Mine.

From Trappers Way to the Standard Mine site, a distance of 3.4 miles, the route follows a mining road that generally runs parallel to CR12 and then Elk Creek, atop a ridge on the easterly side of Elk Basin. Portions of the Trappers Way route are situated on private lands, which the EPA has previously entered under an access agreement.

This route negotiates an elevation rise of about 1,750 feet over a distance of 27,000 feet, for an average profile grade of 6.5 percent. The roadway surface is unimproved (i.e., no pavement, no crushed aggregate base); however, maintenance was performed on portions of the access road during the 2006 construction season.

The existing road width varies along the alignment, with a nominal width of about 12 feet. This existing width was adequate to accommodate articulated, off-road haul trucks and other tracked construction equipment that was mobilized to the site during the 2006 construction season. The access route does not accommodate the transport of large

construction equipment to the site via highway trucks and trailers. Large construction equipment would need to be off-loaded near CR12 and then walked or driven to the site under its own power. In addition, the high altitude setting of the Standard Mine site will result in some decrease in performance of diesel-powered construction equipment. This may necessitate the mobilization of larger pieces of equipment than typically used for similar work at lower elevations.

Construction Season

The high altitude location of the Standard Mine results in a relatively short construction season, typically four months between June and September. The site receives significant snowfall during winter and spring months, which does not typically melt until mid-May to early June.

Average daily high temperatures in Crested Butte (elevation 8,900 feet) vary from about 65 to 75 degrees Fahrenheit during the four-month construction season, with average low temperatures typically between 30 and 38 degrees Fahrenheit. The typical weather pattern during this time includes the chance of short and intense afternoon thundershowers, which could require shutting down construction activities temporarily. Snowfall is possible at the Standard Mine site between June and September.

6.2 ALTERNATIVE A - AREA 245 MINE WASTE REPOSITORY

The proposed Area 245 Mine Waste Repository is located approximately 1.0 mile southeast of the Standard Mine Level 1 area. The repository cannot be accessed from existing roads; temporary roads would need to be constructed to access the site from the existing road. Area 245 Mine Waste Repository is approximately 4.25 acres in size and is situated on a ridge line with south facing slopes. Figure 6 shows the location of the Area 245 Mine Waste Repository and shows the proposed temporary road to be constructed for access to the site.

6.2.1 Design Description

Approach

The conceptual design for the Area 245 Mine Waste Repository was developed to contain waste rock and tailings from the Standard Mine site using the design criteria described in Section 5.1.2. Design considerations in the development of the conceptual grading plan were limited to the minimum storage capacity, minimizing the footprint size, maintaining manageable design grades for surface water runoff, and a repository that blends with the surrounding topography. The following section describes the conceptual design.

Conceptual Design

The Area 245 Mine Waste Repository conceptual design is presented in Figures 9 through 11. The grading plan consists of the following:

- Side slopes graded at 3H:1V and top slope graded at two percent;
- A surface water collection and conveyance channels to intercept surface water runoff are located along the east and west sides of the repository with energy dissipation outfalls at the channel outlets; and
- Surface water diversion at the top of the repository to limit surface water run-on.

Waste rock and tailings would be transported from their current locations at the Standard Mine to the Area 245 Mine Waste Repository using the existing access roads. Additional roads would be constructed from the existing access road to the location of the Area 245 Mine Waste Repository, as indicated on Figure 6. Prior to the placement of waste rock at the repository, the area would be cleared of all existing trees and shrubs. Topsoil would also be removed and stockpiled for future use, where necessary. Oversized material encountered during stripping operations would be collected and stockpiled for the construction of the perimeter channels and the riprap cover. For this site, a small starter berm would be constructed at the toe of the repository using on-site soils. This berm will serve as the starting point for waste rock placement. The exposed subgrade would be

compacted to provide a sound base and the waste rock would be placed and graded such that the soil cover with riprap could be constructed without providing additional material to meet the final grade.

The soil cover with riprap would be constructed of materials taken from local borrow sources. The soil cover would be borrowed from USFS Site 1, where topsoil would be removed and stockpiled for future reclamation of the borrow area. Based on the geotechnical investigation and laboratory testing, the soil at USFS Site 1 consists of a sandy clay soil with gravel and would be a suitable cover soil if screened (URS 2007). Soil cover material would be screened to remove particles larger than three inches in nominal diameter. Oversized material, removed during the screening process, would be collected and stockpiled for the construction of the perimeter channels and the riprap cover. The soil cover material would be transported from USFS Site 1 to the Area 245 Mine Waste Repository over the existing access road. The soil cover would be placed and compacted with a minimum thickness of 12 inches prior to the placement of the riprap cover.

The riprap cover would be constructed of oversized material collected from Area 245 prior to the placement of waste rock, with material screened out of the soil cover from USFS Site 1, and augmented with riprap from Area 99. Based on the on-site observation of riprap at Area 99, the average rock size is approximately nine inches in nominal diameter (URS 2007). The riprap material would be transported from Area 99 to the Area 245 Mine Waste Repository over the existing access road. Riprap would be placed atop the soil cover to an average depth of 12 inches.

Perimeter channels, as indicated on Figure 9, would be constructed and lined with riprap. The channels would either be excavated into the existing grade or the over-built soil cover where the constructed grade meets the existing grade. Riprap energy dissipation structures would be constructed at the outlets of the perimeter channels such that collected water could be discharged from the site with a low velocity to reduce the potential for erosion; this discharged water would be allowed to sheet flow from the outlet of the repository to existing drainage features downhill of the repository.

Prior to construction, the existing access roads would need to be maintained and may need to be widened in areas. Depending on the haul route used, turn-outs may need to be constructed to allow for two-way traffic. Construction access to Area 245 Mine Waste Repository would need to be constructed and maintained throughout the construction of the repository. After construction of the repository, disturbed areas around the repository could be reclaimed with stockpiled topsoil and seeded with native grasses. USFS Site 1 would be graded and reclaimed with the stockpiled topsoil and seeded with native grasses.

6.2.2 Settlement Analysis

Settlement of the mine waste placed in the repository is expected to occur during and after construction. Most of the settlement is anticipated to result from compression of the tailing and waste rock materials under the weight of the cover and the weight of the mine waste. The foundation soils at Area 245 generally consist of silty and clayey sand or gravel with cobbles and boulders, and are not expected to experience significant settlement. Some secondary compression, or creep, may also occur; however, the amount of secondary compression is expected to be negligible as compared to mine waste compression during and immediately following construction.

Based on previous experience with similar structures and published values, mine waste compression is anticipated to be about three (3) percent of the total mine waste thickness. The maximum thickness of mine waste at the proposed Area 245 Mine Waste Repository is about 45 feet, with a corresponding estimated maximum settlement of about 1.5 feet. Most of this settlement is likely to occur during construction.

As shown on Figure 9, most of the proposed repository would be graded with 3H:1V side slopes. The top area would be graded with a two percent slope toward the perimeter channel. Should the maximum estimated settlement occur beneath the top area, the amount of differential settlement would not be large enough to reverse the top cover gradient. Some irregularities and minor ponding atop the cover could occur, but the overall drainage direction toward the perimeter channel should be maintained.

6.2.3 Slope Stability Analyses

Slope stability analyses were performed to evaluate the overall stability of the proposed Area 245 Mine Waste Repository. The stability analyses were performed using the limit equilibrium computer program UTEXAS4 (Wright, 1999) and Spencer's method of slices to compute theoretical factors of safety for various potential shear surfaces. Manual and automated searches were used to find critical shear surfaces, and drained loading conditions were evaluated.

Stability Model Geometry

The stability of the proposed Area 245 Mine Waste Repository was evaluated using the typical cross section shown on Figure 11. This cross section represents the maximum proposed thickness of mine waste and a 3H:1V cover slope up to elevation 11,054 feet.

The existing ground surface used in the stability model is based on the September 2006 topographic map of Area 245, and a four-inch-thick layer of foundation soil was modeled above the bedrock surface. The foundation soil thickness is based on the results of the field investigations presented in the Phase I EE/CA Report (URS 2007). The proposed repository soil cover with riprap was simplified for the stability analyses as a two-foot-thick layer of cover material.

No evidence of shallow groundwater was observed during the site investigations at Area 245 (URS 2007) and the repository is expected to remain above the groundwater surface. Therefore, a phreatic surface was not included in the slope stability model, and only drained loading conditions were evaluated.

Material Properties

The material properties used in the stability analyses are based on results of the site investigations and laboratory testing presented in the Phase I EE/CA Report (URS 2007) as well as published values and engineering judgment. The properties used in the stability analyses are summarized in Table 6-1 and discussed below.

The mine waste was modeled with a drained shear strength friction angle of 30 degrees and a unit weight of 110 pounds per cubic foot (pcf). This shear strength is representative of the tailing material to be placed in the mine waste repository; the waste rock to be placed in the repository is expected to have a higher shear strength, which would result in higher calculated factors of safety.

The proposed cover, consisting of a 12-inch thick layer of riprap underlain by a 12-inch thick layer of compacted soil, was modeled as a single layer of cover material with a drained shear strength friction angle of 31 degrees, 200 pounds per square foot (psf) cohesion, and a unit weight of 131 pcf. The shear strength of the cover material is representative of the borrow soils available from the potential USFS Site 1 borrow area that would be used for the compacted soil cover; the unit weight is based on the results of compaction testing. The riprap to be included in the cover would have greater shear strength than the compacted soil cover, which would result in higher factors of safety.

Based on the site investigations and laboratory testing, the foundation soil at Area 245 generally consists of silty or clayey sand or gravel with cobbles and boulders. This foundation soil was modeled with a drained shear strength friction angle of 34 degrees and a unit weight of 125 pcf. These properties are based on the results of index testing and typical values for similar materials.

Bedrock encountered during the site investigations was competent and was modeled with shear strength sufficiently high to ensure shear surfaces would pass through the overlying materials.

TABLE 6-1
Summary of Material Properties Used in Area 245
Mine Waste Repository Stability Analyses

Material	Unit Weight (pcf)	Drained Shear Strength	
		Cohesion (psf)	Friction Angle (degrees)
Mine Waste (tailing/waste rock)	110	0	30
Cover Material	131	200	31
Foundation Soil	125	0	34
Bedrock	145	5000	45

Results

The results of the stability analyses indicate a calculated minimum theoretical factor of safety of 1.8 for drained loading conditions, which exceeds the recommended minimum value of 1.5. The factor of safety for a shear surface is the ratio of the shear strength of the soil divided by the shear stress required to maintain a just-stable slope. A factor of safety of 1.0 would indicate the shear surface is on the boundary between stability and instability.

Multiple shear surfaces were evaluated as part of the stability analyses. These shear surfaces are theoretical surfaces along which sliding might occur; however, it is the intent of the design that sliding not occur. The minimum calculated theoretical factor of safety corresponds to a relatively shallow shear surface, which would be characteristic of shallow slumping. Other modes of failure were also evaluated, including a deep-seated shear surface. This deep-seated shear surface would be representative of a mass movement involving most of the repository, and has a factor of safety greater than the calculated minimum. These two theoretical shear surfaces and corresponding factors of safety are shown on Figure 12.

6.2.4 Surface Water Analyses

Surface water analyses were performed for the proposed Area 245 Mine Waste Repository to establish precipitation depths for the 2-year and 100-year, 24-hour storm events. These precipitation depths were used to size runoff control structures and evaluate channel riprap requirements.

Precipitation

The National Oceanic and Atmospheric Association (NOAA) Atlas 2, Precipitation Frequency Atlas for the Western United States was used to estimate precipitation depths for selected storm events. Precipitation values were estimated for the Standard Mine site using latitude, longitude, and median elevation (National Oceanic and Atmospheric Association (NOAA) 2006).

The following location information was used for the Standard Mine site:

Latitude: 38.878° N

Longitude: 107.074° W

Median Elevation: 11,000 feet

A standard SCS Type II precipitation distribution was used for the site, and the following precipitation depths were estimated:

2-year, 24-hour: 1.6 inches

100-year, 24-hour: 3.4 inches

The 2-year, 24-hour storm information was used to evaluate likely operation and maintenance requirements related to channel erosion, and the 100-year, 24-hour storm was used to size runoff control structures and to evaluate channel riprap requirements.

Drainage Basin Characteristics

Drainage basins on and contributing to the proposed repository were delineated based on the September 2006 site topographic map and the proposed repository grading plan. Watershed characteristics were then estimated for each of the drainage basins, including basin area, hydraulic length, and average slope.

The SCS Curve Number method was used to estimate precipitation runoff for calculating peak runoff values. Curve Numbers were estimated for the drainage basins based on the soil and vegetative cover type, and assuming an antecedent moisture condition. Drainage basin lag times were calculated using the SCS lag time equation. The natural ground areas upstream of the proposed repository were estimated to have an average Curve Number value of CN 78, based on a mixed land type of forested and bare ground (CN 76 and 91, respectively). The proposed mine waste repository riprap cover was estimated to have a Curve Number value of 75.

Design Flows

Rainfall distributions and drainage basin characteristics were input into the USACE Hydrologic Engineering Center – Hydrologic Modeling System (HEC-HMS) (Version 3.0.0) rainfall/runoff computer program to estimate peak surface water discharges for each drainage basin.

Peak discharges were used to size channels and runoff control structures. Normal depth calculations were used to develop channel configurations based on the proposed slope, channel type, and the runoff that contributed to the downstream discharge point at each channel. A Manning's "n" coefficient representative of riprap was used for the channels.

