FINAL FOCUSED FEASIBILITY STUDY

OPERABLE UNIT 6

California Gulch NPL site

Leadville, Colorado

September 2002

HDR

HDR Engineering, Inc.

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LIST OF ACRONYMS

ARARs	Applicable or Relevant and Appropriate Requirements
ARD	Acid Rock Drainage
AVIRIS	Airborne Visible and Infra-Red Imaging Spectroscopy
BOR	Bureau of Reclamation
BRA	Baseline Risk Assessment
California Gulch Site	California Gulch Superfund Site
CD	Consent Decree
CDNR	Colorado Department of Natural Resources
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	Code of Federal Regulations
cfs	cubic feet per second
CMC	Colorado Mountain College
COC	Contaminant of Concern
COPC	Contaminant of Potential Concern
CY	Cubic Yard
EECA	Engineering Evaluation/Cost Analysis
EG	Evans Gulch
EO	Executive Order
EPA	Environmental Protection Agency
FFS	Focused Feasibility Study
FS	Feasibility Study
ft	feet
ft/ft	foot/foot
gpm	gallons per minute
HDPE	High Density Polyethylene
HI	Hazard Index
HQ	Hazard Quotient
IC	Institutional Control
ID	Inner Diameter
LG	Lincoln Gulch
LMDT	Leadville Mine Drainage Tunnel
MSHA	Mine Safety and Health Administration
MSL	Mean Sea Level
NCP	National Contingency Plan
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NPL Site	California Gulch National Priority List Site
O&M	Operation and Maintenance
^{o}F	Degrees Fahrenheit
OU	Operable Unit
OU6	Operable Unit 6
ppm	parts per million
PRG	Preliminary Remediation Goal

PRP	Potentially Responsible Party
PVC	Polyvinyl Chloride
RA	Risk Assessment
RAO	Remedial Action Objective
RCRA	Resource Conservation and Recovery Act
RI	Remedial Investigation
RMC	Rocky Mountain Consultants, Inc.
ROD	Record of Decision
RUSLE	Revised Universal Soils Loss Equation
SARA	Superfund Amendments and Reauthorization Act
SD	Starr Ditch
SEG	South Evans Gulch
SFS	Screening Feasibility Study
SHG	Stray Horse Gulch
SHPO	State Historic Preservation Office
site	California Gulch Superfund Site
Site	Operable Unit 6
TDS	Total Dissolved Solids
TERA	Terrestrial Ecological Risk Assessment
TIN	Triangulated Irregular Network
TSS	Total Suspended Solids
ug/L	micrograms per liter
USEPA	United States Environmental Protection Agency
USFW	United States Fish and Wildlife
USGS	United States Geological Survey
WAMP	Work Area Management Plan
WE	West Evans Gulch
WEG	West Evans Gulch

EXECUTIVE SUMMARY

This Focused Feasibility Study (FFS) assesses the effectiveness of past Response Actions at Operable Unit No. 6 (OU6) of the California Gulch National Priority List Site (the NPL Site) and identifies and evaluates additional potential actions that will be documented under a Record of Decision (ROD). The purpose of past Response Actions and potential future actions is to cost-effectively control or reduce the release of metals to the environment from mine wastes and consequently reduce the potential risk to human health and the environment, if any, posed by such releases.

The NPL Site is comprised of approximately 16.5 square miles in Lake County, Colorado approximately 100 miles southwest of Denver in a highly mineralized area of the Colorado Rocky Mountains. Mining, mineral processing, and smelting activities have produced gold, silver, lead, zinc and approximately 2,000 mine waste piles within the NPL Site. Operable Unit 6 covers approximately 3.4 square miles in the northeastern quadrant of the NPL Site

The USEPA proposed adding California Gulch to the National Priority List on December 30, 1982. The site was formally listed on September 8, 1983. The United States, the State of Colorado, and the Potentially Responsible Parties (PRPs) entered into a Consent Decree (CD) in 1994. The objectives set forth in the CD related to OU6 were to:

1. Protect public health, welfare, and the environment from releases or threatened releases of Waste material at or from the Site;

2. To improve the quality of Site-wide Surface and Ground Waters through Source Remediation;

The CD defines Source Remediation (mentioned in item 2, above) as:

> *"Response Actions designed to prevent or control the release or threatened release of waste material from sources of contamination such as tailings impoundments, fluvial tailings, waste rock piles and soils into all pathways of migration, but shall not include any treatment of Site-wide Surface or Ground Waters."*

After considering the potential source materials and contaminant migration pathways, the following Remedial Action Objectives were identified for OU6:

1. Control erosion of mine waste rock and deposition into local watercourses.
2. Control leaching and migration of metals from mine waste rock into surface water.
3. Control leaching of metals from mine waste rock into groundwater.

The development of Applicable or Relevant and Appropriate Requirements (ARAR's) revealed no chemical-specific ARARs for OU6. This arises largely from the direction provided in the CD towards source remediation only coupled with the establishment of OU12. Operable Unit 12 was created specifically to address site-wide water quality.

Several action- and location specific ARARs were identified for OU6 including:

Potential Action-Specific ARARs:

- Clean Water Act Ambient Water Quality Criteria
- Colorado Water Quality Control Act
- RCRA Subtitle D and State Solid Waste Regulations
- Solid Waste Closure
- RCRA Subtitle C (including Hazardous Materials Transportation Act)
- Land Disposal Restrictions
- National Pollutant Discharge Elimination System (NPDES)
- Colorado Mined Land Reclamation Act
- Colorado Air Quality Control
- Colorado Noise Abatement

Potential Location-Specific ARAR's:

- Protection of Floodplains
- Clean Water Act Section 404 (including E.O. 11990 and 33 CFR 320-330)
- Fish and Wildlife Coordination Act
- Cultural Resource Requirements
- Solid Waste Disposal Site and Facilities Act

Prior investigative work at OU6 included surface water chemistry, the results of a mine waste pile reconnaissance, and aerial remote sensing data capable of identifying mineral species (AVIRIS). Using these tools, specific piles of mine waste rock were identified as sources for Acid Rock Drainage (ARD). These piles comprise 742,100 cubic yards (CY) located primarily in Stray Horse and Lincoln Gulches.

Nearly all of the ARD generating mine waste rock piles identified in the FFS have been previously addressed through a series of Response Actions. The remedial measures range from consolidation and capping of 100,000's of cubic yards (CY) of mine waste to the construction of multiple small detention ponds at the toe of ARD generating mine waste rock piles. Most of the ARD collected in the detention ponds has been routed via subsurface mine workings to the Leadville Mine Drainage Tunnel (LMDT) for ultimate treatment at a water plant operated by the US Bureau of Reclamation (BOR). This FFS considers the adequacy of the prior Response Actions as a final remedy for OU6 as well as additional remedial measures that may be appropriate.

The FFS developed 13 remedial alternatives of which 8 involved the maintenance of the existing remedies and perpetual treatment of collected ARD at one of three potential treatment facilities (Yak Facility, BOR Facility or a facility constructed within OU6). The remaining 5 alternatives included the No Action Alternative and remedies intended to manage or minimize the generation of ARD at the source areas. These remedies involved engineered caps, an on-Site repository, physical/chemical stabilization of mine waste and the construction of ARD evaporation ponds.

During the screening of alternatives, the alternative involving evaporation basins was dropped from further consideration due to the excessive size requirement for the evaporation basins. In addition, several alternatives involving the conveyance and treatment of ARD collected each spring were also dropped from further consideration. These options involved the long-term use of the LMDT or other mine workings as the means to convey ARD to existing water treatment plants. Other options involving inefficient pipeline alignments were also dropped from further consideration.

The retained alternatives subjected to the detailed and comparative analyses included:

- Alternative 1 - No Action
- Alternative 2a - Maintain Current Remedies – Convey ARD to Yak Tunnel via a pressure line with treatment at the Yak Treatment Plant.
- Alternative 2b - Maintain Current Remedies – Convey ARD to the Yak Treatment Plant surge pond via a gravity pipeline. Construct a storage impoundment along the gravity pipeline to meter ARD to the surge pond with treatment at the Yak Treatment Plant.
- Alternative 2e - Maintain Current Remedies - Convey ARD via a gravity pipeline to the existing extraction well along the LMDT. Use the existing pipeline from the extraction well to convey ARD to the BOR Treatment Plant. Construct a storage impoundment along the gravity pipeline to meter ARD to the BOR Treatment Plant.
- Alternative 2g - Maintain Current Remedies – Construct an engineered plug in the LMDT, pump impounded groundwater and convey the water via a gravity pipeline to the BOR Treatment Plant.
- Alternative 2h - Maintain Current Remedies – Convey ARD via a gravity pipeline to a constructed dedicated water treatment facility with effluent return to Stray Horse Gulch.
- Alternative 4 - Minimize ARD Generation (in combination with Alternative 2) - In-Situ chemical stabilization of selected waste piles coupled with continued collection and treatment of ARD under Alternatives 2a though 2h.
- Alternative 5 - Minimize ARD Generation - Consolidate and cap all ARD generating waste piles with a composite cap consisting of a geomembrane and 8-feet of dolomite waste rock.
- Alternative 6 - Minimize ARD Generation - Excavate, transport and on-Site disposal of all ARD Generating Waste Piles. Locate repository within OU6 and include a top and bottom geomembrane liner with a vegetated soil cover.

The detailed and comparative analyses evaluated each retained alternative against the nine National Contingency Plan (NCP) criteria and several Additional Criteria established to ensure consistency in remedial design and construction at the California Gulch NPL Site. The comparative analysis compared the alternatives to each other using the evaluation criteria as a measure.

The NCP criteria include:

- Overall Protection of Human Health and the Environment
- Compliance with ARARs
- Long-Term Effectiveness and Permanence
- Reduction in Toxicity, Mobility and Volume Through Treatment
- Short-Term Effectiveness
- Implementability
- Cost
- State Acceptance
- Community Acceptance

The Additional Criteria include:

- Surface Erosion Stability
- Slope Stability
- Flow Capacity and Stability
- Surface Water and Groundwater Loading Reduction
- Terrestrial Ecosystem Exposure
- Non-Residential Soils

A summary of the comparative analysis of the alternatives is presented in Table ES-1.

Table ES-1

Comparative Analysis Using NCP Criteria

Evaluation Criteria	Alternative 1 - No Action	Alternative 2a - Pressure Line to Yak Tunnel	Alternative 2b - Gravity Line to Yak Surge Pond w/Storage	Alternative 2e - Gravity Line to Existing Extraction Well along LMDT w/Storage	Alternative 2g - Plug LMDT and Dewater Mine Pool w/Gravity Line to BOR Plant	Alternative 2h - Gravity Line to Dedicated Water Treatment Plant	Alternative 4 - In-Situ Chemical Stabilization (in combination with Alternative 2)	Alternative 5 - Consolidate and Cap	Alternative 6 - Excavate, Transport and Dispose
Effectiveness									
Overall Protection of Human Health and Environment	Some improvement over pre-response action conditions (consolidated and capped mine wastes)	Maintains improvements in Stray Horse Gulch water quality observed in the spring of 2001. Human health risks posed by non-residential soils remain below a level of concern through institutional controls.	See Alternative 2a	See Alternative 2a	Maintains improvements in Stray Horse Gulch water quality observed in the spring of 2001. Potentially results in reduction in contaminated groundwater discharging to surface water via springs through lowering of water table. Human health risks posed by non-residential soils remain below a level of concern through institutional controls.	See Alternative 2a	May result in further improvements in water quality within Stray Horse and Little Stray Horse Gulches. Long-term stability of the in-situ chemical stabilization process is uncertain.	Will result in further improvements in water quality throughout OU6. Results in the creation of a physical barrier between human and ecological receptors.	Will result in further improvements in water quality throughout OU6. Results in the creation of a physical barrier between human and ecological receptors.
Compliance with Remedial Action Objectives and ARARs	Some reduction in metal loading to the watershed through waste capping. No chemical specific ARAR's	Achieves significant reduction in metal loading to the watershed (60%-80% reduction in Zn and Cd 2000-2001 in Stray Horse Gulch and Starr Ditch). Complies with ARAR's	See Alternative 2a	See Alternative 2a	May achieve further reduction in metal loading to the watershed when compared with alternatives 2a, 2b, 2e and 2h through reduction in groundwater discharge to surface water in springs. Complies with ARAR's	See Alternative 2a	May achieve further reduction in metal loading to the watershed when compared with the options under Alternative 2. Complies with ARAR's	Will achieve further reduction in metal loading to the watershed when compared with Alternatives 1, 2 and 4. Complies with ARAR's.	Will achieve further reduction in metal loading to the watershed when compared with Alternatives 1, 2, 4, and 5. The placement of a bottom liner under the waste should provide an incrementally greater reduction in generation of ARD as compared with Alternative 4.Complies with ARAR's.
Long-Term Effectiveness	The consolidation and capping response actions will provide some long-term effectiveness.	Many remedy components require perpetual operation and maintenance. Institutional controls will require perpetual enforcement. Introduction of ARD just upstream of Yak Tunnel bulkhead will minimize potential loss of ARD to regional groundwater.	Many remedy components require perpetual operation and maintenance. Institutional controls will require perpetual enforcement. Substitution of a lined impoundment may provide higher confidence in the integrity of ARD conveyance and storage facilities over Alternative 2a.	See Alternative 2b	Many remedy components require perpetual operation and maintenance. Institutional controls will require perpetual enforcement. Abandonment of the mine pool dewatering system in the future may lead to equilibrium water table conditions that are higher than at present. The impacts of a higher water level in mine workings is not known.	Many remedy components require perpetual operation and maintenance. Institutional controls will require perpetual enforcement.	The long-term ability of the in-situ chemical stabilization process to reduce leaching of metals from mine waste is uncertain.	The conceptual cap design is robust and should require minimal maintenance resulting in high long-term effectiveness and permanence. Institutional controls will require perpetual enforcement.	The placement of ARD producing mine waste in a lined repository will provide long-term effectiveness and permanence potentially exceeding that provided under Alternative 5. The engineered repository cover material is comprised of native soils. Therefore, the cover may require more inspection and maintenance than the dolomite waste rock cap proposed under Alternative 5. Institutional controls will require perpetual enforcement.
Reduction of Toxicity, Mobility and Volume	Reduction in mobility through consolidation and capping.	The treatment of ARD for metal removal results in a reduction in contaminant mobility. However, there is no reduction in contaminant volume or toxicity.	See Alternative 2a	See Alternative 2a	See Alternative 2a	See Alternative 2a	Mobility of contaminants may be reduced through the in-situ chemical stabilization process.	The mobility of contaminants is reduced through the placement of a cap on mine waste. However, no reduction in toxicity or volume is achieved.	See Alternative 5
Short Term Effectiveness	Involves no further remedial action	Does not result in disturbance of mine wastes.	See Alternative 2a	See Alternative 2a	See Alternative 2a	See Alternative 2a	The in-situ chemical stabilization process is not expected to result in significant disturbance of mine wastes.	This alternative involves the disturbance of large volumes of mine waste. Some short term risks will be posed to workers and the community.	See Alternative 5
Implementability									
Technical Feasibility	No Action Required	Pipelines and lift stations are readily available proven technologies. The YAK Treatment Plant effectively treats ARD. Boring vertically into the Yak Tunnel may pose some technical challenges. However, drilling contractors report that the alternative is feasible.	Pipelines and lined impoundments are readily available, proven technologies.	See Alternative 2b	Pumps and pipelines are readily available proven technologies. The BOR treatment plant effectively treated OU6 ARD in 2001. Plugging the LMDT presents some technical challenges. However, contractors report that the alternative is feasible.	All required technologies are readily available. The actual ARD treatment method would be selected after bench-scale treatability testing.	Vendor quote for a demonstration pilot test has been secured. Therefore, the alternative is technically feasible. However, the efficacy of the technology is unknown.	The technologies proposed under this alternative are identical to those implemented successfully under prior response actions.	The technologies required under Alternative 6 are proven to be effective.
Administrative Feasibility	No Action Required	The availability of land for the pipeline alignment has not been evaluated. An agreement would have to be reached with the water treatment plant owner (ASARCO). Institutional controls would have to be administered by the County.	See Alternative 2a	The availability of land for the pipeline alignment has not been evaluated. An agreement would have to be reached with the water treatment plant owner (BOR). Institutional controls would have to be administered by the County.	The LMDT is owned by the BOR. Therefore, this remedy would require an agreement with BOR. In addition, modifications to the BOR treatment plant may have to be negotiated should it be desirable to dewater the mine pool in the short-term through high pumping rates.	The availability of land for the pipeline alignment, impoundment footprint and dedicated water plan site this not been evaluated. Institutional controls would have to be administered by the County.	Administrative obstacles are not anticipated.	Administrative obstacles are not anticipated.	Administrative obstacles are not anticipated.
Availability of Services and Materials	No Action Required	Services and materials are readily available	See Alternative 2a	See Alternative 2a	See Alternative 2a	See Alternative 2a	See Alternative 2a	See Alternative 2a	See Alternative 2a
Anticipated State Acceptance	Unlikely	Assessed during FFS comment period	See Alternative 2a	See Alternative 2a	See Alternative 2a	See Alternative 2a	See Alternative 2a	See Alternative 2a	See Alternative 2a
Anticipated Community Acceptance	Unlikely	Assessed during FFS comment period	See Alternative 2a	See Alternative 2a	See Alternative 2a	See Alternative 2a	See Alternative 2a	See Alternative 2a	See Alternative 2a
Cost									
Capital Costs	$0	$628,274	$1,454,804	$1,623,931	$3,557,843	$5,529,583	$400,000	$24,070,696	$16,908,635
Present Worth Water Treatment Costs	$0	$5,708,000	$5,708,000	$1,400,000	$3,750,156	$2,825,755	$0	$0	$0
Present Worth Water Plant Replacement Costs	$0	$4,950,000	$4,950,000	$4,950,000	$4,950,000	$913,257	$0	$0	$0
Present Worth Other Post-Construction Operation and Maintenance Costs	$0	$1,303,374	$2,203,820	$2,203,820	$1,448,196	$1,064,364	$0	$1,814,462	$2,467,710
Grand Total	$0	$12,589,648	$14,316,624	$10,177,751	$13,706,195	$10,332,959	$400,000	$25,885,158	$19,376,345

NA - Not Available

1.0 INTRODUCTION

1.1 PURPOSE

This Focused Feasibility Study (FFS) assesses the effectiveness of past Response Actions at Operable Unit No. 6 (OU6) of the California Gulch National Priority List Site (the NPL Site) and identifies and evaluates additional potential actions that will be documented under a Record of Decision (ROD). The purpose of past Response Actions and potential future action is to cost-effectively control or reduce the release of metals to the environment from mine wastes and consequently reduce the potential risk to human health and the environment, if any, posed by such releases.

1.2 SITE LOCATION

The NPL Site is comprised of approximately 16.5 square miles in Lake County, Colorado, approximately 100 miles southwest of Denver (Figure 1-1). The California Gulch Site includes the towns of Leadville and Stringtown, and the confluence of California Gulch and the Arkansas River. Elevations range from approximately 9,515 feet above Mean Sea Level (MSL) at the confluence to approximately 12,500 feet above MSL at the eastern boundary of the NPL Site.

OU6 of the NPL Site covers approximately 3.4 square miles in the northeastern quadrant of the Site (Figure 1-2). Operable Unit 6 includes the Stray Horse Gulch watershed, and the upper and lower portions of the Evans Gulch watershed. Elevations within OU6 range from approximately 10,000 feet above MSL to 12,500 feet above MSL on the eastern site boundary below Mosquito Pass.

1.3 SITE HISTORY

The NPL Site is located in a highly mineralized area of the Colorado Rocky Mountains. Mining, mineral processing, and smelting activities have produced gold, silver, lead and zinc for more than 130 years. Mining began in the Leadville area in 1859 when prospectors working the channels of Arkansas River tributaries discovered gold at the mouth of California Gulch. Initial activities consisted only of small-scale placer mining until 1868, when the first gold ore veins were discovered along California Gulch. By 1872, however, problems with water, transportation and labor made ore removal so difficult that most miners had left the area. In 1874, silver-bearing lead carbonate was discovered and mining in the Leadville district boomed.

Extensive replacement deposits of lead, silver and gold ores associated with fissure veins were discovered and mined. Zinc and manganese, which were of little value in the early days, were later mined extensively. As surface veins diminished, miners tunneled deeper into the mountains. Underground mines were developed east and southeast of Leadville.

As mines were developed, waste rock was excavated along with the ore. The waste rock was placed near the mine entrance, and the ore was transported to the mill. At the mill, ores were crushed and separated into metallic concentrates and waste products by physical processes. The metallic concentrates were then shipped elsewhere or further processed at a smelter in the area. The waste products (mill tailings) were generally placed near the mill in a tailings pond. In the smelters, the high-grade ores were refined and concentrated into higher-grade products. Waste products from the smelters included slag and dust, and off-gases. Forty-four known smelters were in the district (Woodward-Clyde, 1994a).

1.4 REGULATORY HISTORY

The United States Environmental Protection Agency (EPA) proposed adding the California Gulch Site to the National Priorities List (NPL) on December 30, 1982. The site was formally listed on September 8, 1983 (CDM, 1997). The following is a brief chronological summary of the major regulatory actions taken at the NPL Site. In addition, a summary of relevant documents is provided in Section 2.1 and a summary of previous Response Actions performed in OU6 is provided in Section 4.1.

- 1982 – California Gulch Site proposed for the NPL (CDM, 1997).
- 1983 – California Gulch Site formally added to the NPL (CDM, 1997).
- 1986 – EPA emergency workers extended public water supply system lines to residences using private wells (CDM, 1997).
- 1987 – EPA began an investigation of mine wastes. Approximately 2,000 mine waste piles within the NPL Site were screened to identify those larger than 100,000 cubic yards. Further screening was based on proximity to populated areas, roadways, and surface water, and potential pile instability. Forty-five waste deposits were selected for field inspection and sampling based on access, size, waste type, stability, and proximity to residential areas and/or watercourses. Eleven of these sites were mine waste piles, with the remainder being slag piles and tailing impoundments (Woodward-Clyde, 1994).
- 1994 – The United States, the State of Colorado, and the Potentially Responsible Parties (PRPs) entered into a Consent Decree (CD). The CD divided the California Gulch Superfund Site into 12 Operable Units (OUs) for the cleanup of geographically based areas within the site. OU6 is one of these OU's (CDM, 1997).

1.5 FFS OVERVIEW AND REPORT ORGANIZATION

The FFS follows the general Feasibility Study (FS) process. However, the step that involves screening of potentially applicable remedial technologies is omitted in this FFS. Rather, the process begins with a list of fully assembled remedial alternatives that are screened against several criteria including effectiveness, implementability and cost. The retained alternatives are then advanced to the detailed and comparative analysis steps.

A Screening Feasibility Study (SFS) was performed by EPA in 1993. This SFS developed and evaluated seven alternatives that were considered applicable to mine wastes considered to be source areas throughout the NPL Site.

This FFS builds on prior work and expands the range of alternatives beyond those contemplated in the SFS for several reasons including:

- Considerable work in the form of remedial actions, other Feasibility Studies and engineering analyses have been conducted at the NPL Site over the past decade. These studies and actions provide valuable information that relates directly to the development and evaluation of remedial alternatives for OU6.

- Numerous Response Actions have been implemented at OU6. The actual performance of these Response Actions provides valuable information for the development of alternatives in this FFS.

- To remain consistent with selected Response Actions both within OU6 and the other OUs, and to maintain consistency with the Work Area Management Plan (WAMP) criteria used in other OUs.

In addition to Response Action performance monitoring data, other information related to the design and implementation of the remedial measures is also used in this FFS. Actual construction, operation and monitoring costs are used instead of traditional construction cost estimating methods. This is particularly true for alternatives that involve the handling of large volumes of mine waste or treatment of collected acid rock drainage (Acid Rock Drainage (ARD) - See Section 4.0 for a complete description of prior Response Actions).

The FFS report is organized into the following major Sections:

Section 1.0 – Introduction – This section describes the purpose of the FFS, summarizes the NPL Site history and provides an overview of the FFS process.

Section 2.0 – Summary of Site Characteristics – This section describes the physical setting, the nature and extent of contamination, and presents the waste volumes assumed in the remedial alternatives.

Section 3.0 – Remedial Action Objectives – This section discusses the remedial action objectives for OU6.

Section 4.0 – Summary of Previous Response Actions – This section provides a description of the remedial actions taken in OU6. A summary of Response Action performance to date is also included.

Section 5.0 – ARARs – This section discusses the potentially Applicable or Relevant and Appropriate Requirements (ARARs) for the remedial alternatives at OU6.

Section 6.0 – Screening of Remedial Alternatives – This section screens the candidate remedial alternatives for effectiveness, implementability and cost. Several alternatives are eliminated at this stage.

Section 7.0 – Detailed Analysis of Alternatives – This section evaluates the retained alternatives against nine criteria specified in the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). The alternatives are also evaluated against several additional criteria intended to maintain consistency in construction practices within the NPL Site.

Section 8.0 – Comparative Analysis of Alternatives – This section compares and contrasts the retained alternatives using the nine NCP and additional criteria as the measure.

Section 9.0 References – This section provides full references for all citations in the body of the report.

2.0 SITE CHARACTERIZATION

This section provides a summary of the investigative work performed to date in OU6 as well as an overview of the physical characteristics of the NPL Site. In addition, this section provides a description of the methodology employed in selecting mine wastes as candidates for remedial action.

2.1 SUMMARY OF PREVIOUS WORK

The reader is referred to the following documents for a comprehensive description of the Site Characteristics.

1. *California Gulch Hydrologic Investigation, Leadville, Colorado (Water, Waste and Land, 1990).* Summary of hydrologic investigations conducted during 1989 including a detailed surface water drainage inventory, groundwater sampling, and a mine and mineral processing waste inventory.

2. *Final Screening Feasibility Study for Remediation Alternatives at the California Gulch Site, Leadville, Colorado (USEPA, 1993).* The purpose of the study was to develop an appropriate range of alternatives to be considered during the detailed feasibility studies for the control and/or remediation of the various contaminated media at the NPL Site.

3. *Final, Mine Waste Piles Remedial Investigation Report, California Gulch Site, Leadville, Colorado (Woodward-Clyde, 1994a).* Part of the Phase II Remedial Investigation of the NPL Site. The purpose of the investigation was to characterize the mine waste pile materials for surface and bulk chemistry, characterize the physical nature of the mine waste materials, evaluate the potential of the materials to leach metals to groundwater and surface water, document the field sampling procedures and analytical methods used during the investigation, and provide data necessary for the preparation of a Baseline Risk Assessment (BRA) for the NPL Site.

4. *Hydrogeologic Remedial Investigation Report, California Gulch Site, Leadville, Colorado (Golder, 1996a).* Major objectives were to characterize groundwater flow conditions and quality, and to develop a conceptual model of possible hydrogeologic transport pathways to groundwater and surface water receptors and the potential water quality impacts at these receptor points.

5. *Surface Water Remedial Investigation Report, California Gulch Site, Leadville, Colorado (Golder, 1996b).* Describes results of surface water quality and flow data sampling and analysis during 1991 and 1992. Drainages sampled include California Gulch and its tributaries and the Arkansas River and its tributaries.

6. *Phase 1: Feasibility Study, Water and Sediment Sampling and Hydrologic Measurement Program, Results and Findings, 1995 Spring Runoff for Operable Unit 6, California Gulch NPL Site (BOR, 1996a).* Phase 1 of a three phase program to conduct pre-design investigations of mine wastes in OU6. Phase 1 consists of the first water and sediment sampling event.

7. *Draft Value Analysis Presentation Report, California Gulch OU6 Removal Action Evaluation and Decision Phase, Leadville, Colorado (BOR, 1996b).* Used traditional Value Methodology procedures to evaluate OU6 potential source areas for relative risk to determine a priority list for the remedial actions and available resources. The Value Study Team then used this list to develop specific proposed remedial alternatives. Also includes delineation of potential source areas with waste volume and area estimates.

8. *Engineering Evaluation/Cost Analysis for Stray Horse Gulch Operable Unit 6, California Gulch NPL Site, Leadville, Colorado (CDM, 1997).* Written to identify and evaluate the Response Action alternatives for Stray Horse Gulch. Alternatives were based on effectiveness, implementability and cost.

9. *Draft Environmental Geology of Operable Unit 6, Removal Action Design Data, California Gulch Superfund Site (BOR, 1997).* Phases 2 and 3 of a three phase program to conduct pre-design investigations of mine wastes in OU6. Phase 2 addresses the sampling and analysis of mine wastes, and Phase 3 is the second water and sediment sampling event.

2.2 PHYSICAL SETTING

2.2.1 Site Physiology

Operable Unit 6 lies in the Southern Rocky Mountain Physiographic Province of the United States, which is characterized by fault-block mountain ranges separated by intermontane valleys. Leadville is located on the east side of the Arkansas River Valley at the base of Mount Evans near the confluence of Evans Gulch with the Arkansas River (see Figure 1-2). Evans Gulch is a large glacial valley that extends down the west slope of Mount Evans from elevations above 13,200 ft above MSL to the Arkansas Valley at approximately 9,900 ft above MSL. Evans Gulch is bordered on the north by Prospect Mountain and on the south by Iron Hill, Breece Hill, and Ball Mountain (see Figure 2-1). Stray Horse Gulch is a small ephemeral stream that lies in the south portion of the Evans Gulch valley, separated by Yankee Hill and a lateral moraine from the former Evans glacier.

2.2.2 Regional Geology

The bedrock formations which underlie OU6 are a series of sedimentary strata that range in age from Cambrian to Pennsylvanian and consist of quartzite, limestone, dolomite and shale. These Paleozoic sedimentary formations were intruded during the late Cretaceous or early Tertiary periods in several episodes by porphory in "blanket" sills and dikes. These porphyry intrusions created the major portion of the mineralized zones and ore deposits (BOR, 1997).

The entire sequence of intruded sedimentary formations and pre-Cambrian granitic bedrock was uplifted and faulted into a series of discrete bedrock blocks by north-south trending normal faults that step downward in elevation from Mosquito Pass on the east to the Arkansas Valley on the west. This series of faults largely controlled the distribution and depth of the ore bodies, as well as groundwater which entered the mines in large quantities prior to the construction of the drainage tunnels. Prior to the construction of the Yak Tunnel and the Leadville Mine Drainage Tunnel (see Section 2.4.1), pumping was required to dewater the lower ore body levels throughout the mining district (BOR, 1997).

Since the start of placer mining in 1859, the sedimentary bedrock units and intrusive ore deposits were mined, and wastes were deposited on the surface. These waste materials become subject to weathering which oxidize, break down, and release remaining contaminant metals into surface and ground water. Wastes containing significant amounts of metal sulfides generate acidic drainage further mobilizing soluble metals.

Throughout much of OU6, the bedrock is overlain by unconsolidated glacial deposits associated with the Evans Gulch glacier.

2.2.3 Climate

The topographic features of Lake County strongly influence the climatic variations in the Leadville area. The elevation of the City of Leadville is approximately 10,000 ft above MSL. Normal temperature extremes range from -30°F to 86°F, with an average minimum temperature of 21.9°F. Average annual precipitation is 18 inches with the wettest months being July and August and the driest months being December and January. Summer precipitation is usually associated with convective showers. The annual peak snowmelt usually occurs in June. The average frost-free season is 79 days. The wind is predominantly from the northwest and ranges from calm to 30 miles per hour (Golder, 1996a).

The National Weather Service operates a meteorological station at the Leadville airport two miles southwest of Leadville. Additional weather observations were measured at the Yak Tunnel meteorological station near the Yak Tunnel Water Treatment Plant. The Final Air Monitoring Report (Woodward-Clyde, 1992a) provides an evaluation of local meteorological data.

2.3 SURFACE WATER AND RELATED MEDIA

2.3.1 Surface Water Hydrology

Operable Unit 6 is made up of two main drainages that contribute surface water to the Arkansas River: Stray Horse Gulch and Evans Gulch (see Figure 2-1). Stray Horse Gulch has one main tributary, Little Stray Horse Gulch, and is routed through the eastern portion of Leadville to its confluence with California Gulch via Starr Ditch. California Gulch is a tributary to the Arkansas River. Evans Gulch contains two sub-drainage basins, Lincoln Gulch and South Evans Gulch. The majority of Evans Gulch lies outside of OU6 (see Figure 2-1).

The Bureau of Reclamation (BOR) performed a three-phase water and sediment sampling and hydrologic measurement program during 1995 and 1996. Phase 1 consisted of water and sediment sampling during the 1995 spring runoff season. Phase 2 involved the sampling and analysis of mine wastes conducted in 1996. Phase 3 consisted of water and sediment sampling during the 1996 spring runoff.

Stray Horse Gulch is an intermittent stream that flows only during spring runoff and intense and/or extended precipitation events. The drainage is approximately 12,300 feet long with an elevation loss of 675 feet. The BOR collected flowrate data during the 1995 (Phase 1) and 1996 (Phase 3) spring runoff periods. Four stations were monitored within the Stray Horse Gulch Drainage during Phase 1: SHG-07, SHG-08, SHG-09 and SHG-10 (see Figure 2-1). An additional station, SHG-07A, was added during the Phase 3 investigation. The flow measurements collected in 1995 and 1996 show that significant surface water loss to the subsurface occurs in Stray Horse Gulch. The majority of the loss occurs between SHG07 and SHG09. There was no net effective gain to stream flow in this reach of the drainage (BOR, 1997). However, over the years of monitoring Stray Horse Gulch has been both a losing and gaining stream, therefore reversals are both possible and occurring. Flows in Stray Horse Gulch ranged from 0 to 3.76 cubic feet per second (cfs) during the 1995 runoff event. Using United States Geological Survey (USGS) peak flow data from Station 07081200 (Arkansas River near Leadville, CO), a flood frequency analysis was performed using the HEC-FFA (Flood Frequency Analysis) program created by the US Army Corps of Engineers Hydrologic Engineering Center. Based on data from years 1968 – 2000, 1995 was determined to be between a 10- and 20-year runoff event.

Evans Gulch is the longest continuous drainage within OU6 and serves as the municipal water supply for the city of Leadville via the Parkville Water District. During Phase 1, BOR monitored eleven sampling stations within the Evans Gulch drainage: EG-01, EG-02, EG-03, WE-01, WE-02, SEG-01, SEG-02, SEG-03, SEG-04, SEG-05, and LG-01 as shown on Figure 2-1. The Evans Gulch Stations exhibited the highest runoff stream flow volumes in OU6, up to 65.5 cfs (BOR, 1996a). The peak flow at the South Evans Gulch stations was 26.6 cfs. Lincoln Gulch exhibited relatively low flows for only a short period of time during the sampling period and carries surface flows only during spring runoff or significant rain events. The Phase 3 sampling program showed similar characteristics to the Phase 1 results (BOR, 1997). Generally, surface flows from Evans Gulch do not reach the confluence with the Arkansas River from late summer until the start of spring runoff and are not considered a significant source of metals to the Arkansas River.

A Wetlands Study was performed by Woodward-Clyde (1992b) to delineate the existing wetlands within the NPL Site. The wetlands within OU6 are shown on Figure 2-1, and consist primarily of the upper reach of Stray Horse Gulch at Adelaide Park and most of the floodplain of the Evans Gulch drainage.

2.3.2 Surface Water Chemistry

During the Phase 1 and Phase 3 surface water sampling events, Stray Horse Gulch exhibited acidic, sulfate-rich water indicative of ARD. The exception was at the upstream station SHG-07, directly downgradient of the Adelaide wetlands, where the water had a near-neutral pH (see Figure 2-2). The pH decreased at each downstream station while zinc and cadmium loadings increased (BOR, 1996a).

Figure 2-2 provides the 1995 zinc and cadmium loading values for OU6 during spring runoff as calculated by the BOR in their Phase 1 report (BOR, 1996a). Zinc and cadmium are shown as they are generally good indicators of water quality and are contaminants of concern (Weston, 1995a). The BOR calculated flow-weighted metal loading using the following equation:

$$[(\text{flow, cfs}) \times (28.3168\ \text{L/cf}) \times (6.048\times10^5\ \text{s/wk}) \times (\text{metal conc, ug/L})] / (1.0\times10^9\ \text{ug/kg})$$

The reported value was then converted to pounds per day for use in this document.

2.3.3 Fluvial Tailings

The Mine Waste Piles and Tailings Disposal Area Remedial Investigations (Woodward-Clyde, 1994a and b) identified the fluvial tailings within the NPL Site and evaluated whether surface and/or groundwater had been affected. Fluvial tailings were categorized as suspected source areas and are shown on Figure 2-3. Note, however, that no fluvial tailings exist within OU6, therefore this document will not address fluvial tailings (see discussion of remedial action objectives in Section 3.0).

2.3.4 Stream Sediments

Stream sediments are naturally occurring throughout drainages of OU6 and have historically been disturbed due to placer mining. Phases 1 and 3 of the BOR study (as described in Section 2.3.1) included a stream sediment sampling program. The BOR report presents the median concentration of various analytes at multiple stations within each watershed for the 1995 spring runoff. Table 2-1 presents a summary of the data.

Median stream bed sediment contaminant metal concentrations were highest in Stray Horse Gulch, followed by Lincoln Gulch, Evans Gulch, and then finally by South Evans

Gulch where median concentrations were the lowest. Contaminant metal concentrations typically increased with decreasing station elevation. This is consistent with the greater contributing watershed at lower surface water monitoring stations (BOR, 1996a).

2.4 GROUNDWATER

2.4.1 Hydrogeology

No hydrogeologic study exists specifically for OU6, therefore relevant information from the California Gulch Site Hydrogeologic RI (Golder, 1996a) is used in this document to describe the hydrogeology of the area. The NPL Site contains two hydrogeologic units: one consists of unconsolidated sediments and the other is a series of igneous and sedimentary bedrock formations. The unconsolidated sediment unit includes a saturated section (alluvial aquifer) and several perched groundwater zones. The bedrock aquifer is the saturated portion of the bedrock unit. Groundwater recharge to the hydrologic units is from infiltration of precipitation, including snow melt and surface water (Golder, 1996a).

The alluvial aquifer is largely contiguous and primarily under unconfined conditions although perched groundwater can occur locally. Depth to groundwater varies from less than one foot near California Gulch to approximately 250 feet at higher elevations, and saturated thickness ranges from 0 to over 1,000 feet in the alluvial aquifer above the bedrock contact. The average groundwater flow direction of the alluvial aquifer is east to west (S88°W) with a 0.03 foot/foot (ft/ft) hydraulic gradient. Lithologic variability, variable recharge rates, and interactions with surface water and/or groundwater cause local variation in the groundwater flow direction and hydraulic gradient (Golder, 1996a). Alluvial aquifer water table contours from 1992 are provided in Figure 2-4.

The bedrock aquifer refers to the areas of granitic, metamorphic and sedimentary bedrock in the California Gulch Site through which groundwater flows. This groundwater flow is primarily controlled by fracture zones associated with faults, solution features associated with calcareous sedimentary rocks, and mine workings. The bedrock aquifer is primarily under unconfined conditions in the eastern third of the California Gulch Site and confined or partially confined conditions in the western two-thirds of the site. Depth to groundwater in the bedrock aquifer ranges from approximately 28 feet to 796 feet below ground surface (Golder, 1996a). Groundwater levels and flow directions indicate that the bedrock aquifer is flowing into both the Yak Tunnel and the Leadville Mine Drainage Tunnel (LMDT). The hydraulic gradient near the Yak Tunnel ranges from 0.54 ft/ft to 0.13 ft/ft (Golder, 1996a). Near the LMDT, the hydraulic gradient is estimated to be 0.04 ft/ft. Outside of the influence of these drainage tunnels, the groundwater flow direction is west-northwest with a hydraulic gradient of 0.02 ft/ft (Golder, 1996a). Potentiometric surface contours for the bedrock aquifer, based on water level measurements taken in 1992, are provided in Figure 2-5.

Limited information concerning the alluvial/bedrock aquifer interaction is available from the Hydrogeologic RI. Groundwater level data was collected from alluvial aquifer piezometer/bedrock monitoring well pairs PZ-4/BMW-1, PZ-6/BMW-2, PZ-10/BMW-3 (see Figure 2-5). At PZ-4/BMW-1 AND PZ-6/BMW-2, an upward gradient of 0.26 and 0.07 ft/ft was observed respectively. The well pair PZ-10/BMW-3 exhibited a downward gradient of 0.39 ft/ft between the aquifers (Golder, 1996a). Subsurface drainage of bedrock aquifer groundwater by the LMDT may cause the relatively low hydraulic head exhibited in the third well pair. There is no direct evidence of flow between bedrock and alluvial aquifer groundwater at this location.

The Yak Tunnel was developed to reduce mine-flooding problems experienced in the Iron Hill region during hard-rock mining for lead ores in the late 1800's. Yak Tunnel construction began in 1895 at a bottom elevation of 10,330 ft. The tunnel proved so effective at draining the Iron Hill area that it was extended to connect with the Ibex and Resurrection mines (CDM, 1997). Construction began on a second tunnel, the LMDT, in 1943 to drain mine workings below 10,063 ft including the lower parts of the Iron Hill basin and the Downtown, Fryer Hill, and Carbonate Hill basins. The LMDT was completed in 1952 from a collar elevation of 9,986 ft to a bottom elevation of 9,960 ft.

2.4.2 Groundwater Chemistry

Only limited information is available regarding groundwater quality in OU6. Figure 2-6 illustrates the groundwater pH values as well as dissolved zinc and cadmium concentrations for November 1991 through January 1992 as reported in the Hydrogeologic RI (Golder, 1996a). Background water quality was also investigated in the Hydrogeologic RI. The investigation showed that both the alluvial and bedrock aquifers are of the calcium-magnesium-carbonate/sulfate type with a pH range between 7.3 to 8.0. Dissolved metals were rarely above the detection limits.

The wells within OU6 (Figure 2-6) have been monitored periodically by CDPHE for chemicals other than zinc and cadmium. A comprehensive summary of these groundwater quality data for the NPL site can be found in RMC, 2001a. Recent exceedences of secondary drinking water and agricultural standards have included magnesium, sulfate and pH in wells WMW-1 and 2 during the summer of 2000. Historical exceedences of groundwater standards included human health standards for arsenic, cadmium, and nickel in 1992. Additional exceedences of agricultural and secondary drinking water standards were observed for manganese and selenium in 1992. These exceedences occurred in wells HM1TMW-4 and 5.

2.5 MINE WASTE

2.5.1 Mine Waste Types

Two types of mine wastes are present within OU6: waste rock and tailings. Mine waste rock piles are usually located near adit and shaft entrances and are comprised of rock excavated during mine development, gangue (un-mineralized rock), and low-grade ores (Water, Waste and Land, 1990). Gangue consists of material such as chert, limestone, quartzite, and minor quantities of rock with metal sulfide mineralization including pyrite, chalcopyrite, sphalerite, and galena. Surface exposure and weathering of these minerals may lead to pyrite oxidation resulting in the production of ARD with elevated metals concentrations.

Mine tailings were the wastes generated during the processing of ore. When ores were taken to the mill they were first crushed and separated into metallic concentrates and waste products. These products were generally placed near the mill in a tailings pond. Tailings occurrence in OU6 is limited to the Hamms Tailings. Mine wastes in the OU6 area are illustrated on Figure 2-7.

2.5.2 Mine Waste Locations

As part of the FFS, a number of mine waste areas have been identified as candidates for possible remedial action (see Figure 2-9 and Table 2-3). These areas were identified from available surface water quality data, Airborne Visible and Infra-Red Imaging Spectroscopy (AVIRIS) data (Figure 2-8), surface soil chemical data, and field observations of mineralogy. In addition, any mine waste area that was subjected to a prior Response Action resulting in mine waste exposed at the surface was considered to be a candidate for remedial action in this FFS, without further analyses.

Surface water quality data was obtained from the BOR Phase 1 and 3 investigations as described in Section 2.3.1 as well as the 2000 and 2001 synoptic sampling event by the Colorado Mountain College (CMC) and Rocky Mountain Consultants (RMC). Synoptic sampling is the sampling of a slug of water as it moves through a hydrologic system (RMCb, 2001). The surface water data was first analyzed to identify drainages that contribute significant loading downstream. When a potential source drainage was identified, the contaminant loading trends between individual surface water monitoring stations were evaluated to isolate sub-drainages of concern.

The sub-drainages were then analyzed with respect to surface mineralogy obtained from Phase 2 of BOR's investigation. The BOR conducted Phase 2 in 1995, involving remote sensing analysis of OU6 to map the distribution of surface minerals (AVIRIS). The AVIRIS instrument collects data from a NASA ER-2 aircraft at an altitude of 65,000 ft with resolution of approximately 17 meters (BOR, 1997). The data is presented by showing the predominant mineral in each 17 x 17 meter pixel as illustrated in Figure 2-8. This data was used extensively to help prioritize ARD-generating source areas for Response Actions implemented in OU6. The key indicators of ARD, as determined by the BOR investigation are pyrite and its secondary minerals as listed below.