Results

As shown on Figure 9, the surface water runoff controls at the proposed Area 245 Mine Waste Repository would consist of a perimeter channel surrounding the proposed repository. This perimeter channel would divert surface water runoff from the upstream drainage basin around the proposed repository, and convey surface water runoff from the repository cover away from the proposed facility. This perimeter channel would divert water from the east and west sides of the proposed repository separately. Dissipation aprons would be constructed at the downstream end of the east and west perimeter channels, and surface water would then be discharged as sheet flow across the existing ground surface. Surface water flows from the south face of the repository would also be discharged as sheet flow across the existing ground surface.

The proposed perimeter channel has a trapezoidal cross section with a five-foot bottom width, three-foot depth, varying longitudinal slopes, and 3H:1V and 2H:1V inboard and outboard side slopes, respectively. The peak discharge from the perimeter channel during the 100-year, 24-hour storm event is estimated to be approximately 15 cubic feet per second (cfs). Normal depth calculations indicate the proposed perimeter channel configuration has sufficient capacity to convey the peak discharge from the 100-year, 24-hour storm event.

Riprap will be placed in the perimeter channel to provide erosion protection. This riprap will consist of durable, cobbles and boulders from the Area 99 riprap borrow area. Based on the 100-year, 24-hour storm and the calculated peak discharge flow rate within the perimeter channel, the riprap required for the lining of the perimeter channels, ranged in size from one inch to eight inches in nominal diameter, depending on the channel slope. These sizes represent the maximum nominal diameter for 50 percent of the riprap particles, by weight (D50). Riprap borrowed from Area 99 would be suitable for use.

6.2.5 Alternative Analysis

Effectiveness

The proposed Area 245 Mine Waste Repository covers approximately 4.25 acres and would require approximately 1,000 feet of road to be constructed for access to the repository. The approximate area of disturbance could exceed 5 acres, depending on the size of the access road. Construction of the repository and access road will require the removal of trees, shrubs, and native vegetation over that same area.

Area 245 is considered heavily forested and the riprap cover may not blend well with the surrounding terrain. The location is expected to have no visibility from Crested Butte or Kebler Pass Road.

The travel distance to the proposed Area 245 Mine Waste Repository from the riprap and soil borrow areas is approximately 0.3 to 1.25 miles, respectively. From the soil borrow area (USFS Site 1) the haul is generally uphill and from the riprap borrow area (Area 99) the haul is generally downhill. The travel distance from the Standard Mine Level 1 mine waste is approximately 1.5 miles and the haul is generally uphill. Repair and maintenance of the existing and constructed access roads would include approximately 2.5 miles of road.

The area above the proposed repository contributing to surface water run-on is approximately 6.2 acres and the area of the repository is approximately 4.5 acres. The maximum peak estimated flow rate in the perimeter channel resulting from the 100-year, 24-hour storm is about 15 cfs.

.The average percolation through the soil cover with riprap, as indicated on Table 5-4, is estimated to be about 1.1 gpm. This rate of infiltration is directly related to the area of the repository that is exposed to precipitation. The Area 245 Mine Waste Repository is oriented such that the majority of the slopes are generally south facing. South facing slopes generally receive more solar radiation during winter months, which results in less snow cover and less overall infiltration.

Based on the site reconnaissance conducted between July and October 2006, Area 245 could be a potential habitat for several forest dwelling Threatened and Endangered Species because of the heavily wooded area.

Implementability

Construction of this repository alternative can be implemented. The technical aspects of this repository alternative include the processing of borrow material, foundation preparation, placement of mine waste, construction of perimeter channels, compaction of the soil cover, placement of riprap, and construction of new haul roads. The location of the soil cover and riprap borrow areas are relatively close and can be accessed from the existing roads.

The construction of this repository alternative can be done with typical construction equipment and experienced labor. There are no specialized skills required for the construction.

Settlement analysis indicates that the amount of differential settlement due to compression of the waste rock would not be large enough to reverse the top cover gradient. Slope stability analyses of this repository alternative indicate that this alternative is expected to meet the minimum recommended factor of safety for slope stability.

Cost

A conceptual level cost estimate for Alternative A is presented on Table 5-6 and is based on the conceptual level designs presented in this report. The primary use and purpose of

the conceptual cost estimate is to provide a basis for the selection of one of the proposed alternatives for final design and to provide an understanding of the potential level of funding necessary to implement the conceptual level designs presented in this report. The cost estimates presented in this report are based on our professional judgment, the existing technical information, the characteristics of the conceptual level structures, and the conceptual nature of the designs. The unit costs used for this study are derived from our experience and data collected on similar projects.

The presented conceptual cost estimate includes the costs for contractor management and administration; quality assurance and control; temporary facilities and equipment; execution layout and survey; borrow excavation and reclamation; clearing, grubbing, and tree disposal; strip and stockpile topsoil; haul and place waste rock; screen, haul, and place compacted soil cover; haul and place riprap cover; construct perimeter channels; and a 35 percent contingency.

The contingency of 35 percent was used in the conceptual cost estimates presented on Table 5-6 to account for unidentified or unlisted quantities or items, to accommodate for project site constraints and conditions including the difficult access to the mine site and limited construction season, to address owner project costs including but not limited to engineering design and construction management, and for final pricing adjustments.

The level of detail associated with this conceptual cost estimate was based on quantities taken from figures prepared for this conceptual level design. Accuracy is not guaranteed, and the use of the conceptual cost estimate should not be deemed as an offering or proposal with respect to the outcome of the cost of an activity or project. The conceptual cost estimate was developed to assist with decision making process relating to future work related to the conceptual level designs and should not be used for other purposes.

Based on the discussion presented in Section 5, O&M costs are expected to be minimal. Annual inspections will be performed for 20 years and have a present worth cost of $34,000.

6.3 ALTERNATIVE B – USFS SITE 2 MINE WASTE REPOSITORY

USFS Site 2 is located approximately 0.5 miles south of the Standard Mine Level 1 area. The site can be accessed from existing roads; temporary roads would need to be constructed to access the entire site from the existing road. The USFS Site 2 Mine Waste Repository is approximately 2.6 acres in size and is situated in a depression with west and south facing slopes. Figure 6 shows the location of the USFS Site 2 Mine Waste Repository and shows the proposed temporary road to be constructed for access to the site.

6.3.1 Design Description

Approach

The conceptual design for the USFS Site 2 Mine Waste Repository was developed to contain waste rock and tailings from the Standard Mine site using the design criteria described in Section 6.1.2. Design considerations in the development of the conceptual grading plan were limited to the minimum storage capacity, minimizing the footprint size, maintaining manageable design grades for surface water runoff, and a repository that blends with the surrounding topography. The following section describes the conceptual design.

Conceptual Design

The USFS Site 2 Mine Waste Repository conceptual design is presented in Figures 7, 8, and 11. The grading plan consists of the following:

- Side slopes graded at 3H:1V and top slope graded at 2 percent;
- Surface water collection and conveyance channels to intercept surface water runoff are located along the west and south edge of the repository with energy dissipation outfalls at the toe of the repository; and
- A surface water diversion at the top of the repository to limit surface water run-on.

Waste rock and tailings would be transported from their current locations at the Standard Mine to USFS Site 2 Mine Waste Repository using the existing access roads. Additional roads would be constructed from the existing access road to the location of USFS Site 2 Mine Waste Repository, as indicated on Figure 7. Prior to the placement of waste rock at the repository, the area would be cleared of all existing trees and shrubs. Topsoil would also be removed and stockpiled for future use, where necessary. Oversized material encountered during stripping operations would be collected and stockpiled for the construction of the perimeter channels and the riprap cover. The exposed subgrade would be compacted to provide a sound base and the waste rock would be placed and graded such that the soil cover with riprap could be constructed without providing additional material to meet the final grade.

The soil cover with riprap would be constructed of materials taken from local borrow sources. The soil cover would be borrowed from USFS Site 1, where topsoil would be removed and stockpiled for future reclamation of the borrow area. Based on the geotechnical investigation and laboratory testing, the soil at USFS Site 1 consists of a sandy clay soil with gravel and would be a suitable cover soil if screened (URS 2007). Soil cover material would be screened to remove particles larger than three inches in nominal diameter. Oversized material, removed during screening operations, would be collected and stockpiled for the construction of the perimeter channels and the riprap cover. The soil cover material would be transported from USFS Site 1 to USFS Site 2 Mine Waste Repository over the existing access road. The soil cover would be placed and compacted with a minimum thickness of 12 inches prior to the placement of the riprap cover.

The riprap cover would be constructed of oversized material collected from USFS Site 2 prior to the placement of waste rock, with material screened out of the soil cover from USFS Site 1, and augmented with riprap from the adjacent talus slope and Area 99. Based on the on-site observation of riprap at Area 99, the average rock size is approximately nine inches in nominal diameter (URS 2007). The riprap material would be transported from the adjacent talus slope and Area 99 to USFS Site 2 Mine Waste Repository over the existing access road. Riprap would be placed atop the soil cover to an average depth of 12 inches.

Perimeter channels, as indicated on Figure 7, would be constructed and lined with riprap. The channels would either be excavated into the existing grade or the over-built soil cover where the constructed grade meets the existing grade. A low level water crossing and energy dissipation structure would be constructed at the outlet of the perimeter channels such that collected water could be discharged across the existing access road and from the site with a low velocity to reduce the potential for erosion. Discharged water would be allowed to sheet flow from the outlet of the repository to existing drainage features downhill of the repository.

Prior to construction, the existing access roads would need to be maintained and may need to be widened in areas. Depending on the haul route used, turn-outs may need to be constructed to allow for two-way traffic. Construction access to USFS Site 2 Mine Waste Repository would need to be constructed and maintained throughout the construction of the repository. After construction of the repository, disturbed areas around the repository could be reclaimed with stockpiled topsoil and seeded with native grasses. USFS Site 1 would be graded and reclaimed with the stockpiled topsoil and seeded with native grasses.

6.3.2 Settlement Analysis

Settlement of the mine waste placed in the repository is expected to occur during and after construction. Most of the settlement is anticipated to result from compression of the tailing and waste rock materials under the weight of the cover and the weight of the mine waste. The foundation soils at the USFS Site 2 generally consist of silty and clayey sand or gravel with cobbles and boulders, and are not expected to experience significant settlement. Some secondary compression, or creep, may also occur; however, the amount of secondary compression is expected to be negligible as compared to mine waste compression during and immediately following construction.

Based on previous experience with similar structures and published values, mine waste compression is anticipated to be about three percent of the total mine waste thickness. The maximum thickness of mine waste at the proposed USFS Site 2 Mine Waste Repository is about 60 feet, with a corresponding estimated maximum settlement of about two feet. Most of this settlement is likely to occur during construction.

As shown on Figure 7, most of the proposed repository would be graded with 3H:1V side slopes. The top area would be graded with a two (2) percent slope toward the perimeter channel. Should the maximum estimated settlement occur beneath the top area, the amount of differential settlement would not be large enough to reverse the top cover gradient. Some irregularities and minor ponding atop the cover could occur, but the overall drainage direction toward the perimeter channel should be maintained.

6.3.3 Slope Stability Analyses

Slope stability analyses were performed to evaluate the overall stability of the proposed USFS Site 2 Mine Waste Repository. The stability analyses were performed using the limit equilibrium computer program UTEXAS4 (Wright 1999) and Spencer's method of slices to compute theoretical factors of safety for various potential shear surfaces. Manual and automated searches were used to find critical shear surfaces, and drained loading conditions were evaluated.

Stability Model Geometry

The stability of the proposed USFS Site 2 Mine Waste Repository was evaluated using the typical cross section shown on Figure 12. This cross section represents the maximum proposed thickness of mine waste and a 3H:1V cover slope up to elevation 10,864 feet.

The existing ground surface used in the stability model is based on the September 2006 topographic map of the USFS Site 2, and a six-foot-thick layer of foundation soil was modeled above the bedrock surface. The foundation soil thickness is based on the results of the field investigations presented in the Phase I EE/CA Report (URS 2007). The proposed repository soil cover with riprap was simplified for the stability analyses as a two-foot-thick layer of cover material.

No evidence of shallow groundwater was observed during the site investigations at the USFS Site 2 (URS 2007), and the repository is expected to remain above the groundwater surface. Therefore, a phreatic surface was not included in the slope stability model, and only drained loading conditions were evaluated.

Material Properties

The material properties used in the stability analyses are based on results of the site investigations and laboratory testing presented in the Phase I EE/CA (URS 2007) as well as published values and engineering judgment. The properties used in the stability analyses are summarized in Table 6-2 and discussed below.

The mine waste was modeled with a drained shear strength friction angle of 30 degrees and a unit weight of 110 pcf. This shear strength is representative of the tailing material to be placed in the mine waste repository; the waste rock to be placed in the repository is expected to have a higher shear strength, which would result in higher calculated factors of safety.

The proposed cover, consisting of a 12-inch thick layer of riprap underlain by a 12-inch thick layer of compacted soil, was modeled as a single layer of cover material with a drained shear strength friction angle of 31 degrees, 200 psf cohesion, and a unit weight of 131 pcf. The shear strength of the cover material is representative of the borrow soils available from the potential USFS Site 1 borrow area that would be used for the compacted soil cover; the unit weight is based on the results of compaction testing. The riprap to be included in the cover would have greater shear strength than the compacted soil cover, which would result in higher factors of safety.

Based on the site investigations and laboratory testing, the foundation soil at USFS Site 2 generally consists of silty or clayey sand or gravel with cobbles and boulders. This foundation soil was modeled with a drained shear strength friction angle of 34 degrees and a unit weight of 125 pcf. These properties are based on the results of index testing and typical values for similar materials.

Bedrock encountered during the site investigations was competent and was modeled with shear strength sufficiently high to ensure shear surfaces would pass through the overlying materials.

TABLE 6-2
Summary of Material Properties Used in USFS Site 2
Mine Waste Stability Analyses

Material	Unit Weight (pcf)	Drained Shear Strength	
		Cohesion (psf)	Friction Angle (degrees)
Mine Waste (tailing/waste rock)	110	0	30
Cover Material	131	200	31
Foundation Soil	125	0	34
Bedrock	145	5000	45

Results

The results of the stability analyses indicate a calculated minimum theoretical factor of safety of 1.8 for drained loading conditions, which exceeds the recommended minimum value of 1.5. The factor of safety for a shear surface is the ratio of the shear strength of the soil divided by the shear stress required to maintain a just-stable slope. A factor of safety of 1.0 would indicate the shear surface is on the boundary between stability and instability.

Multiple shear surfaces were evaluated as part of the stability analyses. These shear surfaces are theoretical surfaces along which sliding might occur; however, it is the intent of the design that sliding not occur. The minimum calculated theoretical factor of safety corresponds to a relatively shallow shear surface, which would be characteristic of shallow slumping. Other modes of failure were also evaluated, including a deep-seated shear surface. This deep-seated shear surface would be representative of a mass movement involving most of the repository, and has a factor of safety greater than the calculated minimum. These two theoretical shear surfaces and corresponding factors of safety are shown on Figure 12.

6.3.4 Surface Water Analyses

Surface water analyses were performed for the proposed USFS Site 2 Mine Waste Repository to establish precipitation depths for the 2-year and 100-year, 24-hour storm events. These precipitation depths were used to size runoff control structures and evaluate channel riprap requirements.

Precipitation

The NOAA Atlas 2, Precipitation Frequency Atlas for the Western United States (http://hydrology.nws.noaa.gov/oh/hdsc/noaaaltas2.html), was used to estimate precipitation depths for selected storm events (NOAA 2006). Precipitation values were estimated for the Standard Mine site using latitude, longitude, and median elevation.

The following location information was used for the Standard Mine site:

- Latitude: 38.878° N
- Longitude: 107.074° W
- Median Elevation: 11,000 feet

A standard SCS Type II precipitation distribution was used for the site, and the following precipitation depths were estimated:

- 2-year, 24-hour: 1.6 inches
- 100-year, 24-hour: 3.4 inches

The 2-year, 24-hour storm information was used to evaluate likely operation and maintenance requirements related to channel erosion, and the 100-year, 24-hour storm was used to size runoff control structures and to evaluate channel riprap requirements.

Drainage Basin Characteristics

Drainage basins on and contributing to the proposed repository were delineated based on the September 2006 site topographic map and the proposed repository grading plan.

Watershed characteristics were then estimated for each of the drainage basins, including basin area, hydraulic length, and average slope.

The SCS Curve Number method was used to estimate precipitation runoff for calculating peak runoff values. Curve Numbers were estimated for the drainage basins based on the soil and vegetative cover type, and assuming an antecedent moisture condition. Drainage basin lag times were calculated using the SCS lag time equation.

The natural ground areas upstream of the proposed repository were estimated to have an average Curve Number value of CN 78, based on a mixed land type of forested and bare ground (CN 76 and 91, respectively). The proposed mine waste repository riprap cover was estimated to have a Curve Number value of CN 75.

Design Flows

Rainfall distributions and drainage basin characteristics were input into the USACE HEC-HMS (Version 3.0.0) rainfall/runoff computer program to estimate peak surface water discharges for each drainage basin.

Peak discharges were used to size channels and runoff control structures. Normal depth calculations were used to develop channel configurations based on the proposed slope, channel type, and the runoff that contributed to the downstream discharge point at each channel. A Manning's "n" coefficient representative of riprap was used for the channels.

Results

As shown on Figure 7, the surface water runoff controls at the proposed USFS Site 2 Mine Waste Repository would consist of a perimeter channel surrounding the proposed repository. This perimeter channel would divert surface water runoff from the upstream drainage basins around the proposed repository, and convey surface water runoff from the repository cover away from the proposed facility. This perimeter channel would divert water from the east and west sides of the proposed repository separately. The flows from these channels would be combined near the south side of the repository and flow across the adjacent roadway via a low-water crossing. A dissipation apron would be

constructed at the downstream end of the low-water crossing and surface water would then be discharged as sheet flow across the existing ground surface.

The proposed perimeter channel has a trapezoidal cross section with a five-foot bottom width, three-foot depth, varying longitudinal slopes, and 3H:1V and 2H:1V inboard and outboard side slopes, respectively. The peak discharge from the perimeter channel during the 100-year, 24-hour storm event is estimated to be approximately 100 cfs. Normal depth calculations indicate the proposed perimeter channel configuration has sufficient capacity to convey the peak discharge from the 100-year, 24-hour storm event.

Riprap will be placed in the perimeter channel to provide erosion protection. This riprap will consist of durable, locally available cobbles and boulders from slopes adjacent to the USFS Site 2 Mine Waste Repository and the Area 99 riprap borrow area. Based on the 100-year, 24-hour storm and the calculated peak discharge flow rate within the perimeter channel, the riprap required for the lining of the perimeter channels, ranged in size from 2 inches to 22 inches in nominal diameter, depending on the channel slope. These sizes represent the maximum nominal diameter for 50 percent of the riprap particles, by weight (D50). Because of the larger watershed area above USFS Site 2 compared to Area 245, larger discharge flowrates for the USFS Site 2 are calculated. As a result riprap borrowed from Area 99 may not be large enough to resist movement during the peak discharge from the 100-year, 24-hour storm event; however, the riprap material at Area 99 would be suitable for peak discharge flow rates associated with the 2-year, 24-hour storm event. Should the repository experience a large storm event similar to the 100-year, 24-hour event, some repairs to the perimeter channels may be required. Further evaluation of the Area 99 riprap to determine its adequacy for this application will be conducted prior to perimeter channel construction. Alternative riprap sources or other stormwater runoff mitigation steps will be investigated as warranted.

6.3.5 Alternative Analysis

Effectiveness

The proposed USFS Site 2 Mine Waste Repository covers approximately 2.6 acres and would require approximately 300 feet of road to be constructed for access to the

repository. The approximate area of disturbance could exceed 3 acres, depending on the size of the access road. Construction of the repository and access road would require the removal of trees, shrubs, and native vegetation over that same area.

USFS Site 2 is considered somewhat heavily forested with trees, shrubs and native grasses. The eastern slope adjacent to the repository is covered with talus and a rock glacier composed of talus. The riprap cover may blend well with the adjacent talus slopes. The location of the repository is situated such that it would be not be visible from Crested Butte or Kebler Pass Road.

The travel distance to the proposed USFS Site 2 Mine Waste Repository from the riprap and soil borrow areas is approximately 1.5 to 0.6 miles, respectively. From the soil borrow area (USFS Site 1) the haul is generally uphill and from the riprap borrow area (Area 99) the haul is generally downhill. It is expected that at least a portion of the required riprap volume will be obtained from the adjacent talus slope. The travel distance from the Standard Mine Level 1 mine waste is approximately 0.4 miles and the haul is generally downhill. Repair and maintenance of the existing and constructed access roads would be required on approximately 2.1 miles of road.

The area above the proposed repository contributing to surface water run-on is approximately 59.3 acres and the area of the repository is approximately 2.6 acres. The maximum peak estimated flow rate in the perimeter channel resulting from the 100-year, 24-hour storm is about 100 cfs.

The average percolation through the soil cover with riprap, as indicated on Table 5-4, is estimated to be 0.7 gpm. This rate of infiltration is directly related to the area of the repository that is exposed to precipitation. The USFS Site 2 Mine Waste Repository is oriented such that the majority of the slopes are generally south and west facing. South facing slopes generally receive more solar radiation during winter months, which results in less snow cover and less overall infiltration.

Based on the site reconnaissance conducted between July and October 2006, USFS Site 2 could be a potential habitat for several open and forest dwelling Threatened and Endangered Species because of the heavily wooded area.

Implementability

Construction of this repository alternative can be implemented. The technical aspects of this repository alternative include the processing of borrow material, foundation preparation, placement of mine waste, construction of perimeter channels, compaction of the soil cover, placement of riprap, and construction of new haul roads. The location of the soil cover and riprap borrow areas are relatively close and can be accessed from the existing roads.

The construction of this repository alternative can be done with typical construction equipment and experienced labor. There are no specialized skills required for the construction.

Settlement analysis indicates that the amount of differential settlement due to compression of the waste rock would not be large enough to reverse the top cover gradient. Slope stability analyses of this repository alternative indicate that this alternative is expected to meet the minimum recommended factor of safety for slope stability.

Cost

A conceptual level cost estimate for Alternative B is presented on Table 7-2 and is based on the conceptual level designs presented in this report. The primary use and purpose of the conceptual cost estimate is to provide a basis for the selection of one of the proposed alternatives for final design and to provide an understanding of the potential level of funding necessary to implement the conceptual level designs presented in this report. The cost estimates presented in this report are based on our professional judgment, the existing technical information, the characteristics of the conceptual level structures, and the conceptual nature of the designs. The unit costs used for this study are derived from our experience and data collected on similar projects.

The presented conceptual cost estimate includes the costs for contractor management and administration; quality assurance and control; temporary facilities and equipment; execution layout and survey; borrow excavation and reclamation; clearing, grubbing, and

tree disposal; strip and stockpile topsoil; haul and place waste rock; screen, haul, and place compacted soil cover; haul and place riprap cover; construct perimeter channels; and a 35 percent contingency.

The contingency of 35 percent was used in the conceptual cost estimates presented on Table 7-2 to account for unidentified or unlisted quantities or items, to accommodate for project site constraints and conditions including the difficult access to the mine site and limited construction season, to address owner project costs including but not limited to engineering design and construction management, and for final pricing adjustments.

The level of detail associated with this conceptual cost estimate was based on quantities taken from figures prepared for this conceptual level design. Accuracy is not guaranteed, and the use of the conceptual cost estimate should not be deemed as an offering or proposal with respect to the outcome of the cost of an activity or project. The conceptual cost estimate was developed to assist with decision making process relating to future work related to the conceptual level designs and should not be used for other purposes.

Based on the discussion presented in Section 5, O&M costs are expected to be minimal. Annual inspections will be performed for 20 years and have a present worth cost of $34,000.

7.0 COMPARATIVE ANALYSES OF REMOVAL ACTION ALTERNATIVES

A comparative analysis was performed for the two proposed repository alternatives, considering the effectiveness, implementability, and cost of each alternative. The costs presented in this section do not include the cost to excavate waste materials or to reclaim excavated areas. This section includes the comparative analysis, and a summary of the alternative analysis is presented on Table 7-1.

7.1 EFFECTIVENESS

Area of Disturbance

The proposed Area 245 Mine Waste Repository covers approximately 4.25 acres and the proposed USFS Site 2 Mine Waste Repository covers approximately 2.6 acres. Both repositories

would require the construction of approximately 1,000 feet and 300 feet of access roads, respectively. The approximate area of disturbance at Area 245 could exceed 5 acres and at USFS Site 2 the area of disturbance could exceed 3 acres, depending on the size of the access roads. Construction of the repository and access roads will require the removal of trees, shrubs, and native vegetation within the footprint of the repository.

Alternative B (USFS Site 2 Mine Waste Repository) would be the most effective at minimizing the area of disturbance.

Aesthetics

Area 245 is considered heavily forested and USFS Site 2 is considered somewhat heavily forested, with a talus slope adjacent to the eastern slope of the site. The riprap cover is not expected to blend well with the surrounding terrain at Area 245, but may blend better with the talus slopes at USFS Site 2.

Alternative B (USFS Site 2 Mine Waste Repository) is expected to be more aesthetically pleasing and may appear more naturally occurring.

The locations of both potential repository sites would generally not be visible from Crested Butte or Kebler Pass Road (Appendix A). Both locations would be visible from locations south of Kebler Pass Road and west of Elk Creek.

Alternative A (Area 245 Mine Waste Repository) would be more effective at utilizing the terrain to mask the presence of a repository.

Material Haulage

The travel distance to the proposed Area 245 Mine Waste Repository from the riprap and soil borrow areas is approximately 0.3 to 1.25 miles, respectively. The travel distance to the proposed USFS Site 2 Mine Waste Repository from the riprap and soil borrow areas is approximately 1.5 to 0.6 miles, respectively. From the soil borrow area (USFS Site 1), the haul to the Area 245 Mine Waste Repository is generally uphill and from the riprap borrow area (Area 99) the haul is generally downhill. From the soil borrow area (USFS Site 1), the haul to USFS Site 2 Mine

Waste Repository is generally uphill and from the riprap borrow area (Area 99) the haul is generally downhill.