Mineral	Chemical Formula	ARD-Generation
• Pyrite	FeS_2	High
• Copiapite	$FeFe_4(SO_4)_6O(OH)\cdot 20H_2O$	↓
• Jarosite	$(Na,K)Fe_3(SO_4)_2(OH)_6$	↓
• Goethite	alpha-FeO(OH)	↓
• Hematite	alpha-Fe_2O_3	Low

The last set of screening tools for identification of ARD-generating mine waste areas is surface soil chemical data and field observations of mineralogy. This information was primarily obtained from the Mine Waste Piles RI (Woodward-Clyde, 1994a). Based on field reconnaissance, the Mine Waste Piles RI categorized the inventoried mine waste piles into five groups:

		ARD-Generation
• Group 1:	No observed minerals of concern.	Low
• Group 3:	Minor amounts of sulfide minerals such as pyrite, sphalerite and chalcopyrite, but no galena.	↓
• Group 2:	Predominantly manganese and carbonate minerals with occasional traces of pyrite.	↓
Group 4:	Abundant amounts of sulfide minerals (except galena) and occasional manganese and carbonate minerals.	↓
• Group 5:	Similar to Group 4 piles, but contain visible galena.	High

The results of this screening identified mine waste areas in Stray Horse, Little Stray Horse and Upper Lincoln Gulch (Ibex/Irene Area). The general areas containing ARD-generating mine wastes are illustrated on Figure 2-9.

The first group of mine waste piles identified as candidates for further remedial action are listed below and include those that have already been addressed by surface water management Response Actions (see discussion of Prior Response Actions in Section 4.0):

- Greenback
- RAM
- Old Mikado
- New Mikado
- Highland Mary
- Adelaide/Ward
- Pyrenees
- Fortune/Resurrection

These mine waste piles were identified as ARD-generating and as contributors of metal loading to the watershed early in the OU6 remedial process (USEPA, 1997). The Ponsardine pile, located in the Little Stray Horse Gulch watershed, was also identified due to ARD-generation and high lead concentrations (USEPA, 1999).

In addition to the previously identified and/or remediated piles, several other areas have been identified as ARD-generating and are candidates for further action. The first of these is the Robert Emmett Pile (Emmett Pile) as illustrated on Figure 2-9.

The Emmett mine area consists of five piles as identified in the Final Mine Waste Piles RI (Woodward-Clyde, 1994a). Two of these piles were directly associated with the Emmett Mine, while the other three are located in the vicinity. The 2001 synoptic sampling data collected by the Colorado Mountain College demonstrates a significant increase in contaminant concentrations between stations SHG-08 and SHG-09, as shown in Table 2-2, which lie just up- and down-stream of the Emmett Pile (see Figure 2-1). While this increase may be attributable in part to the loading contribution from the Emmett Pile, it should be noted that there is uncertainty as to what portion of the loading is from the Emmett Pile and what portion may be from the remediated source areas on the south side of Stray Horse Gulch. These areas (including Maid of Erin, Wolftone and Mahala) have been consolidated and capped. However, the soils underlying the waste piles may continue to discharge ARD as the remedies stabilize.

Based on a Group 5 categorization assigned by the Mine Waste Piles RI as well as visual observations, two of the five piles in the Emmett Mine area have been identified as ARD-generating and are candidates for remedial action (see Figure 2-9).

The final potential source area of concern identified during this process is referred to as Evans F&G. This area was delineated as two areas (Evans F & Evans G) in the Draft BOR Value Analysis Report, which is briefly described in Section 2.1 (BOR, 1996b). The labeling scheme for these areas was retained from the report for continuity. The Evans F&G area was initially identified due to significant contaminant concentration increases between stations SEG-03, SEG-04 and SEG-05 during the 2000 synoptic sampling event. In addition, AVIRIS data showed ARD-generating mineralogies present in Evans areas F & G.

However, 1995 BOR water chemistry data showed that South Evans Gulch had the lowest median flow-weighted metal loading in OU6 (BOR, 1996a). In addition, the BOR eliminated three of the five sampling locations for their 1996 sampling event due to lack of evidence for ARD or high contaminant metal levels in South Evans Gulch during the 1995 sampling (BOR, 1997). Based on this information, and the fact that Evans Gulch is not considered to be a major loading source to the Arkansas River, the Evans F&G area was not retained as a candidate for remedial action. However, long-term water quality monitoring will be performed to observe any changes that may affect the Parkville Water Supply.

Table 2-3 provides a summary of the screening process used to define each of the candidate piles identified in this document.

2.5.3 Mine Waste Quantities

The volume of each mine waste area identified in Figure 2-9 is listed in Table 2-4. The volumes were obtained from the Draft Value Analysis Report (BOR, 1996b) except where otherwise noted.

Since the Emmett mine area was not identified during the Value Analysis, an estimated volume for the two Emmett piles of concern was obtained using GIS topographic and pile location data obtained from the Leadville area GIS database provided by EPA Region 8. Initially, a Triangulated Irregular Network (TIN) model was created using the current topographic information. Then a pre-mining TIN model was produced by estimating the contour locations before mine waste piles began to influence the topographic features. These two TIN models were subtracted from one another to obtain an approximate volume of the piles. This volume is given in Table 2-4.

2.6 SUMMARY OF BASELINE RISK ASSESSMENT

Baseline human health and ecological risk assessments (BRAs) characterize baseline risks at a site. They provide the basis for remedial action and indicate the exposure pathways to be addressed. A number of BRAs have been completed for the NPL Site, and are listed below:

- *Preliminary Human Health Baseline Risk Assessment for the California Gulch NPL Site* (Weston, 1991). The presence of elevated levels of heavy metals in soils in and around the residential and commercial areas of Leadville was discovered during early site investigations. This information was used in the preliminary risk assessment, which indicated that contaminant levels were high enough to be of potential human health concern. Lead and arsenic were identified as the primary chemicals of potential human health concern.

- *Baseline Human Health Risk Assessment for the California Gulch Superfund Site. Part C: Screening Level Soil Concentrations for Workers and Recreational Site Visitors Exposed to Lead and Arsenic* (Weston, 1995b).

  - *Baseline Human Health Risk Assessment for the California Gulch Superfund Site. Part C: Evaluation of Worker Scenario.* This part of the BRA was conducted to evaluate risks to current or future workers in the commercial and business district of the community. This study focused on the risks associated with exposure to lead and arsenic in soil and dust through ingestion.

  - *Baseline Human Health Risk Assessment for the California Gulch Superfund Site. Part C: Evaluation of Recreational Scenarios.* This part of the BRA was conducted to evaluate risks which environmental contamination poses to people who engage in recreational activities (hunting, hiking, bike riding, picnicking, etc.) in areas in and around the community. This study focused on the risks associated with lead and arsenic at the site.

- *Final Baseline Aquatic Ecological Risk Assessment for the California Gulch NPL Site* (Weston, 1995a). The Aquatic Ecological Risk Assessment evaluated the impact of mine waste contamination on the aquatic ecosystem in the NPL Site. The mine wastes in the area are associated with increased heavy metal loading to the surface water and sediments within the site drainages and the Arkansas River.

- *Baseline Human Health Risk Assessment for the California Gulch Superfund Site. Part A – Risks to Residents from Lead* (Weston, 1996a). This document focuses on the risks of lead exposure to young children (age 0-6 years). Young children were selected as the focus because they typically have higher intake rates of environmental media per unit body weight than adults, they tend to absorb a higher fraction of ingested lead than adults, and they tend to be more susceptible to some of the adverse effects of lead than adults. The EPA developed an integrated exposure, uptake, and biokinetic model to predict blood lead values in children exposed to a known concentration of lead in the environment.

- *Baseline Human Health Risk Assessment for the California Gulch Superfund Site. Part B – Risks to Residents from Contaminants other than Lead* (Weston, 1996b). This document focuses on risks to current and future residents of Leadville from environmental media contaminated with mine related wastes other than lead. The assessment adopted a Preliminary Remediation Goal (PRG) approach to the risk analysis where a concentration for each contaminant of potential concern (COPC) was identified using a specific level of health risk for each medium. This PRG was then compared to site-wide data to determine if, where, and by how much site concentrations exceed the calculated value.

- *Ecological Risk Assessment for the Terrestrial Ecosystem, California Gulch NPL Site* (Weston, 1997). The Terrestrial Ecological Risk Assessment (TERA) evaluated the potential for adverse effects on the terrestrial environment or receptors living in the terrestrial ecosystem due to contamination within the NPL Site. Operable Unit 6 was divided into two smaller units for the TERA: OU6a and OU6b. Most of OU6 is defined as the OU6a area, with the exception of a small area in the western section of the OU containing Starr Ditch, which is designated as OU6b.

2.6.1 Human Health Risks

Land use in most of OU6 is currently zoned industrial mining. Therefore, potential human receptors include commercial workers and recreational visitors. The BRAs summarized above focused on lead and arsenic exposure to current and future workers and recreational visitors as these contaminants are considered to be the "risk drivers" at the site. To evaluate risk, calculations were performed to identify concentrations (action levels) in soil that were of potential concern. In order to identify areas where these might be exceeded, the action levels were compared to findings of soil concentration values in previous Remedial Investigations (RIs). Note that it is the average lead and arsenic levels over an area that should be compared to the soil action level. Occasional measurements of concentrations above the action level do not necessarily constitute evidence that an area is unsafe (Weston, 1995b).

Inspection of the prior RIs shows that average lead levels are generally well below the action level of 16,000 parts per million (ppm) for areas where recreational scenarios are considered likely (Weston, 1995b). For the worker scenario, the average lead levels are mostly below the central-tendency range of plausible action levels (6100-7700 ppm) for most areas zoned for commercial land use, with the possible exception of some areas in the historic mining area east of town and in the vicinity of the former AV Smelter located southwest of town (Weston, 1995b).

The expected mean arsenic levels do not appear to exceed the soil action level for workers anywhere at the NPL Site, with the possible exception of the area near the former AV Smelter (Weston, 1995b).

Two small portions of OU6 are either zoned residential or adjoin residential areas. These include the Penrose Mine Waste Pile and Starr Ditch. The Penrose Mine Waste Pile is zoned residential and was capped with a soil cover during a prior Response Action (see Section 4.0). Starr Ditch is currently fenced. Therefore, the human exposure pathway has been interrupted at both of these residential areas. In addition, an extensive education and intervention program to manage lead exposure at the NPL site is included in the Lake County Community Health Program (LCCHP) implemented under the Record of Decision for OU9. This education program focuses on raising public awareness about risk from lead and encourages participation in the LCCHP. The program also includes voluntary blood lead monitoring for children between the ages of 6 and 72 months and pregnant or nursing women.

The non-residential areas of OU6 are currently zoned Industrial Mining. It is possible that changes in zoning may occur leading to land uses other than mining or recreational. Institutional controls are included in the remedial alternatives described in Section 7.0 to address potential future changes in land use.

2.6.2 Ecological Risks

Aquatic risks were assessed by sampling station rather than by OU. Sampling stations of concern in OU6 were in the Stray Horse Gulch and Starr Ditch drainages. However, the physical limitations of these and other OU6 tributaries preclude the support of aquatic life. Therefore, risk evaluations were focused on California Gulch and the Arkansas River (CDM, 1997).

To quantify terrestrial risks, exposure intakes were estimated for upland and wetland receptors and hazard quotients (HQs) were calculated by analyte for each receptor. An HQ is the ratio of the estimated exposure intake to a toxicity benchmark value. An HQ of less than one indicates that risk from exposure is not occurring. An HQ greater than one indicates potential for risk, but does not necessarily indicate that adverse effects will occur. The higher the HQ the more likely that adverse effects will occur (Weston, 1997).

Due to the large number of analytes, receptors and media evaluated, Hazard Indices (HIs) were estimated by summing the HQs for each exposure pathway for all analytes. The OU6 HIs are given in Table 2-5. A review of this table reveals ecological risks above a level of concern for several birds and mammal. Species with HI's above 20 include Blue grouse, Mountain Bluebird and Least Chipmunk.

3.0 REMEDIAL ACTION OBJECTIVES

3.1 INTRODUCTION

The objectives of the Response Actions taken to date in OU6 and contemplated in this FFS are very specific and originate in a Consent Decree. The CD was entered into in 1994 by the United States, the State of Colorado, and the Potentially Responsible Parties. The objectives set forth in the CD were to:

1. Protect public health, welfare, and the environment from releases or threatened releases of Waste material at or from the NPL Site;

2. To divide the NPL Site into areas of responsibility among the parties;

3. To improve the quality of site-wide Surface and Ground Waters through Source Remediation;

4. To reimburse the past and Future Response Costs of the Plaintiffs;

5. To resolve the liabilities of the Settling defendants at the Site

6. To resolve the claims of the Settling defendants against the United States and the State.

The CD defines Source Remediation (mentioned in Item 3, above) as:

> *"Response Actions designed to prevent or control the release or threatened release of waste material from sources of contamination such as tailings impoundments, fluvial tailings, waste rock piles and soils into all pathways of migration, but shall not include any treatment of Site-wide Surface or Ground Waters."*

Item 3, above, provides the most specific direction for remedial measures in OU6. The requirement to improve water quality through source remediation presents an inherent limitation in the scope of the remedial alternatives and remedial objectives. Restricting remedial action to source remediation may preclude the achievement of any specific numerical water quality objectives for surface or groundwater in OU6. This is due to:

- The presence of non-point source pollution.
- The discharge of contaminated groundwater to surface water.
- Natural background contaminant levels.

These limitations coupled with the specific exclusion of site-wide surface or ground water treatment leads to the conclusion that remedial action objectives should not include chemical-specific numerical water quality standards applied within OU6 boundaries.

Rather, the objective is to reduce metal loading to the watershed to the extent practicable. Although this is a subjective standard, the effectiveness of existing and proposed remedial actions can be measured or estimated as a relative improvement in water quality from pre-remedial conditions.

Chemical-specific, numerical water quality standards may be formally addressed under OU12. This OU was established to consider site-wide surface and groundwater quality targets and methods to achieve those targets after source remediation is completed in the other OU's.

3.2 MEDIA OF CONCERN

Before setting the RAO's for OU6, consideration was given to the specific environmental media that constitute a source for metals in the watershed and therefore should be targeted for remedial action.

The CD suggests materials that may be considered sources:

> *"Response Actions designed to prevent or control the release or threatened release of waste material from sources of contamination such as **tailings impoundments, fluvial tailings, waste rock piles and soils into all pathways of migration**, but shall not include any treatment of Site-wide Surface or Ground Waters."*

As discussed in Section 2.0 the only fluvial or impounded tailings in OU6 is the former Hamm's Tailings Impoundment. These mine wastes were consolidated and capped in 1996. No tailings remain exposed at the surface in OU6. Native soils are not considered to be a significant source of ARD.

Although not specifically identified in the CD's definition of Source Remediation, stream sediments were also considered in this FFS as a medium of potential concern. Most of the prior Response Actions included the removal of stream sediments, construction of sediment basins and the re-routing of stream channels around ARD-generating mine wastes. In areas of OU6 where stream sediments have not been physically removed (Evans Gulch), metal loading at the OU6 boundary has been relatively low (see Section 2.0). Therefore, stream sediments are not considered a medium of concern and are not targeted for remedial action through physical removal.

Mine waste rock remains the primary source for metal loading to surface and ground water in OU6.

3.3 MIGRATION PATHWAYS OF CONCERN

Before setting the Remedial Action Objectives (RAO's) for OU6, consideration was given to the potential contaminant pathways of concern. As a starting point, the migration pathways of concern listed in the SFS (EPA, 1993) were considered including:

- Control wind erosion of waste rock materials from the source locations.
- Control water erosion of waste rock materials from the source locations.
- Control leaching and migration of metals from waste rock into surface water.
- Control leaching of metals from waste rock into groundwater.

The first migration pathway (airborne transport) was determined to present a human health risk below a level of concern. The Baseline Human Health Risk Assessment – Part A: Risks to Residents from Lead (Weston, 1996a) concluded that "*inhalation exposure to lead is minimal at this site, and the inhalation exposure was not considered further in this assessment.*" Based on this conclusion, airborne transport of contaminants was not considered further in the FFS.

The second, third and fourth migration pathways relate to the release of metals from source material (mine waste rock, in the case of OU6) to surface and ground water. These migration pathways are considered relevant for the FFS.

3.4 REMEDIAL ACTION OBJECTIVES

Based on the forgoing, the Remedial Action Objectives for OU6 include:

1. Control erosion of mine waste rock and deposition into local water courses.
2. Control leaching and migration of metals from mine waste rock into surface water.
3. Control leaching of metals from mine waste rock into groundwater.

4.0 PREVIOUS RESPONSE ACTIONS

4.1 SUMMARY OF PREVIOUS RESPONSE ACTIONS

The EPA has implemented a number of Time Critical and Non-Time Critical Response Actions within OU6 (Figure 4-1). These Response Actions were conducted primarily to prevent exposure of human populations to contaminants from mine wastes and to reduce leaching and migration of metals from the wastes into surface waters. This section briefly summarizes the Response Actions implemented to date in chronological order. Detailed descriptions of the individual Actions are available within the documents referenced. An evaluation of the effectiveness of the Actions performed to date is provided in Section 4.2.

1. In 1990, ASARCO performed improvements along 5th Street and Starr Ditch between East 5th Street and the Harrison Street slag pile. The improvements involved converting existing open ditches to culverts along both sides of East 5th Street, including the construction of the 5th Street headwall. Starr Ditch was also fenced to restrict public access from just north of 5th Street to Monroe Street, just east of the Harrison Street slag pile (USEPA, 1995).

2. During the summer of 1994, the BOR, on behalf of EPA, implemented sediment control measures on Hamm's Tailing Impoundment as an interim measure (USEPA, 1995).

3. In 1995 and 1996 an emergency Response Action was implemented at Hamm's Tailing Impoundment. The Action involved removal of sediment from sedimentation ponds, enlargement of selected sedimentation ponds, rehabilitation of straw dams and ponds, removal of sediment from culverts and associated drainage structures, construction of an up-gradient run-on control ditch, and reestablishment of Starr Ditch at the base of Harrison Street slag pile (USEPA, 1995). The removed sediment was transported to the Hamm's Tailings Impoundment for disposal (USEPA, 1996).

4. Also in 1996, EPA conducted a Time Critical Response Action for the Hamm's Tailing Impoundment and the Penrose Mine Waste Pile. The majority of mine waste in the Penrose Pile was transported to the Hamm's Tailing Impoundment. The remaining waste at the Penrose Pile was graded to a 3:1, covered with a soil cap, and revegetated. The Hamm's Impoundment was then consolidated, compacted and graded to a stable 3:1 configuration, covered with a soil cap, and revegetated (USEPA, 1996).

5. In 1997, Phase I of a five phase OU6 Respose Action was implemented by EPA. The purpose of the Action was to mitigate the majority of the source areas impacting water quality in the Stray Horse Gulch drainage (USEPA, 1997). The Phase I Action included (CDM, 2000a):

- Capping of three double-compartment mine shafts.
- Construction of five crib walls.
- Consolidation and capping of three waste rock piles.
  - Wolftone
  - Maid of Erin
  - Mahala

Work on the waste rock piles consisted of excavating, transporting, placing, reshaping, and compacting contaminated mine waste rock from adjacent areas including approximately 5,900 cubic yards (CY) of acid generating waste rock from Stray Horse Gulch Road. A polyvinyl chloride (PVC) geomembrane in combination with a Mirafi geofabric was placed on top of each consolidated pile. A minimum of 8 ft of dolomite waste rock was then placed and compacted above the Mirafi geofabric at Wolftone and Maid of Erin at a 1.5:1 side slope (Figure 4-2). White porphyry mixed with dolomite waste rock was used as a veneer material to provide a more aesthetic appearance on the Wolftone Pile. At Mahala, the rock cap was constructed as described above with the exception of the top. The top of the pile was capped with 1-2 ft of white porphyry due to a supply shortage of dolomite waste rock (Pacific Western, 2001).

The Ponsardine Pile and the source areas addressed in the 1998 Phase II Response Action were initially scheduled for Response Action during the Phase I work. The Ponsardine Pile, however, was eliminated due to state and local concerns about potential impacts to historic and cultural resources.

6. In 1998, EPA conducted Phase II of the Response Action to mitigate additional source areas impacting water quality in the Stray Horse Gulch drainage (see Figure 4-3). The Phase II work involved surface water management rather than consolidation and capping to address state and local concerns about potential impacts to historic and cultural resources. The following major components were completed during Phase II (CDM, 2000b):

   - Capping of one double-compartment mine shaft.
   - Construction of water run-on diversions at Highland Mary, Mikados, RAM, Greenback, Pyrenees and Adelaide-Ward.
   - Construction of water runoff channels at Highland Mary, Mikados, Pyrenees and Adelaide-Ward.
   - Construction of ARD retention basins at Highland Mary, Mikados, Pyrenees and Adelaide-Ward.
   - Construction of detention basins in lower Stray Horse Gulch at Adelaide Park and the Emmett waste rock pile.
   - Construction of an interim water runoff collection channels and sediment basin at Fortune/Resurrection No. 1.
   - Rehabilitation of Stray Horse Gulch and Starr Ditch.
   - Sediment removal at the 5th Street Headwall.

During Phase II, the Ponsardine Pile was considered for run-on/runoff control, but was ultimately not included based on the small size of the pile and the insignificant ARD it appeared to contribute based on available information. In addition, according to local observations runoff was believed to infiltrate before reaching the east side of Leadville. Subsequent opportunistic data collected during the 1998 construction season showed that the Ponsardine pile can be a source of ARD and associated metals particularly during storm events (EPA, 1999).

7. Phase III was implemented in 1999 as a continuation of the Phase II work. The following briefly describes the major work conducted (CDM, 2000b):

    - Construction of water runoff collection channels at RAM and Greenback.
    - Construction of water runoff retention basins at RAM and Greenback.
    - Completion of water runoff collection channel and sediment basin at Fortune/Resurrection No. 1.

8. In 2000, EPA conducted Phase IV of the OU6 Response Action. This phase involved removal and disposal of sediments along Starr Ditch, rehabilitation and realignment of Starr Ditch, revegetation of disturbed areas, and slope stabilization at the RAM and Greenback areas (CDM, 2000c).

    During the spring runoff in 2000, the water collected in the retention basins at RAM, Greenback and Pyrenees nearly overtopped due to underdesign of the retention basins. In order to prevent overtopping, the water was collected at the Greenback Pond and siphoned to Stray Horse Gulch. Section 4.2.2 addresses the retention pond sizing issues within OU6.

9. Also in 2000, Parkville Water District, in cooperation with ASARCO and Lake County, rerouted a portion of the Lincoln Gulch drainage basin to the South Evans Gulch basin. This diversion, referred to as the "Diverted Lincoln Gulch" was constructed due to local concerns of an unstable channel, accumulated sediments, and potential threats to the water supply for the Parkville Water District. The action was made by the Parkville Water District and local citizen groups, and did not include any Federal or State agencies (CDM, 2001a).

10. In the Fall of 2000, EPA constructed a discharge to the Marion Mine Shaft to prevent the release of water into Stray Horse Gulch from the Greenback Retention Pond during future spring runoff events. The current capacity of several retention ponds does not accommodate a typical snowmelt event. The Marion Shaft intercepts the LMDT via the Robert Emmett Shaft. The LMDT then carries the collected runoff to the BOR's treatment plant at the portal of the LMDT.

    The connection between the Marion Shaft and the LMDT has been under analysis by EPA. A number of tracer studies were performed to determine the effectiveness of the LMDT as a conveyance structure for the Greenback Pond discharge. Preliminary and unpublished results of these studies confirm a hydraulic connection between the Marion Shaft and the LMDT portal. However, the efficiency of the connection remains under study (Davies, Personal Communication, 2001).

11. During the 2001 construction season, EPA implemented Phase V for surface water management and sediment control in the Ibex/Irene area (USEPA, 2001). This phase involved constructing water run-on diversion ditches on the south side of Lake County Road 1A following the path of the diverted Lincoln Gulch as well as additional ditches that direct surface water towards the Eclipse Mine and existing drainages, eventually leading to South Evans Gulch (see Figure 4-4). Surface water runoff from ARD-generating sources is redirected to a detention basin, which ultimately discharges to Lincoln Gulch. A second detention basin was constructed in the Old Lincoln Gulch channel near Lake County Road 3B to collect sediment from erosion in Lincoln Gulch (CDM, 2001a).

4.2 EFFECTIVENESS OF PRIOR RESPONSE ACTIONS

The effectiveness of previous work within OU6 was assessed in the Draft Technical Memorandum for Effectiveness of Past Work at Operable Unit 6 (CDM, 2001b), which is provided in Appendix A and summarized below.

In order to determine the effectiveness of past work, CDM collected surface water quality and soil analytical data, and made observations on the performance of the caps, vegetation, and water management features. This information was used to evaluate effectiveness in three ways:

- By examining how the actions meet the RAOs.
- By evaluating the performance of the structures based on observations.
- By evaluating changes in surface water quality in Stray Horse Gulch

Each of the prior Response Actions can be categorized into three general types: Sediment Removal, Surface Water Management, or Capping.

4.2.1 Effectiveness Relative to Remedial Action Objectives

A brief summary of how the three general types of response actions meet the RAOs is provided below.

Control erosion of contaminated materials from the source locations

- The Sediment Removal Response Actions directly address this RAO through removal of contaminated sediment source material.
- Surface Water Management Response Actions divert run-on and collect ARD to route it to retention ponds. The retention ponds collect eroded material and are cleaned periodically.

- Capping Response Actions eliminate erosion and transport of source material.

Control of leaching and migration of metal from contaminated materials into surface water

- The Sediment Removal Response Actions directly address this RAO through removal of contaminated sediments.
- Surface Water Management Response Actions divert run-on and collect ARD from waste rock piles to reduce metal-loading to surface water.
- Capping Response Actions minimize leaching and migration based on the type of cap constructed. Vegetated soil cover reduces leaching and migration while a multi-layer geomembrane cap virtually eliminates it.

Control of leaching and migration of metal from contaminated materials into ground water

- Sediment Removal Response Actions may reduce the leaching of metals to groundwater in losing stream reaches in which surface water/groundwater interactions occur.
- Surface Water Management Response Actions divert the majority of surface water run-on, which is therefore unable to leach and transport contaminants from waste rock areas to ground water. See Section 7.5.1.2 and Table 7-1 for a discussion of the detention pond performance component of the Surface Water Management Response Actions. On-going tracer studies indicate a strong connection between the Marion Shaft and the LMDT and BOR Treatment Plant. Therefore, the discharge of ARD to the Marion Shaft should not degrade groundwater. However, on-going groundwater quality monitoring will be used to further assess the effectiveness of Surface Water Management Response Actions.
- Capping Response Actions minimize leaching and migration of contaminants. Vegetated soil covers reduce leaching and migration to groundwater while a multi-layer geomembrane cap virtually eliminates it.

4.2.2 Evaluation of Structure Performance

The three consolidated and capped piles, Maid of Erin, Mahala and Wolftone, were inspected in 1998, one year after construction. At that time, tension cracks were observed in the outer edges of the benches at Maid of Erin and Wolftone. This cracking appeared to be limited to areas where compaction was not performed and was determined not to diminish pile stability. Subsequent inspections of the piles show the caps remain stable with no observed settling. Erosional features were also noted on the Mahala Pile related to a one-time routing of over-flow from the Greenback detention pond over the Mahala Pile via a siphon line. This erosion feature was subsequently repaired.

Also in 1998, the benches on the caps were regarded to promote positive drainage. Overflow weirs and channels were constructed to direct overflow from the Upper and

Lower Adelaide, Mikados, and Highland Mary basins to Stray Horse Gulch. Overflow from Pyrenees, RAM and Greenback retention basins was routed into the Marian mineshaft.

Survey monuments will be established on the consolidated and capped piles to monitor long-term settlement. Collected data will be used to determine the need for and type of corrective action, if any. See section 7.0 for additional discussion.

4.2.3 Evaluation of Surface Water Quality

CDM used the available surface water sampling data from Spring 1995 through Spring 2001 to assess the effectiveness of previous actions with respect to surface water quality. However, analytical results for the 2001 spring synoptic sampling event were not available at the time CDM's draft memo was published. As a result, only flow data and field chemistry (pH and specific conductance) for 2001 could be assessed. CDM used available data to identify trends at each surface water monitoring station within Stray Horse Gulch and Evans Gulch as summarized in Table 4-1 (station locations are provided in Figure 2-1).

To supplement CDM's assessment, available flow data dating back to 1995 was analyzed to evaluate trends in contaminant loading. Figures 4-5 and 4-6 provide cadmium and zinc loading values for stations SHG-09, SHG-09A and SD-3. The data points shown were taken from years which included a May sampling event with flow rate comparable to those recorded during the other utilized sampling events at each individual station. Due to limited data and hydrologic information for each sampling year, the loading values for each of the three stations should not be used for comparison against the calculated loadings at the other stations. Instead, these figures are to provide a graphical representation of the general loading trends within OU6.

This FFS also includes two surface water-monitoring stations as performance monitoring points for OU6: SHG-09A and SD-3. Station SHG-09A is located near the confluence of Stray Horse Gulch and Starr Ditch and most accurately shows the effect of the prior Response Actions on water quality within Stray Horse Gulch. Station SD-3 is located near the OU6 boundary and provides a reference point for pre-Response Action and post-Response Action comparison of surface water exiting OU6. It should be noted that further monitoring is needed to evaluate the hydrology in the area of SD-3 in order to fully understand the influence from upgradient sources. Performance monitoring points were not identified within the Evans Gulch watershed due to a lack of post-Response Action (Phase V) water quality data, the significantly lower contaminant loading as compared to Stray Horse Gulch (see Figure 2-2), and the lack of measurable impacts to the Arkansas River.

The Colorado Mountain College (CMC) in conjunction with RMC performed synoptic sampling during spring runoff in 2000 and 2001 (CMC 2001a and 2001b). Synoptic sampling is the sampling of a slug of water as it moves through a hydrologic system.

During spring runoff, synoptic sampling is desirable due to the large variations in flow throughout the day caused by the sun's effect on the rate of snowmelt. In OU6, the synoptic event involved conducting tracer tests to estimate the travel times between surface water monitoring stations (RMC, 2001). The travel times were then used to determine the sample collection time at each monitoring station.

While many of the OU6 Response Actions were completed by Spring 2000, EPA was forced to siphon water from the retention basins within Stray Horse Gulch during spring runoff that year due to inadequate sizing of the basins (CDM, 2001b). Therefore, Spring 2001 is the first post-Response Action water quality data available. The Spring 2000 data is used as a pre-Response Action comparison point due to the consistent methodology practiced during the two synoptic sampling events. In order to make valid data comparisons between 2000 and 2001, it was necessary to select sampling dates that occurred at the same point on the annual hydrograph. These two dates, May 11, 2000 and May 23, 2001, were selected based on the flow data collected at SHG-09A and SD-3 shown in Table 4-2.

Figure 4-7 illustrates zinc and cadmium loading values at the performance monitoring stations. As demonstrated by Table 4-2 and Figure 4-7, the reductions at the two points range from 58-81%. This is a significant reduction in contaminant metals loading from OU6 watershed to California Gulch and the Arkansas River. An assumption can be made that surface water quality will continue to improve as the past Response Actions continue to stabilize from construction activities and the vegetation becomes established.

5.0 ARARS

5.1 DEFINITION OF ARARS

Remedial actions must attain a general level of cleanup that assures protection of human health and the environment, is cost-effective, and uses permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable. In addition, the Superfund Amendments and Reauthorization Act (SARA) requires that any hazardous substance or pollutant and contaminant remaining on site meet the level or standard of control established by ARAR standards, requirements, criteria, or limitations established under any federal environmental law, or any more stringent standards, requirements, criteria, or limitations promulgated in accordance with a state environmental statute.

A requirement may be either applicable or relevant and appropriate to remedial activities at a site (but not both). Applicable requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstances at a site. In other words, they would be legally applicable notwithstanding the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA).

If a requirement is not applicable, it may still be relevant and appropriate. The basic considerations are whether the requirement (1) regulates or addresses problems or situations sufficiently similar to those encountered at the subject site (i.e. relevance), and (2) is appropriate to the circumstances of the release or threatened release, such that its use is well suited to the particular site. A requirement might be relevant but not appropriate for a specific site; in this case, the requirement would not be an ARAR. Determining whether a requirement is relevant and appropriate is site-specific and must be based on best professional judgment. This judgment is based on a number of factors including the characteristics of the remedial action, the hazardous substances present at the site, and the physical circumstances of the site and of the release.

Compliance with all requirements found to be applicable or relevant and appropriate is required under SARA. Waivers of ARARs may be obtained under the provisions of SARA under certain circumstances (CERCLA Section 121(d)(4)). These waivers apply only to meeting ARARs with respect to remedial actions on-site; other CERCLA statutory requirements, such as the requirement that remedies be protective of human health and the environment, cannot be waived. Chemical, Action and Location Specific ARARs for OU6 are summarized on Table 5-1.

6.0 DEVELOPMENT AND SCREENING OF REMEDIAL ALTERNATIVES

6.1 INTRODUCTION

In this Section the remedial alternatives for waste rock are described and screened against the short- and long-term aspects of the following three criteria:

Effectiveness - This criterion focuses on the degree to which an alternative reduces toxicity, mobility, or volume through treatment, minimizes residual risks and affords long-term protection, complies with ARARs, minimizes short-term impacts, and how quickly it achieves protection.

Implementability - This criterion focuses on the technical feasibility and availability of the technologies each alternative would employ and the administrative feasibility of implementing the alternative.

Cost - The costs of construction and any long-term cost to operate and maintain the alternatives shall be considered. Costs that are grossly excessive compared to the overall effectiveness of the alternative may be considered as one of several factors used to eliminate alternatives.

As discussed in Section 1.0, this FFS builds on the SFS (USEPA, 1993) and considered all the additional work performed in the NPL Site since the SFS when developing the remedial alternatives for OU6. The alternatives that are retained after the screening step are advanced to the detailed and comparative analysis steps of the FFS process (Sections 7.0 and 8.0, respectively).

6.2 WASTE VOLUMES

The waste materials considered for remedial action at OU6 include waste rock that generates ARD (see Section 2.5) and ARD collected through the operation of prior water management Response Actions.

The volume of waste rock is used in developing costs estimates for remedial actions that involve in-place capping and excavation/disposal. The quantity of ARD is used to select storage and conveyance mechanisms to deliver ARD to existing and new treatment facilities as well as to develop cost estimates for remedies that involve active treatment.

6.2.1 Waste Rock

Section 2.5 discusses the screening process used to identify the ARD waste piles to be considered for further remedial action. There are two categories of mine waste piles identified by the FFS as candidates for remedial action; 1) those where prior surface water management remedies were implemented, and 2) those where no prior Response

Actions have occurred. Those mine waste piles that have been capped through prior Response Actions are not considered further in this FFS.

The areas with surface water management remedies in place include Greenback, RAM, Old Mikado, New Mikado, Highland Mary, Adelaide/Ward, Pyrenees, Fortune/Resurrection, and Ibex/Irene (see Section 4.1). In addition to these, the Ponsardine and Emmett piles have been identified as ARD-generating and potentially degrading to downgradient water quality. The volumes of each ARD-generating waste pile is provided in Table 2-4.

6.2.2 Acid Rock Drainage

As discussed in Section 4.0, prior Response Actions at OU6 included the construction of clean water diversion channels around mine waste piles. Contaminated surface water is collected in small retention ponds at the toes of selected mine waste piles. A total of eight ponds were constructed of which three are interconnected, draining to the topographically lowest impoundment at the Greenback waste pile and then to the Marion Shaft which conveys the water to the LMDT as shown on Figure 4-3. ARD in the remaining five isolated ponds is not collected for treatment.

Remedial Alternatives that involve the active treatment of collected ARD require an estimate of total volume as well as peak flow rate. The total volume is used to estimate treatment costs and to size storage facilities. The peak flow rate is used to size piping and pumps.

Because the water management Response Actions have operated for less than 24 months, limited information is available regarding the quantity of collected ARD. For the purposes of developing remedial alternative conceptual design and costs, the volume and peak flow rate of ARD assumed to be treated each year is estimated using data collected in 2001. Appendix B includes a technical memorandum prepared by Colorado Mountain College (CMC) summarizing the flow measurements and watershed calculations used to estimate the total volume of ARD discharged from the Greenback Pond during 2001 (see Appendix B, Technical Memorandum 1). The CMC memorandum describes two methods used to estimate the total volume of ARD discharged to the Marion Shaft during the 2001 runoff event. The first method estimates the volume of precipitation that falls in the watershed. The second method uses the output from a pressure transducer installed in the Marion Pond. Uncertainties regarding the accuracy of the pressure transducer output is detailed in the CMC memorandum and is the basis for selecting the hydrologic analysis method for estimating ARD volume during the 2001 runoff event. The relevant values presented in the CMC memorandum are summarized below.

ARD Volume Estimate:

- The total snow-water equivalent for the 2000-2001 winter season in a 30-acre watershed below the clean-water diversion ditches and above the Marion Pond

(Figure 4-3). This quantity is 8,000,000 gallons and assumes no losses from evaporation or infiltration.

- Estimates of rainfall for May and June of 2001 over the 30-acre watershed. Flow to the Marion pond has not been observed later than June. This quantity is 1,572,124 gallons.

For the purposes of the FFS the total volume of ARD is rounded to 10,000,000 gallons. The actual design volume will be finalized during remedial design if an ARD treatment option is selected.

ARD Peak Flow Rate:

- The CMC memorandum describes a peak flow of 550 gallon per minute under normal ("native") conditions.

The estimated volume of ARD-generating mine waste and collected ARD volume and peak flow for 2001 is summarized in Table 6-1.The proposed sizing of conveyance, storage and treatment plant capacity is discussed in Section 7.3.

6.3 DEVELOPMENT AND SCREENING OF REMEDIAL ALTERNATIVES

This Section describes the remedial alternatives considered for OU6 and screens them for effectiveness, implementability and cost. The alternatives are screened against the first two criteria independently. The alternatives are screened against the last criteria relative to each other. The following remedial alternatives were developed for OU6.

6.3.1 Alternative 1 – No Action

The no-action alternative leaves waste rock in OU6 in its current condition. Remedies previously implemented as Response Actions would be abandoned as-is with no monitoring or maintenance. The current discharge of contaminated surface water to the LMDT (introduction into the Marion Shaft) would be abandoned and the flows allowed to enter the Stray Horse Gulch channel when the collection ponds overtop.

Effectiveness: This alternative would result in a deterioration of water quality in Stray Horse and Evan Gulches as water management remedies deteriorate. The incremental reduction in metals loading resulting from the prior consolidation and capping of selected mine waste piles would remain largely unchanged as the remedy does not require extensive maintenance. The alternative ranks low in effectiveness.

Implementability: Implementation of this alternative requires no action and so implementability is ranked high.

Cost: There will be no costs associated with this alternative. Therefore, this alternative ranks low in cost.

6.3.2 Alternative 2 – Maintain Current Remedies w/Institutional Controls

This alternative involves maintaining the existing remedies (see Section 4.0) and the addition of institutional controls (IC's). Maintenance of capped mine waste materials will require periodic inspection, repair of erosional features and other minor repairs. Maintenance of the water management remedies will require sediment removal from retention ponds and other catch basins, and the conveyance, storage, and treatment of collected ARD.

Alternative 2 includes seven ARD conveyance, storage and treatment options, detailed below. ARD considered under the conveyance/treatment options includes only the current discharge to the Marion Shaft. Treatment options include the Yak and BOR treatment plants or a new, dedicated treatment facility. Institutional controls are administrative and local code restrictions to control prevent human exposure to site contaminants. In the case of OU6 such controls would include land use restrictions precluding a change in land zoning.

Overall Effectiveness: This alternative would maintain the improvement in water quality in OU6 realized in the 2001 runoff season (See Section 4.2.3). Institutional controls would minimize the likelihood of human health risk above a level of concern. This alternative ranks medium in effectiveness.

Implementability: Implementation of this alternative presumes long-term conveyance and treatment of collected ARD. Pipelines, lift stations, and lined impoundments are easily engineered and both the Yak and BOR treatment plants may have adequate excess capacity. However, both plants are operated by independent entities with no assurance that either plant will be available. Construction of a dedicated water treatment plant is also considered under option 2h below, and is technically feasible. Institutional controls may be easily implemented through the overlay district currently contemplated for site-wide institutional controls. Therefore, implementability is consider to be medium for this alternative as qualified below.

Cost: The capital costs for alternatives 2a through 2h vary considerably with significant operation and maintenance (O&M) costs (primarily for water treatment) extending decades into the future. Therefore, the cost of this alternative is considered to be medium (except as qualified below).

- Alternative 2a – This alternative involves the construction of a lift station at the Greenback Pond to deliver ARD via a pressure line to a vertical bore advanced into the Yak Tunnel at a location up-stream the existing bulkhead (Figure 6-1). The subsurface mine workings would be used to store contaminated water that would be metered out and treated at the Yak treatment plant. This alternative is considered to be medium in effectiveness, implementability and cost.

- Alternative 2b – This alternative involves delivering ARD to the Yak surge pond via a gravity pipeline (Figure 6-2). A 10 million gallon lined impoundment would be constructed along the pipeline alignment to permit water to metered out to the Yak water plant surge pond. The basis for sizing the impoundment is discussed in Section 7.3.2. This alternative is considered to be medium in effectiveness, implementability and cost.

- Alternative 2c – This alternative involves delivering ARD to mine workings south of the Yak Tunnel via a gravity pipeline (Figure 6-3). The mine workings are suspected to be hydraulically connected to the Yak Tunnel. The subsurface mine workings would be used to store ARD to be metered out and treated at the Yak treatment plant. The hydraulic connection between the mine workings and the Yak Tunnel are unproven. In addition, this option requires a 1,000-foot long horizontal boring to the south of the Greenback Pond at an estimated cost of $1,500.00 per foot. Therefore, this alternative is considered to have low effectiveness, medium implementability, and high cost.

- Alternative 2d – This alternative involves delivering ARD to the BOR treatment plant via a gravity pipeline (Figure 6-4). A 10-million gallon lined impoundment would be constructed along the pipeline alignment to permit water to metered out to the BOR's plant. This alternative is considered to be medium in effectiveness, implementability and cost.

- Alternative 2e – This alternative involves delivering ARD to the existing extraction well along the lower portion of the LMDT (Figure 6-5). The existing pipeline between the extraction well and the BOR treatment plant would be used to convey OU6 ARD to the BOR's plant. A 10-million gallon lined impoundment would be constructed along the pipeline alignment to permit water to be metered out to the BOR's plant. This alternative is considered to be medium in effectiveness, implementability in cost.

- Alternative 2f – This alternative involves continuing the use of the LMDT as a means to both store and convey ARD to the BOR water treatment plant. ARD currently is discharged to the Marion Shaft. Tracer studies suggest a strong hydraulic connection between the Marion Shaft and the LMDT. However, it is not certain whether all waters introduced into the Marion Shaft ultimately discharge at the LMDT portal or the LMDT extraction well. Further, the current and future integrity of the LMDT has been called into question. It is anticipated that LMDT rehabilitation and long-term maintenance would be required for this option to be considered to be effective. As a result, the cost for this alternative is considered to be high. Effectiveness is considered to be low given the uncertainties regarding the percentage of water introduced in the Marion Shaft actually delivered to the BOR treatment plant. Implementability is considered to be medium. Although this is the existing condition, the BOR's willingness to treat ARD for the long-term has not been established.

- Alternative 2g – This alternative involves continuing the introduction of ARD into the Marion Shaft. A plug would be constructed in the LMDT where it passes through competent rock (Figure 6-6). The resulting impounded ground water would be pumped from a location above the concrete plug and delivered to the BOR treatment plant via a gravity pipeline. A preliminary estimate of a pumping rate for this remedy approaches 3,000 gallons per minute (gpm) (see Appendix B, Technical Memorandum 2). The BOR plant does not have the capacity to treat this quantity of water. Significant plant upgrades would be needed in order for this alternative to be selected. Therefore, cost of this alternative is considered to be high with low implementability. This alternative would result in the treatment of collected ARD as well the accelerated treatment of contaminated groundwater filling the mine workings in OU6. As a result the effectiveness of this alternative is considered to be high.

- Alternative 2h – This alternative involves the construction of an independent water treatment facility to treat ARD collected in OU6. The water would be conveyed to the treatment facility from the Greenback Pond via a gravity pipeline and returned to Stray Horse Gulch after treatment.

  The treatment facility would involve a 650-gpm modular lime addition, Memtek Microfiltration system. A one million gallon equalization lagoon (lined impoundment) would be constructed. A process flow diagram is provided as Figure 6-7. The need to construct a dedicated water treatment plant results in a higher capital cost for this alternative. The need to site a water treatment plant renders its implementability medium. The alternative would result in the long-term treatment of collected ARD. Therefore, the effectiveness is considered to be medium.

6.3.3 Alternative 3 – Additional Surface Water Management (In combination with Alternative Options 2a through 2h)

This alternative involves maintaining the existing remedies (identical to Alternative 2) and implementing surface water controls for those waste rock piles that are considered to be sources for ARD but have not been previously addressed through Response Actions. These include the Ponserdine and Emmett waste rock piles (see discussion in Section 6.2.1). Storm water controls would include clean-water diversion channels and ARD retention ponds. The ponds would be lined and sized to hold and evaporate a single year's runoff using average precipitation (18-inches, Golder, 1996b) and evaporative loss data (20-inches, Landeburg, 1969).

Institutional controls are administrative and local code restrictions to control prevent human exposure to site contaminants. In the case of OU6 such controls would prohibit changes in land zoning.

Overall Effectiveness: This alternative would result in further improvement of water quality in Stray Horse and Little Stray Horse Gulches over that achieved in the 2001 runoff season (See Section 4.2.3). Institutional controls would minimize the likelihood of human health risks above a level of concern. This alternative ranks medium in effectiveness.

Overall Implementability: The expected net loss from an evaporation pond is estimated to be only 2-inches per year (based on the average precipitation of 18-inches (Golder, 1996b) and average evaporative loss of 20-inches per year (Landeburg, 1969)). Therefore, the evaporation pond size would be nearly ten times the area of the watershed captured by the pond. Evaporation ponds of this size are not practical. Therefore, this alternative has low implementability.

Overall Cost: The incremental capital and O&M costs for the portions of Alternative 3 that differ from Alternative 2 are high given the size requirements for evaporation ponds.

6.3.4 Alternative 4 - In-Situ Chemical Stabilization (In combination with Alternative Options 2a through 2h)

This alternative involves maintaining the existing remedies (identical to Alternative 2) and implementing in-situ chemical stabilization of those waste rock piles that are considered to be sources for ARD that have not been previously addressed through Response Actions. These include the Ponserdine and Emmett waste rock piles (see discussion in Section 6.2.1).

This alternative involves the injection and dispersion of buffering agents into the waste mass so that a final equilibrium is reached that inhibits acid generation. Chemically stabilized systems are susceptible to weathering and chemical decomposition therefore the potential for contact by surface water run-on or runoff during storm events should be minimized. Potential neutralization agents include lime, magnesium compounds and several proprietary agents. The actual neutralizing agent will be selected during remedial design. This process will maintain the general integrity of the waste piles for cultural and historical aesthetics. However, some disturbance of the pile would be expected, as equipment will need to access all portions of the pile.

Institutional controls are administrative and local code restrictions to control prevent human exposure to site contaminants. In the case of OU6 such controls would include land use restrictions precluding a change in land zoning.

Overall Effectiveness: This alternative may result in further improvement of water quality in Stray Horse and Little Stray Horse Gulches over that achieved in the 2001 runoff season (See Section 4.2.3). However, the long-term effectiveness of the in-situ stabilization component of this remedy is unknown at this time. Institutional controls would minimize the likelihood of human health risk above a level of concern. This alternative ranks medium in effectiveness.

Overall Implementability: The implementability of the in-situ stabilization portion of this remedy is uncertain. However, one potential contractor with relevant experience and the required equipment has been identified, has visited the site, and has prepared a technical and cost proposal (see Appendix F). The overall implementability of this alternative is considered to be medium.

Overall Cost: The incremental capital and O&M costs for the portions of Alternative 4 that differ from Alternative 2 are low. Therefore, the costs for the unique aspects of Alternative 4 are considered to be low.

6.3.5 Alternative 5 – Consolidate and Cap w/Institutional Controls

This alternative involves consolidating and capping of waste rock piles that are considered to be sources for ARD. This includes piles that have been addressed under prior Response Actions as well as those that have not yet been addressed. This alternative excludes those mine wastes that have already been consolidated and capped (e.g. Maid of Erin, Wolftone, etc.). The cap design will follow that implemented during prior Response Action including a geomembrane and an 8-foot thick dolomite waste rock cap (See Figure 4-2).

Effectiveness: This alternative would result in an improvement in water quality within the OU over that achieved in the 2001-runoff season (see Section 4.2.3). The use of a geomembrane will minimize the generation of ARD resulting in high effectiveness. Institutional controls would minimize the likelihood of human health risk above a level of concern.

Implementability: The technologies and materials needed to construct the remedy are readily available. However, remedies that significantly change the appearance of waste piles have been rejected by the community in the past. Therefore the implementability of this alternative is considered to be low.

Cost: The capital cost of this alternative is high with relatively low O&M costs. The cost of this alternative is ranked high.

6.3.6 Alternative 6 – Excavate, Transport and On-Site Disposal w/Institutional Controls

This alternative involves the excavation, transport, and disposal in an on-site repository of waste rock piles (and underlying soils to a depth of 1-foot) that are considered to be sources for ARD. This includes piles that have been addressed under prior Response Actions as well as those that have not yet been addressed. This alternative excludes those mine wastes that have already been consolidated and capped (e.g. Maid of Erin, Wolftone, etc.). The pile footprint would be vegetated after removal. The repository would be located within OU6 and would meet most of the requirements for an industrial solid waste landfill cell including a geomembrane bottom liner and cover.

Effectiveness: This alternative would result in an improvement in water quality within OU6 over that achieved in the 2001 runoff season (See Section 4.2.3). The placement of waste within a repository coupled with the use of best management practices would minimize the generation of ARD resulting in high effectiveness. Institutional controls would minimize the likelihood of human health risks above a level of concern.

Implementability: The technologies and materials needed to construct the remedy are readily available. However, remedies that significantly change the appearance of waste piles have been rejected by the community in the past. Therefore the implementability of this alternative is considered to be low.

Cost: The capital cost of this alternative is high with relatively low O&M costs. The cost of this alternative is ranked high.

6.4 RESULTS OF ALTERNATIVE SCREENING

Based on the screening described in this section several alternatives were rejected and will not be advanced to the detailed and comparative analysis steps of the FFS process. Table 6-2 summarizes the screening of alternatives and identifies those alternatives that have been retained and those that have been rejected. The justification for retaining or rejecting an alternative is also provided in the table.

7.0 DETAILED ANALYSIS OF ALTERNATIVES

7.1 INTRODUCTION

The detailed analysis is conducted on the limited number of alternatives that represent viable approaches to remedial action after the screening stage. This analysis consists of an assessment of individual alternatives against each of nine evaluation criteria and a comparative analysis that focuses on the relative performance of each alternative against those criteria. In addition to these nine criteria, six additional site-specific criteria were established for the NPL Site, including OU6. These additional criteria are applied to provide consistency in design and construction practices within the NPL Site.

7.2 EVALUATION CRITERIA

The nine standard NCP criteria and the Additional Criteria are described below.

NCP Criteria:

1. *Overall protection of human health and the environment.*
   Alternatives shall be assessed to determine whether they can adequately protect human health and the environment, in both the short- and long-term, from unacceptable risks posed by hazardous substances, pollutants, or contaminants present at the site by eliminating, reducing, or controlling human and exposures.

2. *Compliance with ARARs.*
   The alternatives shall be assessed to determine whether they attain applicable or relevant and appropriate requirements under federal environmental laws and state environmental or facility siting laws or provide grounds for invoking waivers.

   There are no chemical-specific ARARs for OU6, as discussed in Section 5.0.

   The remedial alternatives are evaluated against the following potential action- and location-specific ARARs:

   Potential Action-Specific ARARs:
   - Clean Water Act Ambient Water Quality Criteria
   - Colorado Water Quality Control Act
   - RCRA Subtitle D and State Solid Waste Regs.
   - Solid Waste Closure
   - RCRA Subtitle C (including Hazardous Materials Transportation Act)
   - Land Disposal Restrictions
   - National Pollutant Discharge Elimination System (NPDES)
   - Colorado Mined Land Reclamation Act

- Colorado Air Quality Control
- Colorado Noise Abatement

Potential Location-Specific ARARs:
- Protection of Floodplains
- Clean Water Act Section 404 (including E.O. 11990 and 33 CFR 320-330)
- Fish and Wildlife Coordination Act
- Cultural Resource Requirements
- Solid Waste Disposal Site and Facilities Act

3. *Long-term effectiveness and permanence.*
   Alternatives shall be assessed for the long-term effectiveness and permanence they afford, along with the degree of certainty that the alternative will prove successful. Factors that shall be considered, where appropriate, include the following:

   - Magnitude of residual risk remaining from untreated waste or treatment residuals remaining at the conclusion of the remedial activities.

   - Adequacy and reliability of controls such as containment systems and institutional controls that are necessary to manage treatment residuals and untreated waste.

4. *Reduction of toxicity, mobility or volume through treatment.*
   Alternatives shall be assessed for the degree to which they employ recycling or treatment that reduces toxicity, mobility, or volume, including how treatment is used to address the principal threats posed by the site.

5. *Short-Term effectiveness.*
   The short-term impacts of alternatives shall be assessed considering the following:

   - Short-term risks that might be posed to the community during implementation of an alternative;

   - Potential impacts on workers during remedial action and the effectiveness and reliability of protective measures;

   - Potential environmental impacts of the remedial action and the effectiveness and reliability of mitigative measures during implementation; and

   - Time until protection is achieved.

6. *Implementability.*

   The ease or difficulty of implementing the alternatives shall be assessed by considering the following types of factors as appropriate:

   - Technical feasibility, including technical difficulties and unknowns associated with the construction and operation of a technology, the reliability of the technology, ease of undertaking additional remedial actions, and the ability to monitor the effectiveness of the remedy.

   - Administrative feasibility, including activities needed to be coordinate with other offices and agencies and the ability and time required to obtain any necessary approval and permits from other agencies (for off-site actions).

   - Availability of services and materials, including the availability of adequate off-site treatment, storage capacity, and disposal capacity and services; the availability of necessary equipment and specialists, and provisions to ensure any necessary additional resources; the availability of services and materials; and availability of prospective technologies.

7. *Cost*

   The types of costs that shall be assessed include the following:

   - Capital costs, including both direct and indirect costs;

   - Annual operations and maintenance costs; and

   - Net present value of capital and O&M costs.

EPA guidance (EPA, 2000) requires the use of a 7% discount factor when calculating net present value of capital, operation and maintenance costs for all non-Federal Facilities. However, EPA also suggests using current discount rates published by the Office of Management and Budget (OMB) for Federal Facility Sites. The OMB recommends a discount rate of 3.9% for projects with durations exceeding 30-years. This lower discount rate (reflecting real interest rates on treasury notes and bonds) would result in a significantly higher present worth cost for alternatives with relatively higher, long-term operational costs. However, OU6 is not a federal facility and so the 7% discount rate is used.

8. *State acceptance.*

   Assessment of state concerns may not be completed until comments on the FFS are received but may be discussed to the extent possible, in the proposed plan issued for public comment. The state concerns that shall be assessed include the following:

- The state's position and key concerns related to the preferred alternative and other alternatives; and
- State comments on ARARs or the proposed use of waivers.
- Assurance from the State of Colorado for remedy implementation and O&M cost share contribution.

9. *Community acceptance.*
This assessment includes determining which components of the alternatives interested persons in the community, including local elected officials, support, have reservations about, or oppose. This assessment may not be completed until comments on the proposed plan are received.

Additional Criteria:
Additional Criteria are based on a Draft Work Area Management Plan (Plan) prepared by USEPA in 1995. The Plan identifies criteria to be used to evaluate the effectiveness of remedial alternatives developed in an FS. These criteria are included in this FFS to ensure consistency in remedial design and construction at all operable units as described in the 1994 Consent Decree. The description of the criteria follows EPA, 1995.

1. *Surface Erosion Stability.*
Remedial alternatives for source material shall be assessed for surface erosion stability. Erosion stability would be achieved through the development of surface configurations and implementation of erosion protection measures. Predictions of erosion stability and erosion protective measures include:

    a) Erosional releases of Waste Material will be predicted by use of all or some of the following procedures: the Revised Universal Soils Loss Equation (RUSLE), wind erosion soil loss equation and the procedures set forth in the U.S. Nuclear Regulatory Commission's Staff Technical Position on the Design of Erosion Protection Cover For Stabilization of Uranium Mill Tailings Sites for site specific storm flow condition set forth in l.b. below or other standard recognized engineering methods.

    b) Remediated surfaces located within the 500-year floodplain will be stable under 500-year, 24-hour and 2-hour storm events. Remediated surfaces located outside the 500 year floodplain will be stable under 100-year, 24-hour and 2-hour storm events. On source area embankments or where the slope of the reconstructed source is steeper that 5:1, surface flow will be concentrated by a factor of 3 for purposes of evaluating erosion stability.

2. *Slope Stability.*
   Source remediation alternatives will be assessed for geotechnical stability. Geotechnical stability will be ensured through the development of embankments or slope contours. The remedial design shall meet the following:

   a) Impounding embankments shall be designed with a Factor of Safety (Safety Factor) of 1.5 for static conditions and 1.0 for pseudo-static conditions.

   b) Recontoured slopes shall be designed with a Safety Factor of 1.5 for static conditions and 1.0 for pseudo-static conditions.

   c) Analysis of geotechnical stability shall be performed using an acceptable model. Material and geometry input parameters would be obtained from available data.

3. *Flow Capacity and Stability.*
   Remedial alternatives will be assessed for conformance with flow capacity and stability requirements. The remedial design shall meet the following criteria:

   a) Capacity: Diversion ditches shall be sized to convey the 100-year, 24-hour and 2-hour storm events. Reconstructed stream channels shall be sized to convey flow equal to or greater than the flow capacity immediately upstream of the reconstruction.

   b) Stability: Erosional releases of Waste Material from ditches, stream channels, or retaining structures as determined by all or some of the following models and engineering methods: U.S. Army Corps of Engineers Hydrologic Engineering Center HEC-1 and HEC-2 models or by other recognized engineering erosional models.

      1. Diversion Ditches and Reconstructed Stream Channels: Remedial construction located within the 500-year floodplain shall be designed to be stable under flows resulting from a 500-year, 24-hour and 2-hour storm events. Remedial construction outside of the 500-year floodplain shall be designed to withstand flows resulting from 100-year, 24-hour and 2-hour storm events. Reconstructed stream channels shall be configured to the extent practicable to replicate naturally occurring channel patterns.

      2. Retaining structures: Structures such as gabions, earth dikes, or riprap shall be designed to be stable under the conditions stated above item 3.b.1 for the diversion ditch or stream channel with

which the structure is associated. If riprap is to be placed in stream channels or ditches, the riprap will be sized utilizing one of the following methods:

- U.S. Army Corps of Engineers
- Safety Factor Method
- Stephenson Method
- Abt/CSU Method

Selection of one of these methods will be based on the site specific flow and slope conditions encountered.

4. *Surface Water and Groundwater Loading Reduction.*
Remedial alternatives will be assessed to for reduction of mass loading of Contaminants of Concern (COCs), including Total Suspended Solids (TSS) and sulfate, as defined in the Aquatic Ecosystem Risk Assessment, and change in pH, resulting from run-on, runoff and infiltration from source areas. The FFS shall incorporate the following:

   - For each source of contamination evaluated in the FFS, the present mass loading of COCs (including TSS and sulfate) and present pH measurements shall be calculated for both surface water and ground water using scientifically accepted methods.

   - For each source of contamination evaluated in the FFS, the net loading reduction of COCs (including TSS and sulfate) and change in pH resulting from implementation of each remedial alternative shall be calculated for surface water and groundwater. Scientifically accepted methods for calculating mass loading shall be used.

5. *Terrestrial Ecosystem Exposure.*
Remedial alternatives will be assessed with respect to reduction of risk to the terrestrial ecosystem within OU6. This assessment shall be based on area-wide estimations of risk to receptor populations. Exposure estimations for assessing this risk should consider factors that affect frequency and duration of contact with contaminated media, such as (1) the concentrations and areal extent of contamination; and, (2) the effect of home range on the amount of time a given species will spend in contact with contaminated media. For each source of contamination evaluated in the FFS, the reduction of the potential exposure predicted to result from the implementations of each RA alternative will be compared to the present potential exposure predicted by the Terrestrial Risk Assessment as follows:

   a) For each source of contamination evaluated in the FFS, the present risk due to exposure as defined in the Terrestrial Ecosystem Risk Assessment shall be calculated for soil, each source of contamination, and ponded surface water associated with each source of contamination.

b) For each source of contamination evaluated in the FFS, reduction of exposure and ecological risk resulting from implementation of each RA alternative shall be calculated for soil and other media described above. The potential exposure predicted to result from implementation of each RA alternative would be compared to the present potential baseline exposure predicted by the Terrestrial Ecosystem Risk Assessment.

6. *Non-residential Soils.*
Non-residential areas will be addressed in the FFS. These nonresidential soils are in areas zoned agricultural/forest, and industrial mining. The nonresidential areas within OU6 will be evaluated in the ecological risk assessments and FFS consistent with current and likely future land use. Given existing zoning and land use development patterns, EPA expects that current agricultural/forest, and industrial/mining land uses will not change substantially.

7.3 DETAILED ANALYSIS OF REMEDIAL ALTERNATIVES

This section provides the detailed analysis of the retained remedial alternatives including:

- Alternative 1 - No Further Action
- Alternative 2 - Maintain Current Remedies (including five ARD conveyance, storage and treatment options)
- Alternative 4 - In-Situ Chemical Stabilization (in combination with Alternative 2)
- Alternative 5 - Consolidate and Cap
- Alternative 6 - Excavate, Transport and On-Site Disposal

Opportunities exist for the remedial alternatives described in this section to be used individually or in combination as well as for components of each remedy to be assembled into unique and new alternatives in order to provide an effective remedy. However, for the purposes of the FFS, only those alternatives retained after the screening step are evaluated here.

7.3.1 Alternative 1 - No Further Action

Description:
The no-action alternative leaves waste rock in OU6 in its current condition. Remedies previously implemented as Response Actions (see Section 4.0) would be abandoned as-is with no monitoring or maintenance. The current discharge of ARD to the LMDT (via the Marion Shaft) would be abandoned and the flows allowed to enter Stray Horse Gulch.

Analysis - EPA Criteria:
Overall Protection of Human Health and Environment - Over time, the surface water management remedies would deteriorate resulting in a gradual increase in the amount of ARD reaching Stray Horse and Evans Gulches. The single and multi-layered caps on mine wastes would likely maintain their integrity for decades if not centuries without maintenance. The lack of institutional controls restricting land uses may result in future land uses in areas where the levels of contaminants would present a health risk above a level of concern. This option would ultimately result in conditions that remain somewhat improved over conditions prior to Response Actions.

Compliance with ARARs - ARARs are discussed in Section 5.0. There are no chemical-specific ARARs. Since no-action would be taken under this alternative, action- and location-specific ARARs do not apply.

Long-Term Effectiveness - Components of prior Response Actions such as consolidated and capped mine waste are likely to maintain much of their integrity without maintenance. However, surface water management remedies would gradually deteriorate, particularly when discharge to the LMDT is abandoned. The absence of institutional controls may result in increased risks to human health.

Reduction in Toxicity, Mobility, and Volume through Treatment - Some reduction in mobility would be maintained through the existence of capped wastes.

Short-Term Effectiveness - The short-term effectiveness would remain unchanged under this alternative.

Implementability - Implementation of the No-Action alternative would require no effort.

Cost - There are no costs associated with the No-Action Alternative.

State Acceptance - State acceptance will be determined after the public comment period and proposed plan.

Community Acceptance - Community acceptance will be determined after the public comment period and proposed plan.

Analysis - Additional Criteria:
Surface Erosion Stability - The No-Action Alternative complies with this criterion.

Slope Stability - The No-Action Alternative complies with this criterion.

Flow Capacity and Stability - The No-Action Alternative complies with this criterion.

Surface and Ground Water Loading Reduction - Loading reductions to surface and groundwater are expected to approach 100% for mine waste piles that have been capped with a geomembrane and dolomite waste rock. Lesser reductions are expected for other mine wastes that have been capped with a simple soil cover.

Metal loading to surface and groundwater would increase over time as the low-permeability caps and ARD detention ponds deteriorated over time. Abandonment of the current discharge of ARD to the LMDT with flows returning to Stray Horse Gulch would cause an immediate increase in loading to surface water.

Terrestrial Ecosystem Exposure - The Ecological Risk Assessment (Weston, 1997) identified risks above a level of concern (Hazard Indices >1, see Table 2-5) for birds and mammals. This risk was fully mitigated where mine waste piles were capped with a geomembrane and dolomite waste rock. Some potential exposure remains for burrowing mammals where mine wastes have been capped with a simple soil cover. No mitigation has occurred where mine waste has been addressed through surface water management. In addition, the terrestrial risks may have increased through the ponding of ARD in retention ponds providing a potentially attractive setting for birds and mammals. Protective measures to minimize this threat may have to be considered.

Non-Residential Soils - As discussed in Section 2.6.1, average lead levels are generally well below the nominal action level of 16,000 mg/kg for areas where recreational scenarios are considered likely. The current and likely future land use in OU6 is recreational, although current land zoning is industrial. The lack of institutional controls under the No-Action Alternative may result in future changes in land use resulting in unacceptable human health risks.

7.3.2 Alternative 2 - Maintain Current Remedies

This alternative involves maintaining the existing remedies and the addition of institutional controls. Maintenance of capped waste materials will require periodic inspection, repair of erosional features and other minor repairs. Maintenance of the surface water management remedies will require periodic sediment removal from retention ponds and other catch basins and the conveyance, storage, and treatment of collected ARD. Alternative 2 includes five ARD conveyance, storage and treatment options, detailed below.

ARD considered under the conveyance/treatment options includes only that water currently being discharged to the Marion Shaft. Institutional controls on land use would be implemented as part of this remedy. These are administrative and local code restrictions to control human exposure to site contaminants. In the case of OU6, such controls would prohibit changes in land zoning.

Alternative 2 proposes to use current and anticipated available treatment capacity at existing water treatment plants. In addition, one option under Alternative 2 (2h) considers the construction of a dedicated water treatment facility. Available capacity at existing treatment plants cannot accommodate the peak flows or even moderate flows of ARD that would be collected under this alternative. Therefore, storage must be provided to permit the ARD to be metered out to the treatment facility at an allowable rate. For most conveyance/storage options, the storage takes the form of a lined impoundment. In two cases, underground mine workings are proposed for storage of collected ARD.

The sizing of ARD conveyance and storage facilities under this alternative is based on several factors:

- The total quantity of collected ARD in an average year.
- The expected peak flow.
- The available capacity at existing and proposed treatment facilities.

As described in Section 6.2, the total estimated ARD discharged to the Marion Shaft in 2001 is 9,600,000 gallons with an estimated peak flow of 550 gpm. The anticipated available capacity of the Yak and BOR Treatment Plants is not known with certainty. However, both plants are believed to have current excess capacity of at least 50 gpm of typical OU6 ARD (see Appendix B, Technical Memorandum 2). This quantity is the basis for sizing remedial designs involving the Yak and BOR facilities as summarized below.

- Impoundment capacity – 10,000,000 gallons
- Conveyance capacity – 1,000 gpm

The dedicated treatment plant considered under Alternative 2h would be sized to accommodate a peak flow of 700 gpm of typical OU6 ARD. This will permit a much smaller storage facility of 1,000,000 gallons for use as a flow equalization lagoon. The basis for sizing this impoundment is to provide at least a 24-hour retention time for collected ARD (assuming peak flows of no more than 700 gpm).

The actual impoundment, conveyance system and treatment plant sizing would be selected during the design phase if an option under Alternative 2 requiring storage conveyance and treatment is selected. Sizing would be based on a design volume and maximum flow rate such that an over-capacity situation leading to discharge of untreated ARD to surface water would occur at a specified probability for any given year. For the purposes of the FFS, sizing of equipment and storage facilities was based on the ability to accommodate ARD flows, quality and volume measured or estimated during the spring of 2001, at a minimum.

The FFS assumes that flows above 1,000 gpm would be permitted to discharge directly to Stray Horse Gulch without treatment. Flows that would cause the impoundment to overtop would also be diverted into Stray Horse Gulch without treatment.

Water treatment residuals (sludge) along with sediment periodically removed from existing retention ponds and sediment basins and proposed impoundments will be transported to an appropriate disposal facility. Sediment quantity is based on actual quantities removed during maintenance in 2001. A screening study for a Site-wide repository for treatment residuals and other wastes is currently underway. EPA will publish the results of this study during the fall of 2002 in a document entitled *Site-wide Repository Screening Report*. The reader is referred to this document for further information on potential repository locations and conceptual design. Although EPA considers the site-wide repository preferable to other disposal options, the absence of such a facility at this time requires this FFS to assume the following for costing purposes:

- Future disposal of Yak and BOR water treatment plant residuals is the same as current.
- Sediments will be disposed at Conservation Services Inc.'s industrial landfill in Bennett, Colorado.

Implementation of the site-wide repository option will not affect the relative ranking of remedial alternatives with respect to cost.

The detailed analysis is performed below for each of the five variations of Alternative 2.

7.3.2.1 *Alternative 2a - Pressurized Pipeline to Yak Tunnel w/Institutional Controls*

This alternative involves the construction of a lift station at the Greenback Pond to deliver ARD via a pressure line to a vertical bore advanced into the Yak Tunnel at a location up-stream the existing bulkhead. The subsurface mine workings would be used to store contaminated water that would be metered out and treated at the Yak treatment plant. The remedy would consist of the following elements.

- Pump station capable of delivering 1,000 gpm to the Yak Tunnel access borehole.
- Pump station equipment will be compatible with ARD chemistry.
- 4,277-feet of 12-inch, inside diameter (I.D.), PVC pipe buried below frost depth (including a pipe "pig" and launcher for pipeline maintenance)
- 600-feet of borehole to accommodate a 12-inch diameter stainless steel casing grouted in place to the top of the Yak Tunnel.
- Electric service to the pump station.
- ARD treatment at the Yak treatment plant.
- Periodic cleaning of retention ponds and sediment basins.
- Transport of water treatment residuals, and pond and sediment basin deposits to an appropriate disposal facility.
- Operation and maintenance of new and existing remedy components.
- Institutional controls via an overlay district for the NPL site.

The pipeline alignment and typical pipeline trench section is illustrated on Figures 6-1 and 7-1, respectively. Existing ARD retention ponds and sediment basins would be cleaned of sediment regularly, with spoils transported either to a future repository proximal to OU6 or to an existing disposal facility. For costing purposes, this alternative assumed disposal at an approved off-site facility.

Overall Protection of Human Health and Environment - This alternative would maintain the trends in water quality improvement in Stray Horse Gulch and Starr Ditch achieved in the 2001 runoff season (see Section 4.2.3). Institutional controls would minimize the likelihood of human health risk above a level of concern from exposure to non-residential soils and mine wastes.

Compliance with ARARs - ARARs are discussed in Section 5.0. There are no chemical-specific ARARs. The following summarizes the action- and location-specific ARARs for Alternative 2a.

Potential Action-Specific ARARs:

- Clean Water Act Ambient Water Quality Criteria, NPDES and Colorado Water Quality Control Act - These ARARs are met through the use of the existing discharge permit for the Yak water treatment plant (NPDES Equivalency Permit, under a unilateral administrative order) and implementation of an erosion control plan during remedial construction.

- RCRA Subtitle D, State Solid Waste Regs. and Solid Waste Closure - Pond sediment is considered a solid waste and will be disposed at an appropriate facility.

- RCRA Subtitle C and Land Disposal Restrictions - These regulations will be met under this alternative through appropriate disposal of water treatment plant sludges.

- Colorado Mined Land Reclamation Act - The substantive requirements of this regulation are evaluated under the "Additional Criteria" discussed below.

- Colorado Air Quality Control - No significant disturbance of mine waste is proposed under this alternative.

- Colorado Noise Abatement - No construction is proposed near populated areas under this Alternative.

- Environmental Covenants - It is expected this ARAR will be met through an exemption under CRS 25-15-320(3)(b) through a Site-wide Overlay District enacted as an enforceable ordinance by Lake County.

Potential Location-Specific ARARs:

- Protection of Floodplains - No new work is proposed near floodplains under this alternative.

- Clean Water Act Section 404 (including E.O. 11990) - No new work is proposed near wetlands under this alternative.

- Fish and Wildlife Coordination Act - Disturbance to wildlife would be minimal under this alternative.

- Cultural Resource Requirements - The Programmatic Agreement between EPA and the State Historic Preservation Office (SHPO) would be used to determine if this alternative would have an adverse impact to the identified cultural resources. If an adverse impact were identified, appropriate mitigation measures would be negotiated.

- Solid Waste Disposal Site and Facilities Act - These regulations do not apply to this alternative given no solid waste facility is proposed.

Long-Term Effectiveness – The continued collection and treatment of ARD coupled with the maintenance of low-permeability and physical barriers, sediment basins and retention ponds will maintain recent improvements in surface water quality. Some additional improvement in water quality would be expected in Stray Horse Gulch as the recently implemented Response Actions stabilize. In addition, the completion of the Phase V Response Action in Lincoln Gulch is expected to result in protection of the Leadville water supply during summer storm events.

The degree of certainty that the remedy will be successful is high given that the vast majority of this remedy is already implemented with proven results (See Section 4.2.3). Injecting ARD just up-stream of the Yak Tunnel bulkhead (Figure 7-2) will provide a high degree of confidence that all the injected ARD will reach the treatment plant. This remedy assumes the long-term stability of the Yak Tunnel and little adverse effects of seasonal rise in water levels within the tunnel during the introduction of ARD.

The Yak Plant is capable of effectively treating the ARD from OU6 (see Appendix B, Technical Memorandum 2). Routine plant maintenance and periodic replacement (20-year life) will be necessary to maintain the high degree of certainty regarding the success of the remedy. Many components of this remedy will have to be maintained in near-perpetuity in order to achieve permanence.

Institutional controls prohibiting changes in land use will minimize the likelihood of human health effects above a level of concern. The long-term effectiveness of IC's depends on the diligence of the enforcing agency. The county would enforce the overlay district currently contemplated for the entire Leadville area. EPA and the State would perform periodic reviews of the effectiveness of the IC's.

The essential components of IC's at OU6 would include the following elements and considerations:

- The vast majority of OU6 is zoned for industrial mining use. The actual current land use in OU6 is recreational. Risk Assessments performed to date suggest that the current conditions are protective for recreational use. Should industrial mining activities occur in OU6 in the future, the Mine Safety and Health Administration (MSHA) will regulate human exposure to site contaminants given that by its very nature, mining activities concentrate human exposure to ore materials. In the case of the Leadville mining district, the ore materials contain the contaminants of concern.

- The IC's will restrict changes in land use. However, a provision may be included to allow land use changes to individual parcels if parcel-specific site conditions indicate risks below a level of concern or if the parcel is remediated to reduce human health risks below a level of concern. This and other IC's would be finalized with Lake County upon completion of the OU9 residential overlay district and would cover all remediated property.

Reduction in Toxicity, Mobility, and Volume through Treatment – A large reduction in the mobility of COC's will be realized through the treatment of ARD. Treatment residuals, and pond and sediment basin deposits placed in an appropriate disposal facility would remain isolated from humans and the environment for the foreseeable future.

Maintenance of low-permeability caps on mine wastes would reduce the generation of ARD, and eliminate air and water erosion of mine wastes thereby reducing mobility of the wastes.

Short-Term Effectiveness – No significant disturbance of mine wastes would occur under this alternative. Therefore, the short-term effectiveness is considered to be high.

Implementability – The components of this remedy that do not include ARD treatment are easily implementable presuming that easements may be acquired for the proposed pipeline. The required construction materials are readily available and routine construction techniques would be employed. Institutional controls are implementable through an overlay district currently contemplated for the entire Leadville area.

EPA does not own the Yak treatment plant and an agreement would need to be reached with the owner/operator of this facility prior to remedy implementation. In addition, the impacts of rising water levels in the Black Cloud Mine on the Yak Tunnel mine pools would have to be assessed before implementation of this alternative.

Cost – This remedy will require operation over many decades, if not centuries. Therefore, the period of performance is set at 100-years. The present worth cost for implementation of this remedy is $12,589,648 (based on a 7 percent discount rate). Detailed costing is provided in Appendix C.

State Acceptance – See Section 7.3.1

Community Acceptance – See Section 7.3.1

<u>Analysis - Additional Criteria:</u>
Surface Erosion Stability – No remedial construction involving mine waste is contemplated under this alternative.

Slope Stability - No remedial construction involving mine waste is contemplated under this alternative. Slope stability of existing consolidated and capped mine waste piles will be monitored through the placement of survey monuments on the Maid of Erin, Mahala and Wolftone piles. Long-term monitoring of settlement rates will be used to evaluate the need for corrective action, if any. Details of the monitoring program will be set-out in an Operation and Maintenance Plan for the selected remedy for OU6. The costs associated with monitoring and potential mitigation are not considered in this FFS.

Flow Capacity and Stability – The only water conveyance proposed under this alternative is a pipeline. This criterion does not apply to pipelines. Existing ARD collection and conveyance channels and other structures meet this criterion.
Surface and Ground Water Loading Reduction – Loading reductions to surface and groundwater are expected to approach 100% for mine waste piles that have been capped with a geomembrane and dolomite waste rock. Lesser reductions are expected for other mine wastes that have been capped with a simple soil cover. Mine wastes subjected to surface water management remedies are expected to contribute decreased metal loads to surface water as evidenced by the reduction in zinc loading at monitoring points (SHG-09A and SD-3) in the spring of 2001 (see Section 4.2.3). However, it is possible that loading to groundwater will be increased over the pre-remedial condition as a result of infiltration of impounded ARD in retention ponds. Groundwater will require continued monitoring to assure that there is no serious impact.

Piezometers were installed adjacent to the retention ponds at the time of construction. Boring logs for these piezometers indicate high clay content soils either immediately under the ponds or occurring between the bottom of the pond and the water table. Table 7-1 summarizes the lithologies encountered in the soil borings for each piezometer. Many piezometers were dry at the time of construction, as can be seen on Table 7-1. Further, the construction completion reports indicate many of the ponds were excavated in clay material. The presence of naturally occurring clay soils underlying the ponds coupled with dry conditions in many piezometers suggests that infiltration of ponded water is not great.

The proposed introduction of ARD into the Yak Tunnel raises the possibility of an increase in loading to groundwater should any of the introduced ARD escape from the tunnel. However, this is unlikely given the access borehole is proposed just up-stream of a bulkhead used to meter flow out of the tunnel. A monitoring well network currently exists around the Yak Tunnel allowing monitoring of effects of the additional water in the mine pool.

Terrestrial Ecosystem Exposure – See Section 7.3.1

Non-Residential Soils – As discussed in Section 2.6.1, average lead levels are generally well below the nominal action level of 16,000 mg/kg for areas where recreational scenarios are considered likely. The current and likely future land use in OU6 is recreational, although current land zoning is Industrial Mining. Implementation of institutional controls will minimize the likelihood of unacceptable health risks from residential or other prohibited land uses. Such IC's could require assessment and mitigation of site conditions on a parcel-by-parcel basis; if appropriate. This and other IC's would be finalized with Lake County upon completion of the OU9 residential overlay district and would cover all remediated property.

7.3.2.2 Alternative 2b - Gravity Pipeline to Yak Treatment Plant Surge Pond with Storage w/Institutional Controls

This alternative is identical to Alternative 2a except that ARD will be conveyed via a gravity pipeline to the Yak treatment plant surge pond. A 10-million gallon lined impoundment will be placed along the pipeline alignment to allow collected ARD to be metered out to the Yak surge pond. OU6 ARD chemistry is sufficiently different from water typically treated by the Yak treatment plant that discharging OU6 ARD directly to the Yak surge pond was deemed undesirable.

The pipeline alignment and one possible location for the impoundment is illustrated on Figure 6-2. A typical pipeline trench cross-section and impoundment layout is illustrated in Figure 7-1 and 7-2, respectively. The remedy would consist of the following elements:

- 7,128-feet of 12-inch I.D., PVC pipe buried below frost depth (including a pipe "pig" and launcher for pipeline maintenance)
- 10,000,000-gallon lined impoundment w/inlet and outlet structures..
- ARD treatment at the Yak treatment plant.
- Periodic cleaning of retention ponds and sediment basins.
- Transport of water treatment residuals, and pond and sediment basin deposits to an appropriate disposal facility.
- Operation and maintenance of new and existing remedy components.
- Institutional controls via an overlay district for the NPL site.

Overall Protection of Human Health and Environment – See Section 7.3.2.1

Compliance with ARARs - ARARs are discussed in Section 5.0. There are no chemical-specific ARARs. The following summarizes the action- and location-specific ARARs for this Alternative.

Potential Action-Specific ARARs:

- Clean Water Act Ambient Water Quality Criteria, NPDES and Colorado Water Quality Control Act - These ARARs are met through the use of the existing discharge permit for the Yak water treatment plant and implementation of an erosion control plan during remedial construction.

- RCRA Subtitle D, State Solid Waste Regs. and Solid Waste Closure - Pond sediment is considered a solid waste and will be disposed at an appropriate facility.

- RCRA Subtitle C and Land Disposal Restrictions - These regulations will be met under this alternative through appropriate disposal of water treatment plant sludges.

- Colorado Mined Land Reclamation Act - The substantive requirements of this regulation are evaluated under the "Additional Criteria" discussed below.

- Colorado Air Quality Control - No significant disturbance of mine waste is proposed under this alternative.

- Colorado Noise Abatement - Construction near populated areas would be performed in compliance with the requirements of this regulation.

- Environmental Covenants - It is expected this ARAR will be met through an exemption under CRS 25-15-320(3)(b) through a Site-wide Overlay District enacted as an enforceable ordinance by Lake County.

Potential Location-Specific ARARs:

- Protection of Floodplains - No new work is proposed near floodplains under this alternative.

- Clean Water Act Section 404 (including E.O. 11990) - No new work is proposed near wetlands under this alternative.

- Fish and Wildlife Coordination Act - Disturbance to wildlife would be minimal under this alternative. Coordination with United States Fish and Wildlife (USFW) and Colorado Department of Natural Resources (CDNR) may be prompted by the inclusion of an impoundment under this alternative.

- Cultural Resource Requirements - The Programmatic Agreement between EPA and SHPO would be used to determine if this alternative would have an adverse impact to the identified cultural resources. If an adverse impact were identified, appropriate mitigation measures would be negotiated.

- Solid Waste Disposal Site and Facilities Act - These regulations do not apply to this alternative given no solid waste facility is proposed.

Long-Term Effectiveness – The continued collection and treatment of ARD coupled with the maintenance of low-permeability and physical barriers, sediment basins and retention ponds will maintain recent improvements in surface water quality. Some additional improvement in water quality would be expected in Stray Horse Gulch as the recently implemented response actions stabilize. In addition, the completion of the Phase V Response Action in Lincoln Gulch is expected to result in protection of the Leadville water supply.

The degree of certainty that the remedy will be successful is high given that the vast majority of this remedy is already implemented with proven results (See Section 4.2.3). Delivering ARD to the Yak treatment plant with interim storage in a lined impoundment increases the likelihood that ARD will reach the treatment plant, as compared with Alternative 2a.

The Yak treatment plant is capable of effectively treating the ARD from OU6 (see Appendix B, Technical Memorandum 2). Routine plant maintenance and periodic replacement (20-year life) will be necessary to maintain the high degree of certainty regarding the success of the remedy. Many components of this remedy will have to be maintained in near-perpetuity in order to achieve permanence.

Institutional controls prohibiting changes in land use will minimize the likelihood of human health effects above a level of concern. The long-term effectiveness of IC's. depends on the diligence of the enforcing agency. The county would enforce the overlay district currently contemplated for the entire Leadville area. EPA and the State would perform periodic reviews of the effectiveness of the IC's.

The essential components of IC's at OU6 would include the following elements and considerations:

- The vast majority of OU6 is zoned for industrial mining use. The actual current land use in OU6 is recreational. Risk Assessments performed to date suggest that the current conditions are protective for recreational use. Should industrial mining activities occur in OU6 in the future, the Mine Safety and Health Administration (MSHA) will regulate human exposure to site contaminants given that by its very nature, mining activities concentrate human exposure to ore materials. In the case of the Leadville mining district, the ore materials contain the contaminants of concern.

- The IC's will restrict changes in land use. However, a provision may be included to allow land use changes to individual parcels if a parcel-specific risk assessment indicated risks below a level of concern or if the parcel is remediated to reduce human health risks below a level of concern.

Reduction in Toxicity, Mobility, and Volume through Treatment – See Section 7.3.2.1

Short-Term Effectiveness – See Section 7.3.2.1

Implementability – See Section 7.3.2.1

Cost – This remedy will require operation over many decades, if not centuries. Therefore, the period of performance is set at 100-years. The present worth cost for implementation of this remedy is $14,316,642 (based on a 7 percent discount rate). Detailed costing is provided in Appendix C.

State Acceptance – See Section 7.3.1

Community Acceptance – See Section 7.3.1

Analysis - Additional Criteria:
Surface Erosion Stability – See Section 7.3.2.1

Slope Stability – See Section 7.3.2.1

Flow Capacity and Stability – See Section 7.3.2.1

Surface and Ground Water Loading Reduction – Loading reductions to surface and groundwater are expected to approach 100% for mine waste piles that have been capped with a geomembrane and dolomite waste rock. Lesser reductions are expected for other mine wastes that have been capped with a simple soil cover. Mine wastes subjected to surface water management remedies are expected to contribute decreased metal loads to surface water as evidenced by the reduction in zinc and cadmium loading at monitoring points (SHG-09A and SD-3) in the spring of 2001 (see Section 4.2.3). However, it is possible that loading to groundwater will be increased over the pre-remedial condition as a result of infiltration of impounded ARD in detention ponds. Groundwater will require continued monitoring to assure that there is no serious impact.

Piezometers were installed adjacent to the retention ponds at the time of construction. Boring logs for these piezometers indicate high clay content soils either immediately under the ponds or occurring between the bottom of the pond and the water table. Table 7-1 summarizes the lithologies encountered in the soil borings for each piezometer. Many piezometers were dry at the time of construction, as can be seen on Table 7-1. Further, the construction completion reports indicate many of the ponds were excavated in clay material. The presence of naturally occurring clay soils underlying the ponds coupled with dry conditions in many piezometers suggests that infiltration of ponded water is not great.

Terrestrial Ecosystem Exposure – The Ecological Risk Assessment (Weston, 1997) identified risks above a level of concern (Hazard Indices >1, see Table 2-5). This risk was fully mitigated where mine waste piles were capped with a geomembrane and dolomite waste rock. Some potential exposure remains for burrowing mammals where mine wastes have been capped with a simple soil cover. No mitigation has occurred where mine waste has been addressed through surface water management. In addition, the terrestrial risks may have increased through the ponding of ARD providing a potentially attractive setting for birds and mammals. This may also be of concern for the proposed ARD impoundment. Protective measures to minimize this threat may have to be considered.

Non-Residential Soils - See Section 7.3.2.1

7.3.2.3 Alternative 2e - Gravity Pipeline to Existing Extraction Well along LMDT with Storage w/Institutional Controls

This alternative involves delivering ARD via a gravity pipeline to the existing extraction well along the lower portion of the LMDT. The existing pipeline between the extraction well and the BOR Treatment Plant would be used to convey OU6 ARD to the BOR's plant. A 10 million gallon lined impoundment would be constructed along the pipeline alignment to allow ARD to be metered out to the BOR Plant.

The pipeline alignment, location of existing LMDT extraction well, and one possible location for the impoundment is illustrated on Figure 6-5. A typical pipeline trench cross-section and impoundment layout is illustrated in Figure 7-1 and 7-2, respectively. The remedy would consist of the following elements:

- 9,821-feet of 12-inch I.D., PVC pipe buried below frost depth (including a pipe "pig" and launcher for pipeline maintenance)
- 10,000,000-gallon lined impoundment w/inlet and outlet structures.
- ARD treatment at the BOR's plant.
- Periodic cleaning of retention ponds and sediment basins.
- Transport of water treatment residuals, and pond and sediment basin deposits to an appropriate disposal facility.
- Operation and maintenance of new and existing remedy components.
- Institutional controls via an overlay district for the NPL site.

Overall Protection of Human Health and Environment – See Section 7.3.2.1

Compliance with ARARs - ARARs are discussed in Section 5.0. There are no chemical-specific ARARs. The following summarizes the action- and location-specific ARARs for this Alternative.

Potential Action-Specific ARARs:

- Clean Water Act Ambient Water Quality Criteria, NPDES and Colorado Water Quality Control Act - These ARARs are met through the use of the existing discharge permit for the BOR water treatment plant and implementation of an erosion control plan during remedial construction.

- RCRA Subtitle D and State Solid Waste Regs. and Solid Waste Closure - Pond sediment is considered a solid waste and will be disposed at an appropriate facility.

- RCRA Subtitle C and Land Disposal Restrictions - These ARARs will be met under this alternative through appropriate disposal of water treatment plant sludges.

- Colorado Mined Land Reclamation Act - The substantive requirements of this regulation are evaluated under the "Additional Criteria" discussed below.

- Colorado Air Quality Control - No significant disturbance of mine waste is proposed under this alternative.

- Colorado Noise Abatement - Construction near populated areas would be performed in compliance with the requirements of this regulation.

- Environmental Covenants - It is expected this ARAR will be met through an exemption under CRS 25-15-320(3)(b) through a Site-wide Overlay District enacted as an enforceable ordinance by Lake County.

Potential Location-Specific ARARs:

- Protection of Floodplains - No new work is proposed near floodplains under this alternative.