The travel distance from the Standard Mine Level 1 mine waste to Area 245 and USFS Site 2 is approximately 1.5 miles and 0.4 miles, respectively. From the Standard Mine Level 1 mine waste, the haul to Area 245 is generally uphill, and the haul to USFS Site 2 is generally downhill. Repair and maintenance of the existing and constructed access roads to be used during the construction of the Area 245 Mine Waste Repository and the USFS Site 2 Mine Waste Repository would include approximately 2.5 miles and 2.1 miles of road, respectively.

Alternative B (USFS Site 2 Mine Waste Repository) would be more effective because the transport of most of the material (80,000 cubic yards of mine waste) would be over a shorter distance with a generally downhill haul. Additionally this alternative would require less maintenance and less construction of access roads.

Surface Water Hydrology

The area above the proposed repository at Area 245 contributing to surface water run-on is approximately 6.2 acres and the area of the repository is approximately 4.25 acres, for a total watershed area of about 10.5 acres. The maximum peak estimated flow rate in the perimeter channel resulting from the 100-year, 24-hour storm is about 15 cfs.

The area above the proposed repository at USFS Site 2 contributing to surface water run-on is approximately 59.3 acres and the area of the repository is approximately 2.6 acres, for a total watershed area of about 62 acres. The maximum peak estimated flow rate in the perimeter channel resulting from the 100-year, 24-hour storm is about 100 cubic feet per second. Although perimeter channels have been designed at each site to convey the 100-year. 24-hour storm, Alternative A (Area 245 Mine Waste Repository) is better situated to minimize the quantity of surface water run-on.

Infiltration

The average vertical percolation through the soil cover with riprap at the Area 245 and USFS Site 2 Mine Waste Repositories, as indicated on Table 5-4, are estimated to be about 1.1 and 0.7 gpm.

Alternative B (USFS Site 2 Mine Waste Repository) is more effective at minimizing the quantity of infiltrated water available for leachate generation.

Both repositories are oriented such that the majority of the slopes are generally south facing. South facing slopes generally receive more solar radiation during winter months, which results in less snow cover and less overall infiltration.

Threatened and Endangered Species

Based on the site reconnaissance conducted between July and October 2006, both repositories could be a potential habitat for several open and forest dwelling threatened and endangered species.

7.2 IMPLEMENTABILITY

Both alternatives can be implemented and can be constructed with typical construction equipment. There are no specialized skills required for the construction.

The technical aspects of both repository alternatives include the processing of borrow material, foundation preparation, placement of mine waste, construction of perimeter channels, compaction of the soil cover, placement of riprap, and construction of new haul roads. The location of the soil cover and riprap borrow areas are relatively close and can be accessed from the existing roads.

Settlement analyses of both alternatives indicate that the amount of differential settlement due to compression of the waste rock would not be large enough to reverse the top cover gradient. Slope stability analyses of both alternatives indicate they are expected to meet the minimum recommended factor of safety for slope stability.

7.3 COST

A conceptual level cost estimate for Alternatives A and B is presented on Table 7-2 and is based on the conceptual level designs presented in this report.

The presented conceptual cost estimates include the costs for contractor management and administration; quality assurance and control; temporary facilities and equipment; execution layout and survey; borrow excavation and reclamation; clearing, grubbing, and tree disposal; strip and stockpile topsoil; haul and place waste rock; screen, haul, and place compacted soil cover; haul and place riprap cover; construct perimeter channels; and a 35 percent contingency.

The contingency of 35 percent was used in the conceptual cost estimates presented on Table 7-2 to account for unidentified or unlisted quantities or items, to accommodate project site constraints and conditions including the difficult access to the mine site and the limited construction season, to address owner project costs including but not limited to engineering design and construction management, and for final pricing adjustments.

The level of detail associated with these conceptual cost estimates was based on quantities taken from figures prepared for this conceptual level design. Based on the costs presented on Table 7-2 Alternative B has a lower estimated capital cost than Alternative A and would be the more cost effective alternative.

As discussed in Section 5, for the purposes of this report, O&M costs include the cost of annual inspections that will document the condition of the repository. Any issues that could impact the ability of the repository to contain the waste as designed will be identified. It is assumed that one mobilization trip will be required to make minor repairs in the riprap and soil cover. The combined present worth cost of inspections and repairs is $48,000 for each potential repository site.

7.4 RECOMMENDED REMOVAL ACTION ALTERNATIVE

Results of this comparative analysis indicate that Alternative B, the USFS Site 2 Mine Waste Repository, would be the most cost effective alternative. Alternative B offers the best protection against total vertical infiltration; the smallest area of disturbance; better hauling conditions from the waste rock location to the repository; the least amount of access road construction, upgrade, and maintenance; less obtrusive geometry; and a more aesthetically pleasing and naturally occurring appearance.

Although the Alternative A site has a smaller watershed area than Alternative B, perimeter channels can be constructed surrounding the Alternative B site to convey the flows from upland area and minimize the potential for surface water run-on. Both sites are wooded and could be potential habitats for threatened and endangered species.

TABLE 7-1
Repository Alternatives Analysis

Alternative	Effectiveness		Implementability		Cost	
	Protectiveness	**Ability to Achieve RAOs**	**Technical**	**Availability**	**Capital**	**O&M**
Alternative A – Area 245 Mine Waste Repository	Construction of the repository and access road will require the removal of trees, shrubs and native vegetation over an area of approximately five acres Area 245 is considered heavily forested and the riprap cover may not blend well with the surrounding terrain. The location of the repository is situated such that it would be generally not be visible from Crested Butte or Kebler Pass Road. The travel distance to the proposed Area 245 Mine Waste Repository from the riprap and soil borrow areas is approximately 0.3 to 1.25 miles, respectively. From the soil borrow area (USFS Site 1) the haul is generally uphill and from the riprap borrow area (Area 99) the haul is generally downhill. The travel distance from the Standard Mine Level 1 mine waste is approximately 1.5 miles and the haul is generally uphill. Repair and maintenance of the existing and constructed access roads would include approximately 2.5 miles of road. The maximum peak estimated flow rate in the perimeter channel resulting from surface water run-on and runoff from the 100-year, 24-hour storm is about 15 cfs. The average percolation through the soil cover with riprap is estimated to be about 1.1 gpm. Repository is oriented such that most of the slopes are generally south facing and would generally receive more solar radiation during winter months, which results in less snow cover and less overall infiltration. Area 245 could be a potential habitat for several forest-dwelling threatened and endangered species.	Construction of the repository at this location will satisfy the Removal Action Objective of reducing metal loading to Elk Creek due to site soils and water. Placement of waste rock and tailings into a capped repository will eliminate wildlife contact with metals present in the site soils addressed in this action and potentially site vegetation. Reclamation of excavated areas will include construction of drainage channels that will contain storm water and mine discharge runoff. Controlling the runoff will serve to limit erosion and reduce human and ecological exposure to low pH water will elevated metals concentrations.	Can be implemented. The technical aspects of this repository alternative include the processing of borrow material, foundation preparation, placement of mine waste, construction of perimeter channels, compaction of the soil cover, placement of riprap, and construction of new haul roads. Can be done with typical ~~construction equipment and~~ experienced labor. There are no specialized skills required for the construction. May require more long-term maintenance than the riprap cover alternatives.	Location of the soil cover and riprap borrow areas are relatively close and can be accessed from the existing access roads. Settlement analysis indicates that the amount of differential settlement due to compression of the waste rock would not be large enough to reverse the top cover gradient. Slope stability analyses of ~~this repository alternative~~ indicate this alternative is expected to meet the minimum recommended factor of safety for slope stability.	$2,019,000	$48,000
Alternative B – USFS Site 2 Mine Waste Repository	Construction of the repository and access road will require the removal of trees, shrubs and native vegetation over an area of approximately three acres. USFS Site 2 is considered somewhat heavily forested with trees, shrubs, and native grasses, with a talus slope adjacent to the eastern slope of the site. The riprap cover may blend well with the talus slopes. The location of the repository is situated such that it would not be visible from Crested Butte or Kebler Pass Road. The travel distance to the proposed USFS Site 2 Mine Waste Repository from the riprap and soil borrow areas is approximately 1.5 to 0.6 miles, respectively. From the soil borrow area (USFS Site 1) the haul is generally uphill and from the riprap borrow area (Area 99) the haul is generally downhill. The travel distance from the Standard Mine Level 1 mine waste is approximately 0.4 miles and the haul is generally downhill. Repair and maintenance of the existing and constructed access roads would include approximately 2.1 miles of road. The maximum peak estimated flow rate in the perimeter channel resulting from surface water run-on and runoff from a 100-year, 24-hour storm is about 100 cfs. The average percolation through the soil cover with riprap is estimated to be 0.7 gpm. Repository is oriented such that the majority of the slopes are generally south facing and would generally receive more solar radiation during winter months, which results in less snow cover and less overall infiltration. USFS Site 2 could be a potential habitat for several open and forest dwelling threatened and endangered species.	Construction of the repository at this location will satisfy the Removal Action Objective of reducing metal loading to Elk Creek due to site soils and water. Placement of waste rock and tailings into a capped repository will eliminate wildlife contact with metals present in the site soils addressed in this action and potentially site vegetation. Reclamation of excavated areas will include construction of drainage channels that will contain storm water and mine discharge runoff. Controlling the runoff will serve to limit erosion and reduce human and ecological exposure to low pH water will elevated metals concentrations.	Can be implemented. The technical aspects of this repository alternative include the processing of borrow material, foundation preparation, placement of mine waste, construction of perimeter channels, compaction of the soil cover, placement of riprap, and construction of new haul roads. Can be done with typical construction equipment and experienced labor. There are no specialized skills required for the construction. May require more long-term maintenance than the riprap cover alternatives.	Locations of the soil cover and riprap borrow areas are relatively close and can be accessed from the existing access roads. Settlement analysis indicates that the amount of differential settlement due to compression of the waste rock would not be large enough to reverse the top cover gradient. Slope stability analyses of this repository alternative indicate this alternative is expected to meet the minimum recommended factor of safety for slope stability.	$1,568,000	$48,000

TABLE 7-2 – Repository Alternative Costs

		USFS Site 2			Area 245		
		Unit cost	Soil Cover with Riprap		Unit cost	Soil Cover w/ Riprap	
Description	**Unit**	**Labor & Materials**	**Estimated Quantity**	**Estimated Cost**	**Labor & Materials**	**Estimated Quantity**	**Estimated Cost**
CAPITAL COST							
General Requirements							
Administration (4.25%)	EA		1	$ 33,000			$ 42,000
Quality (1.75%)	EA		1	$ 14,000			$ 17,000
Temporary Facilities (1.25%)	EA		1	$ 10,000			$ 12,000
Mobilization, Execution, and Demobilization(7.75%)	EA		1	$ 60,000			$ 77,000
Subtotal:				$ 117,000			$ 148,000
General Construction							
Maintain Existing Access Roads	LF	$ 10.00	11,200	$ 112,000	$ 10.00	11,500	$ 115,000
Construct/Maintain Haul Roads	LF	$ 40.00	300	$ 12,000	$ 40.00	1,000	$ 40,000
Clear and Grub	SY	$ 1.80	13,200	$ 24,000	$ 1.80	20,900	$ 38,000
Strip and Stockpile Topsoil (6")	CY	$ 5.00	2,200	$ 11,000	$ 5.00	3,600	$ 18,000
Haul and Place Waste Rock	CY	$ 5.30	80,000	$ 424,000	$ 6.50	80,000	$ 520,000
Cover Construction							
Screen, Haul and Place Compacted Soil Cover	CY	$ 6.00	4,350	$ 26,000	$ 6.00	7,240	$ 43,000
Haul and Place Riprap Cover	CY	$ 14.50	4,350	$ 63,000	$ 12.00	7,240	$ 87,000
Perimeter Channels							
Construct Perimeter Channels	LF	$ 50.00	1,340	$ 67,000	$ 50.00	1,900	$ 95,000
Place Riprap for Channels	CY	$ 25.00	1,320	$ 33,000	$ 18.00	2,200	$ 40,000
Subtotal:				$ 772,000			$ 996,000
SUBTOTAL				**$ 889,000**			**$ 1,144,000**
Contingency (Conceptual level 20% allowance)				$ 178,000			$ 229,000
SUBTOTAL				**$ 1,067,000**			**$ 1,373,000**
Other Costs							
Contingency (15% of Subtotal)				$ 160,000			$ 206,000
Project Management (5% of Subtotal)				$ 53,000			$ 69,000
Engineering Design (12% of Subtotal)				$ 128,000			$ 165,000
Construction Management (15% of Subtotal)				$ 160,000			$ 206,000
TOTAL CAPITAL COST				**$ 1,568,000**			**$ 2,019,000**
Operations and Maintenance (O&M)				$ 48,000			$ 48,000
TOTAL COST				**$ 1,616,000**			**$ 2,067,000**