- Clean Water Act Section 404 (including E.O. 11990) - No new work is proposed near wetlands under this alternative.

- Fish and Wildlife Coordination Act - Disturbance to wildlife would be minimal under this alternative. Coordination with USFW and CDNR may be prompted by the inclusion of an impoundment under this alternative.

- Cultural Resource Requirements - The Programmatic Agreement between EPA and SHPO would be used to determine if this alternative would have an adverse impact to the identified cultural resources. If an adverse impact were identified, appropriate mitigation measures would be negotiated.

- Solid Waste Disposal Site and Facilities Act - These regulations do not apply to this alternative given no solid waste facility is proposed.

Long-Term Effectiveness – The continued collection and treatment of ARD coupled with the maintenance of low-permeability and physical barriers, sediment basins, and detention ponds will maintain recent improvements in surface water quality. Some additional improvement in water quality would be expected in Stray Horse Gulch as the recently implemented response actions stabilize. In addition, the completion of the Phase V Response Action in Lincoln Gulch is expected to result in protection of the Leadville water supply during summer storm events.

The degree of certainty that the remedy will be successful is high given that the vast majority of this remedy is already implemented with proven results (see Section 4.2.3). Delivering ARD to the BOR's plant with interim storage in a lined impoundment increases the likelihood that ARD will reach the treatment plant, as compared with Alternative 2a (introduction into Yak Tunnel).

The BOR's plant is capable of effectively treating the ARD from OU6 (see Appendix B, Technical Memorandum 2). Routine plant maintenance and periodic replacement (20-

year life) will be necessary to maintain the high degree of certainty regarding the success of the remedy. Many components of this remedy will have to be maintained in near-perpetuity in order to achieve permanence.

Institutional controls prohibiting changes in land use will preclude human health effects above a level of concern. The long-term effectiveness of IC's depends on the diligence of the enforcing agency. The county would enforce the overlay district currently contemplated for the entire Leadville area. EPA and the State would perform periodic reviews of the effectiveness of the IC's.

The essential components of IC's at OU6 would include the following elements and considerations:

- The vast majority of OU6 is zoned for industrial mining use. The actual current land use in OU6 is recreational. Risk Assessments performed to date suggest that the current conditions are protective for recreational use. Should industrial mining activities occur in OU6 in the future, the Mine Safety and Health Administration (MSHA) will regulate human exposure to site contaminants given that by its very nature, mining activities concentrate human exposure to ore materials. In the case of the Leadville mining district, the ore materials contain the contaminants of concern.

- The IC's will restrict changes in land use. However, a provision may be included to allow land use changes to individual parcels if a parcel-specific risk assessment indicated risks below a level of concern or if the parcel is remediated to reduce human health risks below a level of concern.

Reduction in Toxicity, Mobility, and Volume through Treatment – See Section 7.3.2.1

Short-Term Effectiveness – See Section 7.3.2.1

Implementability – The components of this remedy that do not include the actual ARD treatment are easily implementable presuming that easements may be acquired for the proposed pipeline. The required construction materials are readily available and routine construction techniques would be employed. Institutional controls are implementable through an overlay district currently contemplated for the entire Leadville area.

However, EPA does not own the BOR's treatment plant not is it understood what, if any, upgrades at this plant would be needed in order to implement the remedy. Long-term agreements would have to be reached between EPA, the State of Colorado, and BOR on O&M and facility improvements. EPA is also not responsible for monitoring and maintenance of the LMDT.

Cost – This remedy will require operation over many decades, if not centuries. Therefore, the period of performance is set at 100-years. The present worth cost for implementation of this remedy is $10,177,751. The present worth of implementing this remedy over 100-years is based on a 7 percent discount rate. The construction cost of the BOR's plant is not available for use in calculating the periodic replacement costs for this facility. Therefore, the actual construction cost of the Yak water treatment plant is used for developing a cost estimate for this alternative. Detailed costing is provided in Appendix C.

State Acceptance – See Section 7.3.1

Community Acceptance – See Section 7.3.1

Analysis - Additional Criteria:
Surface Erosion Stability – See Section 7.3.2.1

Slope Stability – See Section 7.3.2.1

Flow Capacity and Stability – See Section 7.3.2.1

Surface and Ground Water Loading Reduction – See Section 7.3.2.2

Terrestrial Ecosystem Exposure – See Section 7.3.2.2

Non-Residential Soils - See Section 7.3.2.1

7.3.2.4 Alternative 2g - Plug LMDT and Dewater Mine Pool with Gravity Pipeline to BOR Treatment Plant w/Institutional Controls

This alternative involves continuing the introduction of ARD into the Marion Shaft. A plug would be constructed in the LMDT where it passes through competent rock. The resulting impounded groundwater (mine pool) would be pumped from a location above the concrete plug and delivered to the BOR treatment plant via a gravity pipeline. Groundwater entering the LMDT below the plug would ultimately be allowed to exit the tunnel portal and flow downstream without treatment. EPA anticipates that the water quality would improve over time to a level complying with discharge permits. Water treatment would be required until the water quality reached the level required by discharge permits.
The estimated volume of water in the mine pool above the elevation of the LMDT is 750 million gallons (see Appendix B, Technical Memorandum 2). A pumping rate of 3,000 gpm was estimated in order to dewater the mine pool in less than two years to the elevation of the LMDT (see Appendix B, Technical Memorandum 2). After dewatering the mine pool, an equilibrium-pumping rate would be maintained in perpetuity.

The BOR plant does not have the capacity to treat water at an initial pumping rate of 3,000 gpm. Significant plant upgrades would be needed in order for this alternative to be selected. The type of plant upgrades depends not only on the pumping rate but also on the quality of the water in the mine pool. At the present time the mine pool water chemistry is not fully characterized.

As an alternative, the mine pool may be dewatered at a much lower pumping rate for a longer period of time. In either case, an equilibrium-pumping rate will have to be maintained.in perpetuity. It is not known whether the current BOR plant capacity is adequate to dewater the mine pool in any reasonable period of time as the water quality is not fully characterized.

For costing purposes, the quantity of mine pool water treated annually is based on the current estimated minimum excess capacity of 50 gpm (see Section 7.3.2). It is assumed that a minimum of 50 gpm of mine pool water would be delivered to the BOR treatment plant continuously throughout the year. However, pumping and conveyance equipment proposed under this alternative is sized for a maximum pumping rate of 3,000 gpm. The mine pool water would need to be more thoroughly characterized before this alternative could be selected.

The pipeline alignment and locations of the proposed plug in the LMDT and extraction well are shown on Figure 6-6. A typical pipeline trench cross-section is illustrated in Figure 7-1. A technical and cost proposal for plugging the LMDT was solicited from TSS Tunnel & Shaft Sealing Ltd. by the BOR (Appendix D). The proposal was used to develop and cost portions of Alternative 2g. The remedy would consist of the following elements:

- 375-feet of 2.4 meter diameter vertical shaft.
- Concrete plug in LMDT.
- Pump system capable of delivering 3,000 gpm.
- 7,287- feet of 18-inch I.D., PVC pipe buried below frost depth (including a pipe "pig" and launcher for pipeline maintenance)
- ARD treatment at the BOR's plant.
- Periodic cleaning of retention ponds and sediment basins.
- Transport of water treatment residuals, and pond and sediment basin deposits to an appropriate disposal facility.
- Operation and maintenance of new and existing remedy components.
- Institutional controls via an overlay district for the NPL site.

Overall Protection of Human Health and Environment – This alternative would maintain the improvement in water quality in Stray Horse Gulch and Starr Ditch achieved during the 2001 runoff season (see Section 4.2.3). By dewatering the mine pool, a reduction in bedrock water table would be expected potentially reducing the number of springs in the area discharging contaminated groundwater.
Institutional controls would minimize the likelihood of human health risk above a level of concern from exposure to non-residential soils and mine wastes.

Compliance with ARARs - ARARs are discussed in Section 5.0. There are no chemical-specific ARARs. The following summarizes the action- and location-specific ARARs for this Alternative.

Potential Action-Specific ARARs:

- Clean Water Act Ambient Water Quality Criteria, NPDES and Colorado Water Quality Control Act - These ARARs are met through the use of the existing discharge permit for the BOR water treatment plant and implementation of an erosion control plan during remedial construction.

- RCRA Subtitle D and State Solid Waste Regs. and Solid Waste Closure - Pond sediment is considered a solid waste and will be disposed at an appropriate facility.

- RCRA Subtitle C and Land Disposal Restrictions - These ARARs will be met under this alternative through appropriate disposal of water treatment plant sludges.

- Colorado Mined Land Reclamation Act - The substantive requirements of this regulation are evaluated under the "Additional Criteria" discussed below.

- Colorado Air Quality Control - No significant disturbance of mine waste is proposed under this alternative.

- Colorado Noise Abatement - Construction near populated areas would be performed in compliance with the requirements of this regulation.

- Environmental Covenants - It is expected this ARAR will be met through an exemption under CRS 25-15-320(3)(b) through a Site-wide Overlay District enacted as an enforceable ordinance by Lake County.

Potential Location-Specific ARARs:

- Protection of Floodplains - No new work is proposed near floodplains under this alternative.

- Clean Water Act Section 404 (including E.O. 11990) - No new work is proposed near wetlands under this alternative.

- Fish and Wildlife Coordination Act - Disturbance to wildlife would be minimal under this alternative.

- Cultural Resource Requirements - The Programmatic Agreement between EPA and SHPO would be used to determine if this alternative would have an adverse impact to the identified cultural resources. If an adverse impact were identified, appropriate mitigation measures would be negotiated.

- Solid Waste Disposal Site and Facilities Act - These regulations do not apply to this alternative given no solid waste facility is proposed.

Long-Term Effectiveness – The continued collection and treatment of ARD coupled with the maintenance of low-permeability and physical barriers, sediment basins and detention ponds will maintain recent improvements in surface water quality. Some additional improvement in water quality would be expected in Stray Horse Gulch as the recently implemented response actions stabilize. In addition, the completion of the Phase V Response Action in Lincoln Gulch is expected to result in protection of the Leadville water supply during summer storm events.

Impounding water behind an engineered plug in the LMDT coupled with the introduction of ARD into the Marion Shaft raises the possibility that some injected ARD may escape into the regional bedrock aquifer. However, the high pumping rate option contemplated under this alternative would likely generate a large hydraulic capture area minimizing the risk of fugitive ARD.

The construction of a permanent plug in the LMDT creates uncertainty regarding the effect on the local and regional hydrogeology should pumping from the mine pool be discontinued in the future. It is likely that the water level would rise above its present level seeking discharge points to currently unsaturated fractured geology and/or surface water.

The ability of the BOR's plant to effectively treat mine pool water at a pumping rate above 50 gpm is unclear due to uncertainty regarding mine pool water quality. It is likely that significant plant upgrades would be required in the short-term with routine plant maintenance and periodic replacement (20-year life) necessary for the long-term to ensure a high degree of certainty in the success of the remedy. Many components of this remedy will have to be maintained in near-perpetuity in order to achieve permanence.

Institutional controls prohibiting changes in land use will minimize the likelihood of human health effects above a level of concern. The long-term effectiveness of IC's depends on the diligence of the enforcing agency. The county would enforce the overlay district currently contemplated for the entire Leadville area. EPA and the State would perform periodic reviews of the effectiveness of the IC's.

The essential components of IC's at OU6 would include the following elements and considerations:

- The vast majority of OU6 is zoned for industrial mining use. The actual current land use in OU6 is recreational. Risk Assessments performed to date suggest that the current conditions are protective for recreational use. Should industrial mining activities occur in OU6 in the future, the Mine Safety and Health Administration (MSHA) will regulate human exposure to site contaminants given that by its very nature, mining activities concentrate human exposure to ore materials. In the case of the Leadville mining district, the ore materials contain the contaminants of concern.

- The IC's will restrict changes in land use. However, a provision may be included to allow land use changes to individual parcels if a parcel-specific risk assessment indicated risks below a level of concern or if the parcel is remediated to reduce human health risks below a level of concern.

Reduction in Toxicity, Mobility, and Volume through Treatment – See Section 7.3.2.1

Short-Term Effectiveness – See Section 7.3.2.1

Implementability – A technical and cost proposal for construction of an engineered plug was solicited from TSS Tunnel & Shaft Sealing Ltd on March 30, 2000 (Appendix D). Based on the proposal, plugging of the LMDT is considered to be implementable. The required pumps and pipelines are easily constructed presuming that easements may be secured for the proposed pipeline. The required construction materials are readily available and routine construction techniques would be employed.

However, the EPA does not own the BOR's treatment plant nor is it understood what, if any, upgrades to this plant would be needed in order to implement the remedy. Long-term agreements would have to be reached between EPA, the State of Colorado, and BOR on O&M and facility improvements. EPA is also not responsible for monitoring and maintenance of the LMDT.

Institutional controls are implementable through an overlay district currently contemplated for the entire Leadville area.

Cost – This remedy will require operation over many decades, if not centuries. Therefore, the period of performance is set at 100-years. The present worth cost for implementation of this remedy is $13,706,195. The present worth of implementing this remedy over 100-yeasr is based on a 7 percent discount rate. The construction cost of the BOR's plant is not available for use in calculating the periodic replacement costs for this facility. Therefore, the actual construction cost of the Yak water treatment plant is used for developing a cost estimate for this alternative. Detailed costing is provided in Appendix C.

State Acceptance – See Section 7.3.1

Community Acceptance – See Section 7.3.1

Analysis - Additional Criteria:
Surface Erosion Stability – See Section 7.3.2.1

Slope Stability – See Section 7.3.2.1

Flow Capacity and Stability – See Section 7.3.2.1

Surface and Ground Water Loading Reduction – Loading reductions to surface and groundwater are expected to approach 100% for mine waste piles that have been capped with a geomembrane and dolomite waste rock. Lesser reductions are expected for other mine wastes that have been capped with a simple soil cover. Mine wastes subjected to surface water management remedies are expected to contribute decreased metal loads to surface water as evidenced by the reduction in zinc and cadmium loading at monitoring points (SHG-09A and SD-3) in the spring of 2001 (Section 4.2.3). However, it is possible that loading to groundwater will be increased over the pre-remedial condition as a result of infiltration of impounded ARD in retention ponds. Groundwater will require continued monitoring to assure that there is no serious impact.

Piezometers were installed adjacent to the detention ponds at the time of construction. Boring logs for these piezometers indicate high clay content soils either immediately under the ponds or occurring between the bottom of the pond and the water table. Table 7-1 summarizes the lithologies encountered in the soil borings for each piezometer. Many piezometers were dry at the time of construction, as can be seen on Table 7-1. Further, the construction completion reports indicate many of the ponds were excavated in clay material. The presence of naturally occurring clay soils underlying the ponds coupled with dry conditions in many piezometers suggests that infiltration of ponded water is not great.

The proposed introduction of ARD into the Marion Shaft raises the possibility of an increase in metal loading to groundwater should any of the introduced ARD escape from the LMDT into regional groundwater. However, the high pumping rate option contemplated under this alternative will likely generate a large hydraulic capture area minimizing the risk of fugitive ARD.

Terrestrial Ecosystem Exposure – See Section 7.3.2.2

Non-Residential Soils - See Section 7.3.2.1

7.3.2.5 Alternative 2h - Gravity Pipeline to Dedicated Water Treatment Plant w/Institutional Controls

This alternative involves the construction of an independent water treatment facility to treat ARD collected in OU6. The water would be conveyed to the treatment facility from the Greenback Pond via a gravity pipeline. Plant discharge would be to Stray Horse Gulch or Starr Ditch.

Three options were considered for treatment including:

- Modular lime addition Memtek microfiltration system.
- Traditional lime addition/clarifier/multimedia filter combination.
- Lime addition/settling basin/lined lagoon system.

USFilter of Warrendale, PA was contacted for a technical and cost proposal using actual collected ARD chemistry as influent quality and Yak and BOR's plant effluent quality as the target treatment plant effluent quality. The assumed influent and effluent chemistry as well as the technical and cost proposal from US Filter is provided as Appendix E.

Based on a review of the USFilter proposal and subsequent conversations with the vendor, it was determined that without bench-scale treatability studies, only the Memtek microfiltration option would ensure the required effluent quality. For that reason, the microfiltration option is advanced under this alternative. A conceptual process flow schematic is provided as Figure 6-7.

Preliminary cost estimates suggest that the microfiltration option is the most costly. The other options may be considered further after completing bench-scale testing.

The proposed water treatment plant would be operated during the 60 to 90-day spring runoff. The current collection pond system would be maintained to manage runoff collected during rain events. Potential locations for the facility have not been identified. For costing purposes, 500-feet of PVC pipeline is assumed for delivery of ARD to the plant with effluent returned to Stray Horse Gulch. Sizing of the equalization lagoon is based on at least 24-hour detention time at an assumed peak flow of 700 gpm.

The remedy would consist of the following elements:

- 500-feet of 12-inch I.D., PVC pipe buried below frost depth (including a pipe "pig" and launcher for pipeline maintenance)
- Two-stage reaction tank.
- Two microfiltration system.
- Concentrate blow-down thickener.
- Lime silo.
- Lime slurry feed tank.
- Final pH adjustment tank.
- Filter press.
- Coagulant storage tank.
- Sulfuric acid storage tank.
- 1,000,000 gallon, lined flow-equalization lagoon w/inlet and outlet structures.
- Transport of water treatment residuals, and pond and sediment basin deposits to an appropriate disposal facility.
- Operation and maintenance of new and existing remedy components.
- Institutional controls via an overlay district for the NPL site.

Overall Protection of Human Health and Environment – See Section 7.3.2.1

Compliance with ARARs - ARARs are discussed in Section 5.0. There are no chemical-specific ARARs. The following summarizes the action- and location-specific ARARs for this Alternative.

Potential Action-Specific ARARs:

- Clean Water Act Ambient Water Quality Criteria, NPDES and Colorado Water Quality Control Act - These ARARs will be met through the establishment of water quality standards for treatment plant effluent and through the implementation of an erosion control plan during remedial construction. Effluent quality at the Yak and BOR water treatment plants was used as the basis for conceptual design of the water plant options evaluated under this alternative. Therefore, it is expected this ARAR will be met.

- RCRA Subtitle D and State Solid Waste Regs. and Solid Waste Closure - Pond sediment is considered a solid waste and will be disposed at an appropriate facility.

- RCRA Subtitle C and Land Disposal Restrictions - These ARARs will be met under this alternative through appropriate disposal of water treatment plant sludges.

- Colorado Mined Land Reclamation Act - The substantive requirements of this regulation are evaluated under the "Additional Criteria" discussed below.

- Colorado Air Quality Control - No significant disturbance of mine waste is proposed under this alternative.

- Colorado Noise Abatement - Construction near populated areas would be performed in compliance with the requirements of this regulation.

- Environmental Covenants - It is expected this ARAR will be met through an exemption under CRS 25-15-320(3)(b) through a Site-wide Overlay District enacted as an enforceable ordinance by Lake County.

Potential Location-Specific ARARs:

- Protection of Floodplains - No new work is proposed near floodplains under this alternative.

- Clean Water Act Section 404 (including E.O. 11990) - No new work is proposed near wetlands under this alternative.

- Fish and Wildlife Coordination Act - Disturbance to wildlife would be minimal under this alternative. Coordination with USFW and CDNR may be prompted by the inclusion of an impoundment under this alternative.

- Cultural Resource Requirements - The Programmatic Agreement between EPA and SHPO would be used to determine if this alternative would have an adverse impact to the identified cultural resources. If an adverse impact were identified, appropriate mitigation measures would be negotiated.

- Solid Waste Disposal Site and Facilities Act - These regulations do not apply to this alternative given no solid waste facility is proposed.

Long-Term Effectiveness – The continued collection and treatment of ARD coupled with the maintenance of low-permeability and physical barriers, sediment basins and retention ponds will maintain recent improvements in surface water quality. Some additional improvement in water quality would be expected in Stray Horse Gulch as the recently implemented response actions stabilize. In addition, the completion of the Phase V Response Action in Lincoln Gulch is expected to result in protection of the Leadville water supply during summer storm events.

Institutional controls prohibiting changes in land use will minimize the likelihood of human health effects above a level of concern. The long-term effectiveness of IC's depends on the diligence of the enforcing agency. The county would enforce the overlay district currently contemplated for the entire Leadville area. EPA and the State would perform periodic reviews of the effectiveness of the IC's.

The essential components of IC's at OU6 would include the following elements and considerations:

- The vast majority of OU6 is zoned for industrial mining use. The actual current land use in OU6 is recreational. Risk Assessments performed to date suggest that the current conditions are protective for recreational use. Should industrial mining activities occur in OU6 in the future, the Mine Safety and Health Administration (MSHA) will regulate human exposure to site contaminants given that by its very nature, mining activities concentrate human exposure to ore materials. In the case of the Leadville mining district, the ore materials contain the contaminants of concern.

- The IC's will restrict changes in land use. However, a provision may be included to allow land use changes to individual parcels if a parcel-specific risk assessment indicated risks below a level of concern or if the parcel is remediated to reduce human health risks below a level of concern.

Reduction in Toxicity, Mobility, and Volume through Treatment – See Section 7.3.2.1

Short-Term Effectiveness – See Section 7.3.2.1

Implementability – The components of this remedy are easily implementable presuming that easements may be acquired for the proposed pipeline and arrangements with property owners can be made to place the treatment facility. The proposed water treatment technology is available and easily constructed. Other construction materials are readily available and routine construction techniques would be employed. Institutional controls are implementable through an overlay district currently contemplated for the entire Leadville.

Cost – This remedy will require operation over many decades, if not centuries. Therefore, the period of performance is set at 100-years. The present worth cost for implementation of this remedy is $10,332,959 (based on a 7 percent discount rate). Detailed costing is provided in Appendix C.

State Acceptance – See Section 7.3.1

Community Acceptance – See Section 7.3.1

Analysis - Additional Criteria:
Surface Erosion Stability – See Section 7.3.2.1

Slope Stability – See Section 7.3.2.1

Flow Capacity and Stability – See Section 7.3.2.1

Surface and Ground Water Loading Reduction – See Section 7.3.2.2

Terrestrial Ecosystem Exposure – See Section 7.3.2.2

Non-Residential Soils - See Section 7.3.2.1

7.3.3 Alternative 4 - In-Situ Chemical Stabilization (In combination with Alternatives 2a through 2h)

This alternative involves maintaining the existing remedies (identical to Alternative 2) and implementing in-situ chemical stabilization of those waste rock piles that are considered to be sources for ARD not previously addressed through Response Actions. These include the Ponserdine and Emmett waste rock piles (See discussion in Section 6.2.1).

This alternative involves the injection and dispersion of buffering agents into the waste mass so that a final equilibrium is reached that inhibits acid generation. Chemically stabilized systems are susceptible to weathering and chemical decomposition therefore the potential for contact by surface water run-on or runoff during storm events should be minimized. Potential neutralization agents include lime, magnesium compounds and several proprietary agents. The actual neutralizing agent will be selected during remedial design. This process will maintain the general integrity of the waste piles for cultural and historical aesthetics. However, some disturbance of the pile would be expected as equipment will need to access all portions of the pile.

Institutional controls are legal and administrative restrictions to prevent human or ecological exposure to site wastes. In the case of OU6 such controls would include land use restrictions precluding residential development.

Overall Protection of Human Health and Environment – This alternative may result in further improvement of water quality in Stray Horse and Little Stray Horse Gulches over that achieved in the 2001 runoff season (see Section 4.2.3). However, the effectiveness of the in-situ stabilization component of this remedy is unknown at this time. Institutional controls would minimize the likelihood of human health risk above a level of concern.

Compliance with ARARs - ARARs are discussed in Section 5.0. There are no chemical-specific ARARs. The following summarizes the action- and location-specific ARARs for the chemical stabilization portion of this Alternative. See Section 7.3.2 for an evaluation of the portion of this remedy involving maintenance of existing remedies.

<u>Potential Action-Specific ARARs:</u>

- Clean Water Act Ambient Water Quality Criteria, NPDES and Colorado Water Quality Control Act - No discharges of water are contemplated under this alternative beyond those identified under Alternative 2. These ARARs will be met through the implementation of an erosion control plan during remedial construction.

- RCRA Subtitle D and State Solid Waste Regs. and Solid Waste Closure - These regulations do not apply to this alternative given no solid waste is proposed for disposal.

- RCRA Subtitle C and Land Disposal Restrictions - No hazardous wastes will be generated or handled under the in-situ chemical stabilization portion of this alternative.

- Colorado Mined Land Reclamation Act - The substantial requirements of this regulation are evaluated under the "Additional Criteria" discussed below.

- Colorado Air Quality Control - The in-situ stabilization process is not expected to result in significant disturbance of mine waste.

- Colorado Noise Abatement - No construction is proposed near populated areas under this Alternative.

- Environmental Covenants - It is expected this ARAR will be met through an exemption under CRS 25-15-320(3)(b) through a Site-wide Overlay District enacted as an enforceable ordinance by Lake County.

Potential Location-Specific ARARs:

- Protection of Floodplains - No new work is proposed near floodplains under this alternative.
- Clean Water Act Section 404 (including E.O. 11990) - No new work is proposed near wetlands under this alternative.
- Fish and Wildlife Coordination Act - Disturbance to wildlife would be minimal under this alternative.
- Cultural Resource Requirements - The Programmatic Agreement between EPA and SHPO would be used to determine if this alternative would have an adverse impact to the identified cultural resources. If an adverse impact were identified, appropriate mitigation measures would be negotiated.
- Solid Waste Disposal Site and Facilities Act - These regulations do not apply to this alternative given no solid waste facility is proposed.

Long-Term Effectiveness – The long-term effectiveness of the in-situ stabilization portion of the remedy is not known. The technology is theoretically effective and several pilot studies conducted in Region 8 suggest the technology is effective, at least in the short-term. However, no long-term monitoring performance data is available. In addition, the technology appears most well suited for the subsurface portion of the waste materials. Erosion of surface materials may not be mitigated by this remedial technology.

Reduction in Toxicity, Mobility, and Volume through Treatment – A reduction in waste mobility is expected under the in-situ stabilization portion of this alternative. However, no reduction in volume or toxicity is anticipated.

Short-Term Effectiveness – Minimal disturbance of mine wastes would occur under this alternative.

Implementability – The implementability of the in-situ stabilization portion of this remedy is uncertain. However, one potential contractor with relevant experience and the required equipment has been identified, has visited the site, and has prepared a technical and cost proposal (Appendix F).

Cost – The incremental capital cost for in-situ chemical is $400,000. No O&M is assumed to be associated with in-situ stabilization. Detailed costing is provided in Appendix C.

State Acceptance – See Section 7.3.1

Community Acceptance – See Section 7.3.1

Analysis - Additional Criteria:
Surface Erosion Stability – No significant remedial construction involving mine waste is contemplated under this alternative.

Slope Stability – The geometry and location of the Ponserdine and Emmett mine waste piles will not be modified under this alternative.

Flow Capacity and Stability – No channels will be constructed under this alternative.

Surface and Ground Water Loading Reduction – This alternative would result in further reduction in metal loading to surface and groundwater by chemically and potentially physically stabilizing the Ponserdine and Emmett waste piles. However, the expected decrease in metal loading is likely to be small relative to the improvement observed over the last year.

Terrestrial Ecosystem Exposure – No change in terrestrial ecosystem exposure is expected under Alternative 4 as compared with Alternative 2.

Non-Residential Soils – See Section 7.3.2.1

7.3.4 Alternative 5 - Consolidate and Cap Mine Waste w/Institutional Controls

This alternative involves consolidating and capping of waste rock piles that are considered sources for ARD. This includes piles that have been addressed under Response Actions as well as those that have not yet been addressed. This alternative excludes those mine wastes that have already been consolidated and capped. The cap design will follow that implemented during prior response actions including a geomembrane and an 8-foot thick dolomite waste rock cap.

The typical cap design is illustrated in Figure 4-2. This conceptual design was adopted for Alternative 5 for several reasons including:

- The June 24, 1997 Action Memorandum addressing the consolidation and capping of selected ARD-generating mine waste piles required special consideration be given to aesthetics of the final remedy including the use of dolomite waste rock as the cap material.
- The result of the cap design analysis performed in the Engineering Analysis and Cost Evaluation (EECA) (CDM, 1997) yielded the design proposed in this alternative.
- In addition to the aesthetic considerations, the use of dolomite waste rock offers some buffering capacity for ARD. When combined with a geomembrane top liner, the cap system is robust and low maintenance.

The specific mine wastes proposed for consolidation and capping are listed below and illustrated on Figure 2-9.

- Greenback
- RAM
- Old/New Mikado
- Highland Mary
- Adelaide/Ward
- Pyrenees
- Fortune/Resurrection
- Ibex/Irene
- Ponsardine
- Emmett

The basis for selection of mine wastes to be treated under Alternative 5 is detailed in Section 2.5.2. Costing was based, in part, on the actual costs (adjusted to 2002) implementing the identical remedy on selected mine waste piles under the Phase I Response Action (CDM, 1997). The actual consolidation scheme for Alternative 5 would be determined during remedial design.

The remedy consists of the following elements:

- Consolidate 742,100 CY of mine waste including the first 1-foot of native soils underlying the waste (this FFS assumes a 1-foot depth for costing purposes, actual depth will be determined through sampling).
- Amend native soils and vegetate mine waste pile footprints.
- Establish 1.5:1 slopes on consolidated mine waste.
- Place 40-mil polyvinyl chloride geomembrane in combination with a geofabric.
- Place 8-foot thick layer of dolomite waste rock over geomembrane.
- Top dress exterior slopes with crushed porphory.
- Perform periodic inspection and maintenance.
- Institutional controls via an overlay district for the NPL site.

Overall Protection of Human Health and Environment - This alternative would result in further improvement in water quality in all of the drainages in OU6. Capping all remaining ARD-generating materials with low-permeability covers would minimize the generation of ARD. Institutional controls would minimize the likelihood of human health risk above a level of concern from exposure to non-residential soils and non ARD-generating mine wastes.

Compliance with ARARs - ARARs are discussed in Section 5.0. There are no chemical-specific ARARs. The following summarizes the action- and location-specific ARARs for this Alternative.

<u>Potential Action-Specific ARARs:</u>

- Clean Water Act Ambient Water Quality Criteria, NPDES and Colorado Water Quality Control Act - No discharges to surface water are proposed under this alternative. These ARARs will be met through the implementation of an erosion control plan during remedial construction.

- RCRA Subtitle D and State Solid Waste Regs. and Solid Waste Closure - Waste pile caps include a geomembrane liner. This design may comply with Subtitle D requirements.

- RCRA Subtitle C and Land Disposal Restrictions - Hazardous wastes will not be generated under this alternative. Mine wastes have been identified as extraction or beneficiation wastes that are specifically exempted from the definition of a hazardous waste.

- Colorado Mined Land Reclamation Act - The substantial requirements of this regulation are evaluated under the "Additional Criteria" discussed below.

- Colorado Air Quality Control - Colorado air quality requirements will be achieved by adhering to a fugitive emissions control plan prepared in accordance with this ARAR.

- Colorado Noise Abatement - No construction is proposed near populated areas under this Alternative.

- Environmental Covenants - It is expected this ARAR will be met through an exemption under CRS 25-15-320(3)(b) through a Site-wide Overlay District enacted as an enforceable ordinance by Lake County.

Potential Location-Specific ARARs:

- Protection of Floodplains - Some mine wastes proposed for consolidation and capping may lie in the 100-year floodplain. However, all work is proposed in Upper Stray Horse and Little Stray Horse Gulches. No significant structures exist in these portions of the watershed that might be affected by mine waste piles partially obstructing the 100-year stream flows. In addition, mine waste pile stability with respect to water erosion is addressed under the "Additional Criteria" discussed below.

- Clean Water Act Section 404 (including E.O. 11990) - No new work is proposed near wetlands under this alternative.

- Fish and Wildlife Coordination Act - EPA will coordinate with the USFW and the CDNR should it appear that this remedy would impact wildlife resources.

- Cultural Resource Requirements - The Programmatic Agreement between EPA and SHPO would be used to determine if this alternative would have an adverse impact to the identified cultural resources. If an adverse impact were identified, appropriate mitigation measures would be negotiated.

- Solid Waste Disposal Site and Facilities Act - These regulations do not apply to this alternative given no solid waste facility is proposed.

Long-Term Effectiveness – The construction of robust low-permeability caps on ARD-generating mine wastes would provide long-term effectiveness. Permanence would be achieved through relatively minimal maintenance of final cover material.

Institutional controls prohibiting changes in land use will minimize the likelihood of human health effects above a level of concern. The long-term effectiveness of IC's depends on the diligence of the enforcing agency. The county would enforce the overlay district currently contemplated for the entire Leadville area. EPA and the State would perform periodic reviews of the effectiveness of the IC's.

The essential components of IC's at OU6 would include the following elements and considerations:

- The vast majority of OU6 is zoned for industrial mining use. The actual current land use in OU6 is recreational. Risk Assessments performed to date suggest that the current conditions are protective for recreational use. Should industrial mining activities occur in OU6 in the future, the Mine Safety and Health Administration (MSHA) will regulate human exposure to site contaminants given that by its very nature, mining activities concentrate human exposure to ore materials. In the case of the Leadville mining district, the ore materials contain the contaminants of concern.

- The IC's will restrict changes in land use. However, a provision may be included to allow land use changes to individual parcels if a parcel-specific risk assessment indicated risks below a level of concern or if the parcel is remediated to reduce human health risks below a level of concern.

Reduction in Toxicity, Mobility, and Volume through Treatment – Alternative 5 would achieve a greater reduction in volume and mobility of wastes than Alternatives 1, 2, or 4. Under this alternative, no ARD treatment is required. Therefore, no treatment residuals or retention pond sediment would be generated. Low permeability caps would preclude erosion of mine wastes by wind and water as well as minimize the generation of ARD.

Short-Term Effectiveness – Significant disturbance of mine wastes would occur under this alternative. Therefore increased risks to construction workers and the community may occur.

Implementability – Alternative 5 is technically implementable. The required construction materials are readily available and routine construction techniques would be employed. Access and agreements to obtain the capping materials would have to be made. These materials and techniques are identical to those employed during the Phase I Response Action in OU6. However, community opposition to such large-scale disturbance of mine wastes as historic features resulted in the abandonment of this remedial approach during implementation. Capping of mine wastes was abandoned despite elaborate cap designs intended to mimic the original shape and color of mine waste piles. Based on past community opposition to such large-scale remedial action, this alternative may not be implementable.

Institutional controls are implementable through an overlay district currently contemplated for the entire Leadville area.

Cost – Cap maintenance will be required in perpetuity. Therefore, the period of performance is set at 100-years. The present worth cost for implementation of this remedy is $25,885,158 (based on a 7 percent discount rate). Detailed costing is provided in Appendix C.

State Acceptance – See Section 7.3.1

Community Acceptance – See Section 7.3.1

Analysis - Additional Criteria:
Surface Erosion Stability – Alternative 5 adopts the conceptual design implemented during the Phase I Response Action.

Slope Stability - Alternative 5 adopts the conceptual design implemented during the Phase I Response Action. Also, see Section 7.3.2.1.

Flow Capacity and Stability – No water conveyances are proposed under this Alternative.

Surface and Ground Water Loading Reduction – Loading reductions to surface and ground water are expected to approach 100% for mine waste piles under this alternative as well as for wastes that were similarly capped under the Phase I Response Action. Lesser reductions are expected for mine wastes that have been capped with a simple soil cover.

Terrestrial Ecosystem Exposure – Capping of mine wastes with a minimum 8-feet of crushed rock will eliminate the ecological exposure pathway. Non-ARD generating mine wastes and non-residential soils will remain unchanged under this and all of the alternatives.

Non-Residential Soils – Capping of ARD-generating mine wastes will eliminate the human exposure pathway. Non-ARD generating mine wastes and non-residential soils will remain unchanged under this and all of the alternatives. As discussed in Section 2.6.1, average lead levels are generally well below the nominal action level of 16,000 mg/kg for areas where recreational scenarios are considered likely. The current and likely future land use in OU6 is recreational, although current land zoning is Industrial Mining. Implementation of institutional controls will minimize the likelihood of unacceptable health risks from residential or other prohibited land uses.

Such IC's could require assessment and mitigation on a parcel-by-parcel basis, if appropriate. This and other IC's would be finalized with Lake County upon completion of the OU9 residential overlay district and could cover all remediated property.

7.3.5 Alternative 6 - Excavate, Transport and On-Site Disposal w/Institutional Controls

This alternative involves the excavation, transportation, and disposal in an on-site repository of ARD-generating mine waste (and underlying soils to a depth of 1-foot). This includes piles that have been addressed under Response Actions as well as those that have not yet been addressed. This alternative excludes those mine wastes that have already been consolidated and capped (e.g. Maid of Erin, Wolftone, etc.). The pile footprint would be vegetated after removal. The repository will be located within the OU6 and will meet the requirements for an industrial solid waste landfill cell including a geomembrane bottom and cover liner. A screening document to rank potential repository locations is currently underway.

A conceptual layout of the repository is provided in Figure 7-3. Three possible locations for the repository are illustrated on Figure 7-4.

The remedy consists of the following elements:

- Prepare repository to accommodate 742,100 CY of mine waste including the first 1-foot of native soils underlying the waste (this FFS assumes a 1-foot depth for costing purposes, actual depth will be determined through sampling). This will include over excavated and recompacted native soils overlain by a 60-mil high-density polyethylene (HDPE) geomembrane covered with 18-inches of native soils. Repository will be located within OU6.
- Excavate, load and transport mine waste to repository (assume 4-mile haul).
- Amend native soils and vegetate mine waste pile footprints.
- Install 60-mil HDPE liner over mine waste.
- Place 18-inches of native soils and 6-inches of topsoil over mine waste and vegetate final cover.
- Install groundwater quality monitoring network and perform annual sampling.
- Perform annual cap inspection and maintenance.
- Institutional controls via a Site-wide overlay district.

Overall Protection of Human Health and Environment - This alternative would result in further improvement in water quality in all of the drainages in OU6. Consolidating all remaining ARD-generating materials in an on-site repository with a low-permeability liner and cover would minimize the generation of ARD. This alternative may provide some incremental increase in overall protection through the inclusion of a low-permeability barrier under the waste as compared with Alternative 5.

Institutional controls would minimize the likelihood of human health risk above a level of concern from exposure to non-residential soils and non ARD-generating mine wastes.

Compliance with ARARs - ARARs are discussed in Section 5.0. There are no chemical-specific ARARs. The following summarizes the action- and location-specific ARARs for this Alternative.

Potential Action-Specific ARARs:

- Clean Water Act Ambient Water Quality Criteria, NPDES and Colorado Water Quality Control Act - No discharges to surface water are proposed under this alternative. These ARARs will be met through the implementation of an erosion control plan during remedial construction.

- RCRA Subtitle D and State Solid Waste Regs. and Solid Waste Closure - The waste repository location and design may have to comply with the substantive requirements of RCRA Subtitle D. The repository location has not been finalized. However, several proposed locations are advanced in the FFS. The selection criteria included a location where the groundwater is expected to lie below the bottom of the repository. The conceptual design of the repository is a dry tomb consisting of a top and bottom geomembrane liner to minimize the generation of leachate and the loss of leachate to the environment. This design may meet the substantive requirements of these ARARs.

- RCRA Subtitle C and Land Disposal Restrictions - Hazardous wastes will not be generated under this alternative. Mine wastes have been identified as extraction or beneficiation wastes that are specifically exempted from the definition of a hazardous waste.

- Colorado Mined Land Reclamation Act - The substantial requirements of this regulation are evaluated under the "Additional Criteria" discussed below.

- Colorado Air Quality Control - Colorado air quality requirements will be achieved by adhering to a fugitive emissions control plan prepared in accordance with this ARAR.

- Colorado Noise Abatement - No construction is proposed near populated areas under this Alternative.

- Environmental Covenants - It is expected this ARAR will be met through an exemption under CRS 25-15-320(3)(b) through a Site-wide Overlay District enacted as an enforceable ordinance by Lake County.

Potential Location-Specific ARARs:

- Protection of Floodplains - The repository will not be located in a floodplain.

- Clean Water Act Section 404 (including E.O. 11990) - No new work is proposed near wetlands under this alternative.

- Fish and Wildlife Coordination Act - EPA will coordinate with the USFW and the CDNR should it appear that this remedy would impact wildlife resources.

- Cultural Resource Requirements - The Programmatic Agreement between EPA and SHPO would be used to determine if this alternative would have an adverse impact to the identified cultural resources. If an adverse impact were identified, appropriate mitigation measures would be negotiated.

- Solid Waste Disposal Site and Facilities Act - See discussion of RCRA under Action Specific ARAR.

Long-Term Effectiveness – The consolidation of ARD-generating mine waste in an on-site repository would provide long-term effectiveness and permanence.

Institutional controls prohibiting changes in land use will minimize the likelihood of human health effects above a level of concern. The long-term effectiveness of IC's depends on the diligence of the enforcing agency. The county would enforce the overlay district currently contemplated for the entire Leadville area. EPA and the State would perform periodic reviews of the effectiveness of the IC's.

The essential components of IC's at OU6 would include the following elements and considerations:

➢ The vast majority of OU6 is zoned for industrial mining use. The actual current land use in OU6 is recreational. Risk Assessments performed to date suggest that the current conditions are protective for recreational use. Should industrial mining activities occur in OU6 in the future, the Mine Safety and Health Administration (MSHA) will regulate human exposure to site contaminants given that by its very nature, mining activities concentrate human exposure to ore materials. In the case of the Leadville mining district, the ore materials contain the contaminants of concern.

➢ The IC's will restrict changes in land use. However, a provision may be included to allow land use changes to individual parcels if a parcel-specific risk assessment indicated risks below a level of concern or if the parcel is remediated to reduce human health risks below a level of concern.

Reduction in Toxicity, Mobility, and Volume through Treatment – Alternative 6 may achieve some additional reduction in mobility of wastes over Alternative 5. This would be achieved by the addition of a low-permeability barrier under the wastes, as compared with Alternative 5. Under this alternative, no ARD treatment is required. Therefore, no treatment residuals or retention pond sediment would be generated. Low permeability caps would preclude erosion of mine wastes by wind and water as well as minimize the generation of ARD.

Short-Term Effectiveness – See Section 7.3.4

Implementability – Alternative 6 is technically implementable. The required construction materials are readily available and routine construction techniques would be employed. The suitable repository location has not been determined and a screening document to rank potential repository sites is currently underway. Community opposition to such large-scale disturbance of mine wastes as historic features may render this alternative not implementable (see Section 7.3.4).

Institutional controls are implementable through an overlay district currently contemplated for the entire Leadville area.

Cost – Repository Cap maintenance will be required in perpetuity. Therefore, the period of performance is set at 100-years. The present worth cost for this remedy is $19,376,345 (based on a 7 percent discount rate). Detailed costing is provided in Appendix C.

State Acceptance – See Section 7.3.1

Community Acceptance – See Section 7.3.1

Analysis - Additional Criteria:
Surface Erosion Stability – All ARD-generating mine waste addressed in Alternative 6 will be encapsulated in an on-site repository.

Slope Stability - Alternative 6 does not include impounding embankments or recontoured slopes composed of mine waste. Also, see Section 7.3.2.1.

Flow Capacity and Stability – No water conveyances are proposed under this Alternative.

Surface and Ground Water Loading Reduction – Loading reductions to surface and groundwater are expected to approach 100% for mine waste consolidated in an on-site repository as well as for wastes that were capped under the Phase I Response Action. Lesser reductions are expected for other mine wastes that have been capped with a simple soil cover.

Terrestrial Ecosystem Exposure – Consolidating mine waste into an on-site repository will reduce exposures. The ecological exposure pathway has also been eliminated for mine wastes consolidated and capped under prior Response Actions. Non-ARD generating mine wastes and non-residential soils will remain unchanged under this and all of the Alternatives.

Non-Residential Soils – Consolidating mine waste into an on-site repository will reduce human exposures. Non-ARD generating mine wastes and non-residential soils will remain unchanged under this and all of the alternatives. As discussed in Section 2.6.1, average lead levels are generally well below the nominal action level of 16,000 mg/kg for areas where recreational scenarios are considered likely. The current and likely future land use in OU6 is recreational, although current land zoning is Industrial Mining.

Implementation of institutional controls will minimize the likelihood of unacceptable health risks from residential or other prohibited land uses. Such IC's could require assessment and mitigation on a parcel-by-parcel basis, if appropriate. This and other IC's would be finalized with Lake County upon completion of the OU9 residential overlay district and could cover all remediated property.

8.0 COMPARATIVE ANALYSIS

This section compares the retained alternatives to each other using the nine NCP criteria and additional criteria as a measure. Table 8-1 presents the comparative analysis for the nine NCP criteria. Table 8-2 present the comparative analysis for the Additional Criteria.

8.1 OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

The range of alternatives provides the full spectrum of protectiveness from No Action (Alternative 1) through alternatives that result in the isolation of source material from humans and the environment (Alternative 5 and 6). The intermediate alternative (Alternative 2) offers protectiveness equal or somewhat greater than that already achieved through prior Response Actions.