8.0 LIST OF REFERENCES

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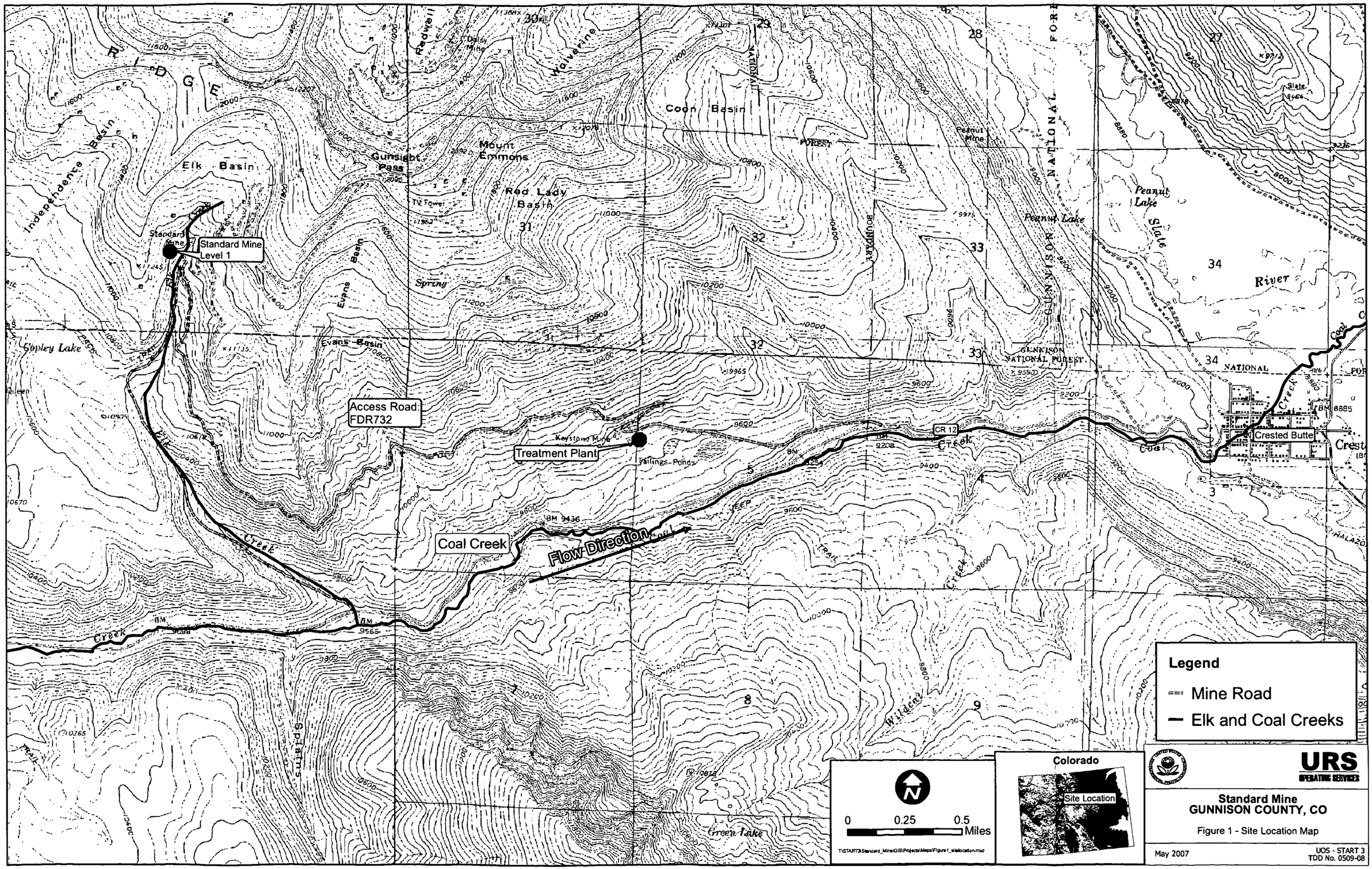

Standard Mine
Level 1
Access Road:
FDR732
Treatment Plant
Coal Creek
Flow Direction
CR 12
Crested Butte
Legend
Mine Road
Elk and Coal Creeks
0
0.25
0.5
Miles
Colorado
Site Location
URS
OPERATING SERVICES
Standard Mine
GUNNISON COUNTY, CO
Figure 1 - Site Location Map
May 2007
UOS - START 3
TDD No. 0509-08

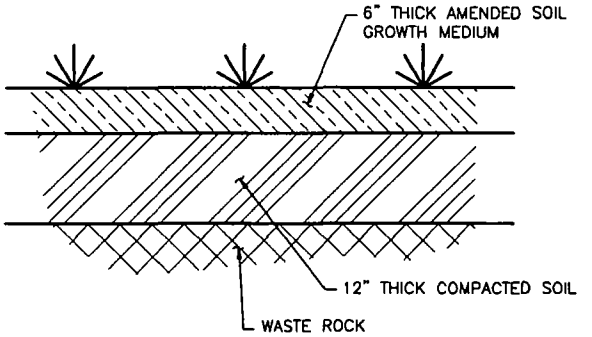
Color Map(s)

The following pages contain color that does not appear in the scanned images.

To view the actual images, contact the Region VIII Records Center at (303) 312-6473.

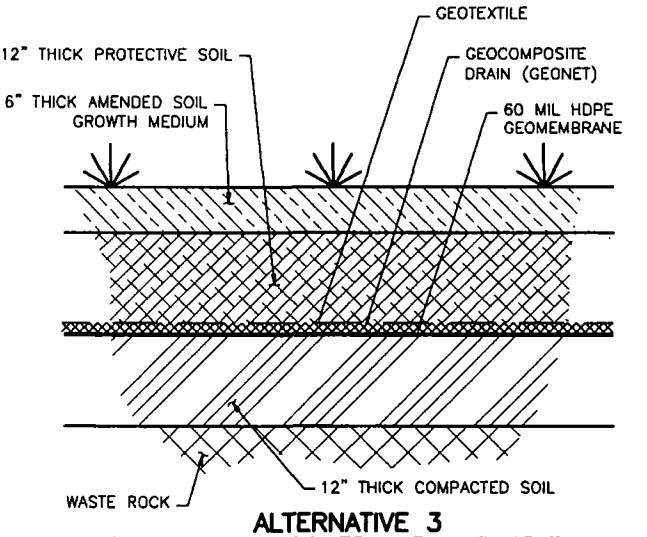
Level 99A
Level 99B
Level 98
Level 98 A
Level 98 B
Level 5B
Level 5
Level 5A
Level 4
Level 4
Level 3
Level 2
Level 1
1 North Pond Area
1 Millsite Area
1 West Embankment
1 West Tailings Pond
1 Northeast (inc. Southeast) Embankment
Legend
Tailings Piles
Adits
Mine Road
Elk Creek
N
0
250
500
Feet
Tuesday, May 24, 2006
T:\START3\Standard_Mine\GIS\figure2_standardMinelocation.mxd
Colorado
Site Location
URS
OPERATING SERVICES
Standard Mine
GUNNISON, CO
Figure 2 - Detailed Site Map
May 2007
Source:
Spectrum Mapping 2006
UOS - START3
TDD No. 0509-08

Legend
Mine Roads
Potential Repository Site
Potential Borrow Site
Elk Creek
0 250 500 1,000 1,500
Feet
N
STANDARD MINE
LEVEL 1
FS 2
FS 1
Potential Cover Soil
Borrow Site
245
URS
OPERATING SERVICES
Standard Mine
GUNNISON, CO
Figure 3 - Potential Repository and
Cover Soil Borrow Areas
May 2007
Source:
Spectrum Mapping 2006
UOS - START3
TDD No. 0509-08



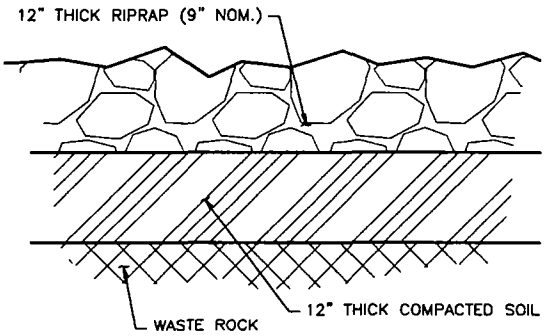
ALTERNATIVE 1
SOIL COVER WITH VEGETATION

0 1 2 3
SCALE IN FEET



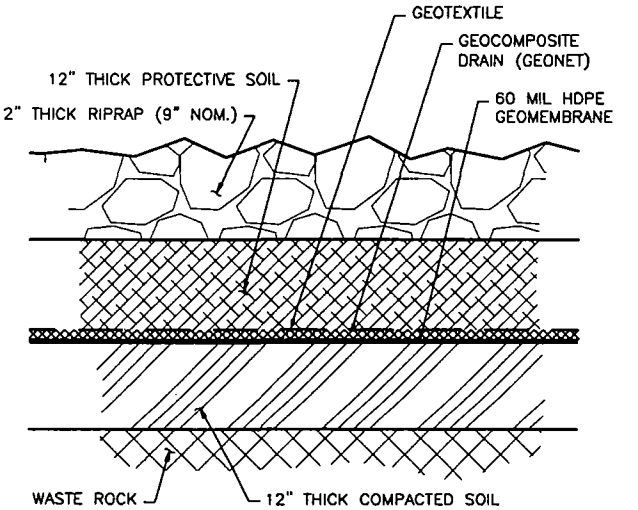
ALTERNATIVE 3
GEOMEMBRANE COVER WITH VEGETATION

0 1 2 3
SCALE IN FEET



ALTERNATIVE 2
SOIL COVER WITH RIPRAP

0 1 2 3
SCALE IN FEET



ALTERNATIVE 4
GEOMEMBRANE COVER WITH RIPRAP

0 1 2 3
SCALE IN FEET

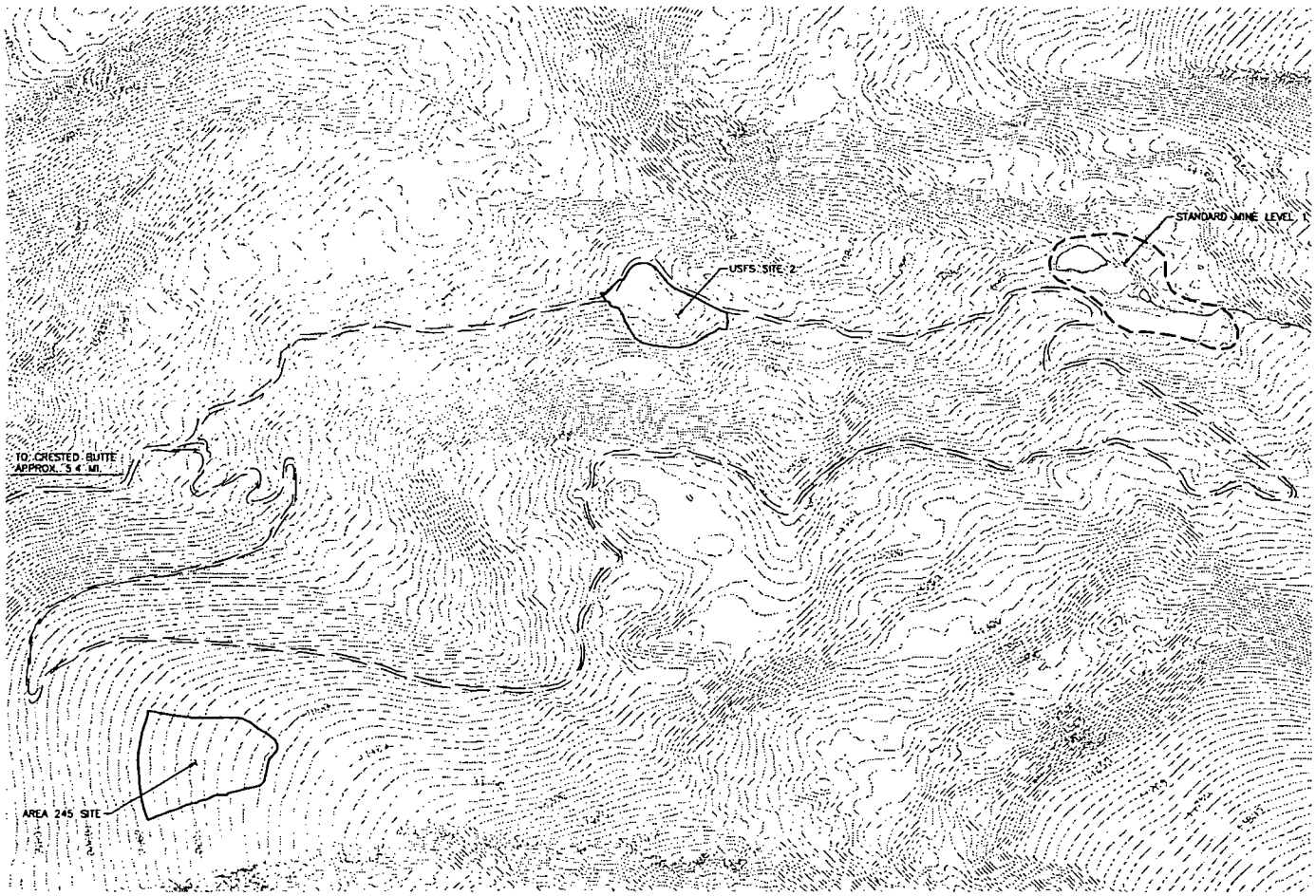
URS
OPERATING SERVICES

STANDARD MINE
GUNNISON COUNTY, CO

Cover Alternatives
Figure 4

May 2007 TDD No. 0509-08

DATE: 05/16/2007 RAM FILENAME: N:\Projects\22238347_Standard_Mine\Sub_00\09.0_CAD\Conceptual Design\FIG_4.dwg