Recent water quality data suggests metal loading reductions on the order of 60 - 80% have already been achieved in Stray Horse Gulch and Starr Ditch. While Alternatives 5 and 6 are expected to achieve further reduction in metal loadings, the magnitude of the effort required to achieve the improvements is disproportionate when compared with the level of effort expended to reach the current condition. In other words, after achieving 60 – 80% reductions in metal loading, the law of diminishing returns may apply to any further actions. The current condition would be maintained under Alternatives 2a, 2b, 2e and 2h. Some additional improvement in water quality may be expected under Alternatives 2g and 4. Continued reductions shall be seen as the remediated areas continue to stabilize and vegetation becomes more established.

All of the alternatives (except Alternative 1) require institutional controls to minimize the likelihood of human health risks above a level of concern.

8.2 COMPLIANCE WITH ARARS

There are no chemical-specific ARARs for OU6. All of the alternatives are expected to comply with action- and location-specific ARARs. Compliance with action-specific ARARs will be achieved through compliance with NPDES permits for water treatment plant effluent and the implementation of engineering controls during remedial construction. Location-specific ARARs will be met through avoidance of wetlands and through mitigation of cultural and historic resources, as necessary.

8.3 SHORT-TERM EFFECTIVENESS

Alternatives 1, 2, and 4 do not involve significant disturbance of mine wastes. Therefore, little short-term impacts are expected. Alternatives 5 and 6 involve large-scale disturbance of mine wastes. Therefore, significant short-term impacts would be expected.

8.4 LONG-TERM EFFECTIVENESS AND PERMANENCE

Alternatives 2 and 4 require near perpetual operation of ARD collection, conveyance and treatment facilities. Therefore, while these alternatives are effective in the long-term they are not permanent. Alternatives 5 and 6 offer equal or greater long-term effectiveness when compared with the other alternatives. Alternatives 5 and 6 also offer greater permanence than the other alternatives. The isolation of ARD-generating source material either under engineered caps or through placement in a landfill cell provides permanence with low maintenance.

Within the variations on Alternative 2, option 2g (plug LMDT) offers some additional long-term effectiveness when compared with the other options. Under option 2g, the likelihood of untreated ARD being discharged to surface water is minimized through the use of the LMDT mine pool to store ARD even during high runoff years.

8.5 REDUCTION IN TOXICITY, MOBILITY OR VOLUME THROUGH TREATMENT

Treatment of source materials is provided only under Alternative 4, In-situ Chemical Stabilization. This technology, if effective, will reduce the mobility of the contaminants through chemical and possibly physical fixation. Alternative 2 will treat collected ARD and convert the dissolved metals to solid metal complexes thereby reducing the mobility of the contaminants. Alternatives 5 and 6 will minimize the generation of ARD, thereby reducing the mobility of the contaminants. None of the alternatives affect contaminant volume or toxicity.

8.6 IMPLEMENTABILITY

All of the alternatives are technically and administratively implementable. However, past community objection to remedies that result in significant disturbance to mine wastes may render Alternatives 5 and 6 not implementable.

8.7 COST

The costs of Alternative 2g (dewater mine pool) are difficult to quantify at this time given uncertainties regarding water treatment plant upgrades that may be needed. In addition, the BOR plant replacement costs are also uncertain and impact Alternatives 2e and 2g.

Despite these uncertainties, it is possible to rank the alternatives by cost. Alternative 1 has no costs associated with it. The options under Alternative 2 are all expected have a lower present worth cost than Alternatives 5 and 6. Alternative 6 is less costly than Alternative 5. All costs are summarized on Table 8-1.

8.8 STATE ACCEPTANCE

To be determined during the FFS comment period and proposed plan.

8.9 COMMUNITY ACCEPTANCE

To be determined during the FFS comment period and proposed plan.

8.10 ADDITIONAL CRITERIA

Surface Erosion Stability and Slope Stability - Alternatives 1, 2, and 4 do not require significant disturbance of mine wastes. Alternatives 5 and 6 will leave no ARD-generating mine waste exposed at the surface.

Flow Capacity and Stability - None of the alternatives involve the construction of channels with the possible exception of Alternative 6, which may involve the diversion of storm water around and off of the on-site repository.

Surface and Groundwater Metal Loading - Each alternative, from Alternative 2 through 6 provides a further reduction in metal loading to surface and groundwater.

Terrestrial Ecosystem Exposure - The options under Alternative 2 and 4 involve the maintenance of existing ARD retention ponds and, in some cases, the construction of lined impoundments to store ARD prior to treatment. These impoundments may be attractive to waterfowl and additional controls may have to be considered. Alternatives 5 and 6 result in the isolation of ARD-generating mine wastes from the environment eliminating the terrestrial exposure pathway. Non-ARD generating mine wastes will not be addressed under any of the alternatives.

Non-residential Soils - All of the alternatives (except Alternative 1) include institutional controls to minimize the likelihood of unacceptable human health risks from non-residential soils. Alternatives 5 and 6 will result in the isolation of ARD-generating mine wastes from humans.

9.0 REFERENCES

Alpine Archaeological Consultants, Inc., 1996. *Cultural Resource Inventory of a Proposed 15-Acre Borrow Area and Access Road, Operable Unit 6, California Gulch Superfund Site, Lake County, Colorado,* June 1996.

Alpine Archaeological Consultants, Inc., 1997. *Cultural Resource Inventory of Two High Priority Survey Areas, California Gulch Superfund Site, Lake County, Colorado,* January 1997.

Alpine Archaeological Consultants, Inc., 1997. *Cultural Resource Inventory of a 76.2-Acre Remediation Area South of Stray Horse Gulch, California Gulch Superfund Site, Lake County, Colorado,* May 1997.

Alpine Archaeological Consultants, Inc., 1997. *Cultural Resource Inventory of Three Remediation Areas in the Vicinity of the Matchless Mine, California Gulch Superfund Site, Lake County, Colorado,* May 1997.

ASARCO, 1992. *Final Air Monitoring Report.*

CDM, 1997. *Engineering Evaluation/Cost Analysis for Stray Horse Gulch, Operable Unit 6, California Gulch NPL Site, Leadville, Colorado,* June 1997.

CDM, 2000a. *Final Phase I Removal Action Completion Report for the California Gulch Superfund Site, Lake County, Colorado, Operable Unit 6,* December 11, 2000.

CDM, 2000b. *Final Phase II/III Removal Action Completion Report for the California Gulch Superfund Site, Lake County, Colorado, Operable Unit 6,* December 2000.

CDM, 2000c. *Final Phase IV Removal Action Completion Report for the California Gulch Superfund Site, Lake County, Colorado, Operable Unit 6,* December 2000.

CDM, 2000d. *Technical Memorandum, 1999 – Soil Boring and Monitoring Well Installation at California Gulch OU6,* January 20, 2000.

CDM, 2001b. *California Gulch NPL Site, Leadville, Colorado, Draft Technical Memorandum for Effectiveness of Past Work at Operable Unit 6,* July 2001.

CDM, 2001a. *Final Technical Memorandum Response Action Alternative Evaluation of Ibex/Irene Site at Operable Unit 6, California Gulch Superfund Site, Lake County, Colorado,* July 2001.

Colorado Mountain College (CMC) Natural Resource Management Institute, 2001a. *Site-Wide Water Quality Summary of Events, Complete by the Natural Resource Institute 2000,* March 2001.

Colorado Mountain College (CMC) Natural Resource Management Institute, 2001b. *Site-Wide Water Quality Summary for the Sampling Events Conducted the Year of 2001, California Gulch Superfund Site.* November 2001.

Davies, Gareth, 2001. *Personal Communication.*

Fleischer, M., 1980. *Glossary of Mineral Species, Mineralogic Record*, Tucson, Arizona, p. 192, 1980.

Golder Associates, Inc., 1996a. *Hydrogeologic Remedial Investigation Report, California Gulch Site, Leadville, Colorado, Volume I,* May 1996.

Golder Associates, Inc., 1996b. *Surface Water Remedial Investigation Report, California Gulch Site, Leadville, Colorado, Volume I,* May 1996.

Landeburg, 1969. *Physical Climatology,* 1969.

Office of Management and Budget, 1992. *Circular No. A-94, Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs,* October 1992.

Pacific Western Technologies, Ltd., 2001. *Evaluation of Mahala Waste Pile, Stray Horse Gulch, Removal Action for the California Gulch Superfund Site, OU6,* June 27, 2001.

Rocky Mountain Consultants, Inc., 2001a. *Summary of Groundwater Quality Data, California Gulch NPL Site, Lake County, Colorado,* March 26, 2001.

Rocky Mountain Consultants, Inc., 2001b. *California Gulch Superfund Site, Synoptic Sampling of Stray Horse Gulch, Starr Ditch, and Lower California Gulch (OU6), Spring 2000,* January 2001.

Roy F. Weston, Inc., 1991. *Preliminary Human Health Baseline Risk Assessment for the California Gulch NPL site, Leadville, Colorado*, December 1991.

Roy F. Weston, Inc., 1995b. *Baseline Human Health risk Assessment for the California Gulch Superfund Site, Part C – Evaluation of Worker and Recreational Scenarios,* April 1995.

Roy F. Weston, Inc., 1995a. *Final Baseline Aquatic Ecological Risk Assessment for the California Gulch NPL Site,* September 1995.

Roy F. Weston, Inc., 1996a. *Baseline Human Health risk Assessment, California Gulch Superfund Site, Leadville, Colorado, Part A – Risks to Residents from Lead,* January 1996.

Roy F. Weston, Inc., 1996b. *Baseline Human Health risk Assessment, California Gulch Superfund Site, Leadville, Colorado, Part B – Risks to Residents from Contaminants other than Lead,* January 1996.

Roy F. Weston, Inc., 1997. *Ecological Risk Assessment for the Terrestrial Ecosystem, California Gulch NPL Site, Leadville, Colorado,* January 1997.

United States Department of the Interior, Bureau of Reclamation, 1996b. *Value Analysis, Draft-Presentation Report, Project: California Gulch OU6 Removal Action Evaluation and Decision Phase, Leadville, Colorado,* April 1996.

United States Department of the Interior, Bureau of Reclamation, 1996a. *Phase I: Feasibility Study, Water and Sediment Sampling and Hydrologic Measurement Program, Results and Findings, 1995 Spring Runoff for Operable Unit 6, California Gulch NPL Site, Leadville, Colorado,* November 1996.

United States Department of the Interior, Bureau of Reclamation, 1997. *Draft Environmental Geology of Operable Unit 6, Removal Action Design Data, California Gulch Superfund Site, Leadville, Colorado,* February 1997.

U.S. Army Corps of Engineers, Hydroloic Engineering Center, HEC-FFA, Davis, California, May 1992.

United States District Court for the District of Colorado. *Consent Decree with Asarco Incorporated,* Resurrection Mining Company, Newmont Mining Corporation, and the Res-Asarco Joint Venture, Civil Action No. 83-C-2388, August 25, 1994.

USEPA, 1988. *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA,* Interim Final, EPA/540/G-89/004. October 1988.

USEPA, 1993. *Final Screening Feasibility Study for Remediation Alternatives at the California Gulch NPL Site, Leadville, Colorado,* September 1993.

USEPA, 1995b. *Work Area Management Plan for the California Gulch Superfund Site, Implementation by the U.S. Environmental Protection Agency,* June 14, 1995.

USEPA, 1995. *Action Memorandum. Subject: Request for Removal (Response) Action at the California Gulch National Priorities List Site, Leadville, Colorado*: ACTION MEMORANDUM for an Emergency Removal Action for Rehabilitation and Construction of Drainage and Sediment Control Features, Hamm's Tailing Impoundment. Ref: 8HWM-SR, November 6, 1995.

USEPA, 1996a. *Action Memorandum. Subject: Request for Removal (Response) Action at the California Gulch National Priorities List Site, Leadville, Colorado*: ACTION MEMORANDUM for an Emergency Response Removal for the removal of sediments from the 5th Street Drainage Ditch and Starr Ditch, Operable Unit 6, (OU6). Ref: EPR-SR, May 1, 1996.

USEPA, 1996. *Action Memorandum. Subject: Request for Removal (Response) Action at the California Gulch National Priorities List Site, Leadville, Colorado:* ACTION MEMORANDUM for Time Critical Removal Actions for Hamm's Tailings Impoundment and the Penrose Mine Waste Pile. Ref: 8EPR-SR, July 26, 1996.

USEPA, 1997. *Work Area Management Plan for the California Gulch Superfund Site, Implementation by the U.S. Environmental Protection Agency*: ACTION MEMORANDUM for Non-Time Critical Removal Actions for Source Control Activities at Designated Mine Waste Piles (Operable Unit VI). Ref: 8EPR-SR, June 24, 1997.

USEPA, 1999. *Action Memorandum. Subject: Request for Removal (Response) Action at the California Gulch National Priorities List Site, Leadville, Colorado:* ACTION MEMORANDUM AMENDMENT for subsequent Non-Time Critical Removal Actions for Surface Water Management at Designated Mine Waste Piles. Ref: 8EPR-SR, June 2, 1999.

USEPA, 2000. *A Guide to Developing and Documenting Costs During the Feasibility Study, EPA 540-R00-002.* July 2000.

USEPA, 2001. *Action Memorandum. Subject: Request for Removal (Response) Action at the California Gulch National Priorities List Site, Leadville, Colorado:* ACTION MEMORANDUM for a Non-Time Critical Removal Action for Water Management Activities at the Ibex/Irene Mine Waste Pile at the upper end of Lincoln Gulch. (A portion of Operable Unit 6)(Phase V) Ref: 8EPR-SR, June 25, 2001.

Water, Waste and Land, Inc., 1990. *California Gulch Hydrologic Investigation, Leadville, Colorado,* August 1990.

Woodward-Clyde Consultants, 1992a. *Final Air Monitoring Report, California Gulch Site, Leadville, Colorado, Volume I,* May, 1992.

Woodward-Clyde Consultants, 1992b. *Wetlands Map for California Gulch RI/FS Study Area,* September 1992.

Woodward-Clyde Consultants, 1994a. *Final Mine Waste Piles Remedial Investigation Report, California Gulch Site, Leadville, Colorado,* January 1994.

Woodward-Clyde Consultants, 1994b. *Final Tailings Disposal Area Remedial Investigation Report, California Gulch Site, Leadville, Colorado,* January 1994.

TARGET SHEET

EPA REGION VIII

SUPERFUND DOCUMENT MANAGEMENT SYSTEM

DOCUMENT NUMBER: 2000128

SITE NAME: CALIFORNIA GULCH

DOCUMENT DATE: 09/01/2002

DOCUMENT NOT SCANNED

Due to one of the following reasons:

- ☐ PHOTOGRAPHS
- ☐ 3-DIMENSIONAL
- ☐ OVERSIZED
- ☐ AUDIO/VISUAL
- ☐ PERMANENTLY BOUND DOCUMENTS
- ☐ POOR LEGIBILITY
- ☐ OTHER
- ☐ NOT AVAILABLE
- ☑ TYPES OF DOCUMENTS NOT TO BE SCANNED (Data Packages, Data Validation, Sampling Data, CBI, Chain of Custody)

DOCUMENT DESCRIPTION:

TABLES 2-1 through 2-5, 4-1 and 4-2

Contact the Superfund Records Center to view available document.
(303) 312-6473

Table 5-1
Chemical-Specific ARARs

Standard, Requirement or Criteria	Description	Potentially Applicable	Potentially Relevant and Appropriate	Comment
FEDERAL				
Clean Water Act (33 USC Sect. 1351-1376) Ambient Water Quality Criteria (40 CFR Part 131; Quality Criteria for Water, 1976, 1980, 1986, 1987; Ambient Water Quality Criteria for Selenium, 1987)	Requires EPA and states to establish ambient water quality control criteria (AWQC) and standards, respectively, for surface water based on use classifications and the criteria stated under Sections 304(a) and 303 of the Clean Water Act.	No	No	Federal (or State) freshwater AWQCs are not considered to be ARAR as the remedial action objectives for OU6 as identified in the CD requires reduction in metal loading to the watershed from source areas. Specific numerical performance standards within the OU are not part of the RAO's. Achievement of chemical-specific numerical performance standards will be addressed under the site-wide surface and groundwater operable unit (12).
Clean Air Act (42 USC Sect. 7401-7642) National Ambient Air Quality Standards (40 CFR Part 50)	Establishes ambient air quality standards for certain "criteria pollutants" to protect public health and welfare	No	No	National ambient air quality standards (NAAQS) are implemented through the New Source Review Program and State Implementation Plans (SIPs). The federal New Source Review program address only major sources. Current air emissions from undisturbed mine waste are below a level of concern per EPA's Baseline Human health Risk Assessment, Part A (1996). Emissions associated with remedial action are addressed under Action-specific ARARs.
National Emissions Standards for Hazardous Air Pollutants (40 CFR Part 61)	Establishes emission standards for certain industrial pollutants and sources.	No	No	NESHAPs are a subset of the Clean Air Act. NESHAP's is not considered to be ARAR as discussed above.
National Primary Drinking Water Standards 40 CFR Part 141 FR 8750 (1990)	Establishes maximum contaminant levels (MCLs) for specific contaminants which are health-based standards for public drinking water systems.	No	No	MCLs are applicable for drinking water at the tap and may be relevant and appropriate for drinking water sources. However, remedial action objectives for OU6 as identified in the CD requires reduction in metal loading to the watershed from source areas. Specific numerical performance standards within the OU are not part of the RAO's. Achievement of chemical-specific numerical performance standards will be addressed under the site-wide surface and groundwater operable unit (12). Further, the Leadville water supply located in the Evan's Gulch watershed consistently meets MCL's.
National Secondary Drinking Water Standards 40 CFR Part 143	Establishes secondary maximum contaminant levels (SMCLs) which are non-enforceable guidelines for public drinking water systems to protect the aesthetic quality of the water.	No	No	SMCLs may be applicable for drinking water at the tap and relevant and appropriate for drinking water sources. However, remedial action objectives for OU6 as identified in the CD requires reduction in metal loading to the watershed from source areas. Specific numerical performance standards within the OU are not part of the RAO's. Achievement of chemical-specific numerical performance standards will be addressed under the site-wide surface and groundwater operable unit (12).
Maximum Contaminant Level Goals (MCLGs) PL No. 99-339, 100 Stat. 642 (1986), FR 8750 (1990)	Establishes drinking water quality goals set at a level at which no adverse health effects may arise with an adequate margin of safety.	No	No	MCLGs set above zero levels may be relevant and appropriate at the tap. However, remedial action objectives for OU6 as identified in the CD requires reduction in metal loading to the watershed from source areas. Specific numerical performance standards within the OU are not part of the RAO's. Achievement of chemical-specific numerical performance standards will be addressed under the site-wide surface and groundwater operable unit (12).
RCRA Land Disposal Restrictions (LDRs) (40 CFR Part 268)		No	No	RCRA LDRs are not applicable to mine wastes because the materials have been identified as extraction or beneficiation wastes that are specifically exempted from the definition of a hazardous waste. Further, waste placement pre-dates the RCRA. A discussion of LDR's as ARAR for treatment residuals (water plant sludge and impoundment sediment) is provided under Action-Specific ARAR's.
Identification and Listing of Hazardous Wastes 40 CFR Part 261	Identifies those solid wastes which are subject to regulation as hazardous wastes under Parts 262 through 265, 268, and Parts 270, 271, and 124, and which are subject to the notification requirements of Section 3010 of Resource Conservation and Recovery Act of 1976 (RCRA).	No	No	Mine wastes are not hazardous wastes because the materials have been identified as extraction or beneficiation wastes that are specifically exempted from the definition of a hazardous waste. Further, waste placement pre-dates the RCRA. A discussion of LDR's as ARAR for treatment residuals (water plant sludge and impoundment sediment) is provided under Action-Specific ARAR's.

Table 5-1
Chemical-Specific ARARs

Standard, Requirement or Criteria	Description	Potentially Applicable	Potentially Relevant and Appropriate	Comment
STATE				
Colorado Water Quality Control Act 5-CCR-1002.31 - Basic Standards and Methodologies for Surface Water	Establishes Statewide Water Quality Standards	Yes		State freshwater AWQCs are not considered to be ARAR as the remedial action objectives for OU6 as identified in the CD requires reduction in metal loading to the watershed from source areas. Specific numerical performance standards within the OU are not part of the RAO's. Achievement of chemical-specific numerical performance standards will be addressed under the site-wide surface and groundwater operable unit (12).
Colorado Air Pollution Prevention and Control Act (5 CCR 1001-14 and 5 CCR 1001-10 Part C (I) & (II) Regulation 8)	No	No	No	Current air emissions from undisturbed mine waste are below a level of concern per EPA's Baseline Human health Risk Assessment, Part A (1996). Emissions associated with remedial action are addressed under Action-specific ARARs.

Table 5-2
Location-Specific ARARs

Standard, Requirement or Criteria	Description	Potentially Applicable	Potentially Relevant and Appropriate	Comment
FEDERAL				
E.O.. 11988 Protection of Floodplains (40 CFR 6.302 and Appendix A)	Limits activities in floodplains. Floodplain is defined as "the lowland and relatively flat areas adjoining inland and coastal waters including flood prone areas of off-shore islands, including at a minimum, that area subject to a one percent or greater chance of flooding in any given year." Federal agencies must evaluate the potential effects of actions taken in a floodplain and avoid adverse impacts from remedial activities.	Yes		Portions of OU6 lie within a 100-year floodplain. If remedial activities are conducted within the floodplain, this regulation will be applicable.
E.O.. 11990 Protection of Wetlands (40 CFR 6.302(a) and Appendix A)	Minimizes adverse impacts on areas designated as wetlands.	Yes		Wetlands are present in portions of OU6 as defined in a 1992 study by Woodward Clyde. Regulations are applicable only if remedial activities impact the wetlands areas.
Clean Water Act Section 404 (33 USC 1251, et seq; 40 CFR 230, 231)	Requires Federal agencies to avoid, to the extent possible, adverse impacts associated with destruction or loss of wetlands. Regulates the discharge of dredged or fill material into waters of U.S. Consultation with the Regional Response Team required.	Yes		Wetlands are present in portions of OU6 as defined in a 1992 study by Woodward Clyde. Regulations are applicable only if remedial activities impact the wetlands areas. Dredge and fill substantive requirements will apply if Stray Horse Gulch are determined to be "waters of the United States" or the Arkansas River receive fill material from remedial activities.
Endangered Species Act (16 USC 1531 et seq; 50 CFR 200, 50 CFR 402	Protects endangered species and threatened species and preserves their habitat. Requires coordination with federal agencies for mitigation of impacts.	No	No	Provides protection for threatened and endangered species and their habitats. However, site-specific studies did not document the presence of threatened or endangered species. If threatened or endangered species are encountered during remedial activities in OU6, then requirements of the Act would be applicable.
Fish and Wildlife Coordination Act (16 USC 661 et seq; 40 CFR 6.302(g))	Requires coordination with federal and state agencies on activities affecting/modifying streams or rivers if the activity has a negative impact on fish or wildlife.	Yes	No	Requires coordination with federal and state agencies to provide protection of fish and wildlife in water resource development programs; regulates actions that impound, divert, control, or modify any body of water. If it appears that remedial activities may impact wildlife resources, EPA will coordinate with both the U.S. Fish and Wildlife Service and the Colorado Department of Natural Resources.
Rivers and Harbors Act of 1899: Section 10 (33 USC 403, 33 CFR 320-330)	Section 10 permit required for structures or work in or affecting navigable waters.	No		Stray Horse Gulch, Evans Gulch and Starr Ditch are not considered "navigable rivers."

Table 5-2
Location-Specific ARARs

Standard, Requirement or Criteria	Description	Potentially Applicable	Potentially Relevant and Appropriate	Comment
National Historic Preservation Act (NHPA) (16 USC 470 et seq.; 40 CFR 6.301(b); 36 CFR Part 63, Part 65, Part 800)	Requires the preservation of historic properties included in or eligible for the National Register of Historic Places and to minimize harm to National Historic Landmarks.	Yes		This Act is applicable as OU6 lies within the Leadville National Historic Landmark District. A Programmatic Agreement has been entered into between the EPA, the Advisory Council on Historic Preservation, and the Colorado State Historic Preservation Officer in accordance with Sections 106 and 110(f) of NHPA.
The Historic and Archeological Data Preservation Act of 1974 (16USC 469; 40 CFR 6.301(c))	Establishes procedures to provide for preservation of historical and archeological data which might be destroyed through alteration of terrain as a result of a federal construction project or a federally licensed activity program.	Yes		Establishes procedures to provide for preservation of historical and archeological data which might be destroyed through alteration of terrain as a result of a federal construction project or a federally licensed activity program. A cultural resource survey was completed in OU6 to identify historic properties which may be affected by removal activity.
E.O.. 11593 Protection and Enhancement of the Cultural Environment (16 USC 470)	Federal agencies directed to institute procedures to ensure programs contribute to the preservation and enhancement of non-federally owned historic resources. Consultation with the Advisory Council on Historic Preservation required.	Yes		This Act is applicable as OU6 lies within the Leadville National Historic Landmark District. A Programmatic Agreement has been entered into between the EPA, the Advisory Council on Historic Preservation, and the Colorado State Historic Preservation Officer in accordance with Sections 106 and 110(f) of NHPA.
The Archeological Resources Protection Act of 1979 (16 USC 470aa-470ll)	Requires a permit for any excavation or removal of archeological resources from public lands or Indian lands.	No	Yes	May be relevant and appropriate if any remedial activity involves removal of archeological resources; substantive requirements need to be met.
The Historic Sites Act of 1935 (16 USC 461-467)	Enables the National Park Service to preserve historic resources for public use.	No	No	May be "applicable" if remedial activities impact areas eligible for inclusion in the Nation Register of Historic Places.
Wilderness Act (16 USC 1311, 16 USC 668; 50 CFR 53, 50 CFR 27)	Limits activities within areas designated as wilderness areas or National Wildlife Refuge Systems.	No	No	The site is not within a federally-owned area designated as a wilderness area or a National Wildlife Refuge System.
Wild & Scenic Rivers Act (16 USC 1271; 40 CFR 6.302(e))	Protects rivers that are designated as wild, scenic, or recreational.	No	No	The Arkansas River is not listed as a Wild and Scenic River.
Resource Conservation and Recovery Act (RCRA), Subtitle D (40 CFR 258.10-15)	Facilities where treatment, storage, or disposal of solid waste will be conducted must meet certain location standards. These include location restrictions on proximity to airports, floodplains, wetlands, fault areas, seismic impact zones, and unstable areas.	Yes		Applicable if interim storage, treatment, and disposal is conducted as part of the OU6 remedial action.

Table 5-2
Location-Specific ARARs

Standard, Requirement or Criteria	Description	Potentially Applicable	Potentially Relevant and Appropriate	Comment
STATE				
Colorado Historical, Prehistorical and Archeological Resources Act (Colorado Revised Statutes, Title 24, Article 80, Sections 401-411)	Establishes procedures and requires a permit for investigation, excavation, gathering, or removal from the natural state of any historical, prehistorical, or archeological resources on state lands for the benefit of recognized scientific or educational institutions. Also requires an excavation permit and notification if human remains are found on state land.	No	No	No State lands included.
Register of Historic Places (Colorado Revised Statues, Title 24, Article 80, Sections 101-108)	Establishes requirements for protecting properties of historical significance.	Yes		May be applicable if remedial actions impact any property listed on the Register of Historic Places.
Colorado Non-game, Endangered, or Threatened Species Act (Colorado Revised Statutes, Title 33, Article 2, Sections 101-108)	Protects endangered and threatened species and preserves their habitats. Requires coordination with the Division of Wildlife if remedial activities impact on state-listed endangered/threatened species or their habitat.	No	No	Standards for regulation of non-game wildlife and threatened and endangered species. Site-specific studies did not document the presence of threatened or endangered species. If threatened or endangered species are encountered during remedial activities at OU6, then requirements of Act will be applicable.
Colorado Species of Special Concern and Species of Undetermined Status (Colorado Division of Wildlife Administrative Directive E-1, 1985, modified)	Protects animals listed on the Colorado Division of Wildlife generated list. Coordination with the Division of Wildlife is strongly urged if animal species are to be impacted.	No	No	Protects species listed on the Colorado Division of Wildlife generated list. Urges coordination with the Division of Wildlife if wildlife species are to be impacted. No evidence of species of special concern have been identified at this site.
Colorado Natural Areas (Colorado Revised Statutes, Title 33, Article 33, Section 104)	The Colorado Natural Areas Program maintains a list of plant species of special concern for the State. Although not protected by State statute, coordination with Division of Parks and Outdoor Recreation is recommended if activities will impact listed species.	No	No	Maintains a list of plant species of "special concern." Although not protected by State statute, coordination with Division of Parks and Outdoor Recreation is recommended if activities will impact listed species.
State Solid Waste Disposal Sites and Facilities Act (Colorado Revised Statutes, Title 30, Article 20, Sections 101-118; 6 CCR 1007-2)	Establishes regulations for solid waste management facilities including location standards.	Yes		Applicable if remedial activities involve the disposal of solid waste materials. Permits are not required for onsite activities at a site listed on the NPL.
Colorado Wildlife Act (Colorado Revised Statutes, Title 33, Article 1, Sections 101-120)	Establishes provisions governing the taking, possession, and use of wildlife and migratory birds.	No	No	Remedial actions being considered will not involve any taking, possession, or use of wildlife and migratory birds.

Table 5-3
Action-Specific ARARs

Standard, Requirement or Criteria	Description	Potentially Applicable	Potentially Relevant and Appropriate	Comment
FEDERAL				
Clean Water Act (33 USC Sect. 1351-1376) Ambient Water Quality Criteria (40 CFR Part 131; Quality Criteria for Water, 1976, 1980, 1986, 1987; Ambient Water Quality Criteria for Selenium, 1987)	Requires EPA and states to establish ambient water quality control criteria (AWQC) and standards, respectively, for surface water based on use classifications and the criteria stated under Sections 304(a) and 303 of the Clean Water Act.	Yes		Federal (or State) freshwater AWQCs may be applicable to discharges from water treatment facilities if they are a part of the remedial action in OU6. Non-point source discharges during construction would be mitigated through an Erosion Control Plan.
Clean Air Act (42 USC Sect. 7401-7642) New Source Performance Standards (40 CFR 60)	Establishes emission standards for certain categories of industrial stationary sources.	No	No	National ambient air quality standards (NAAQS) are implemented through the New Source Review Program and State Implementation Plans (SIPs). The federal New Source Review program address only major sources. Emissions associated with the proposed remedial action in OU6 will be limited to fugitive dust emissions associated with earth moving activities during construction and will occur in isolated areas over a short period of time. Remedial work in OU6 will be completed in industrial zoned areas significant distances from residential areas. These remedial activities will not constitute a major source. Therefore, attainment and maintenance of NAAQS pursuant to the New Source Review Program are not ARARs. See Colorado Air Pollution Prevention and Control Act concerning the applicability of requirements implemented through the SIP.
Solid Waste Disposal Act (SWDA) as amended by the Resource Conservation and Recovery Act of 1976 (RCRA) (42 USC Sect. 6901-6987) Criteria for Classification of Solid Waste Disposal Facilities and Practices (Subtitle D) (40 CFR Part 257)	Establishes criteria for use in determining which solid waste disposal facilities and practices pose a reasonable probability of adverse effects on health.	Yes		May be applicable to stockpiling, treatment, and disposal of non-hazardous solid waste. Selected portions of Part 257 pertaining to floodplains and air are applicable. These provisions establish criteria for classification of solid waste disposal facilities and practices. Permits are not required for on-site activities at a site listed on the NPL.
Solid Waste Closure (40 CFR 259.60 b, c, h, I, j)	Placement of Cap over solid waste landfill	Yes		May be applicable to remedial activities involving the construction of a non-hazardous landfill. Permit not required for CERCLA sites.
Identification and Listing of Hazardous Wastes (Subtitle C) 40 CFR part 261	Defines those solid wastes which are subject to regulation as hazardous wastes under 40 CFR Parts 262-265 and Parts 124, 270, and 271.	Yes		Applicable if remedial action involves generation of hazardous waste (water treatment residuals).
Standards Applicable to Generators of Hazardous Waste (Subtitle C) 40 CFR Part 262	Establishes standards for generators of hazardous waste.	Yes		Applicable if remedial action involves off-Site disposal or treatments of hazardous materials.
Standards Applicable to Transporters of Hazardous Waste (Subtitle C) 40 CFR Part 263	Establishes standards which apply to persons transporting hazardous waste within the US if the transportation requires a manifest under 40 CFR Part 262.	Yes		Applicable if remedial action involves off-Site transportation of hazardous waste (water treatment residuals).

Table 5-3
Action-Specific ARARs

Standard, Requirement or Criteria	Description	Potentially Applicable	Potentially Relevant and Appropriate	Comment
Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities (Subtitle C) 40 CFR Part 264	Establishes minimum national standards which define the acceptable management of hazardous waste for owners and operators of facilities which treat, store, or dispose hazardous waste.	Yes		Applicable if remedial action involves on-site storage, treatment, or disposal of hazardous waste (water treatment residuals).
Interim Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities (Subtitle C) 40 CFR Part 265	Establishes minimum national standards which define the acceptable management of hazardous waste during the period of interim status and until certification of final closure or if the facility is subject to post-closure requirements, until post-closure requirements, until post-closure responsibilities are fulfilled..	Yes		Applicable if remedial action involves on-site storage, treatment, or disposal of hazardous waste (water treatment residuals).
Land Disposal 40 CFR Part 268	Establishes a timetable for restriction of burial of wastes and other hazardous materials.	Yes		Applicable if the remedial action involves land disposal of regulated waste.
Hazardous Materials Transportation Act (49 USC Sect. 1801-1813; 49 CFR Parts 107, 171-177)	Regulates transportation of hazardous materials.	Yes		Applicable if remedial action entails the off-site transportation of hazardous materials (water treatment residuals).
Underground Injection Control Regulations 40 CFR 144-147	Provides for protection of underground sources of drinking water.	Yes		Applicable if remedial action involves the injection of contaminated surface water to groundwater.
National Pollutant Discharge Elimination System 40 CFR parts 122, 125	Requires permits for the discharge of pollutants from any point source into waters of the United States	Yes		Applicable if the remedial action involves discharge to surface waters located off-Site or relevant and appropriate for discharges to on-Site surface water.
Guidelines establishing Test Procedures for the Analysis of Pollutants 40 CFR 136	Specific analytical procedures for NPDES applicants and reports.	Yes		Applicable if contaminants are released to surface waters or if treated surface water is discharged to surface waters.

Table 5-3
Action-Specific ARARs

Standard, Requirement or Criteria	Description	Potentially Applicable	Potentially Relevant and Appropriate	Comment
STATE				
Environmental Covenants (CRS 25-15-317-327)	Requires environmental convenant whenever contamination left in place requires restrictions on land use.	Yes		Potentially Applicable.
Colorado Water Quality Control Act 5-CCR-1002.31 - Basic Standards for Surface Water	Assigns State-wide Water Quality Standards	Yes		State freshwater AWQCs may be applicable to discharges from water treatment facilities if they are a part of the remedial action in OU6. Non-point source discharges during construction would be mitigated through an Erosion Control Plan. CRS 28-8-101 and Colorado Discharge Permit System Regulations (5CCR 1002.61) are also potentially applicable to control discharges from treatment facilities.
State Solid Waste Disposal Sites and Facilities Act (CRS 30-20-101 to 118) Colorado Solid Waste Management Regulations (6CCR 1007-2)	Establishes policy for licensing, locating, constructing, and operating of solid waste facilities.	No	Yes	May be relevant and appropriate to stockpiling, treatment, and disposal of non-hazardous solid waste. Permits are not required for on-site activities at a site listed on the NPL.
Colorado Mined Land Reclamation Act (CRS 34-32-101 to 125) Mineral Rules and Regulations (2CCR 407-1)	Regulates all aspects of land use for mining, including the location of mining operations and related reclamation activities and other environmental and socio-economic impacts.	No	Yes	May be relevant and appropriate to remedial activities involving drilling, water control measures, and treatment and disposal of waste piles. Permit not required for CERCLA sites.
Colorado Air Quality Control Act (5CCR 1001-1, 3, 4, 5, 8, 10)	Establishes emissions standards for PM10 and lead.	Yes		Pursuant to the Colorado Air Pollution Prevention and Control Act, applicants for construction permits are required to evaluate whether the proposed source will exceed NAAQS. Applicants are also required to evaluate whether the proposed activities would cause the Colorado ambient standard for PM10 to be exceeded. Remedial work in OU6 will be completed in industrial zoned areas significant distances from residential areas. Colorado regulates fugitive emissions through Regulation No. 1. Compliance with applicable provisions of the Colorado air quality requirements will be achieved by adhering to a fugitive emissions control plan prepared in accordance with Regulation No. 1. Regulation 8 sets emission limits for lead. Applicants are required to evaluate whether the proposed activities would result in the Regulation 8 lead standard being exceeded. The proposed remedial action in OU6 is not projected to exceed the emission levels for lead, although some lead emissions may occur. Compliance with Regulation 8 will be achieved by adhering to a fugitive be achieved by adhering to a fugitive emissions control plan prepared in accordance with Regulation No. 1. The substantive requirements of Regulation 3 are potentially applicable.
Colorado Noise Abatement Act (CRS 25-12-101 to 108)	Establishes maximum permissible noise levels for particular time periods and land use zones	Yes		Applicable to remedial activities involving construction activities.

Table 5-3
Action-Specific ARARs

Standard, Requirement or Criteria	Description	Potentially Applicable	Potentially Relevant and Appropriate	Comment
Regulations on the Collection of Aquatic Life (2CCR 406-8, Ch.13, Article III, Section 1316)	Requirements governing the collection of wildlife for scientific purposes.	No	No	Remedial actions will not trigger the need for biological monitoring.
Colorado Hazardous Waste Regulations (6 CCR 1007-3, Part 264: Section 264.301, (g), (h), (l), and (j); Section 264.310, (a)(1) through (a)(4); Section 264.310, (b)(1) and (b)(5))		Yes	No	These specific provisions of the hazardous waste regulations may be applicable for conducting remedial actions and handling of water treatment residuals. These provisions may also be potentially relevant and appropriate for actions involving the conveyance or storage of ARD. However, the determination will be based on best professional judgment.

TARGET SHEET

EPA REGION VIII

SUPERFUND DOCUMENT MANAGEMENT SYSTEM

DOCUMENT NUMBER: 2000128

SITE NAME: CALIFORNIA GULCH

DOCUMENT DATE: 09/01/2002

DOCUMENT NOT SCANNED

Due to one of the following reasons:

☐ PHOTOGRAPHS

☐ 3-DIMENSIONAL

☐ OVERSIZED

☐ AUDIO/VISUAL

☐ PERMANENTLY BOUND DOCUMENTS

☐ POOR LEGIBILITY

☐ OTHER

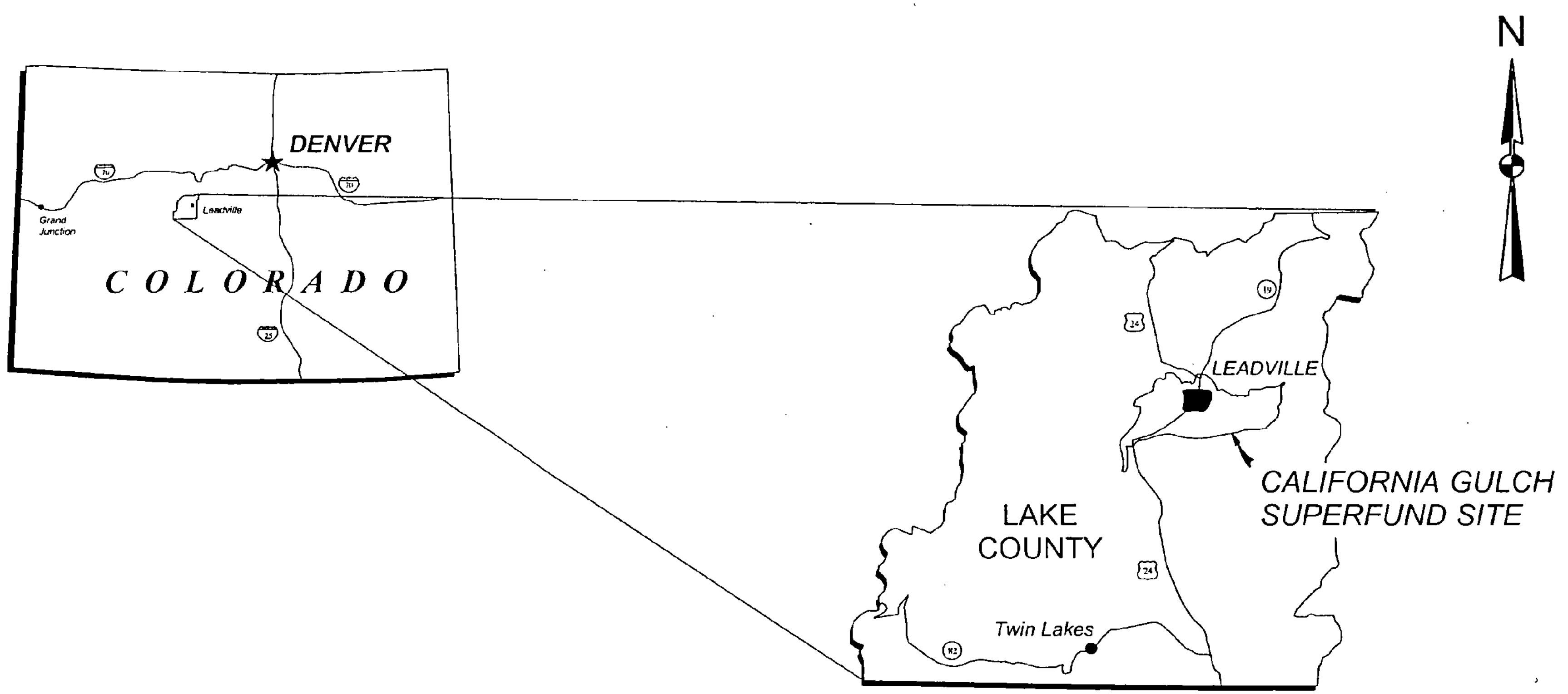
☐ NOT AVAILABLE

☑ TYPES OF DOCUMENTS NOT TO BE SCANNED
(Data Packages, Data Validation, Sampling Data, CBI, Chain of Custody)

DOCUMENT DESCRIPTION:

TABLES 6-1 and 6-2, 7-1, 8-1 and 8-2

Contact the Superfund Records Center to view available document.
(303) 312-6473



NOTES:

1. Figure after CDM Federal Programs Corporation Engineering Evaluation/Cost Analysis for Stray Horse Gulch, OU6, California Gulch NPL Site, Leadville, Colorado, June 1997.

HDR Engineering, Inc.

SITE LOCATION MAP

CALIFORNIA GULCH OU6
FOCUSED FEASIBILITY STUDY

DATE: SEPT., 2002

FIGURE 1-1

Color Chart(s)

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

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

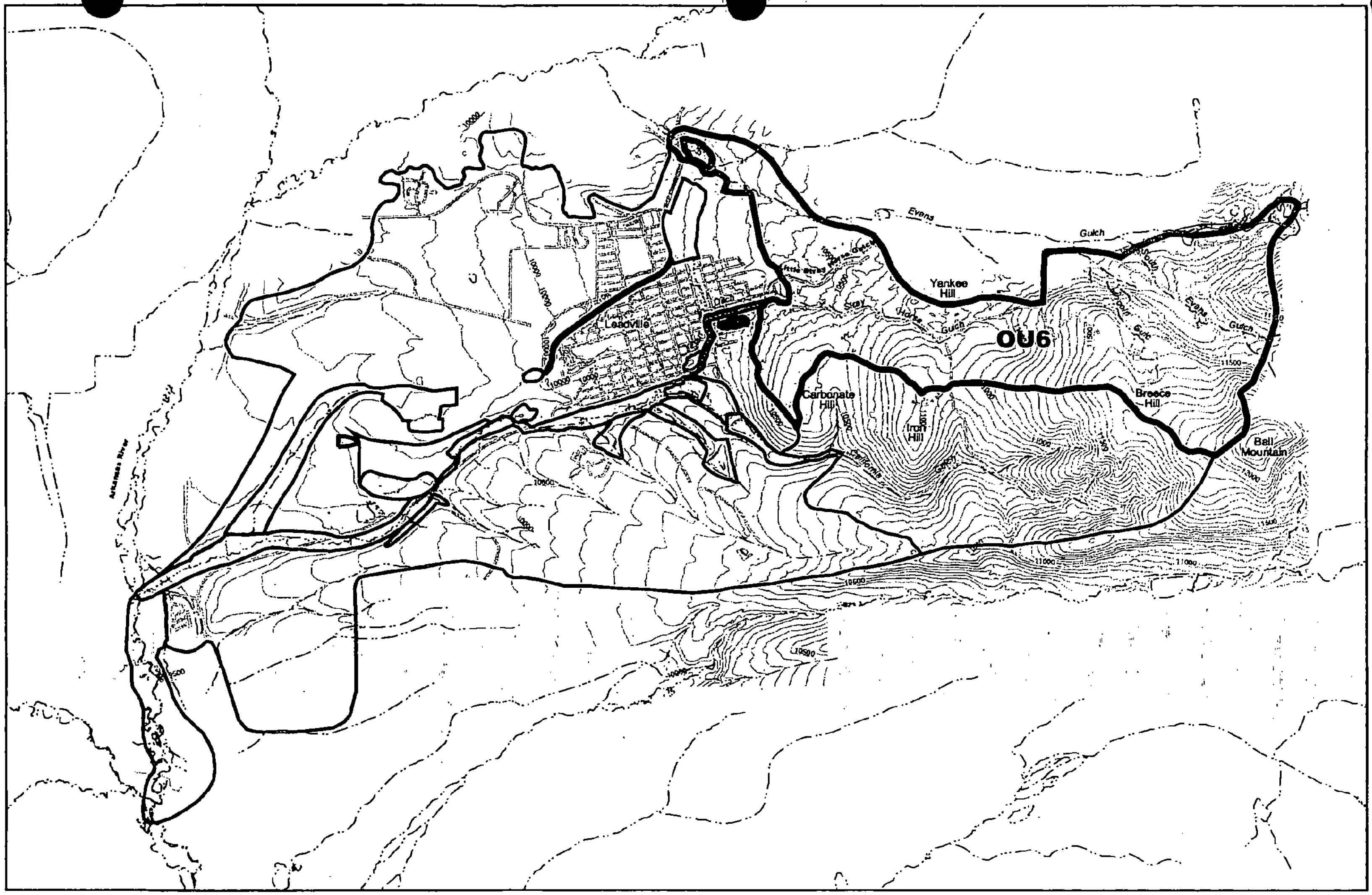


Figure adapted from GIS Database provided by USEPA Region 8.