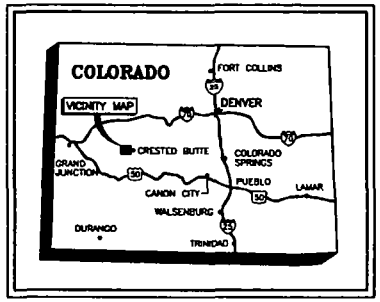


LOCATION MAP

0 250 500 750

SCALE IN FEET

CONTOUR INTERVAL = 10'



STATE MAP

NTS

NOTE:

1. BASE TOPOGRAPHY PROVIDED BY URS OPERATING SERVICES (UOS) IN SEPTEMBER, 2006.

PRELIMINARY
NOT FOR
CONSTRUCTION

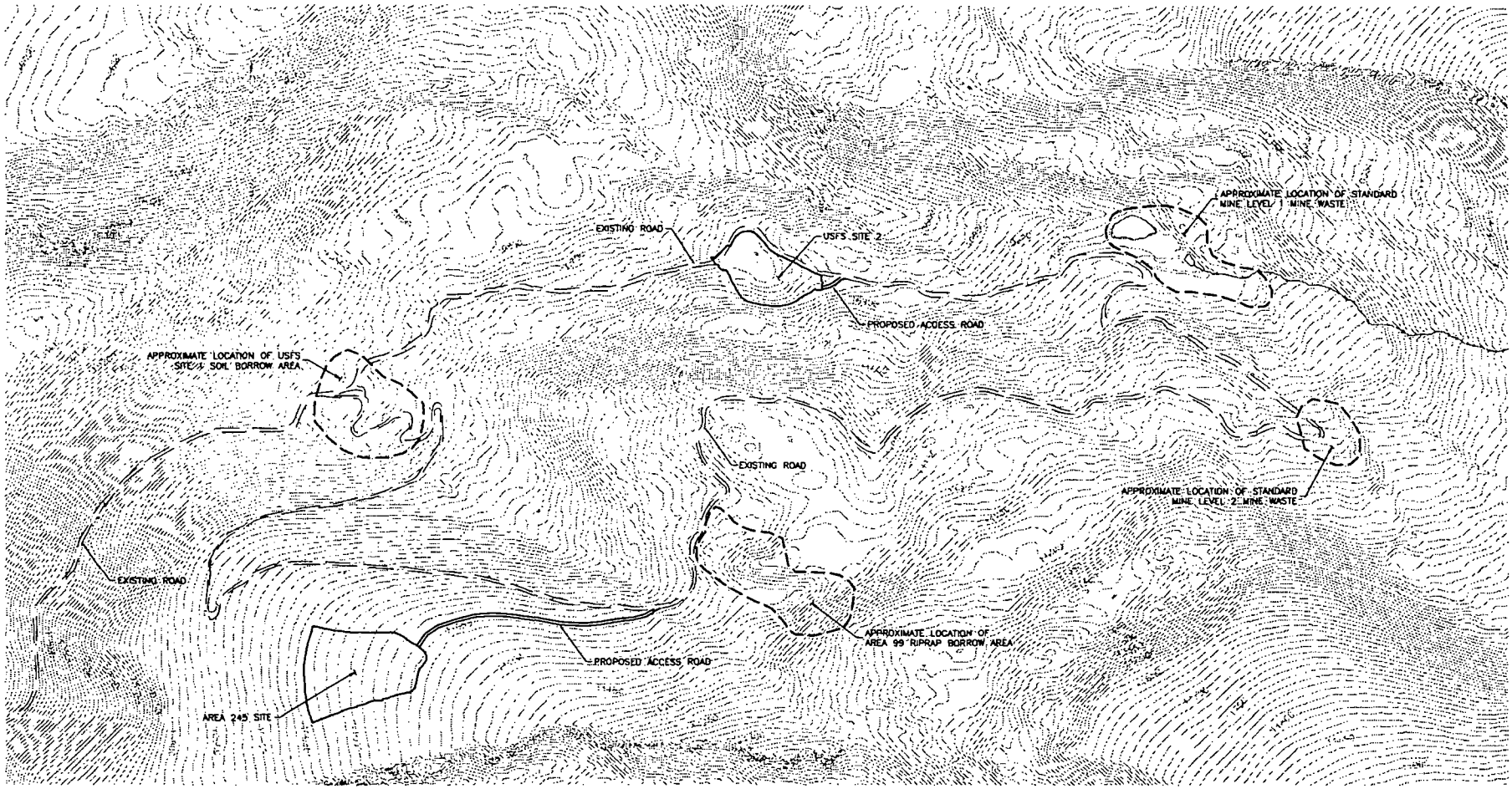
URS OPERATING SERVICES

STANDARD MINE
GUNNISON COUNTY, CO

Location Map and Existing Conditions
Figure 5

May 2007 TDD No. 0509-06

DATE: 05/16/2007 RAM FILENAME: N:\Projects\22238347_Standard_Mine\Sub_00\09.0_CAD\Conceptual Design\FIG_5.dwg



PLAN

0 250 500 750

SCALE IN FEET

CONTOUR INTERVAL = 10'

NOTE:
1. BASE TOPOGRAPHY PROVIDED BY URS OPERATING SERVICES (UOS) IN SEPTEMBER, 2006.

PRELIMINARY
NOT FOR
CONSTRUCTION

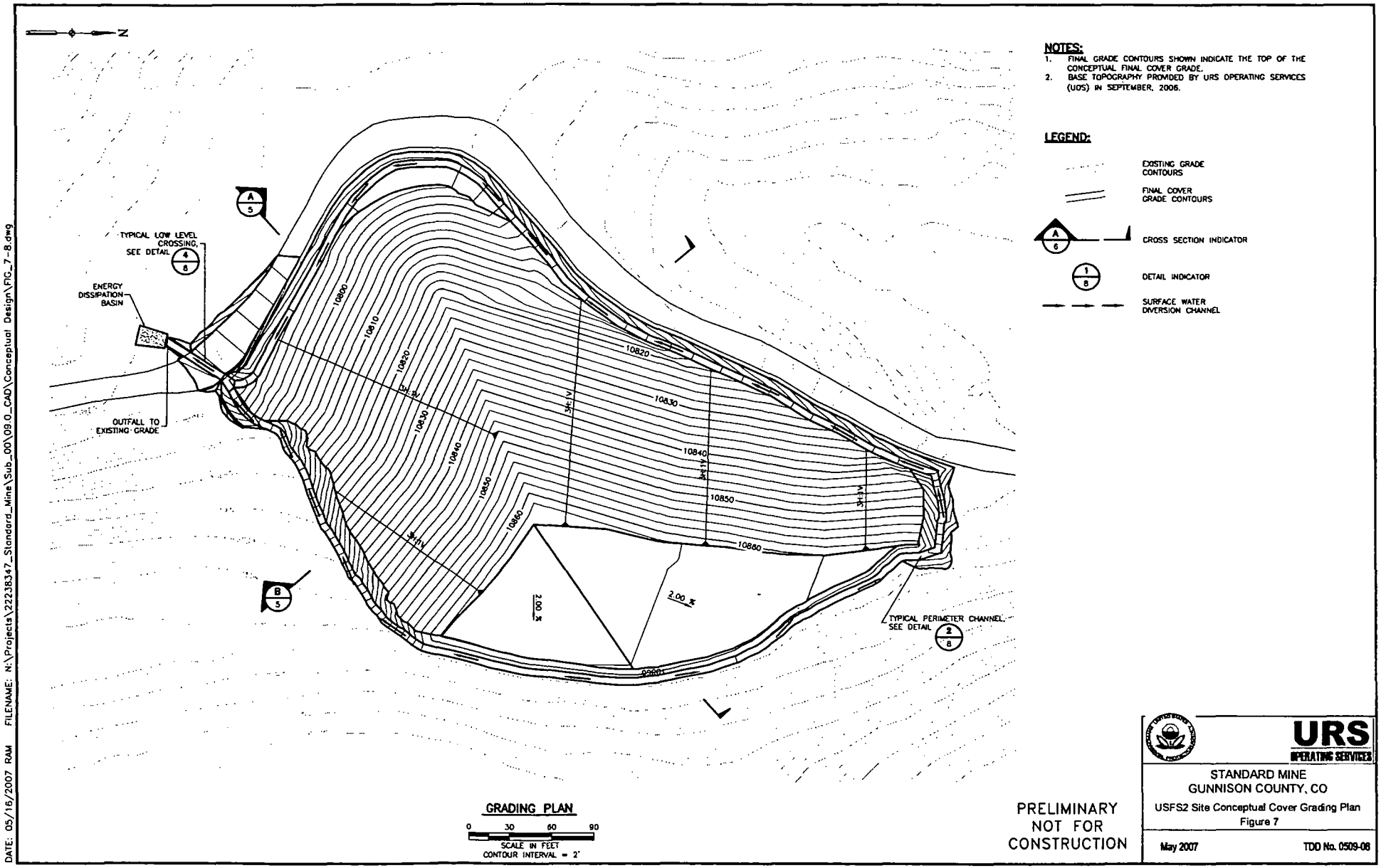
URS OPERATING SERVICES

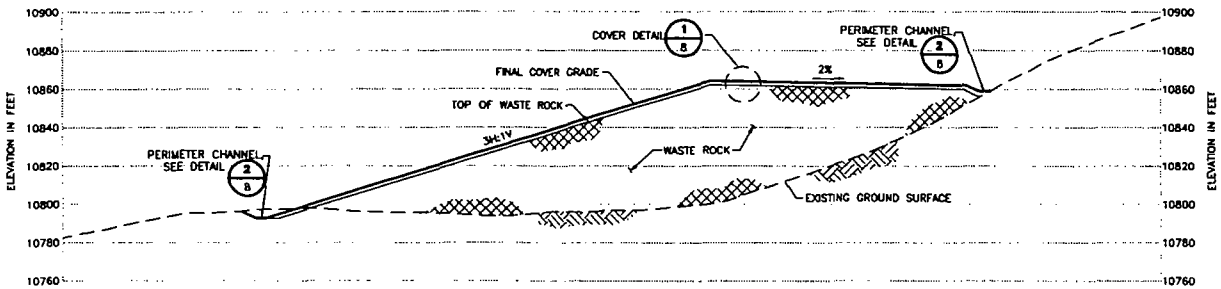
STANDARD MINE
GUNNISON COUNTY, CO

Borrow Sources & Haul Roads
Figure 6

May 2007 | TDD No. 0509-06

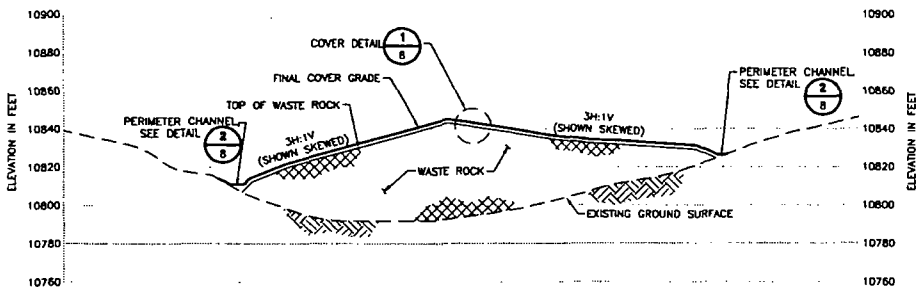
DATE: 05/16/2007 RAM FILENAME: N:\Projects\22238347_Standard_Mine\Sub_00\09.0_CAD\Conceptual Design\FIG_6.dwg


N
TYPICAL LOW LEVEL CROSSING, SEE DETAIL 4/8
ENERGY DISSIPATION BASIN
OUTFALL TO EXISTING GRADE
A 5
B 5
10800
10810
10820
10830
10840
10850
10860
3H:1V
2.00 %
TYPICAL PERIMETER CHANNEL, SEE DETAIL 2/8
NOTES:
1. FINAL GRADE CONTOURS SHOWN INDICATE THE TOP OF THE CONCEPTUAL FINAL COVER GRADE.
2. BASE TOPOGRAPHY PROVIDED BY URS OPERATING SERVICES (UOS) IN SEPTEMBER, 2006.
LEGEND:
EXISTING GRADE CONTOURS
FINAL COVER GRADE CONTOURS
CROSS SECTION INDICATOR
DETAIL INDICATOR
SURFACE WATER DIVERSION CHANNEL
GRADING PLAN
0 30 60 90
SCALE IN FEET
CONTOUR INTERVAL = 2'
PRELIMINARY NOT FOR CONSTRUCTION
URS OPERATING SERVICES
STANDARD MINE
GUNNISON COUNTY, CO
USFS2 Site Conceptual Cover Grading Plan
Figure 7
May 2007
TDD No. 0509-06
DATE: 05/16/2007 RAM FILENAME: N:\Projects\22238347_Standard_Mine\Sub_00\09.0_CAD\Conceptual Design\FIG_7-8.dwg



SECTION A/5

0 30 60 90
SCALE IN FEET



SECTION B/5

0 30 60 90
SCALE IN FEET

PRELIMINARY
NOT FOR
CONSTRUCTION

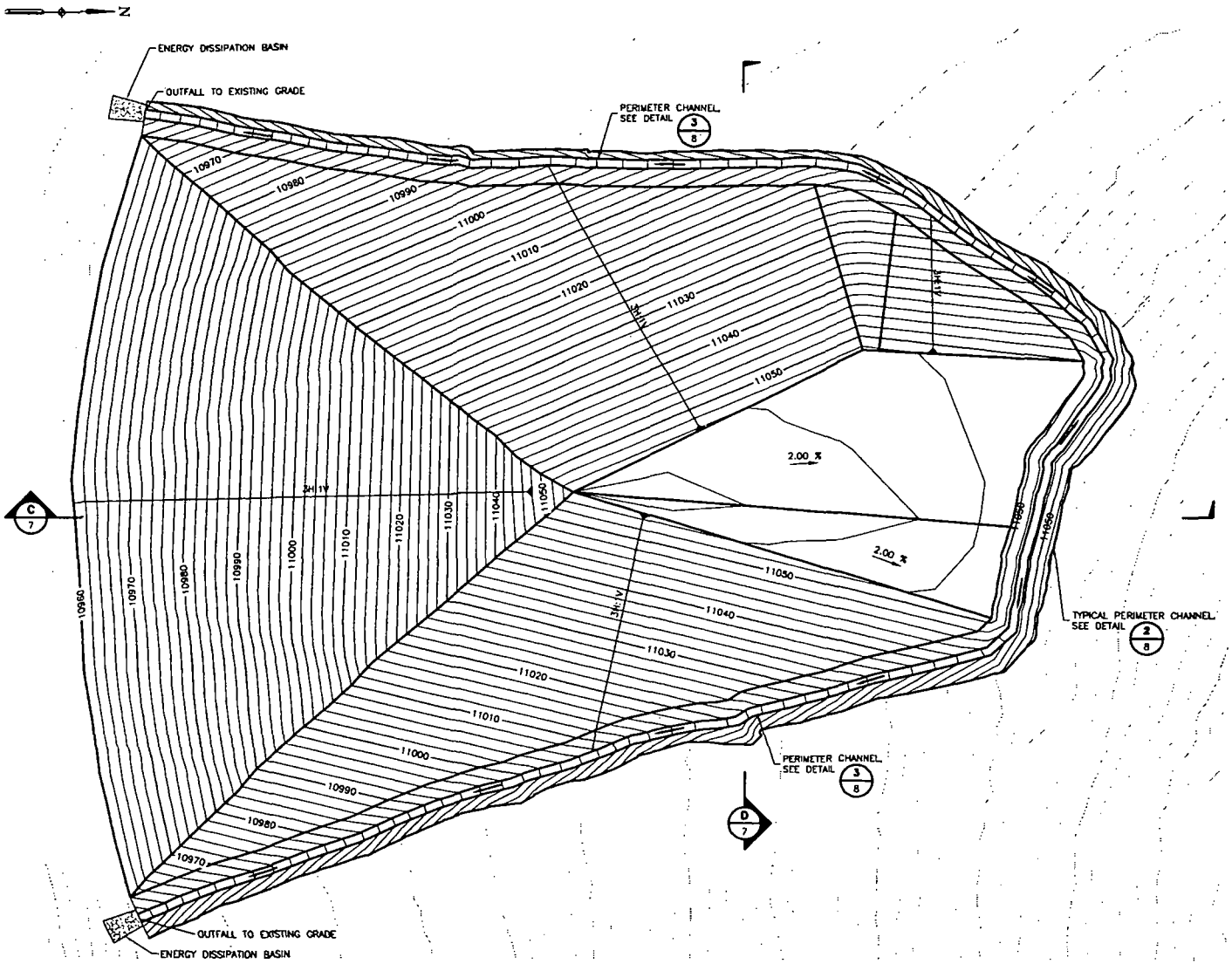
URS OPERATING SERVICES

STANDARD MINE
GUNNISON COUNTY, CO

USFS2 Site Conceptual Cover Grading Sections
Figure 8

May 2007 TDD No. 0509-08

DATE: 05/16/2007 RAM FILENAME: N:\Projects\22238347_Standard_Mine\Sub_00\09.0_CAD\Conceptual Design\FIG_7-8.dwg



NOTES:

1. FINAL GRADE CONTOURS SHOWN INDICATE THE TOP OF THE CONCEPTUAL FINAL COVER GRADE.
2. BASE TOPOGRAPHY PROVIDED BY URS OPERATING SERVICES (UOS) IN SEPTEMBER, 2006.

LEGEND:

- EXISTING GRADE CONTOURS
- FINAL COVER GRADE CONTOURS
- A/5 CROSS SECTION INDICATOR
- 1/8 DETAIL INDICATOR
- SURFACE WATER DIVERSION CHANNEL

GRADING PLAN

0 30 60 90
SCALE IN FEET
CONTOUR INTERVAL = 2'

PRELIMINARY
NOT FOR
CONSTRUCTION

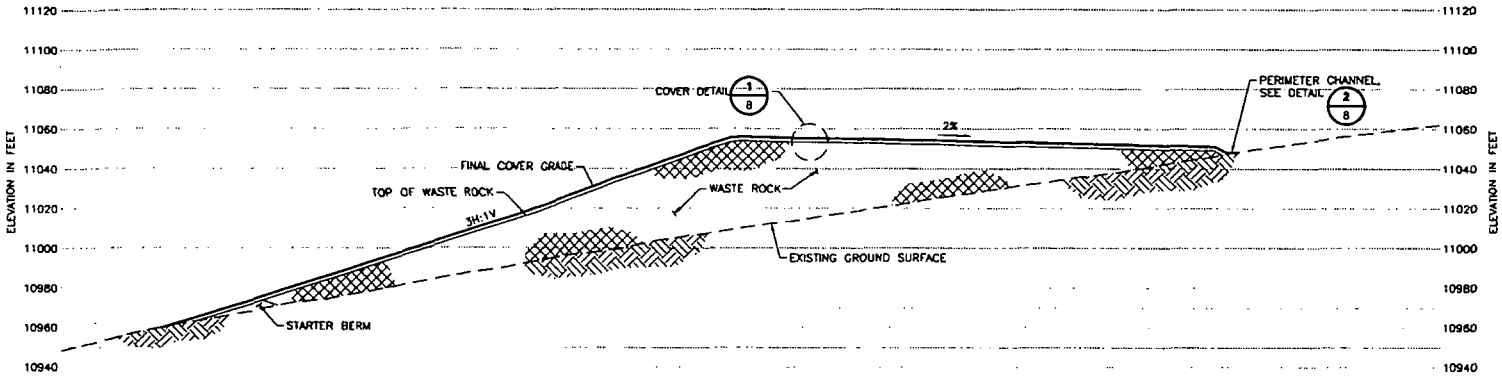
URS OPERATING SERVICES

STANDARD MINE
GUNNISON COUNTY, CO

Area 245 Site Conceptual Cover Grading Plan
Figure 9

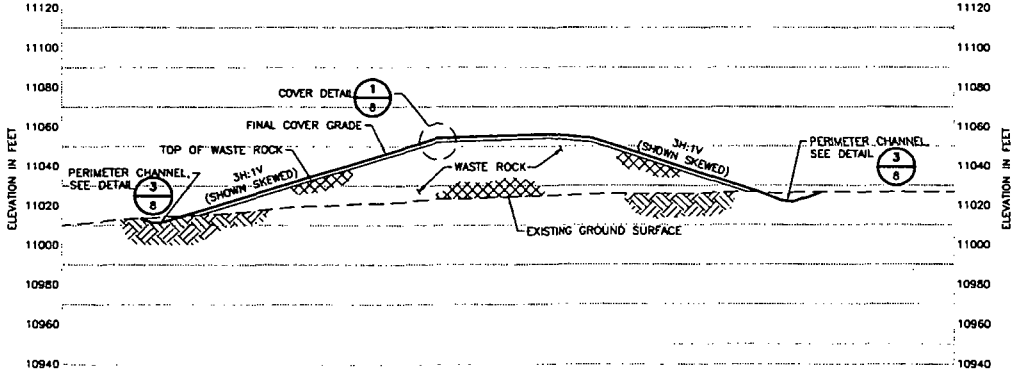
May 2007 TDD No. 0509-08

DATE: 05/16/2007 RAM FILENAME: N:\Projects\22238347_Standard_Mine\Sub_00\09.0_CAD\Conceptual Design\FIG_9-10.dwg



SECTION C/7

0 30 60 90
SCALE IN FEET



SECTION D/7

0 30 60 90
SCALE IN FEET

PRELIMINARY
NOT FOR
CONSTRUCTION

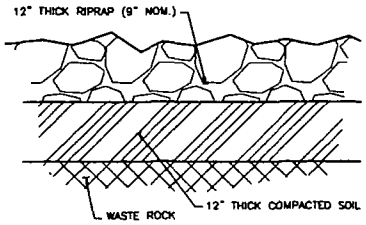
URS OPERATING SERVICES

STANDARD MINE
GUNNISON COUNTY, CO

Area 245 Site Conceptual Cover Grading Sections
Figure 10

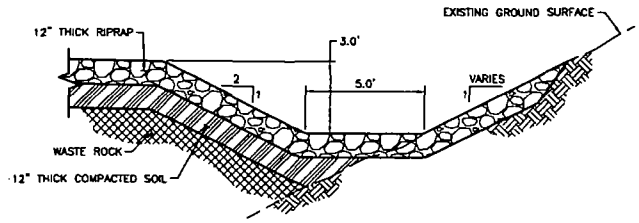
May 2007 TDD No. 0509-08

DATE: 05/16/2007 RAM FILENAME: N:\Projects\22238347_Standard_Mine\Sub_00\09.0_CAD\Conceptual Design\FIG_9-10.dwg



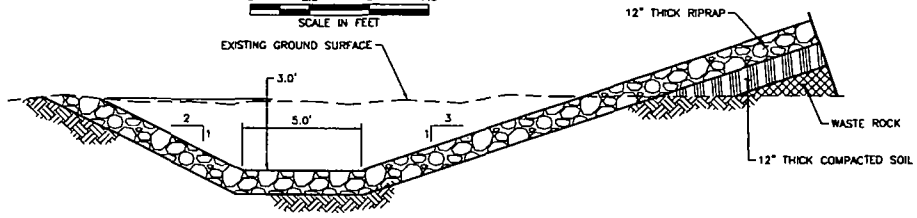
SOIL COVER WITH RIPRAP DETAIL (1/8)

0 1 2 3
SCALE IN FEET



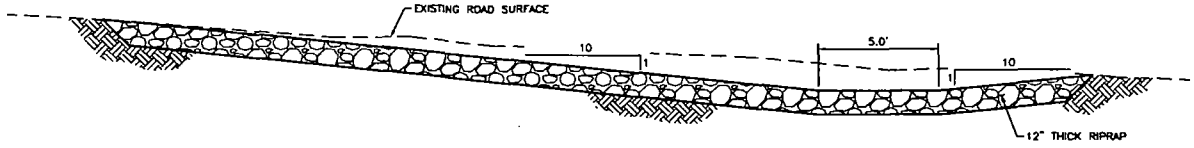
PERIMETER CHANNEL DETAIL (2/8)

0 2.5 5 7.5
SCALE IN FEET



PERIMETER CHANNEL DETAIL (3/8)

0 2.5 5 7.5
SCALE IN FEET



LOW LEVEL CROSSING DETAIL (4/8)

0 2.5 5 7.5
SCALE IN FEET

PRELIMINARY
NOT FOR
CONSTRUCTION

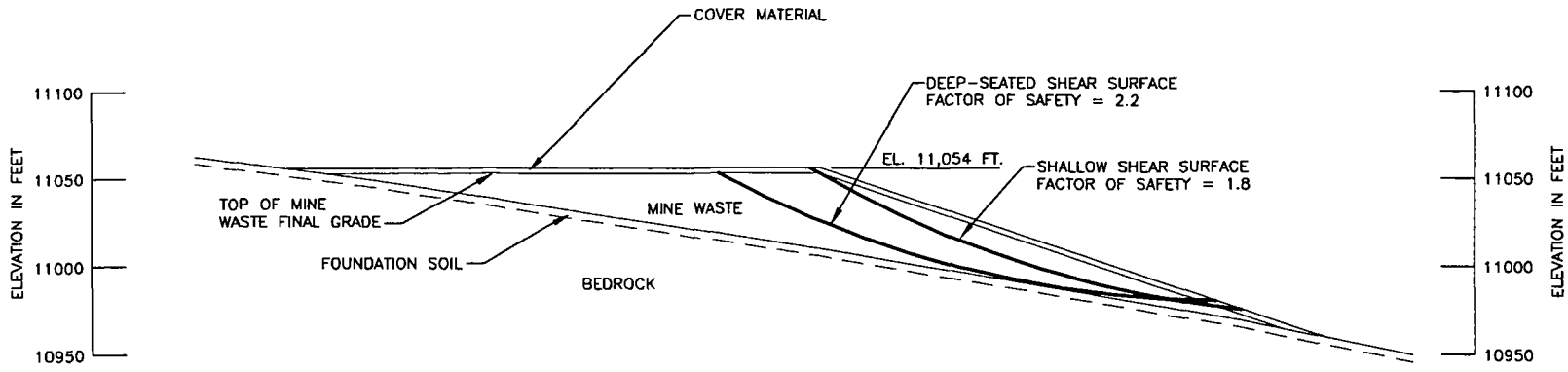
URS OPERATING SERVICES

STANDARD MINE
GUNNISON COUNTY, CO
STANDARD MINE WASTE REPOSITORY
Details
Figure 11

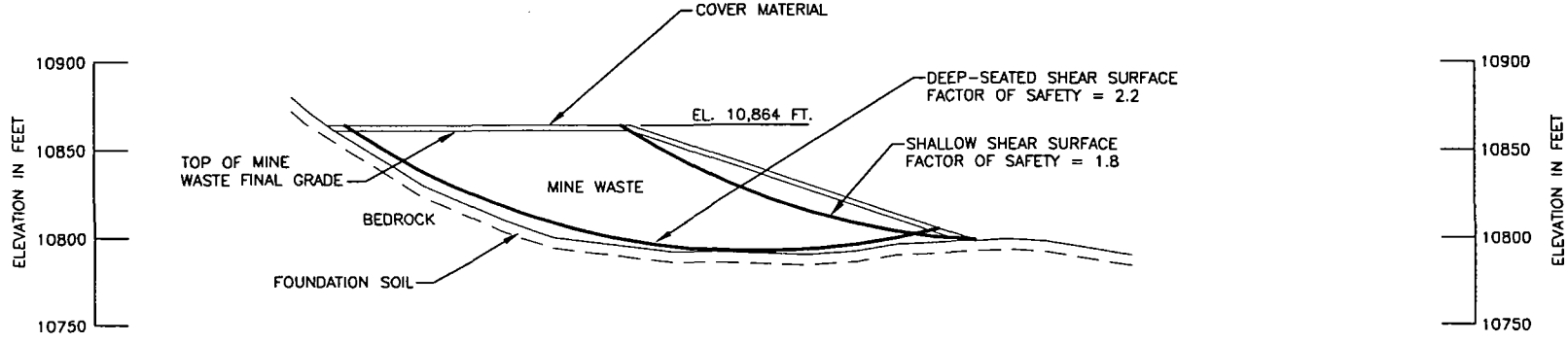
May 2007 TDD No. 0509-08

DATE: 05/16/2007 RAM FILENAME: N:\Projects\22238347_Standard_Mine\Sub_00\09.0_CAD\Conceptual Design\FIG_11.dwg