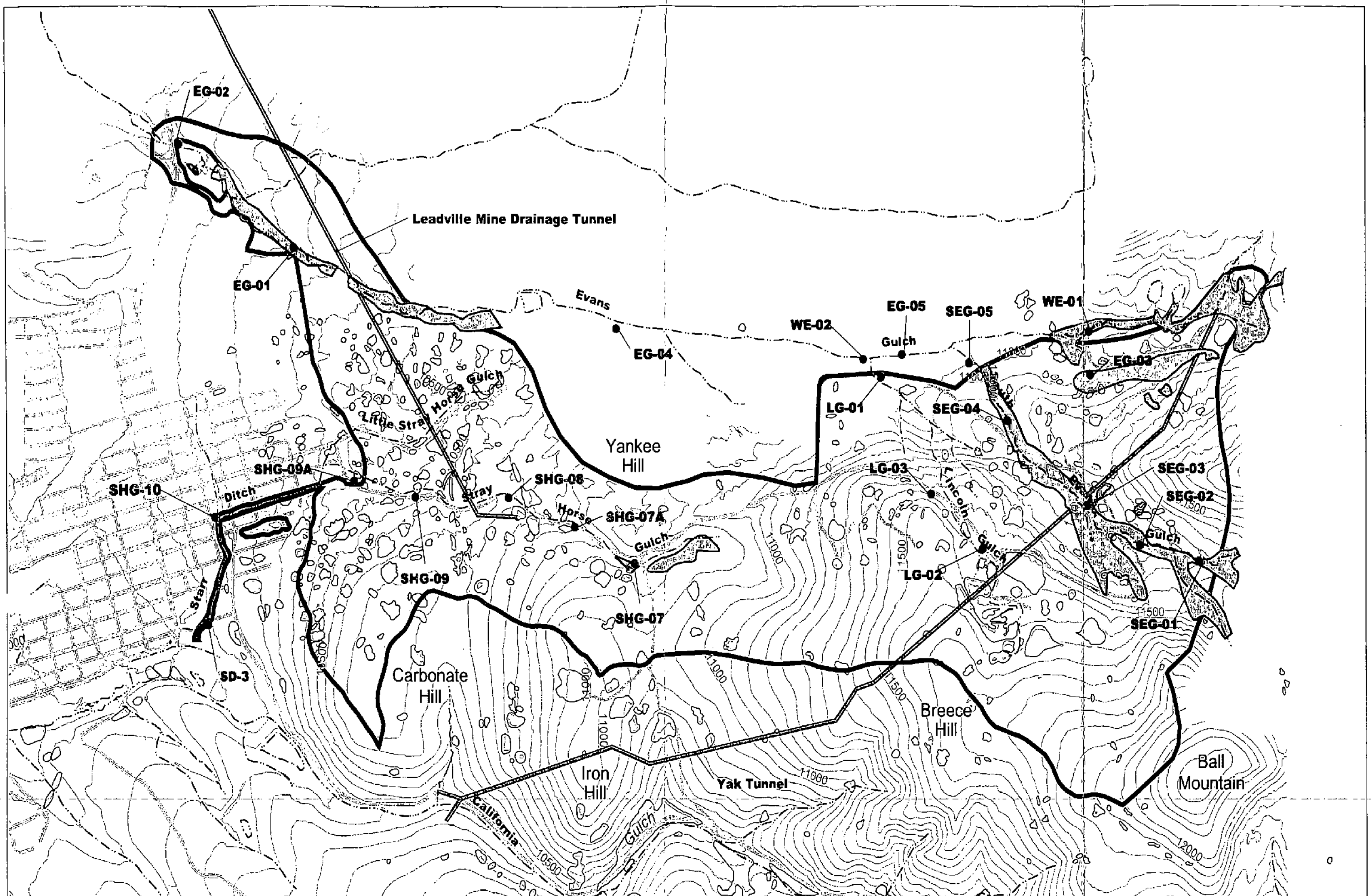
HDR Engineering, Inc.

CALIFORNIA GULCH
SUPERFUND SITE MAP

CALIFORNIA GULCH OU6
FOCUSED FEASIBILITY STUDY

DATE: SEPT., 2002

FIGURE 1-2



NOTES:

1. Wetland areas from Woodward-Clyde 1992 study.
2. Figure adapted from GIS Database provided by USEPA Region 8.

LEGEND

- Wetland Areas
- Sampling Station Location
- Contour (50' Interval)
- OU6 Boundary
- Major Drainages
- Paved Roads
- Mine Waste Piles
- Drainage Tunnel

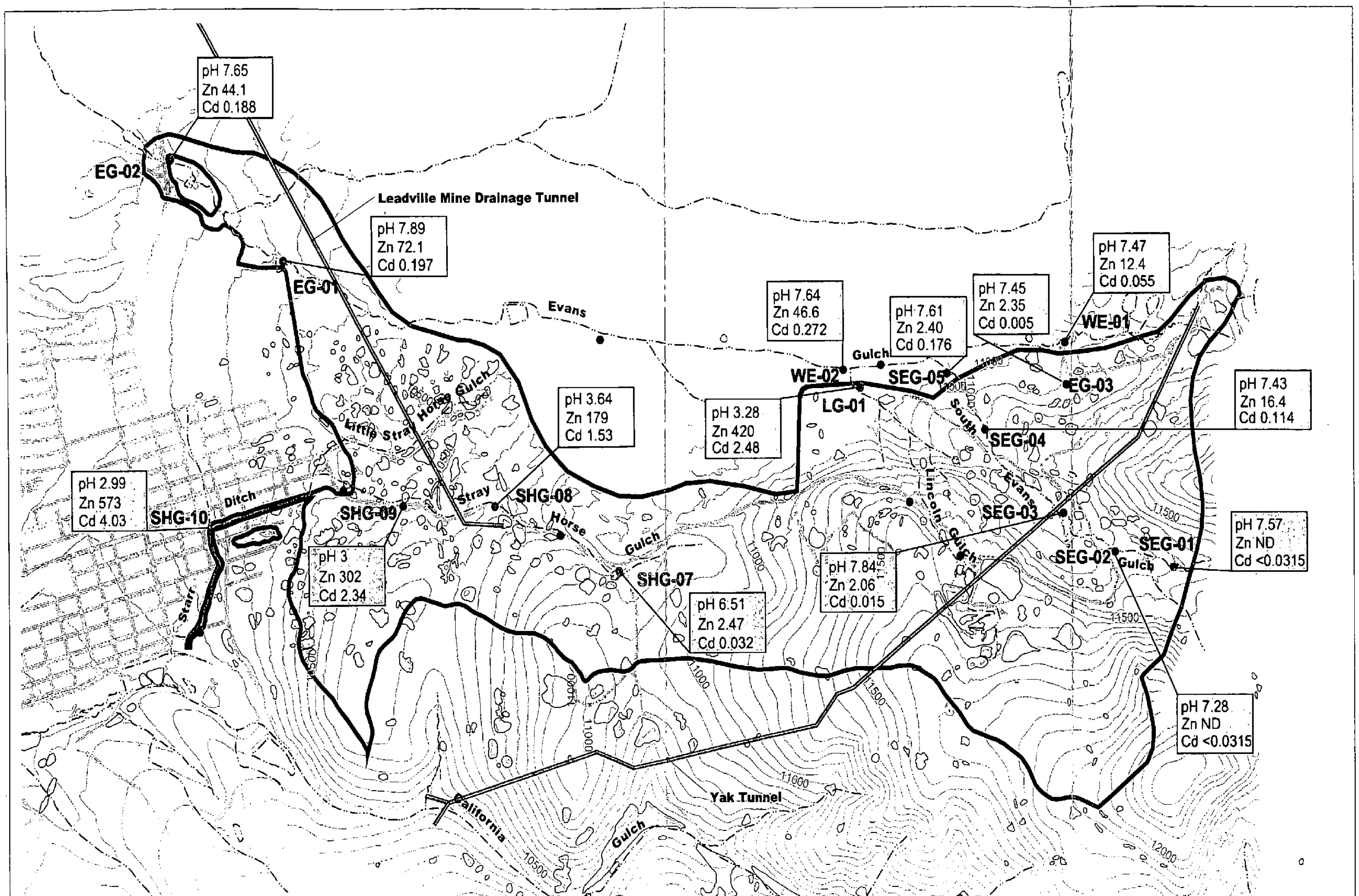
HDR Engineering, Inc.

SURFACE WATER FEATURES AND WETLAND AREAS

CALIFORNIA GULCH OU6 FOCUSED FEASIBILITY STUDY

DATE: SEPT., 2002

FIGURE 2-1



NOTES:

1. Loading and pH values obtained from Phase I: Feasability Study, Water and Sediment Sampling and Hydrologic Measurement Program, Results and Findings, 1995 Spring Runoff for Operable Unit 6, Bureau of Reclamation, Nov. 1996.
2. Figure adapted from GIS Database provided by USEPA Region 8.
3. Loading rates (lbs/day) calculated from BOR kg/wk data from 1995 snowmelt period.

LEGEND

- ● Sampling Station Location
- WE-01 Station ID
- pH 7.47 Median pH values, from 1995 snowmelt runoff
- Zn 39.5 Median flow-weighted total zinc loading, from 1995 snowmelt runoff, lbs/day
- Cd 0.174 Median flow-weighted total cadmium loading, from 1995 snowmelt runoff, lbs/day
- Note: "ND" = Element not detected in sample
- OU6 Boundary
- Major Drainages
- Paved Roads
- Mine Waste Piles
- Drainage Tunnel
- Contour (50' Interval)

1000 0 1000 2000 Feet

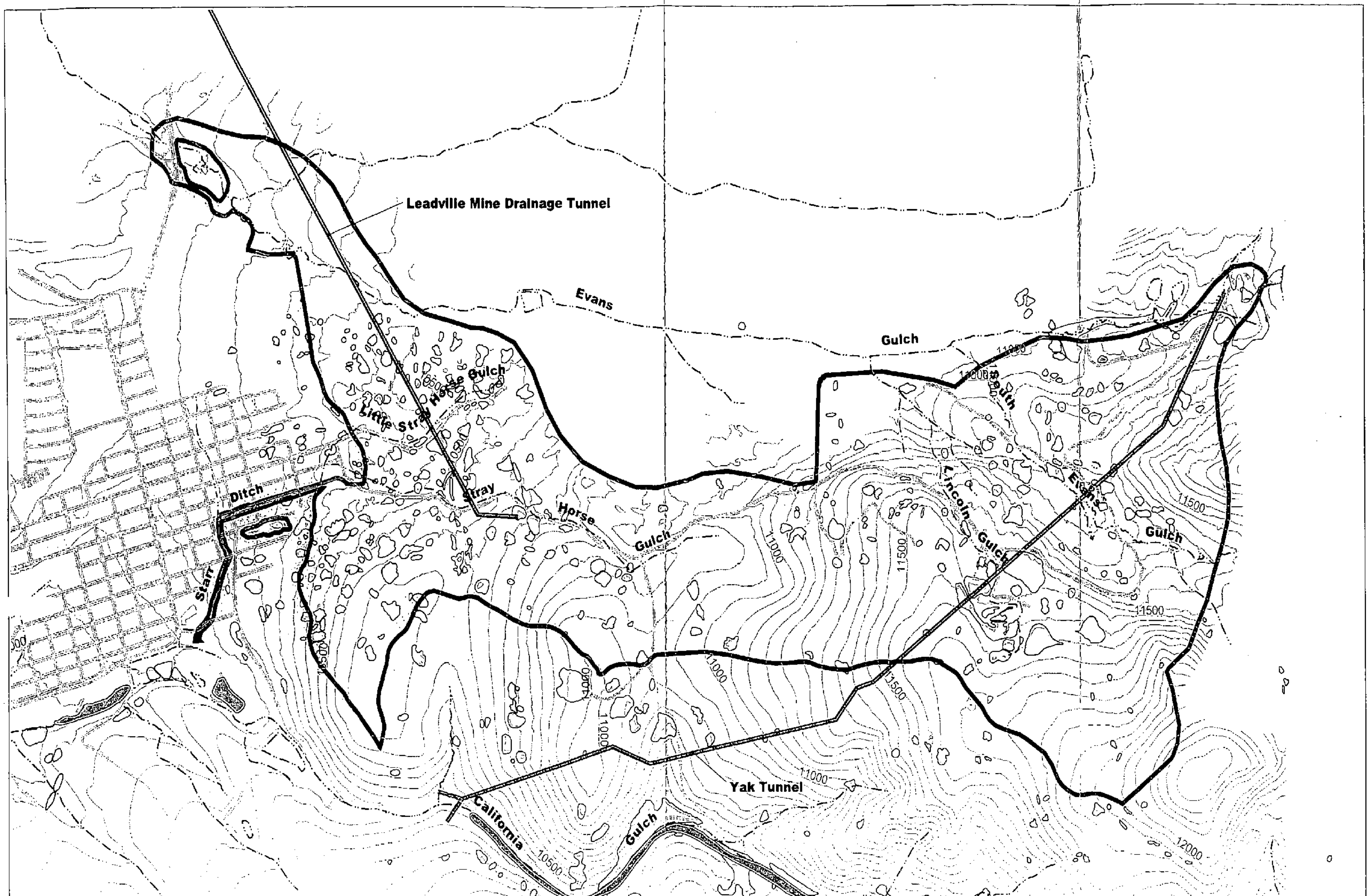
HDR Engineering, Inc.

PRE-REMEDIAL 1995 SURFACE WATER CONTAMINANT LOADING

CALIFORNIA GULCH OU6
FOCUSED FEASIBILITY STUDY

DATE: SEPT., 2002

FIGURE 2-2



Notes:

1. Figure adapted from GIS Database provided by USEPA Region 8.

LEGEND

- Fluvial Tailings
- Contour (50' Interval)
- OU6 Boundary
- Major Drainages
- Paved Roads
- Mine Waste Piles
- Drainage Tunnel

1000 0 1000 2000 Feet

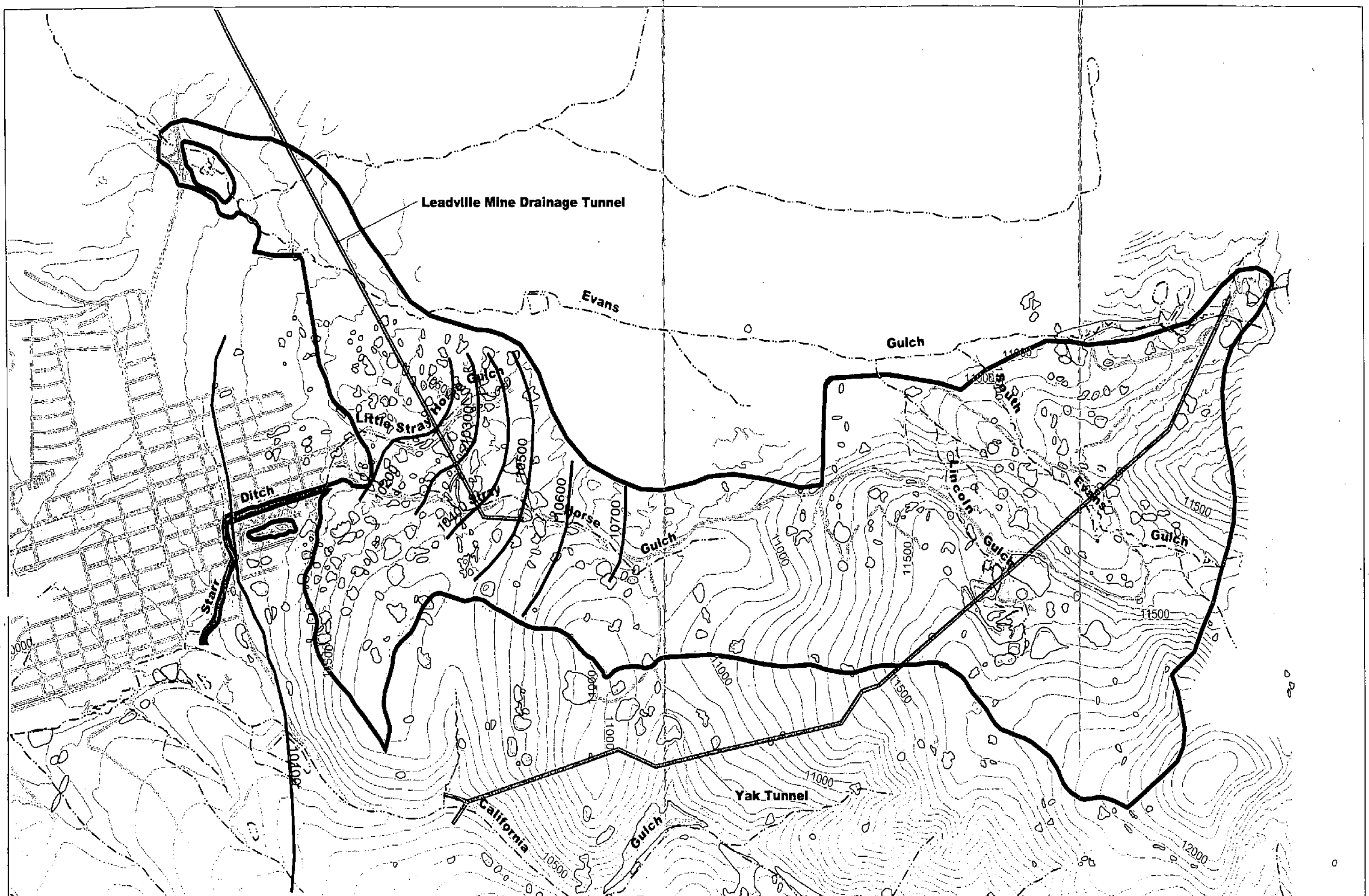
HDR Engineering, Inc.

FLUVIAL TAILINGS LOCATIONS

CALIFORNIA GULCH OU6
FOCUSED FEASIBILITY STUDY

DATE: SEPT., 2002

FIGURE 2-3



NOTES:

1. Aquifer contours obtained from Woodward-Clyde 1992 data.
2. Figure adapted from GIS Database provided by USEPA Region 8.

LEGEND

- Drainage Tunnel
- Contour (50' Interval)
- OU6 Boundary
- Major Drainages
- Paved Roads
- Mine Waste Piles
- Alluvial Aquifer Water Table Contours

1000 0 1000 2000 Feet

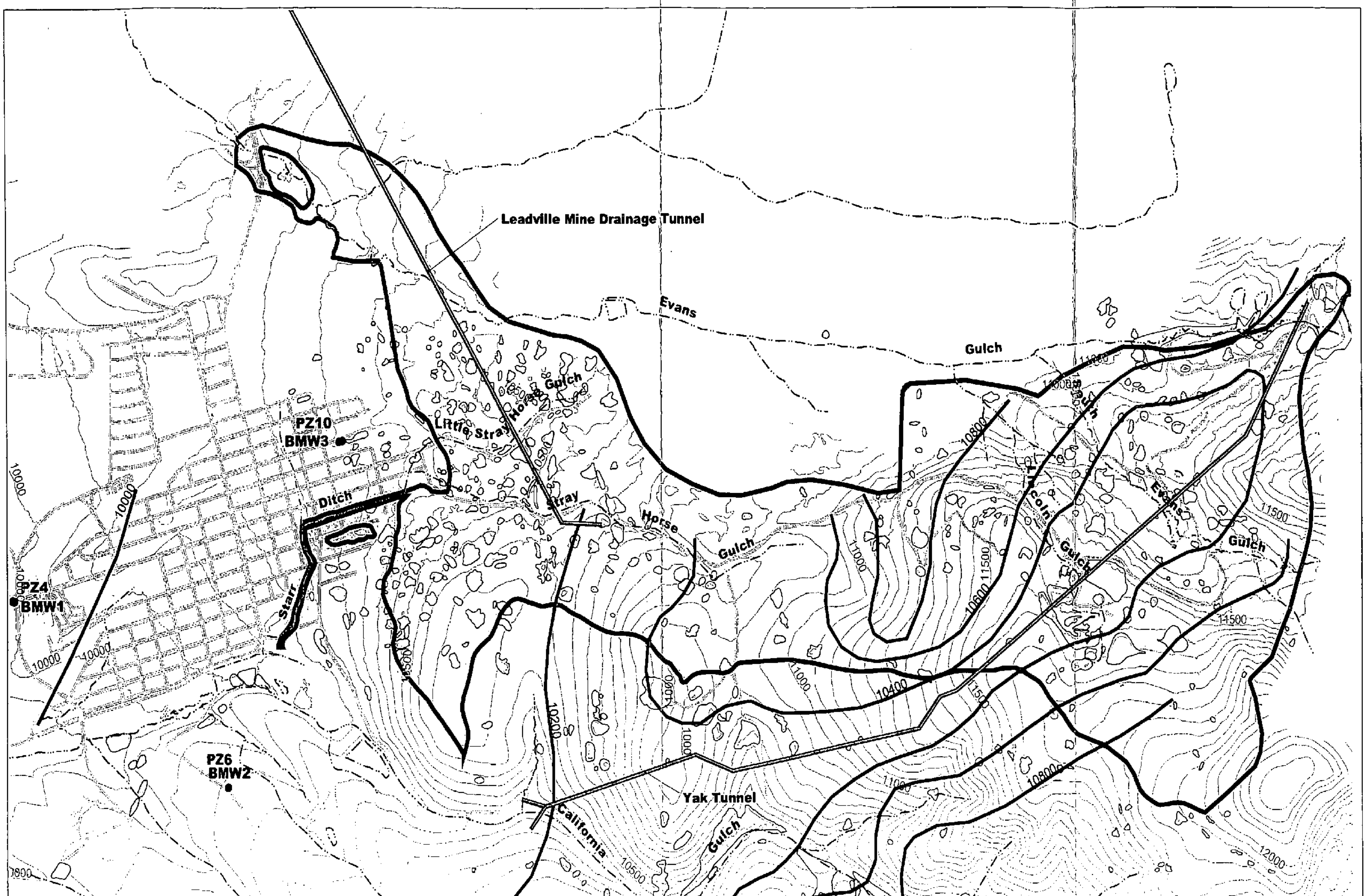
HDR Engineering, Inc.

ALLUVIAL AQUIFER WATER TABLE CONTOURS

CALIFORNIA GULCH OU6
FOCUSED FEASIBILITY STUDY

DATE: SEPT., 2002

FIGURE 2-4



NOTES:

1. Aquifer contours obtained from Woodward-Clyde 1992 data.
2. Figure adapted from GIS Database provided by USEPA Region 8.

LEGEND

- Drainage Tunnel
- PZ4 / BMW1 Well Pair Locations
- Contour (50' Interval)
- OU6 Boundary
- Major Drainages
- Paved Roads
- Mine Waste Piles
- Potentiometric Surface Contours

1000 0 1000 2000 Feet

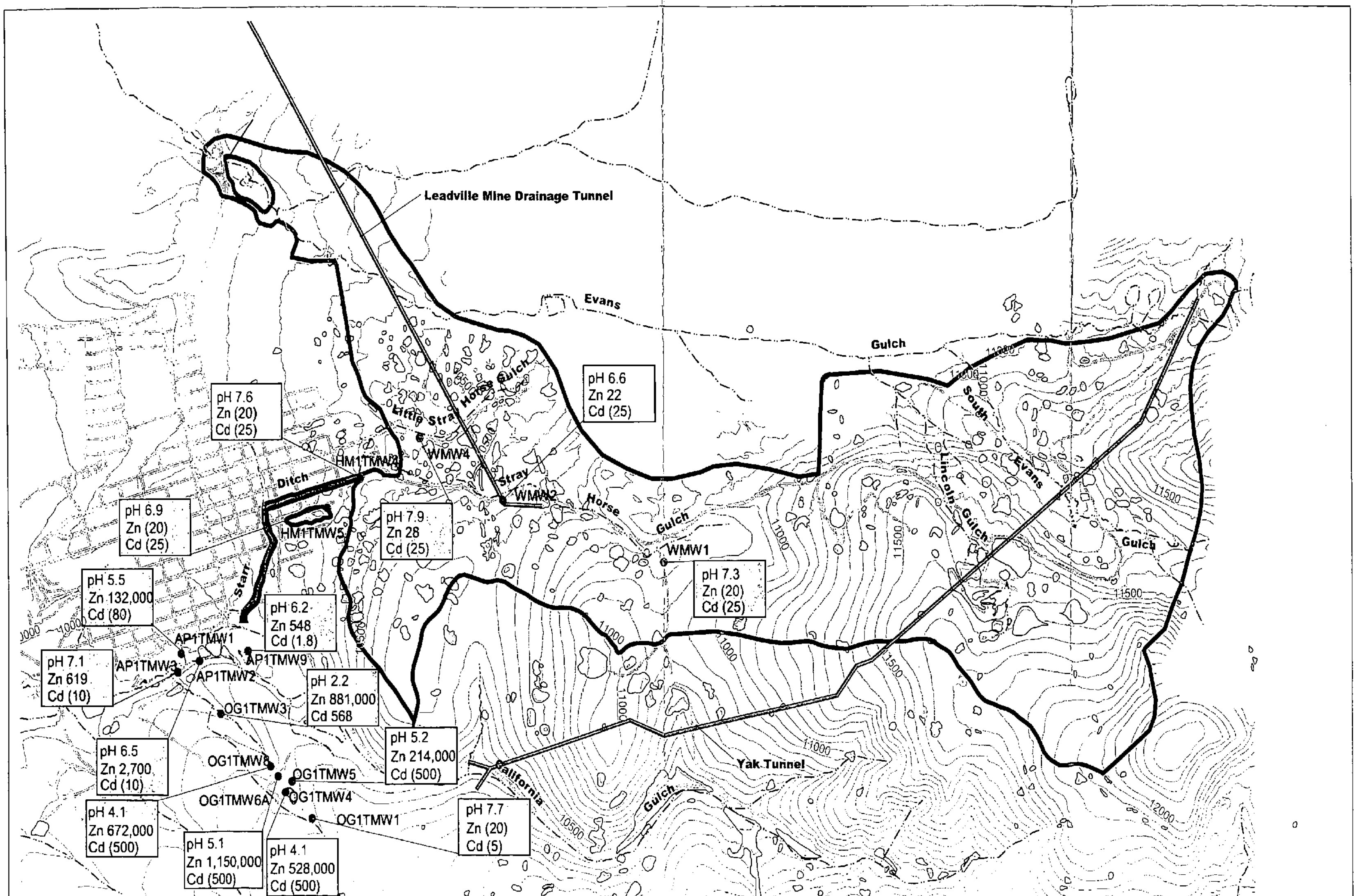
HDR Engineering, Inc.

POTENTIOMETRIC SURFACE CONTOURS OF BEDROCK AQUIFER

CALIFORNIA GULCH OU6 FOCUSED FEASIBILITY STUDY

DATE: SEPT., 2002

FIGURE 2-5



NOTES:

1. Figure adapted from GIS Database provided by USEPA Region 8.
2. Groundwater chemistry from Woodward-Clyde 1992 data.

LEGEND

- ● Groundwater Monitoring Location
- WMW1 Station ID
- pH 5.5 Average pH values, from based on sampling data collected Nov. 1991 to Jan. 1992
- Zn (80) Average dissolved Zinc concentration based on sampling data collected Nov. 1991 to Jan. 1992, ug/L
- Cd 132,000 Average dissolved Cadmium concentration based on sampling data collected Nov. 1991 to Jan. 1992, ug/L

Note: (80) = Not detected-value given is reporting limit in ug/L

- OU6 Boundary
- Major Drainages
- Paved Roads
- Mine Waste Piles
- Drainage Tunnel
- Contour (50' Interval)

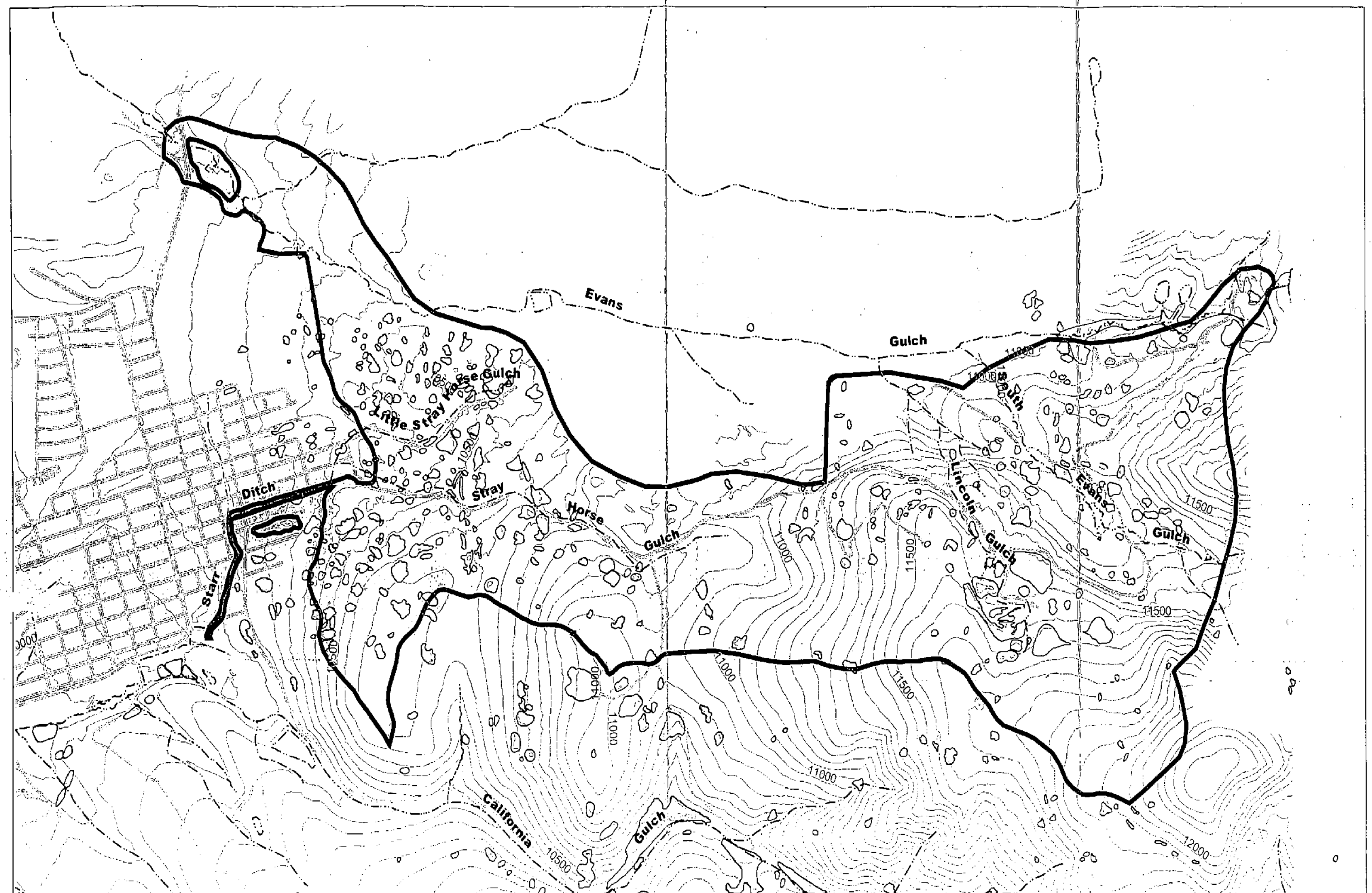
HDR Engineering, Inc.

BEDROCK AQUIFER
GROUNDWATER CHEMISTRY
NOV. 1991-JAN. 1992

CALIFORNIA GULCH OU6
FOCUSED FEASIBILITY STUDY

DATE: SEPT., 2002

FIGURE 2-6



NOTES:
1. Figure adapted from GIS Database provided by USEPA Region 8.

LEGEND
- OU6 Boundary
- Major Drainages
- Paved Roads
- Mine Waste Rock Piles
- Contour (50' Interval)

1000 0 1000 2000 Feet

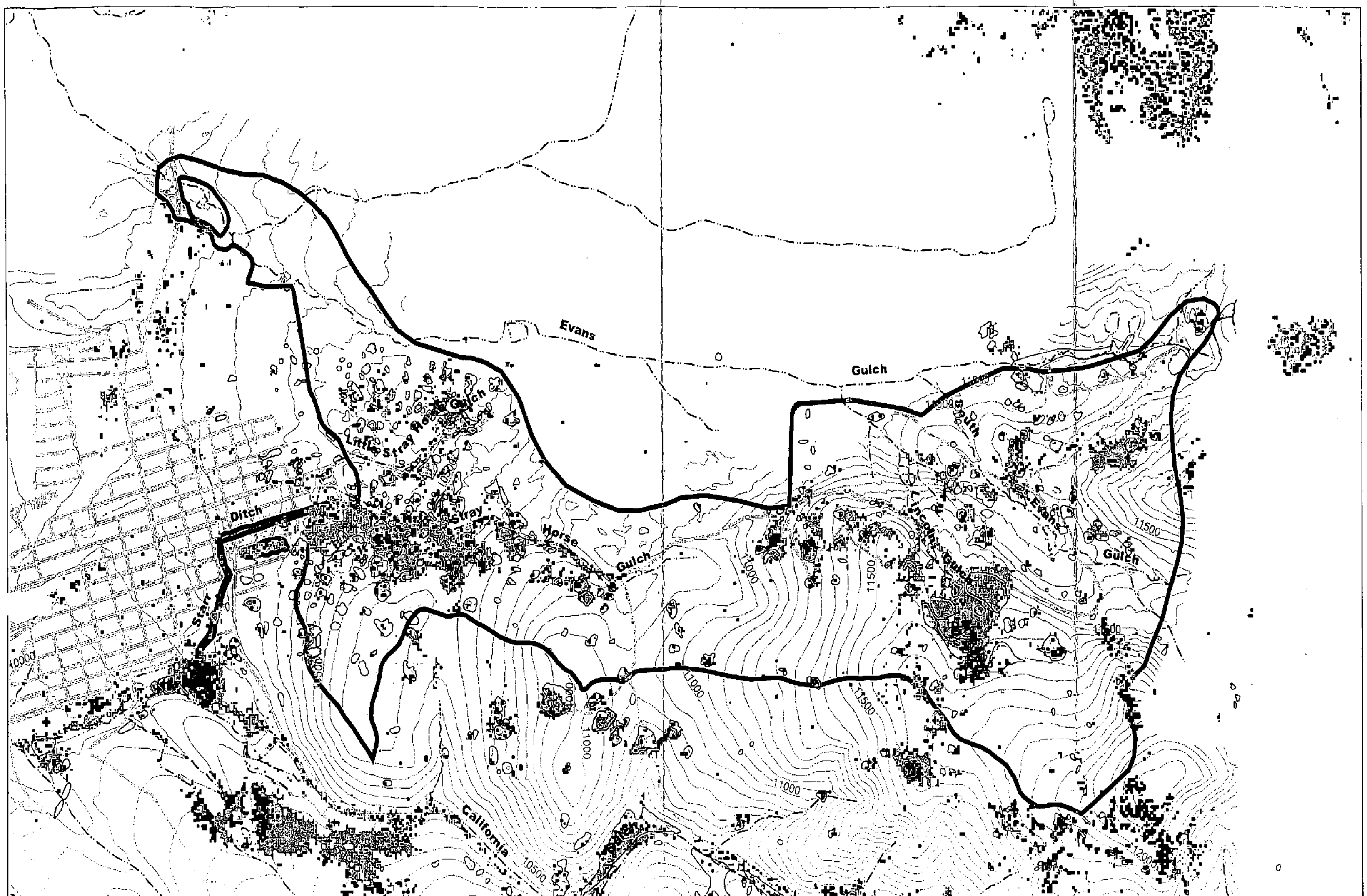
HDR Engineering, Inc.

WASTE ROCK PILE LOCATIONS

CALIFORNIA GULCH OU6
FOCUSED FEASIBILITY STUDY

DATE: SEPT., 2002

FIGURE 2-7



Notes:

1. Figure adapted from GIS Database provided by USEPA Region 8.
2. Formulas from Fleischer, 1980.

LEGEND

Highly Acidic Mineral Assemblages	Acidic to Neutral Mineral Assemblages	
Pyrite FeS_2	Goethite $FeO(OH)$	OU6 Boundary
Jarosite $KFe_3(SO_4)_2(OH)_6$	Hematite 1 Fe_2O_3	Major Drainages
Jarosite + Geothite Areal Mix	Hematite 2 Fe_2O_3	Paved Roads
	Amorphous Fe-Hydroxide $Fe(OH)_3$	Mine Waste Piles
		Contour (50' Interval)

1000 0 1000 2000 Feet

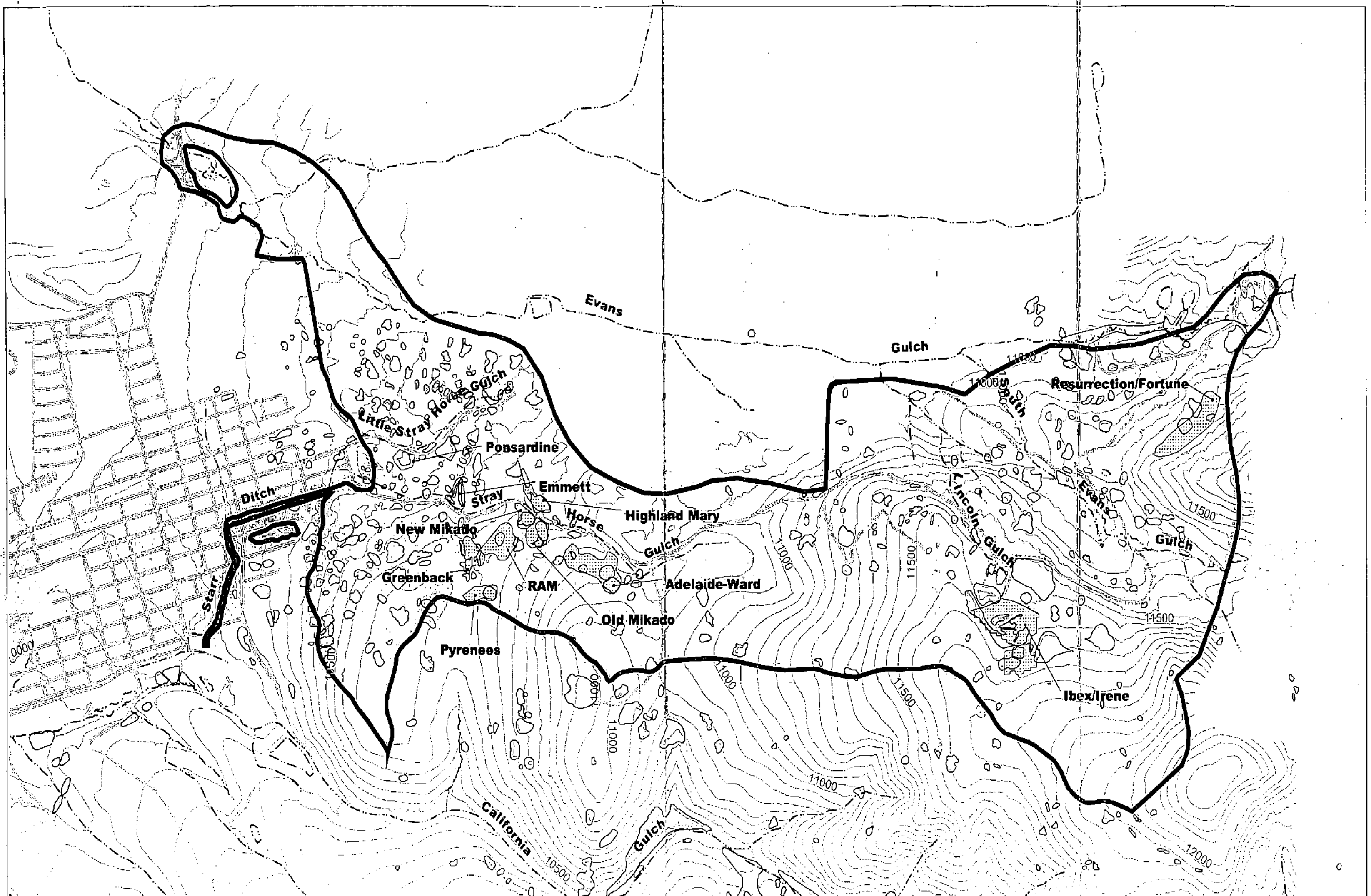
HDR Engineering, Inc.

AVIRIS MINERAL ASSEMBLAGES

CALIFORNIA GULCH OU6
FOCUSED FEASIBILITY STUDY

DATE: SEPT., 2002

FIGURE 2-8



Notes:

1. Figure adapted from GIS Database provided by USEPA Region 8.
2. Areas that were consolidated and capped are not identified, as they no longer constitute source areas of concern.

LEGEND

- Additional Areas of Concern
- Areas with Surface Water Management in place
- Contour (50' Interval)
- OU6 Boundary
- Major Drainages
- Paved Roads
- Mine Waste Piles

1000 0 1000 2000 Feet

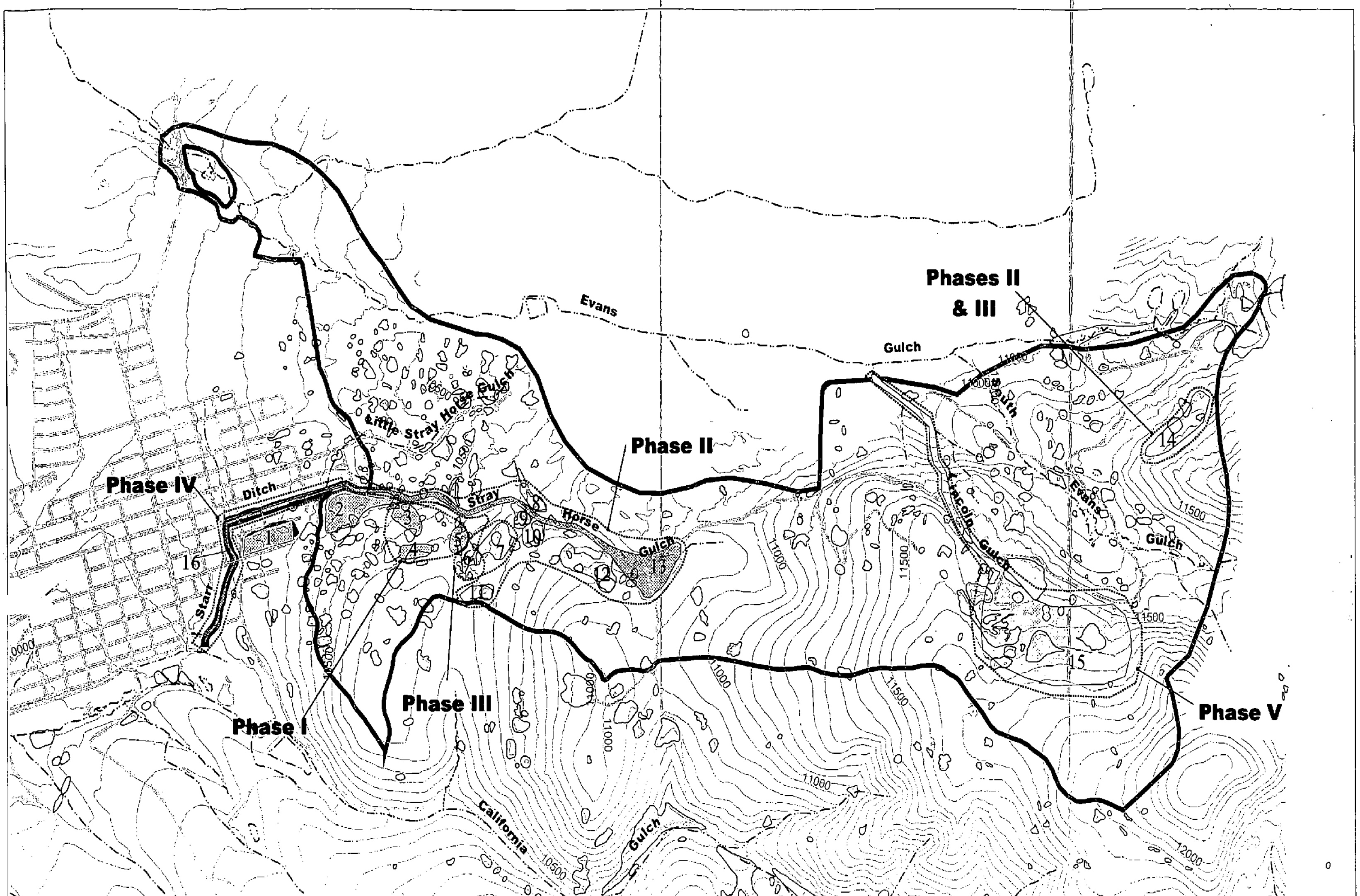
HDR Engineering, Inc.

ARD-GENERATING SOURCE AREAS OF CONCERN

CALIFORNIA GULCH OU6 FOCUSED FEASIBILITY STUDY

DATE: SEPT., 2002

FIGURE 2-9



NOTES:

1. Figure adapted from GIS Database provided by USEPA Region 8.

LEGEND

1. Penrose
2. Hamms
3. Maid of Erin
4. Wolftone
5. Mahala
6. Greenback
7. RAM
8. Highland Mary
9. New Mikado
10. Old Mikado
11. Pyrenees
12. Adelaide/Ward
13. Stray Horse Gulch
14. Resurrection/Fortune
15. Ibex/Irene
16. Starr Ditch

Surface Water Management Areas
Consolidated & Capped Areas
Sediment Excavation & Removal Areas
Phase Area Outline
OU6 Boundary
Major Drainages
Paved Roads
Mine Waste Piles
Contour (50' Interval)

1000 0 1000 2000 Feet

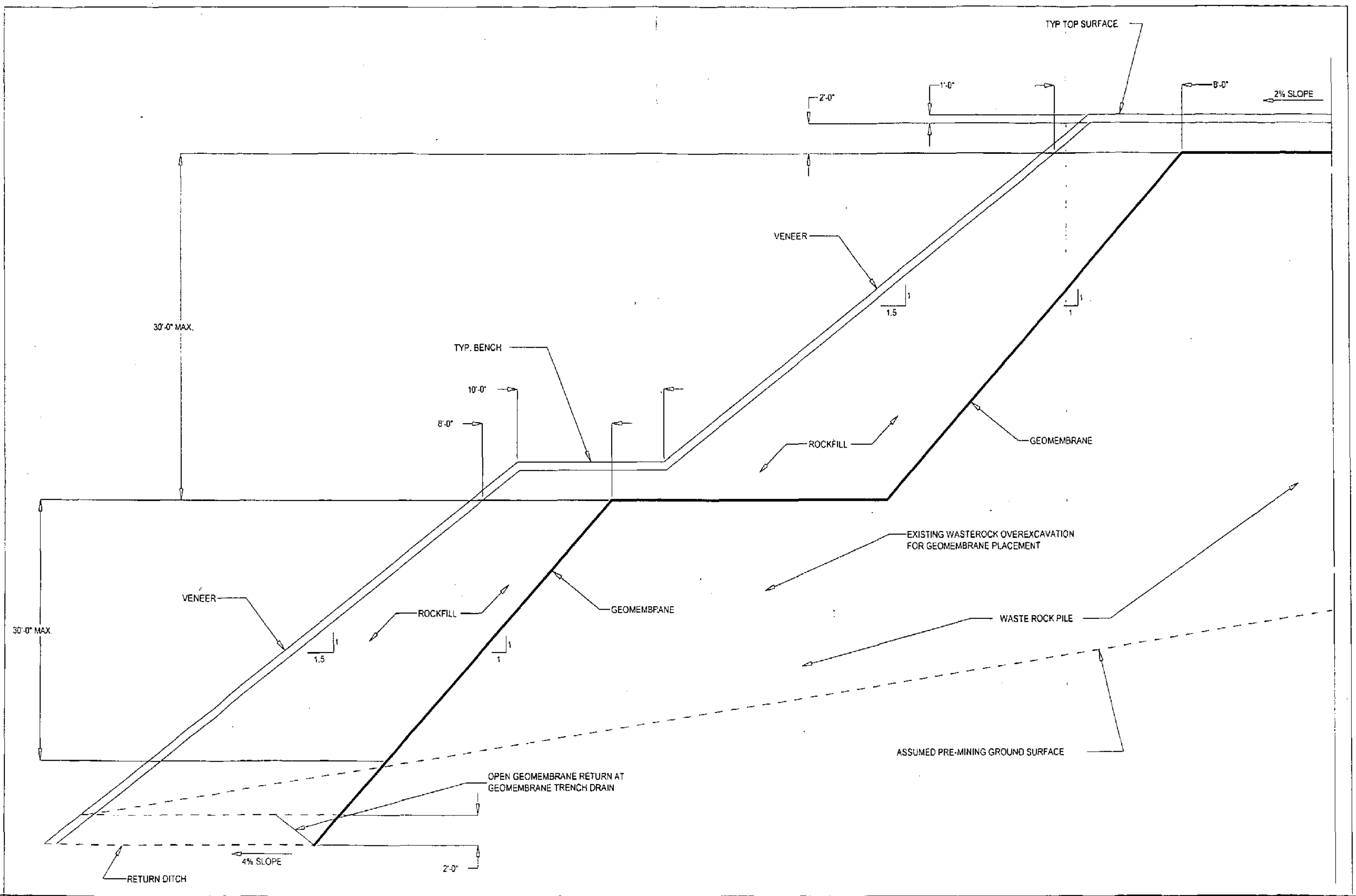
HDR Engineering, Inc.

PREVIOUS REMOVAL ACTION AREAS

CALIFORNIA GULCH OU6
FOCUSED FEASIBILITY STUDY

DATE: SEPT., 2002

FIGURE 4-1



NOTES:

1. After CDM Federal Programs Corporation Engineering Evaluation/Cost Analysis for Stray Horse Gulch, OU6, California Gulch NPL Site, Leadville, Colorado, June 1997

Drawing Not To Scale

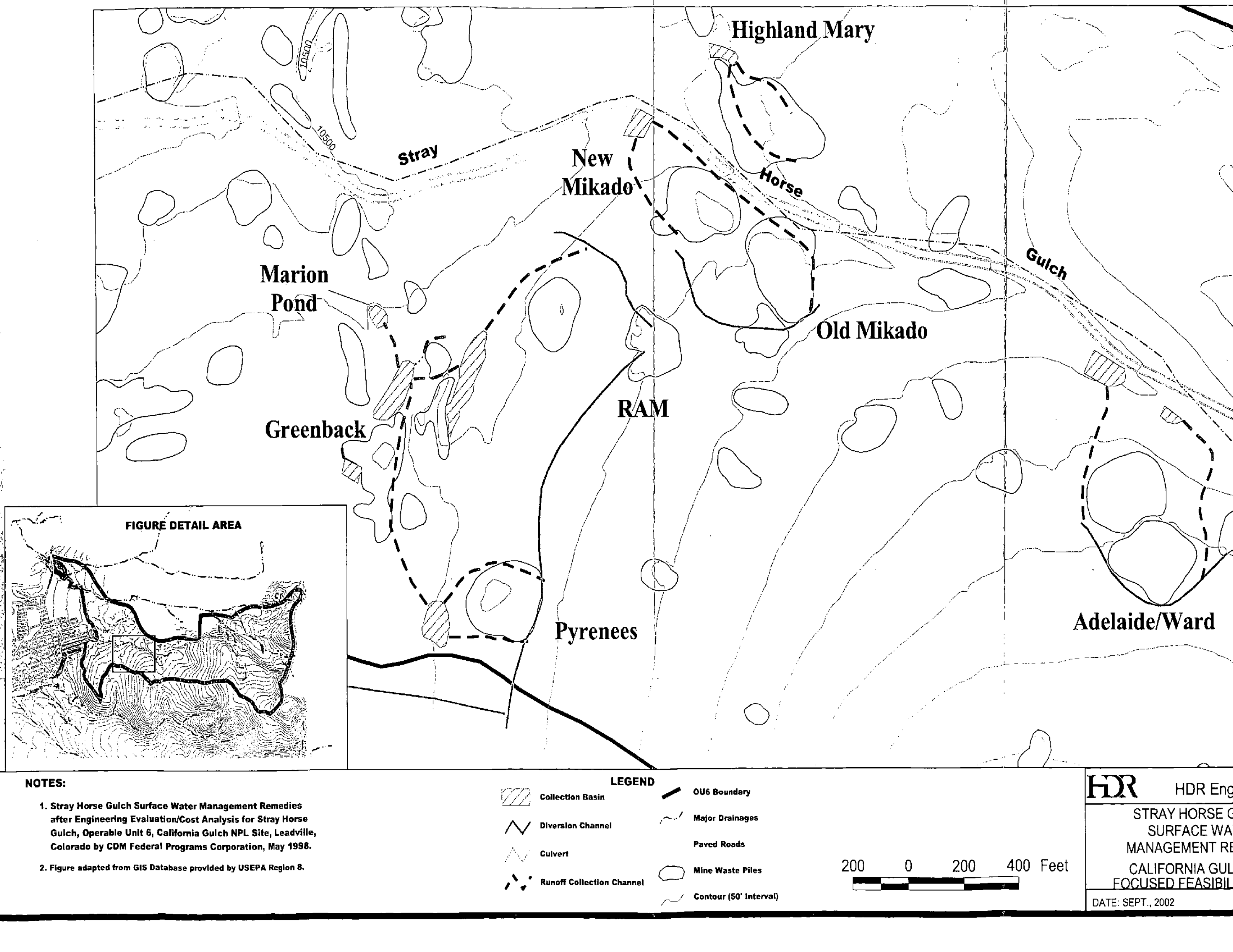
HDR Engineering, Inc.

TYPICAL CAP CROSS-SECTION

CALIFORNIA GULCH OU6
FOCUSED FEASIBILITY STUDY

DATE: SEPT., 2002

FIGURE 4-2



NOTES:

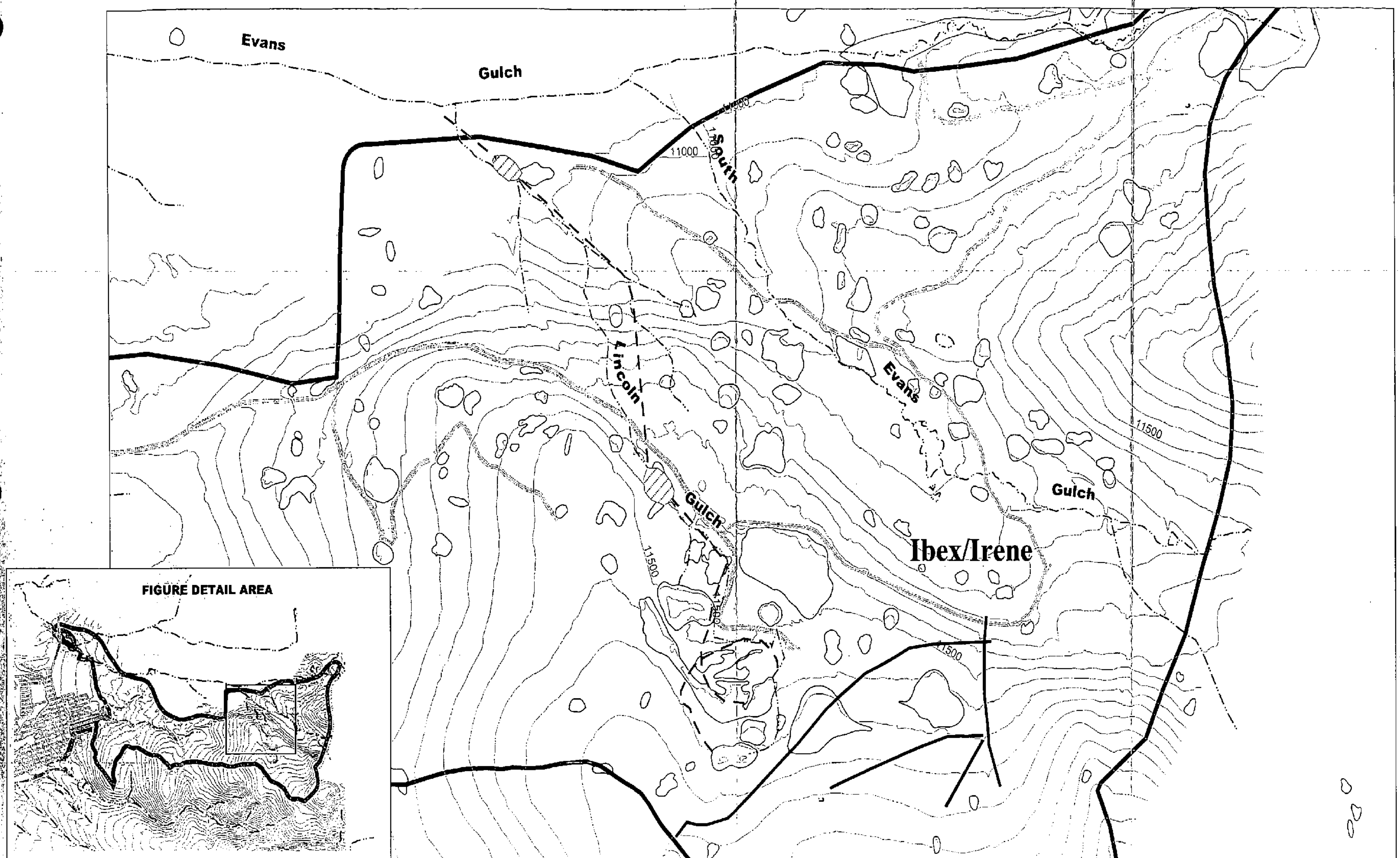
1. Stray Horse Gulch Surface Water Management Remedies after Engineering Evaluation/Cost Analysis for Stray Horse Gulch, Operable Unit 6, California Gulch NPL Site, Leadville, Colorado by CDM Federal Programs Corporation, May 1998.
2. Figure adapted from GIS Database provided by USEPA Region 8.

HDR Engineering, Inc.

STRAY HORSE GULCH
SURFACE WATER
MANAGEMENT REMEDIES
CALIFORNIA GULCH OU6
FOCUSED FEASIBILITY STUDY

DATE: SEPT., 2002

FIGURE 4-3



NOTES:

1. Ibex/Irene Surface Water Management Remedies after Engineering Evaluation/Cost Analysis for Ibex/Irene, Operable Unit 6, California Gulch NPL Site, Leadville, Colorado by CDM Federal Programs Corporation, May 1998.
2. Figure adapted from GIS Database provided by USEPA Region 8.

LEGEND

- Collection Basin
- Runon Diversion Channel
- Runoff Collection Channel
- Contour (50' Interval)
- OU6 Boundary
- Major Drainages
- Paved Roads
- Mine Waste Piles

500 0 500 Feet

HDR Engineering, Inc.

IBEX/IRENE
SURFACE WATER
MANAGEMENT REMEDIES
CALIFORNIA GULCH OU6
FOCUSED FEASIBILITY STUDY

DATE: SEPT., 2002

FIGURE 4-4

Figure 4-5
Total Cadmium Loading Trends
(Data from RMC California Gulch Mornitoring Database, 2001)

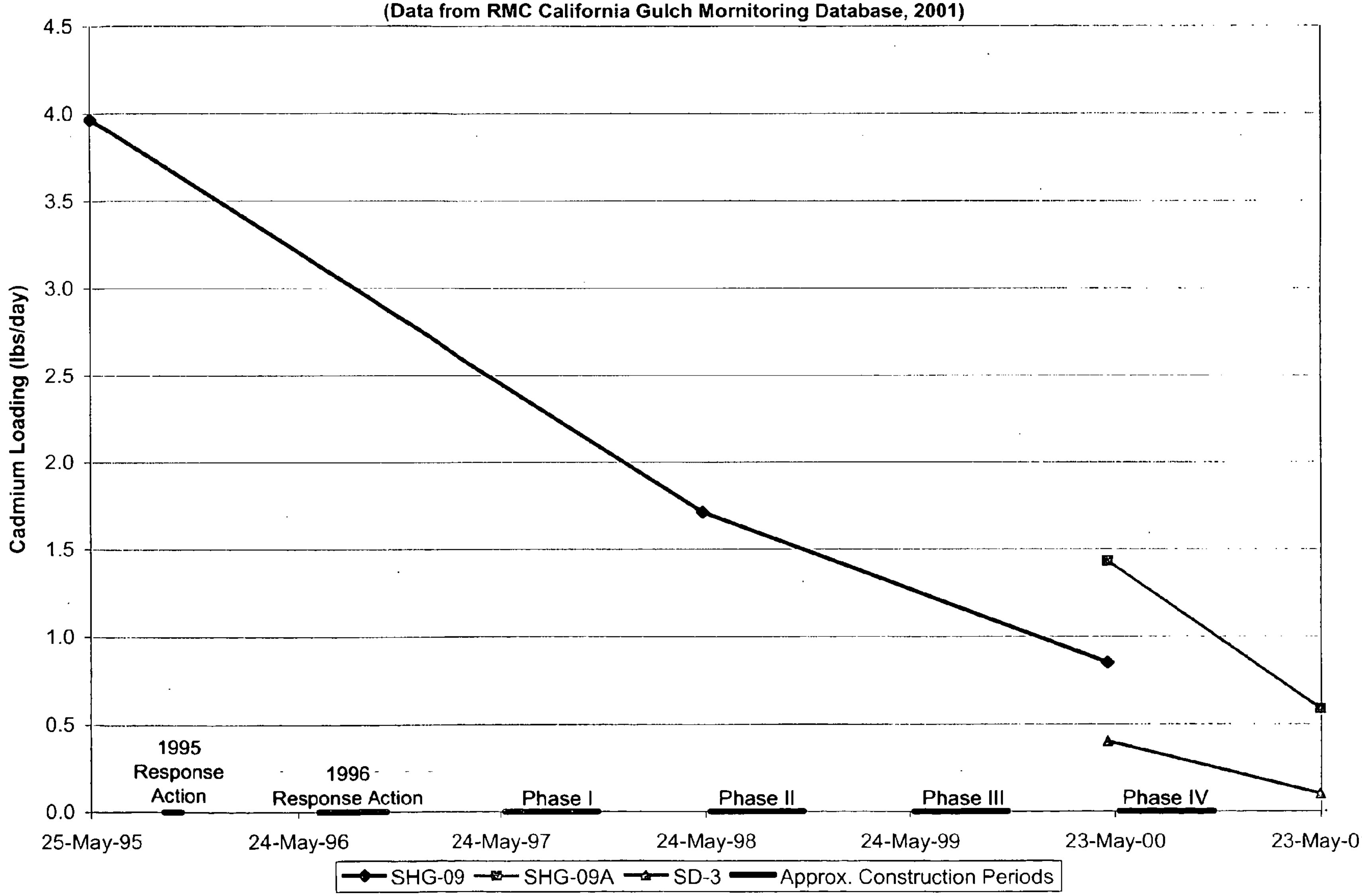
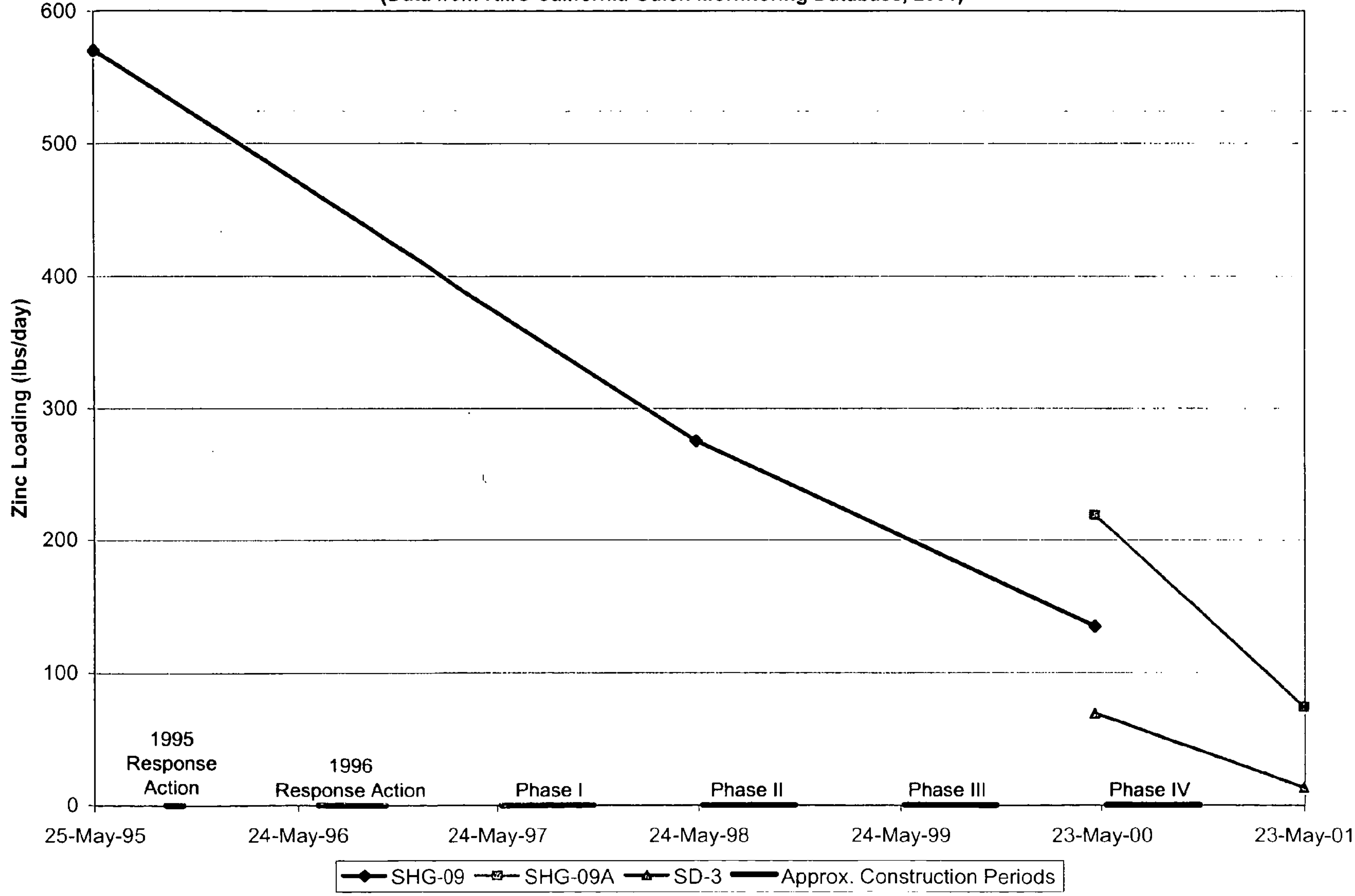
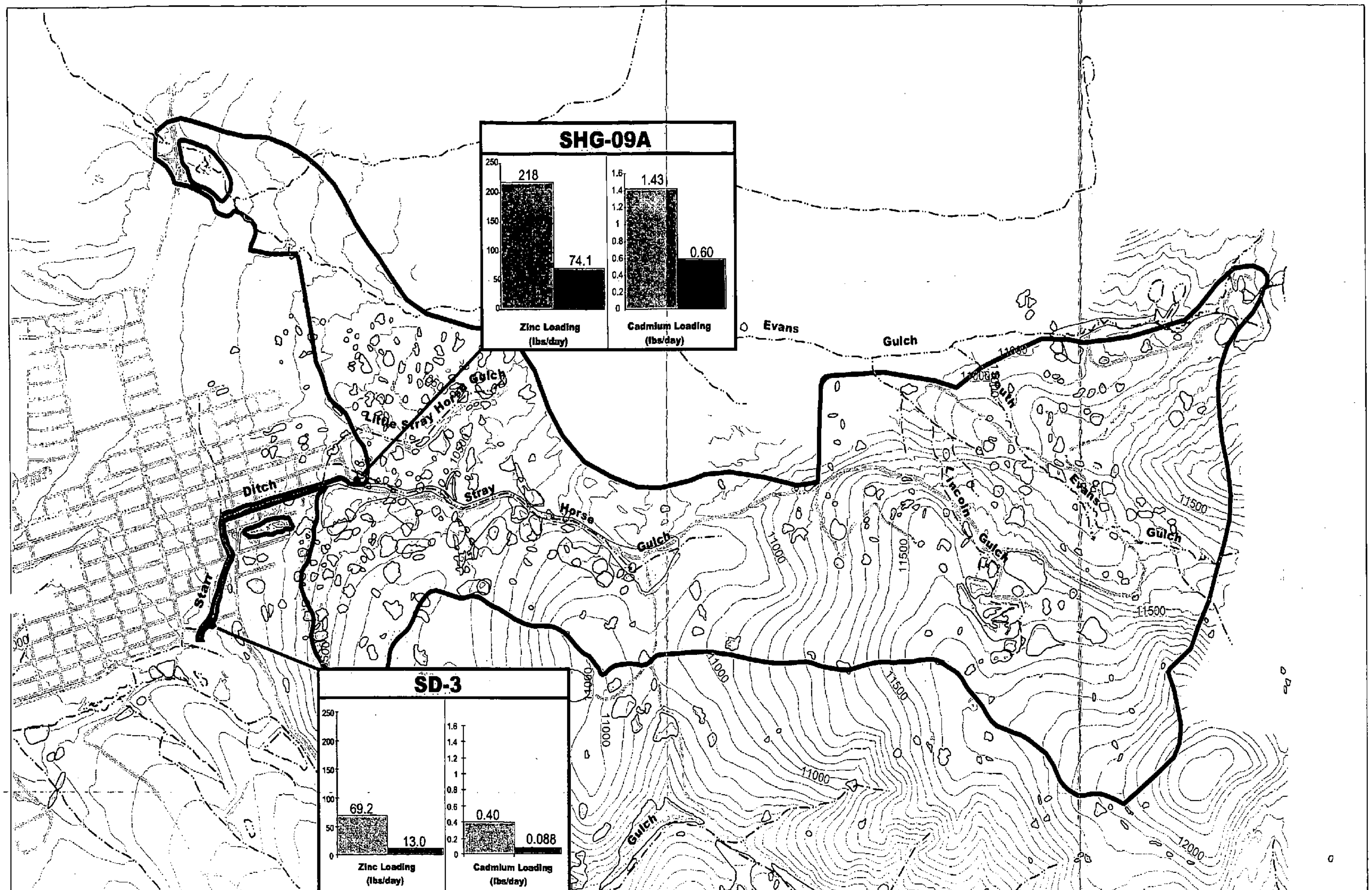


Figure 4-6
Total Zinc Loading Trends
(Data from RMC California Gulch Mornitoring Database, 2001)





NOTES:

1. Figure adapted from GIS Database provided by USEPA Region 8.
2. Metal loading data calculated based on RMC Synoptic Sampling Data, 2000 and 2001.

LEGEND

- Station Location
- Stray Horse Gulch Previous Removal Action Areas
- May 11, 2000 Data
- May 23, 2001 Data
- OU6 Boundary
- Major Drainages
- Paved Roads
- Mine Waste Piles
- Contour (50' Interval)

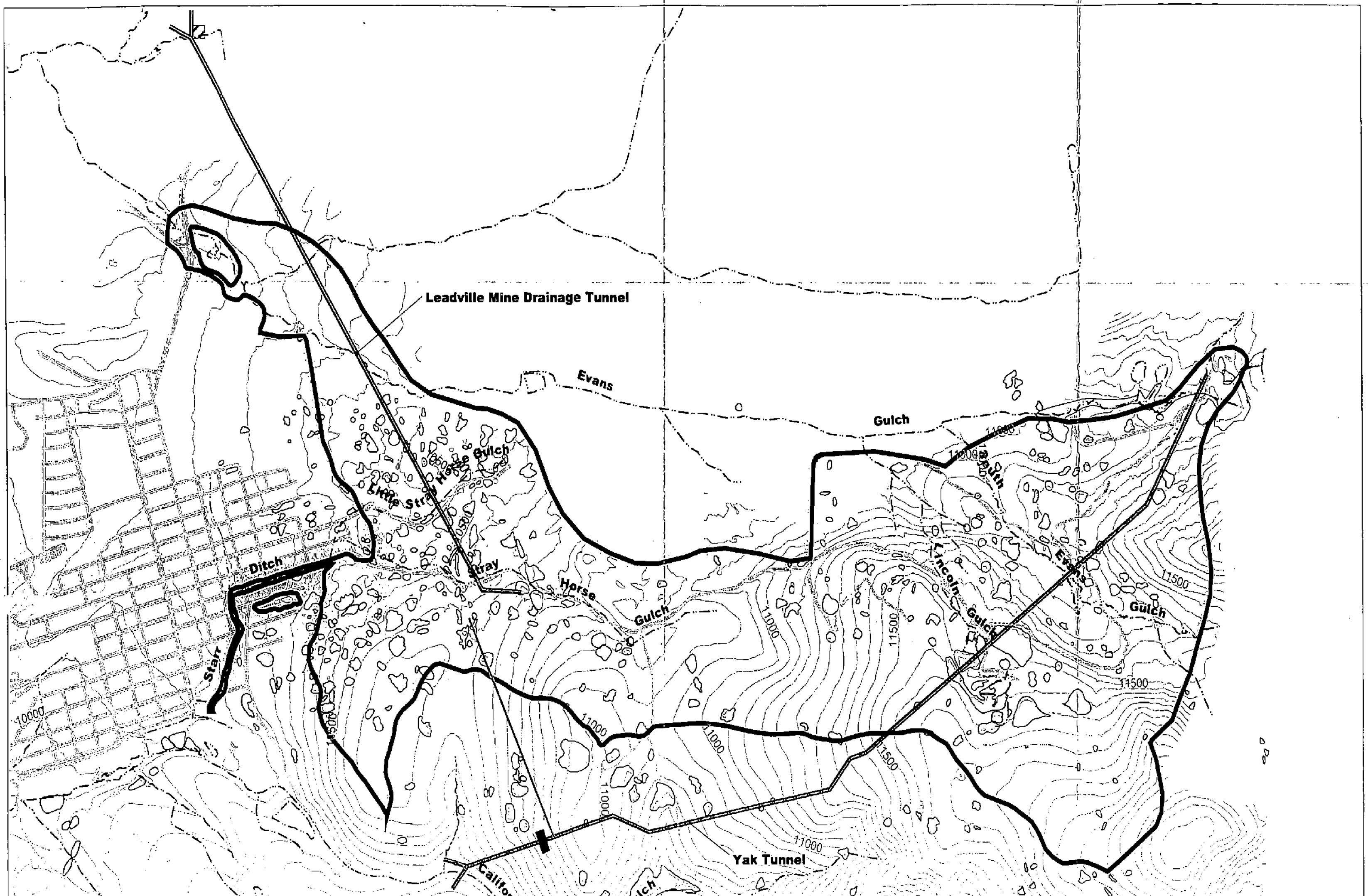
1000 0 1000 2000 Feet

HDR Engineering, Inc.

POST REMEDIAL REDUCTION IN METAL LOADING AT PERFORMANCE MONITORING POINTS

CALIFORNIA GULCH OU6 FOCUSED FEASIBILITY STUDY

DATE: SEPT., 2002 | FIGURE 4-7



NOTES:

1. Figure adapted from GIS Database provided by USEPA Region 8.

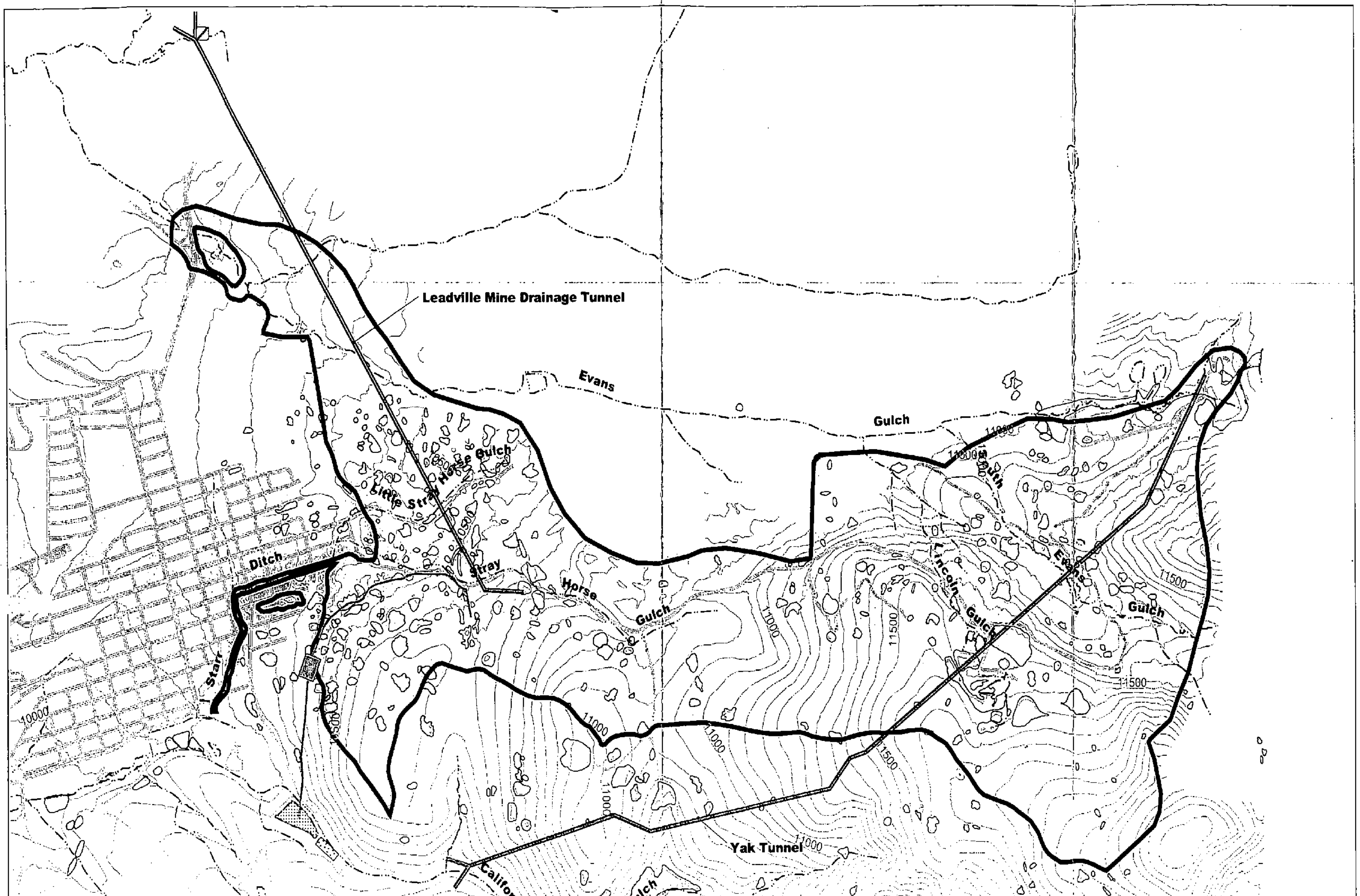
HDR Engineering, Inc.

ALTERNATIVE 2A

CALIFORNIA GULCH OU6
FOCUSED FEASIBILITY STUDY

DATE: SEPT., 2002

FIGURE 6-1



NOTES:

1. Figure adapted from GIS Database provided by USEPA Region 8.

LEGEND

- Gravity Line to Yak Surge Pond with Storage
- DrainageTunnel
- Impoundment Location
- BOR Plant
- Yak Treatment Plant
- OU6 Boundary
- Major Drainages
- Paved Roads
- Mine Waste Piles
- Yak Surge Pond
- Contour (50' Interval)

1000 0 1000 2000 Feet

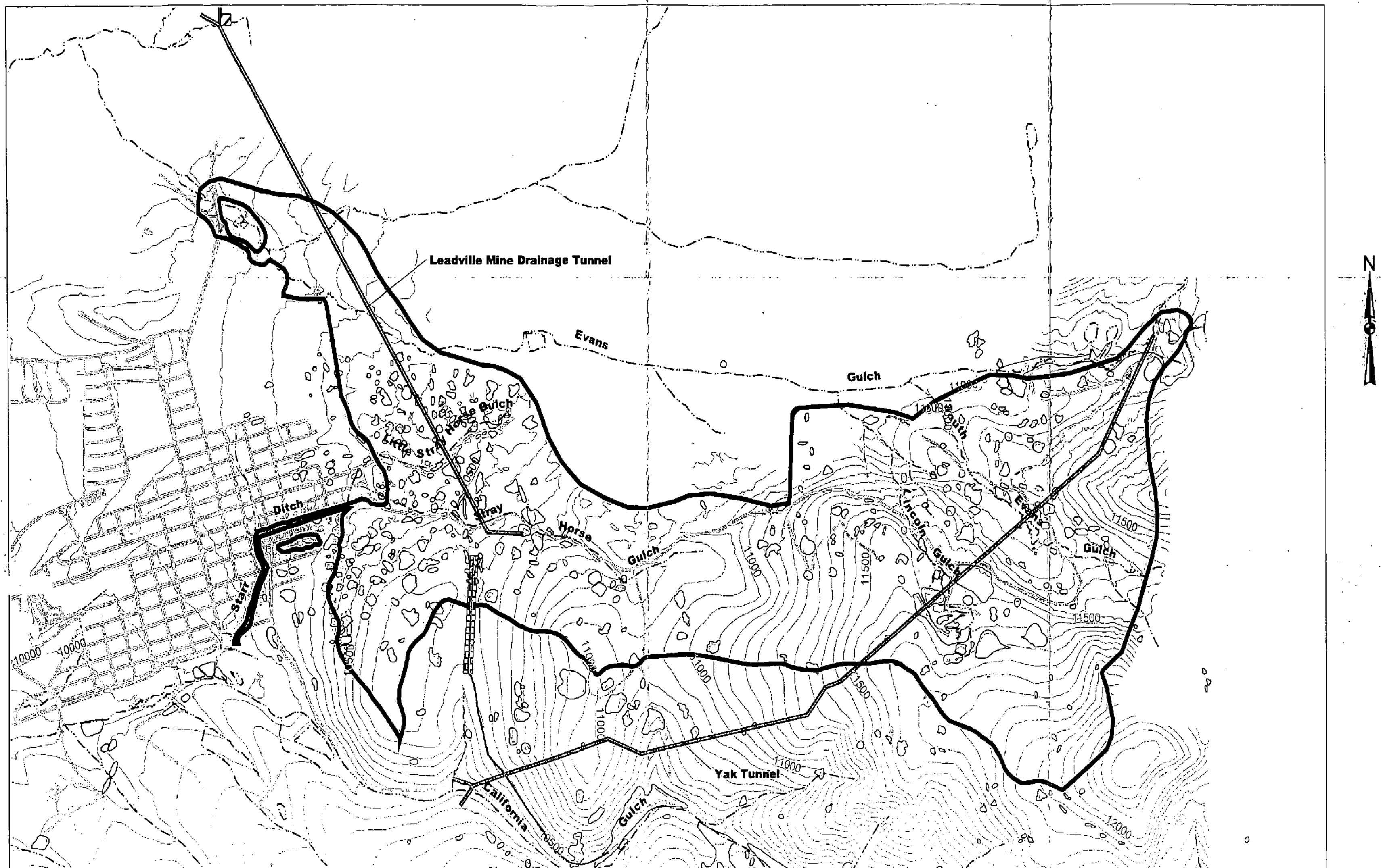
HDR HDR Engineering, Inc.

ALTERNATIVE 2B

CALIFORNIA GULCH OU6
FOCUSED FEASIBILITY STUDY

DATE: SEPT., 2002

FIGURE 6-2



NOTES:

1. Figure adapted from GIS Database provided by USEPA Region 8.

LEGEND

- Gravity Line to Mine Working South of Yak Tunnel
- Segment of Line Completed by Boring
- Drainage Tunnel
- BOR Plant
- OU6 Boundary
- Major Drainages
- Paved Roads
- Mine Waste Piles
- Contour (50' Interval)

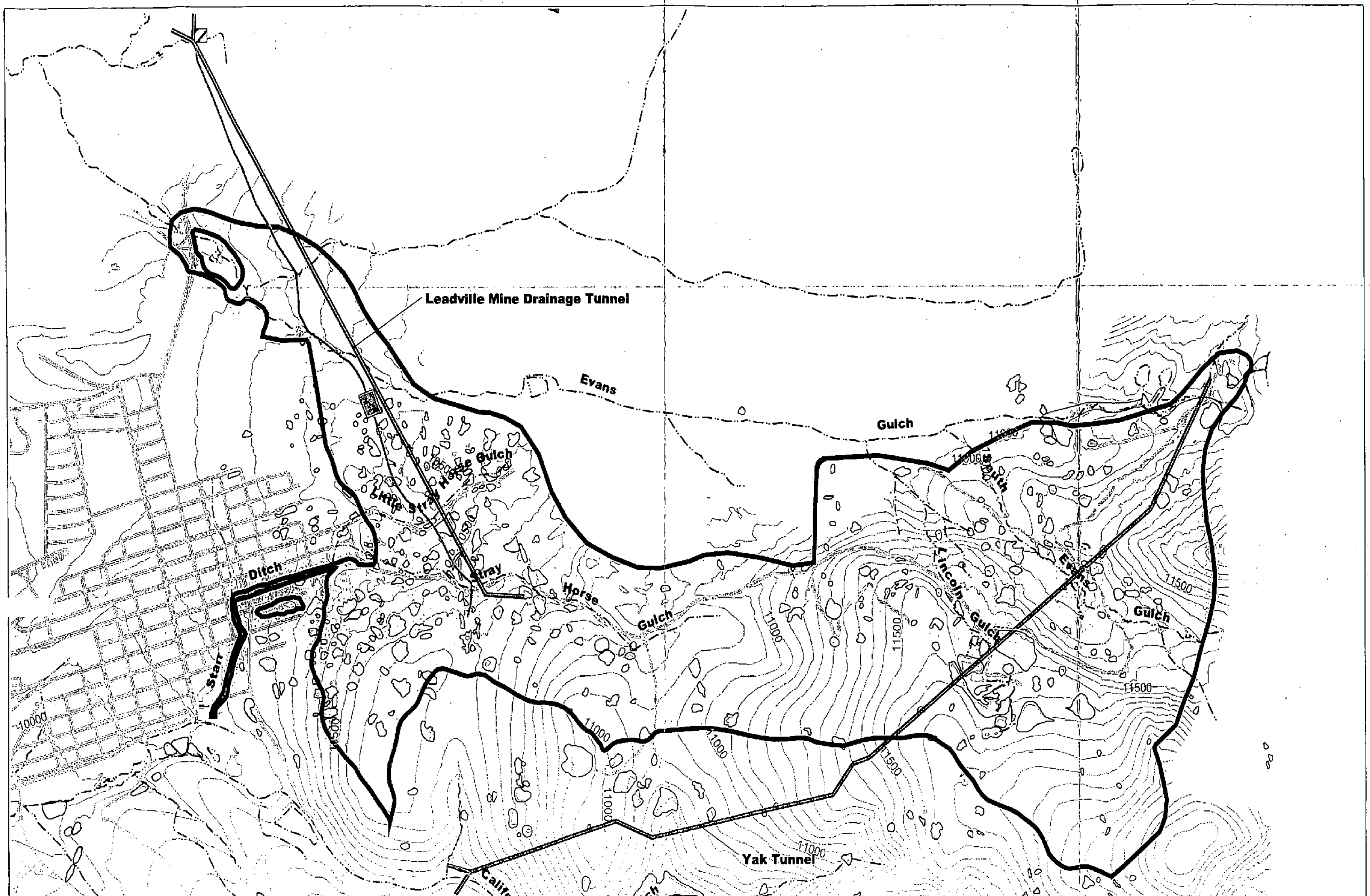
HDR Engineering, Inc.

ALTERNATIVE 2C

CALIFORNIA GULCH OU6
FOCUSED FEASIBILITY STUDY

DATE: SEPT., 2002

FIGURE 6-3



NOTES:

Figure adapted from GIS Database provided by USEPA Region 8.