DATE: 05/16/2007 RAM FILENAME: N:\Projects\22238347_Standard_Mine\Sub_00\09.0_CAD\Conceptual Design\FIG_12.DWG



AREA 245 STABILITY ANALYSES RESULTS



USFS SITE 2 STABILITY ANALYSES RESULTS

NOTES:
1. FACTORS OF SAFETY SHOWN ARE RELATIVE MINIMUMS.
2. MATERIAL PROPERTIES ARE SUMMARIZED IN TABLES 5-1 AND 5-2.

0 50 100 150
SCALE IN FEET

PRELIMINARY
NOT FOR
CONSTRUCTION

URS OPERATING SERVICES

STANDARD MINE
GUNNISON COUNTY, CO

Slope Stability Results
Figure 12

May 2007 TDD No. 0509-08

APPENDIX A

GIS VIEWSHED ANALYSIS

URS

URS OPERATING SERVICES, INC.
START 3 - REGION 8

MEMORANDUM

TO: **Gina Andrews**

FROM: Andrew Longworth

DATE: **21 May 2007**

SUBJECT: **View-shed analysis for potential repositories FS2 and 245**

View-shed analysis was conducted by UOS Start3 in May 2007 to analyze the visibility of potential repositories FS2 and 245. The analysis was conducted using the ARCInfo® 3D Analyst extension. This extension uses line of sight algorithms to determine areas of visibility from a point or nodes of a line. Several parameters of this analysis can be manipulated to tailor the analysis to site specific conditions.

Figure 1 is a schematic figure of the inputs for view-shed analysis using the ARCInfo® extension. Table 1 shows the values used in the analysis and rational for the selection these values.

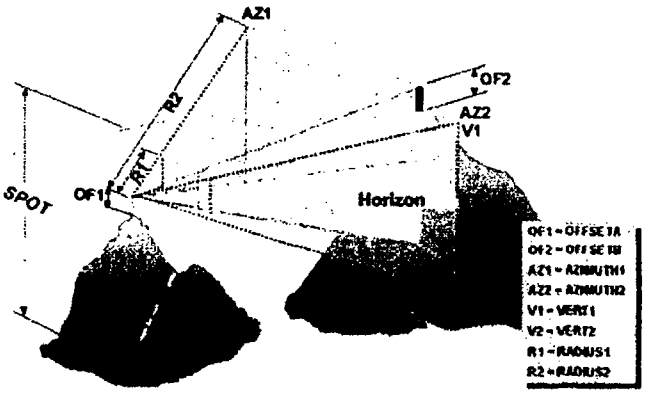


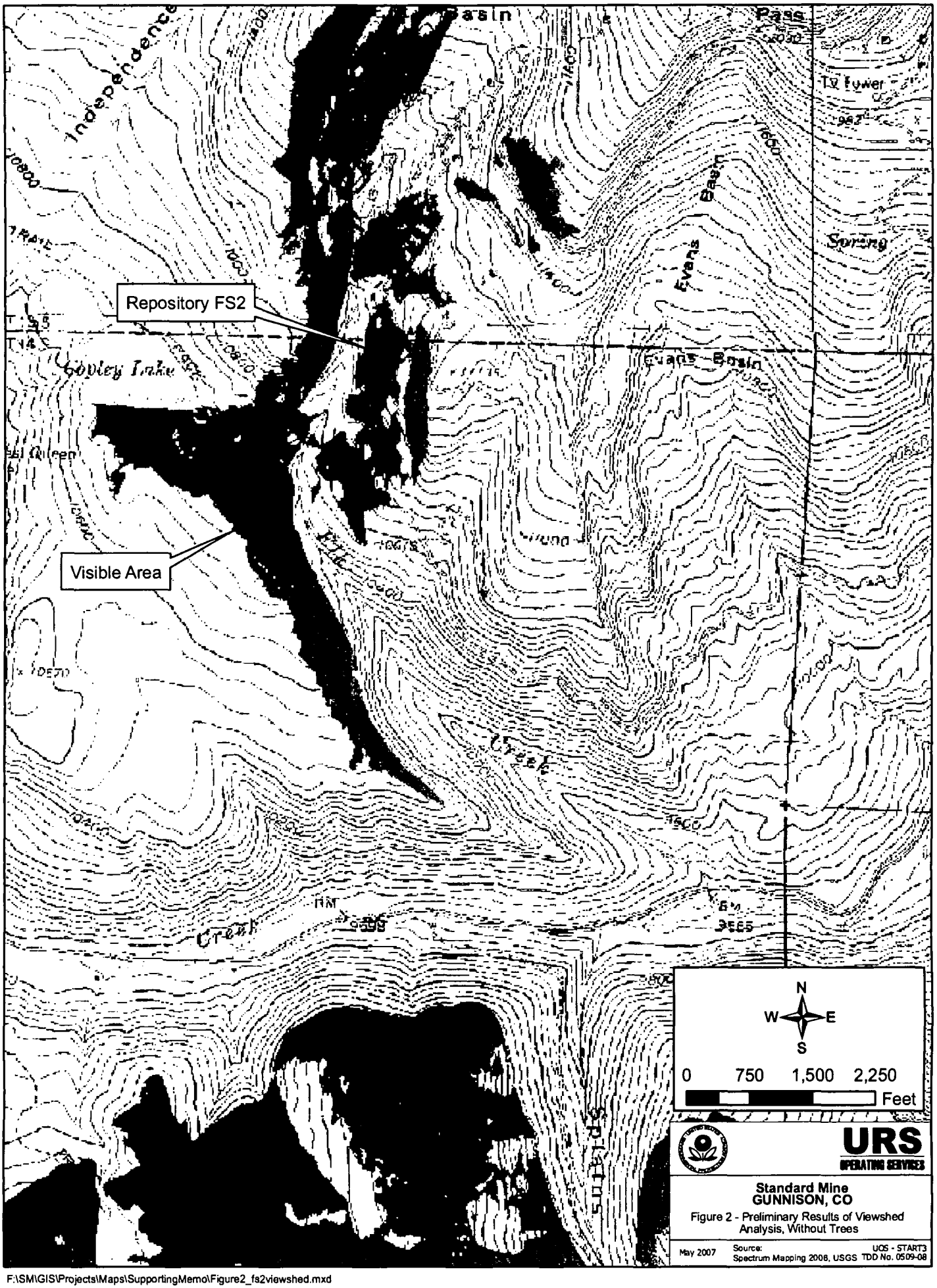
Figure 1. Schematic of inputs for view-shed analysis

Parameter	Value	Rationale
OF1	Absolute elevation of node	Assumes no cover is to be applied above the finished grade of the repository.
OF2	5'8"	Assumed height of observer.
AZ1 – AZ2	0 to 360	Accounts for potential observations from around the entire repository.
V1 – V2	-90 to 90	Worst case scenario
R1 – R2	1 – infinity	Worst case scenario

No account was made within the analysis for the screening of the repository by trees or other vegetation. No account was made of the potential for the repository to "blend" the surrounding area making the visual detection of the repository more difficult.

The elevations for the existing surface were derived from Light Detecting and Ranging (LIDAR) data collected by Spectrum Mapping in July 2006 at 1meter horizontal scale. Elevations for the finished surface of the potential repositories were provided by URS.

The results of this analysis are presented in Figures 2 and 3.



URS OPERATING SERVICES

Standard Mine
GUNNISON, CO

Figure 2 - Preliminary Results of Viewshed Analysis, Without Trees

May 2007

Source: Spectrum Mapping 2008, USGS

UOS - START3
TDD No. 0509-08

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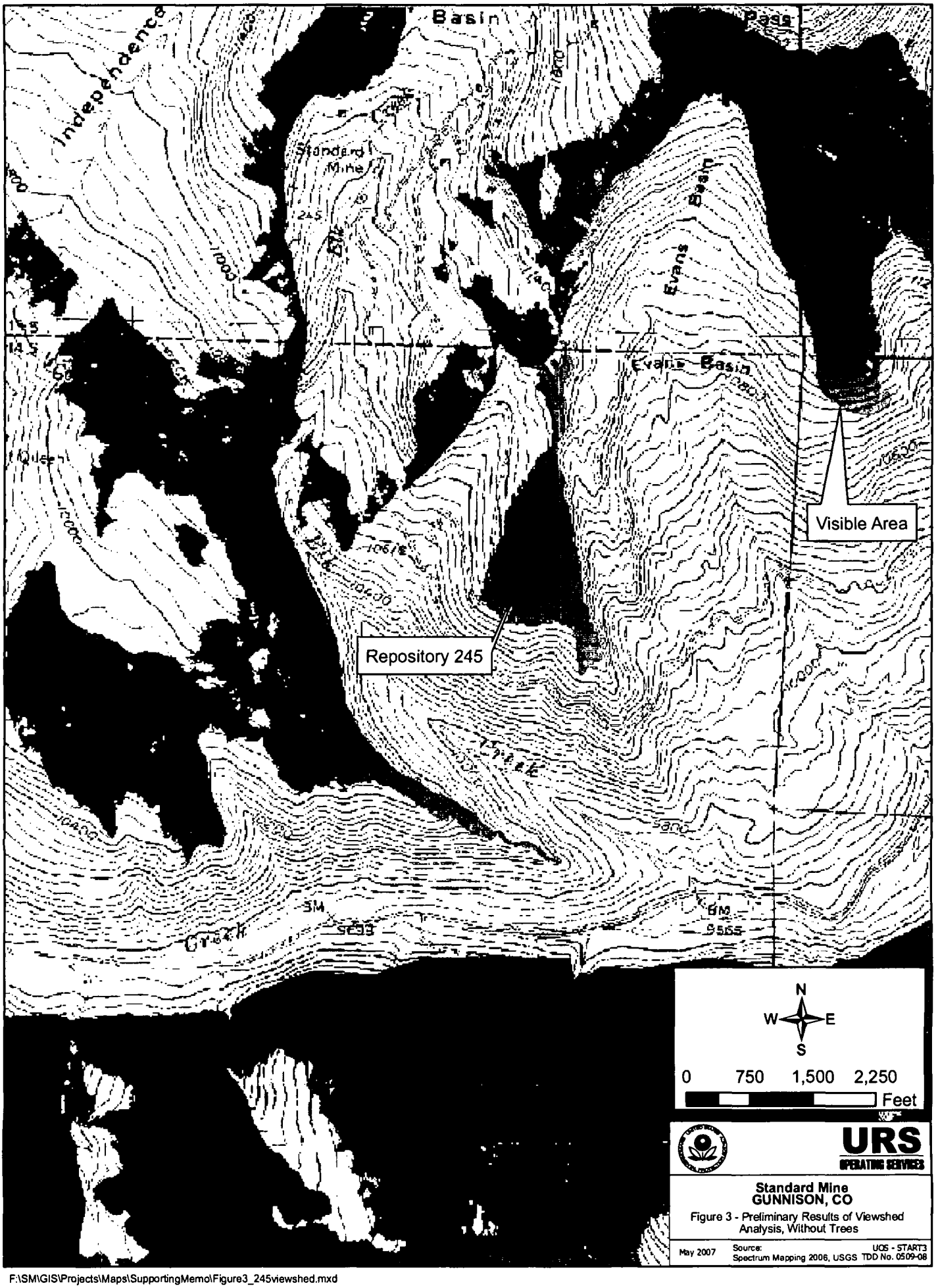

URS OPERATING SERVICES

Standard Mine
GUNNISON, CO

Figure 3 - Preliminary Results of Viewshed Analysis, Without Trees

May 2007 | Source: Spectrum Mapping 2006, USGS | UGS - START3 TDD No. 0509-08

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