LEGEND

- Gravity Line to BOR Plant with Storage
- Drainage Tunnel
- Impoundment Location
- BOR Plant
- OU6 Boundary
- Major Drainages
- Paved Roads
- Mine Waste Piles
- Contour (50' Interval)

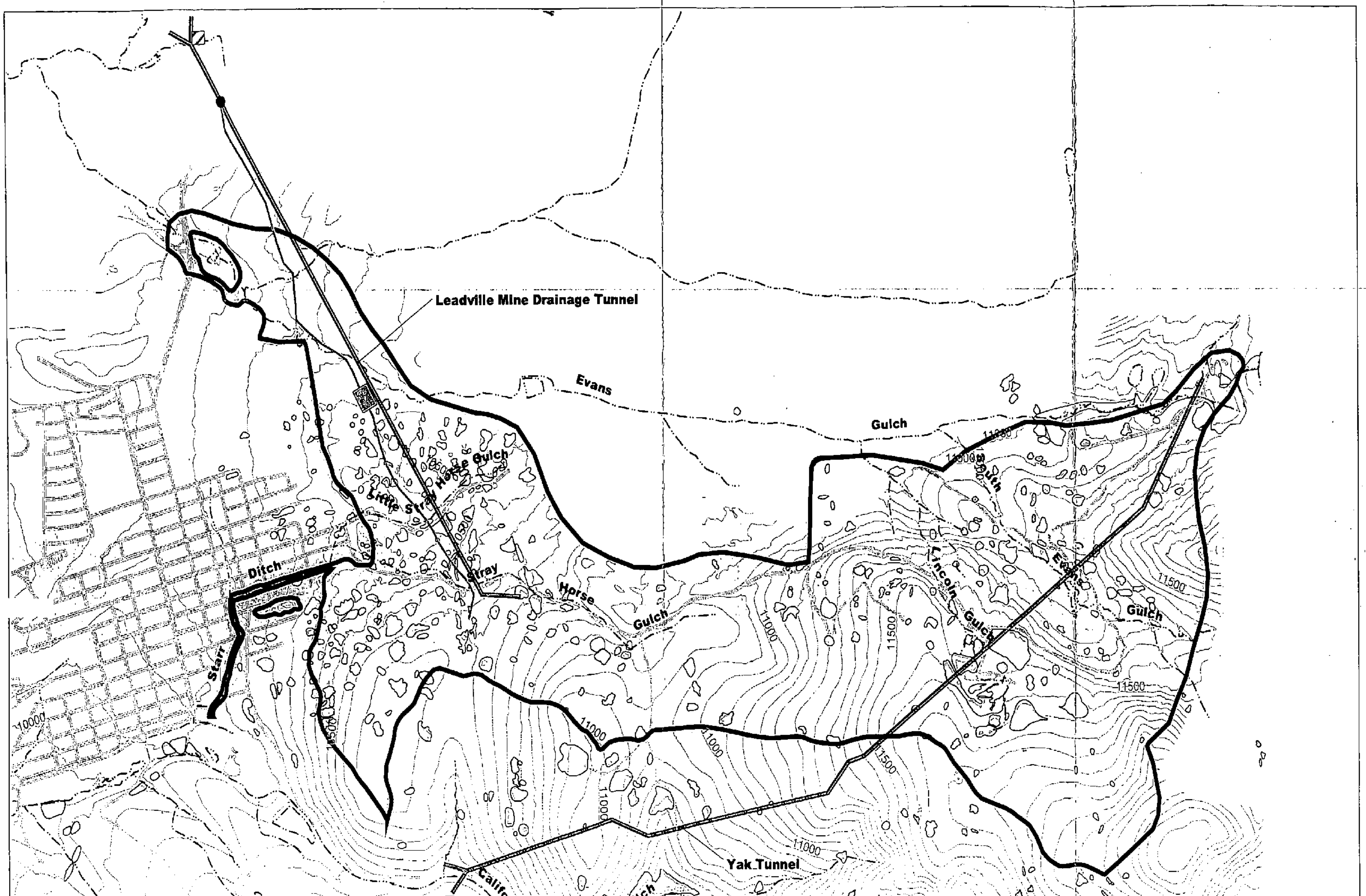
HDR Engineering, Inc.

ALTERNATIVE 2D

CALIFORNIA GULCH OU6
FOCUSED FEASIBILITY STUDY

DATE: SEPT., 2002

FIGURE 6-4



NOTES:

1. Figure adapted from GIS Database provided by USEPA Region 8.

LEGEND

- Gravity Line to Existing Extraction Well Along LMDT with Storage
- Drainage Tunnel
- Existing Extraction Well
- Impoundment Location
- BOR Plant
- OU6 Boundary
- Major Drainages
- Paved Roads
- Mine Waste Piles
- Contour (50' Interval)

1000 0 1000 2000 Feet

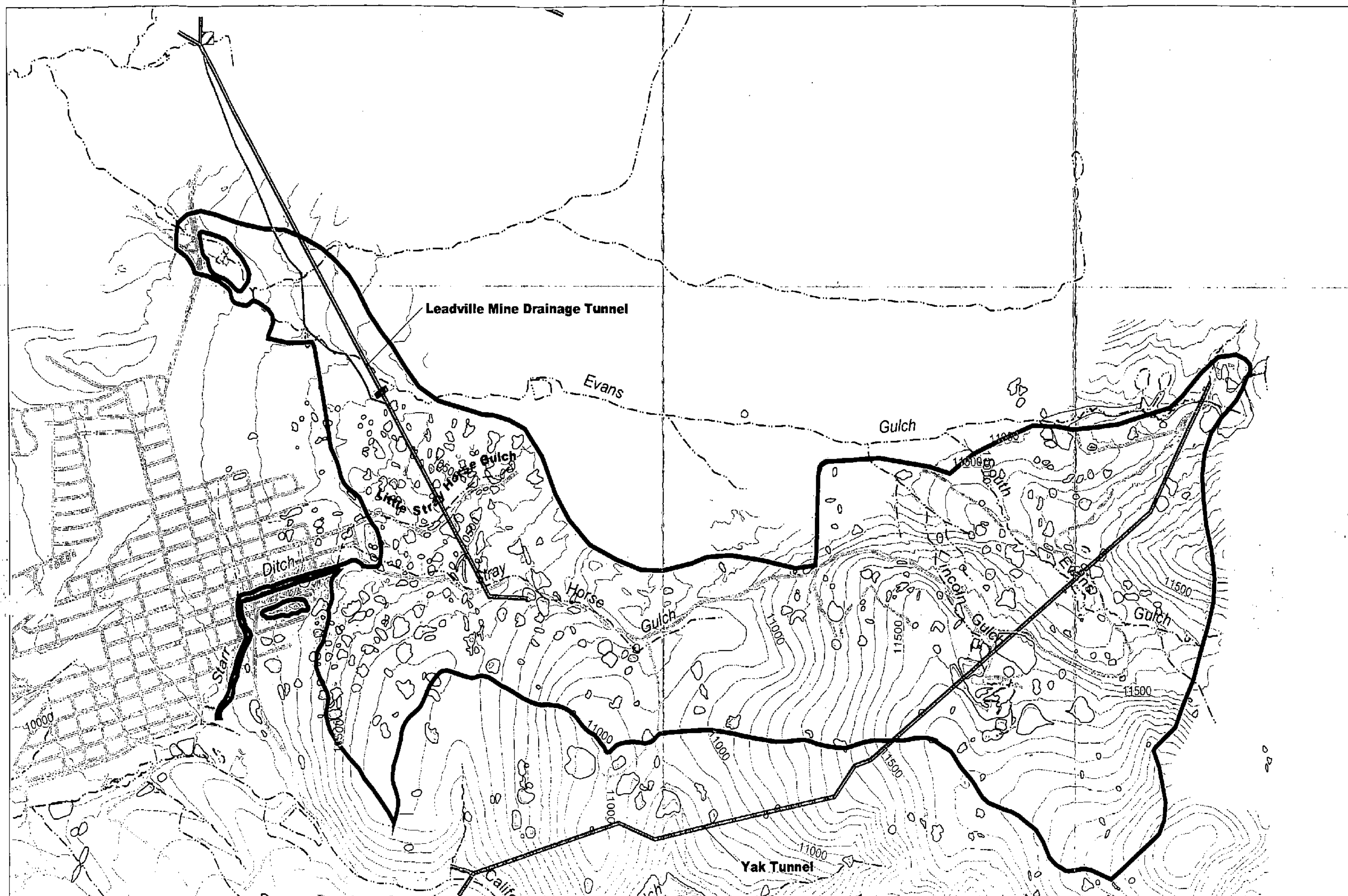
HDR Engineering, Inc.

ALTERNATIVE 2E

CALIFORNIA GULCH OU6
FOCUSED FEASIBILITY STUDY

DATE: SEPT., 2002

FIGURE 6-5



NOTES:

1. Figure adapted from GIS Database provided by USEPA Region 8.

LEGEND

- Gravity Line from Proposed LMDT Plug To BOR Plant
- Drainage Tunnel
- LMDT Plug
- BOR Plant
- OU6 Boundary
- Major Drainages
- Paved Roads
- Mine Waste Piles
- Contour (50' Interval)

1000 0 1000 2000 Feet

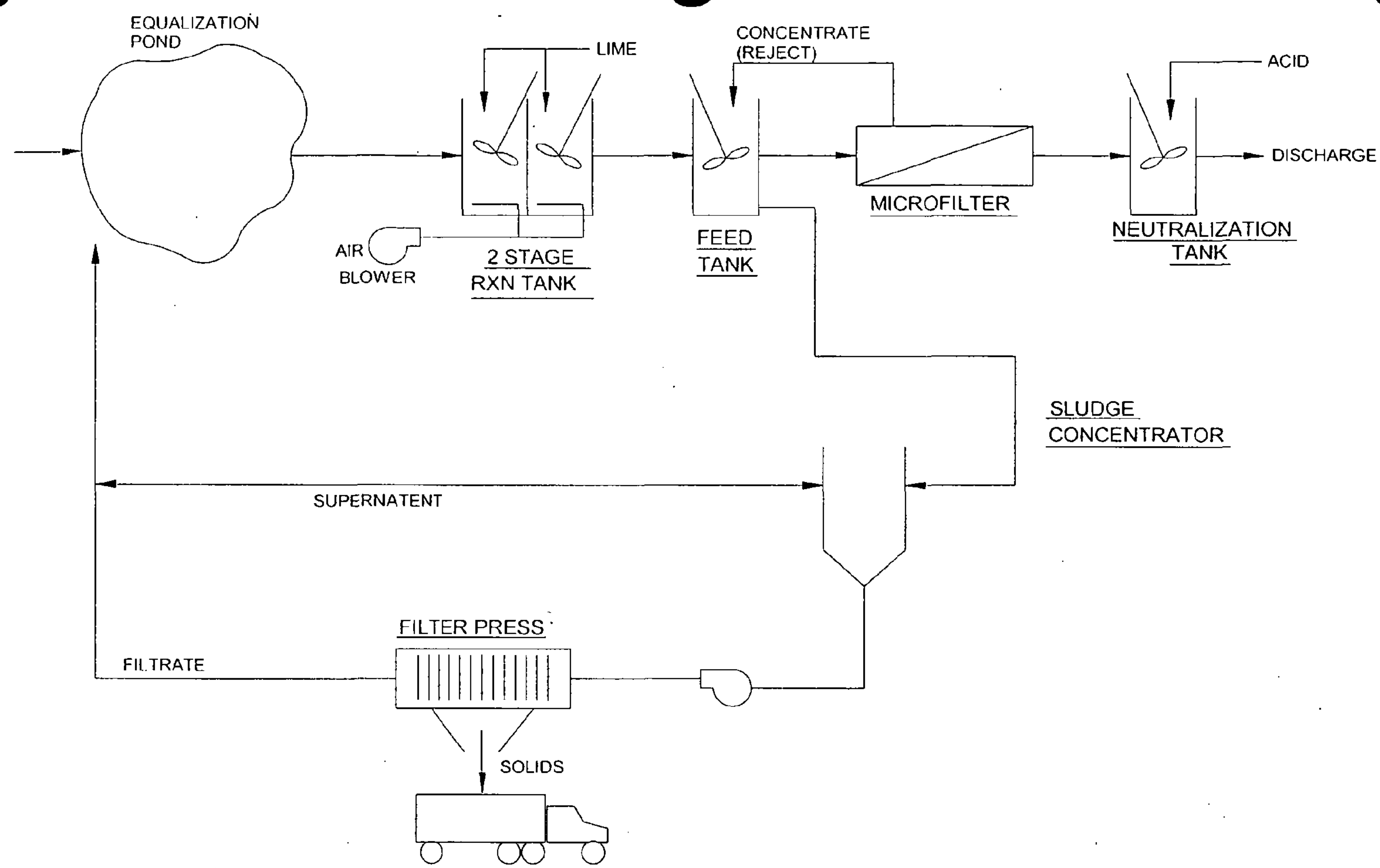
HDR Engineering, Inc.

ALTERNATIVE 2G

CALIFORNIA GULCH OU6
FOCUSED FEASIBILITY STUDY

DATE: SEPT., 2002

FIGURE 6-6



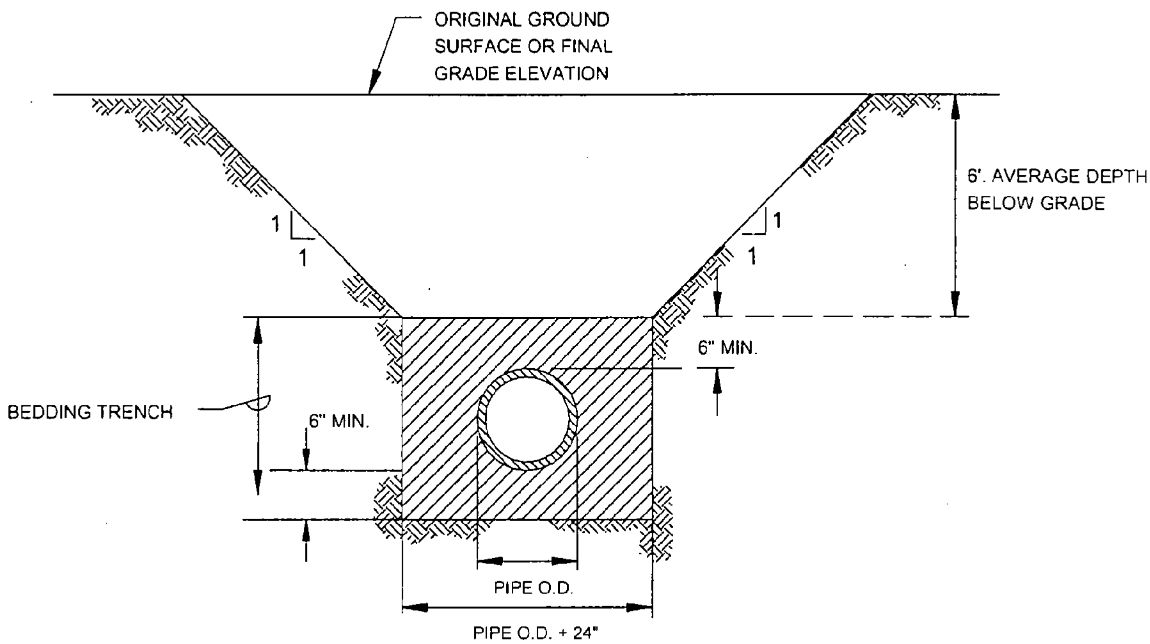
HDR Engineering, Inc.

PROCESS FLOW SCHEMATIC

CALIFORNIA GULCH OU6
FOCUSED FEASIBILITY STUDY

DATE: SEPT., 2002

FIGURE 6-7



Drawing not to scale

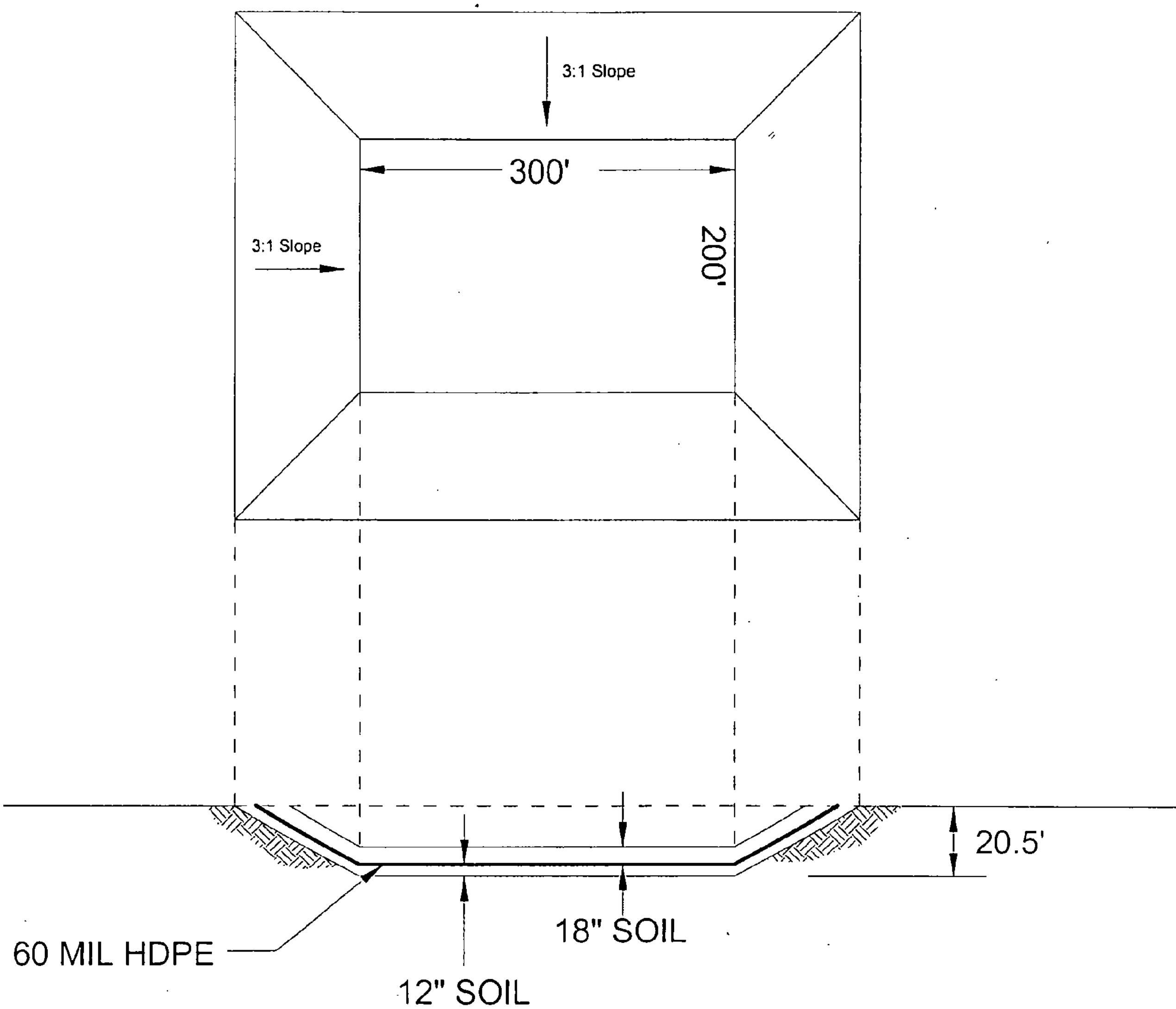
HDR Engineering, Inc.

STANDARD TRENCH SECTION

CALIFORNIA GULCH OU6
FOCUSED FEASIBILITY STUDY

DATE: SEPT., 2002

FIGURE 7-1



Drawing not to scale

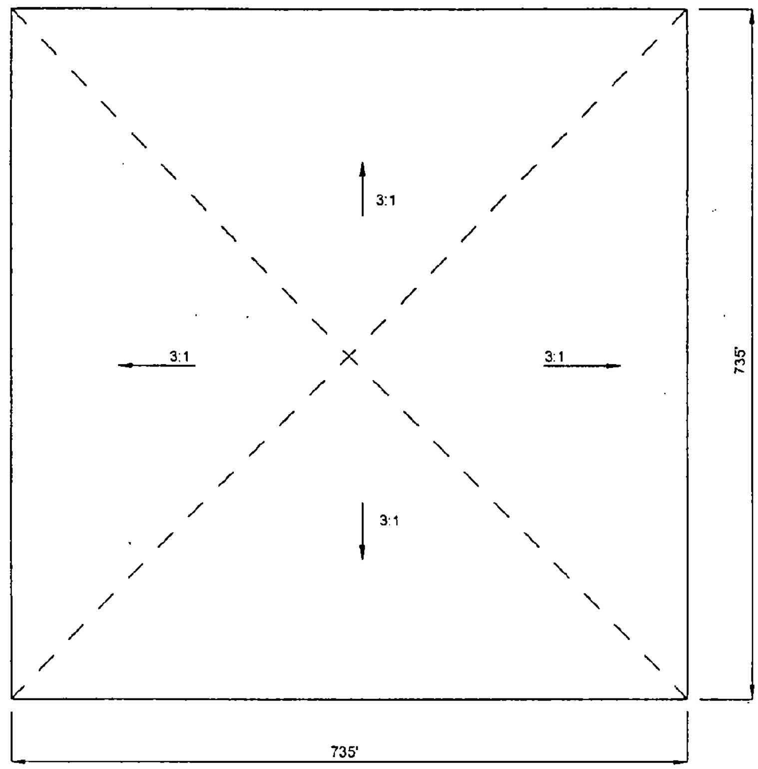
HDR Engineering, Inc.

IMPOUNDMENT CONCEPTUAL LAYOUT

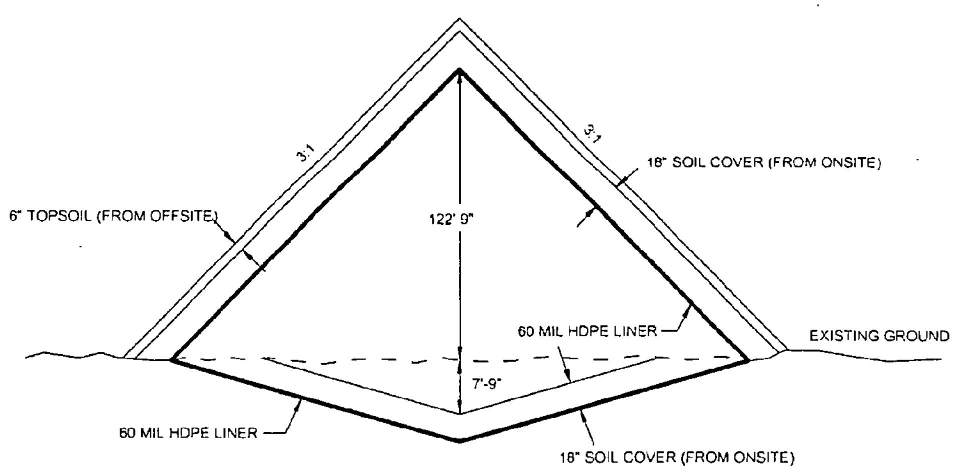
CALIFORNIA GULCH OU6 FOCUSED FEASIBILITY STUDY

DATE: SEPT., 2002

FIGURE 7-2



PLAN VIEW



PROFILE VIEW

Drawing not to scale

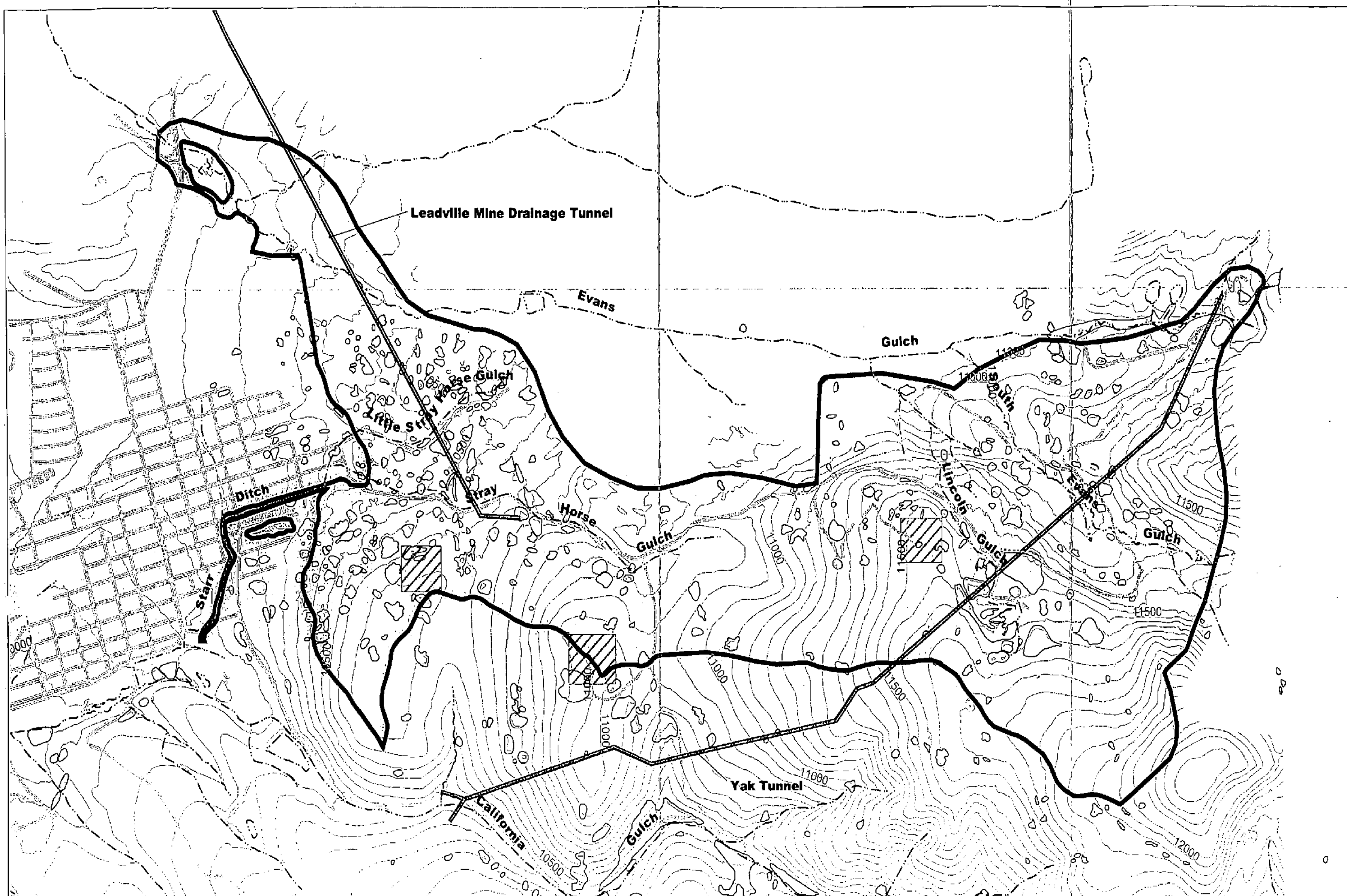
HDR Engineering, Inc.

PROPOSED REPOSITORY LAYOUT

CALIFORNIA GULCH OU6 FOCUSED FEASIBILITY STUDY

DATE: SEPT., 2002

FIGURE 7-3



NOTES:

1. Figure adapted from GIS Database provided by USEPA Region 8.

LEGEND

- Proposed Repository Location
- Drainage Tunnel
- Contour (50' Interval)
- OU6 Boundary
- Major Drainages
- Paved Roads
- Mine Waste Rock Piles

HDR Engineering, Inc.

PROPOSED REPOSITORY LOCATIONS

CALIFORNIA GULCH OU6
FOCUSED FEASIBILITY STUDY

DATE: JUNE, 2002

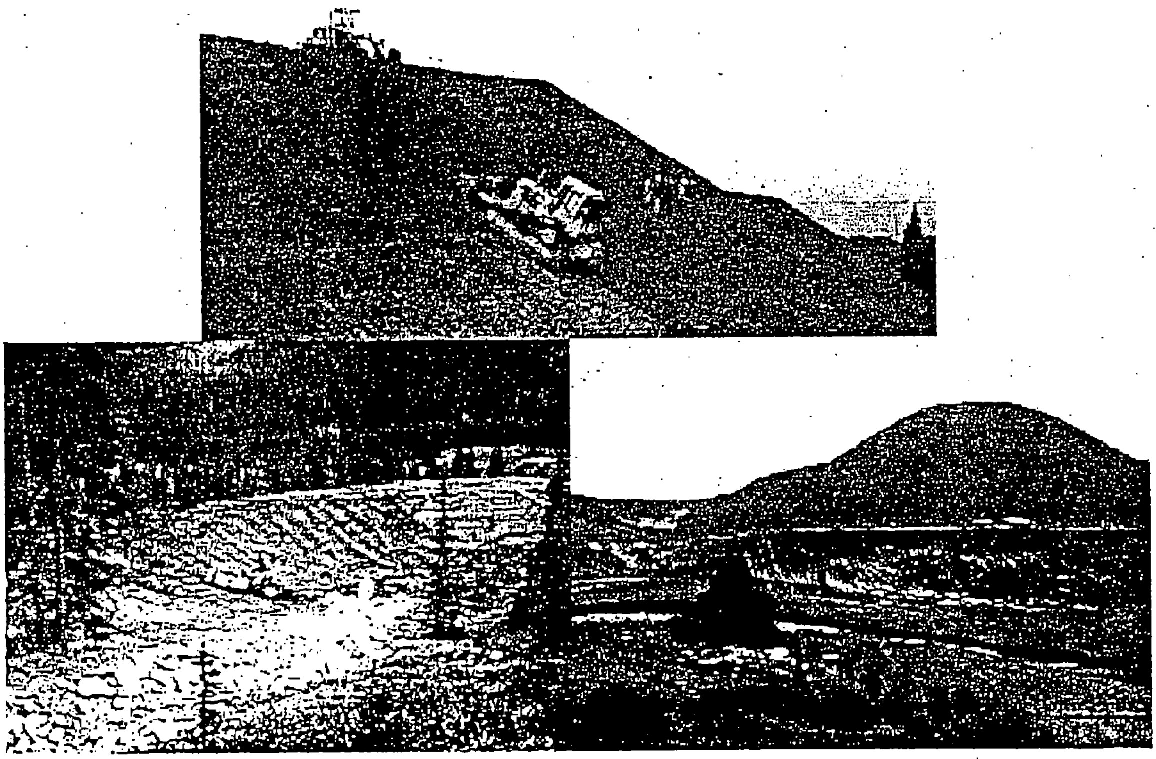
FIGURE 7-4

APPENDIX A
Effectiveness of Past Response Actions

California Gulch NPL Site
Leadville, Colorado

Draft Technical Memorandum for Effectiveness of Past Work at Operable Unit 6

July 2001



Draft Technical Memorandum

Response Action Contract
for Remedial Enforcement Oversight and Non-Time
Critical Removal Activities at Sites of Release or
Threatened Release of Hazardous Substances
in EPA Region VIII

U.S. EPA Contract No. 68-W5-0022

Draft Technical Memorandum
for
Effectiveness of Past Work
at
Operable Unit 6

California Gulch NPL Site
Leadville, Colorado

Work Assignment Number: 080-RICO-0829
Document Control Number: 3280-080-RT-OTHR-11762

July 2001

Prepared for:

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Region VIII
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Response Action Contract
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Critical Removal Activities at Sites of Release or
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U.S. EPA Contract No. 68

Draft Technical Memorandum
for
Effectiveness of Past Work
at
Operable Unit 6

California Gulch NPL Site
Leadville, Colorado

Work Assignment No.: 080-RICO-0829

Prepared by: ______________________ Date: 7·12·01
Buz Cotton
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Reviewed by: ______________________ Date: 7/12/01
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Linda Brown, Ph.D.
Program Manager

Contents

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Acronyms

BOR	United States Department of the Interior, Bureau of Reclamation
CDM Federal	CDM Federal Programs Corporation
CMC	Colorado Mountain College
EE/CA	Engineering Evaluation/Cost Analysis
EPA	U.S. Environmental Protection Agency
FFS	Focused Feasibility Study
HDPE	High-density polyethelene
LSG	Leadville Silver and Gold
NPDES	National Pollutant Discharge Elimination System
NPL	National Priority List
NRCS	Natural Resources Conservation Service
NRHP	National Register of Historic Places
OU	Operable Unit
ppm	Parts per million
PVC	Polyvinyl chloride
RAOs	Removal Action Objectives
RCP	Reinforced concrete pipe
Site	Cal Gulch Superfund Site
TDS	Total dissolved solids
XRF	X-ray fluorescence

Section 1 Introduction

This technical memorandum was prepared for the U.S. Environmental Protection Agency (EPA) Region VIII as part of work assignment no. 080-RICO-0829 under EPA contract No. 68-W5-0022 by CDM Federal Programs Corporation (CDM Federal). This document presents the results of the evaluation of the effectiveness of past removal actions conducted at the operable unit (OU) 6 located at the California Gulch Superfund Site (Site) in Leadville, Colorado.

1.1 Purpose

The purpose of this technical memorandum is to summarize the past removal actions that have been completed in OU 6, provide an evaluation of the effectiveness of the actions, and evaluate whether the remedies are operating as intended. The removal actions were conducted as time critical and non-time critical. Non-time critical actions are also known as phase I through phase IV removal actions. This work was conducted in accordance with the "Revised Work Plan For California Gulch Superfund Site, Lake County, Colorado, Operable Unit 6" (CDM Federal 2000).

1.2 Background

The Site is located in Lake County Colorado, and includes the City of Leadville. The Site is a mining district covering 16 square miles of a watershed area that drains along California Gulch to the Arkansas River. The region is highly mineralized containing low-grade silver ore and several other precious mineral ores. Mining, mineral processing, and smelting activities have produced gold, silver, lead, and zinc for more than 140 years and continued into 1999 when the last major mining operation shut down. The Site has been divided into 12 OUs. OU 6 includes Stray Horse Gulch and numerous abandoned mining operations where previous activities impacted the soil, surface water, and groundwater.

The Site was added to the national priority list (NPL) in 1983. In 1987, EPA began an investigation of mine wastes at the Site and identified several mine waste piles in OU 6 as potentially unstable (EPA 1989). In addition, several remedial investigations (RIs) were conducted at the Site.

In 1996, the Bureau of Reclamation (BOR) evaluated alternatives for OU 6 and presented the findings in the *Revised Plan for Removal Action, Stray Horse Gulch Drainage, Operable Unit 6, California Gulch Superfund Site* (EPA 1996c). Following this report, the removal actions for Hamms and Penrose mines were performed.

In 1997, an engineering evaluation/cost analysis (EE/CA) (CDM Federal 1997) was conducted to address the non-time critical removal actions at OU 6. Implementation of the non-time-critical removal action selected under the June 24, 1997 action memorandum (EPA 1997) issued by the EPA was initiated in the summer of 1997 (phase I removal action) and addressed three of the larger source areas in lower Stray Horse Gulch.

In 1998, an addendum to the EE/CA (CDM Federal 1998) was prepared to address the remedial activities for the remaining Stray Horse Gulch mine waste piles that were not initiated as originally proposed in the action memorandum because of State and local concerns about potential impacts on the historic and cultural resources. Phase II portion of the Stray Horse Gulch removal action was performed during the 1998 construction season. Phase II was implemented under the action memorandum for non-time-critical removal actions dated July 15, 1998 (EPA 1998a).

During the 1998 (Phase II) implementation of the Stray Horse Gulch removal action as identified in the EE/CA addendum, additional state and local concerns were identified. To address these concerns, the EPA issued EE/CA Addendum No. 2

(CDM Federal, 1999). Remedial activities associated with the EE/CA addendum no. 2 were performed during the 1999 construction season (phase III) and 2000 construction season (phase IV). The remedial alternative selected for the resurrection no. 1/Fortune mine area was based on the value analysis study (BOR 1996b) and implemented under the action memorandum for non-time-critical removal actions dated October 26, 1998 (EPA 1998b).

1.3 Removal Action Objectives

The removal action objectives (RAOs) for the removal action at OU 6 as presented in the EE/CA Addendum (CDM Federal 1998a) are as follows:

- Control airborne transport of contaminated materials
- Control erosion of contaminated materials into local water courses
- Control leaching and migration of metals from contaminated materials into surface water
- Control leaching and migration of metals from contaminated materials into ground water
- Control direct contact with and ingestion of contaminated materials
- Maintain/preserve historic and cultural features of the OU consistent with the National Register of Historic Places (NPHP) and current tourism draw

1.4 Organization of Technical Memorandum

A brief description of the contents of each of the sections in this memorandum is as follows:

- Section 1 – Introduction; includes the purpose, background, objectives, and organization of this technical memorandum
- Section 2 - Summary of Removal Actions; provides a description of the removal action activities chronologically and by area
- Section 3 - Evaluation of Effectiveness; presents qualitative and quantitative evaluations of the performance of the removal actions and a summary of representative surface water quality data
- Section 4 - References, lists the documents referred to during the development of this technical memorandum and other that may be relevant to the issues discussed in this report

Section 2
Summary of Removal Actions

Past removal actions were conducted as time critical (pre-1997 and 2000) and as non-time critical (1997 through 2000). Non-time critical actions are also known as phase I, phase II, phase III, and phase IV removal actions. A chronological overview of the activities performed as part of these actions is presented in Section 2.1. A summary of the activities performed in each area or mine site is presented in Section 2.2.

The source area sites where past removal actions have occurred are as follows:

- Adelaide-Ward site
- Greenback Site
- Hamm's tailing impoundment
- Highland Mary Site
- Mikados Site
- Mahala Site
- Maid of Erin Site
- Penrose Site
- Ponsardine Site
- Pyrenees Site
- R.A.M. Site
- Resurrection No. 1/Fortune Site
- Starr Ditch
- Stray Horse Gulch
- 5th Street Headwall
- Wolftone Site

All of these sites, with the exception of the Resurrection No.1/Fortune site, are located in the Stray Horse Gulch drainage area. The Resurrection No. 1 / Fortune area is in the upper portion of Evans Gulch. Locations are presented in Figures 1 and 2.

2.1 Chronological Summary of Removal Activities

2.1.1 Time Critical Actions (Pre-1997)

Time critical construction activities were completed largely as emergency response removal actions prior to 1997. A detailed description of these removal activities can be found in the memoranda prepared by the EPA (EPA 1995; EPA 1996a, EPA, 1996b) and in a construction report prepared by the BOR (BOR 1998a). The following remedial activities were conducted in Stray Horse Gulch as part of time critical actions:

- Installation of 5th Street culverts, 1990 (EPA 1995a)
- Sediment control at Hamm's site tailings, 1994 (EPA 1995a)
- Repairs to Hamm's site drainage and sediment structures, 1995 (EPA 1995b)
- Removal of sediment from 5th Street drainage ditch, 1996 (EPA 1996a)
- Removal of Penrose mine waste pile and depositing waste in Hamm's tailings impoundment, 1996 (EPA 1996b, BOR 1998a)
- Capping of Hamm's tailings pile, 1996-1997 (BOR 1998a)

2.1.2 Phase I Removal Actions (1997)

The revised plan for removal action (EPA 1996c) identified waste rock piles as sources of constituent loading to Stray Horse Gulch and advised remediation of these piles. Subsequently, the piles were included in the EE/CA evaluation (CDM Federal 1997) and a removal action design was prepared (BOR 1997c). Phase I removal action construction activities were completed over the period from March to September 1997. Inspection work was completed in the summer of 1998 and the work was accepted in September 1998.

Phase I remedial activities included excavating, transporting, placing, and compacting contaminated mine waste; capping the constructed piles with geosynthetics and rockfill, abandoning (plugging) mine shafts; constructing surface drainage structures around the piles; and making improvements to existing roads at the Site. These activities were limited to the Wolftone, Maid of Erin, and Mahala waste rock piles. (Figure 1). A detailed description of the removal activities can be found in the final phase I removal action completion report (CDM 2000b).

The following activities were completed as part of phase I:

- Waste rock was consolidated into three waste rock piles; Mahala, Maid of Erin, and Wolftone. These piles were capped.
- Contaminated material within Stray Horse Gulch Road was excavated and placed in the Maid of Erin waste rock pile.
- Three double-compartment mine shafts were capped.
- Five crib walls, totaling 878 linear feet were constructed at the Maid of Erin pile.
- Asbestos discovered in the Wolftone and Maid of Erin waste rock piles was removed.

Consolidation and capping work scheduled for the Ponsardine pile in phase I was not performed. The removal action at Ponsardine was subsequently modified and resulted in a stabilization effort that was completed in 1999.

2.1.3 Phase II and Phase III Removal Actions (1998 - 1999)

Phase II and III removal actions were conducted as a continuation of the plans for removal action outlined in the revised plan for removal action (EPA 1996c), the EE/CA evaluation (CDM Federal, 1997), and the EE/CA addendum (CDM Federal 1998a). Phase II construction activities were completed over the period from July to November 1998. Phase III construction activities were completed over the period from May to October 1999. Inspection work was completed and the work accepted in October of 1999.

Phase II and phase III remedial activities included construction of a surface water management system (run-on diversions, run-off collection channels, retention and detention basins), rehabilitation of Stray Horse Gulch, rehabilitation of Starr Ditch, abandoning one mine shaft, and making improvements to existing roads at the Site. A detailed description of the removal activities can be found in the final phase II/III removal action completion report (CDM 2000c).

The following activities were completed as part of phase II:

- The double-compartment mine shaft near the Adelaide-Ward pile was abandoned and capped.
- Surface water run-on diversions were constructed at the Highland Mary, Adelaide/Ward, Pyrenees, Mikados, and R.A.M. piles.
- Surface water run-off collection channels and surface water retention basins were constructed at the Highland Mary, Adelaide/Ward, Pyrenees, Mikados, and Resurrection No. 1/Fortune piles.
- A surface water detention basin was constructed at Adelaide Park.
- A pipeline was constructed in Stray Horse Gulch to direct flow around the Mikados pile.
- Sediments were excavated from the 5th Street headwall, Stray Horse Gulch, and Starr Ditch.
- Stray Horse Gulch channel was reshaped, and erosion protection was installed.
- Starr Ditch was rehabilitated.
- A crib wall was constructed at the Mikados pile.
- Disturbed areas from phase I, Hamm's pile, and Penrose pile were revegetated.

The following activities were completed as part of Phase III:

- Surface water run-off collection channels and surface water retention basins were constructed at R.A.M., Greenback, and Fortune/Resurrection.
- Concrete overflow weirs and riprap rundown channels were provided for all retention basins constructed in phases II and III.
- A detention basin was constructed in lower Stray Horse Gulch (Emmet Detention Basin).
- The Greenback crib wall and drainage system was constructed.
- Hamm's pile drainage channels and culverts were constructed.
- Phase I, II and III disturbed areas were revegetated.

In the spring of 1999, water from the Upper and Lower Adelaide retention basins was siphoned off to prevent overflow from the basins and the potential for catastrophic failure. The siphoned water was discharged to Stray Horse Gulch.

In the summer of 1999, piezometers were installed at the Adelaide, Greenback No. 2, Highland Mary, Mikados, Pyrenees and R.A.M. Retention Basins to monitor ground water level fluctuations in the vicinity of the ponds (CDM Federal 2000g). A total of ten piezometers were installed (Figures 3 and 4).

In the summer and fall of 1999, a surface and subsurface investigation was performed at the former building location at the Penrose site. Identified waste materials were removed.

In the fall of 1999, the Ponsardine pile was stabilized as a demonstration project.

2.1.4 Phase IV Removal Actions (2000)

Phase IV removal actions were conducted as a continuation of the plans for removal action outlined in the revised plan for removal action (EPA 1996c), the EE/CA evaluation (CDM Federal 1997), and the EE/CA addendum (CDM Federal 1998a). Phase IV construction activities were completed over the period from July to November 2000.

Phase IV remedial activities consisted of the continued rehabilitation of Starr Ditch (downstream of 3rd Street to the confluence with lower California Gulch), improvements to haul roads, installation of culverts and sloping boulder drop structures, slope stabilization at R.A.M. and Greenback, and revegetation. A detailed description of the removal activities can be found in the final phase IV removal action completion report (CDM 2000d).

The following activities were completed as part of phase IV:

- Slope stabilization at R.A.M. and Greenback
- Stray Horse Gulch channel excavation, shaping, and erosion protection
- Rehabilitation of Starr Ditch
- Construction of culverts
- Revegetation of disturbed areas

In the spring of 2000, water from the Greenback No. 2 retention basin was siphoned off to prohibit overflow from the basins. The siphoned water was discharged to Stray Horse Gulch.

2.1.5 Time Critical Removal Actions (2000)

An emergency removal action was completed in the spring of 2000 in the drainage northwest of the Greenback, R.A.M. and Pyrenees mine waste piles to address conditions that developed since the construction of the Greenback - R.A.M. surface water management system in 1999 (EPA 2000). The work was completed in the summer of 2000 and consisted of constructing a conveyance system that collects overflow from the Greenback No. 2 retention basin and routes it into the Marion mineshaft. As a result, all collected run-off from the Pyrenees, Greenback, and R.A.M. is now routed into the Marion shaft. The Marion shaft ultimately intercepts the underground workings of the Emmet mine.

2.2 Summary of Removal Actions by Area

The following sections summarize the removal actions and associated activities completed at each mine site location. Locations of the sites are presented in Figures 1 and 2.

2.2.1 Adelaide-Ward Site

Remedial activities completed at the Adelaide-Ward site include construction of a surface water management system and abandonment of a mineshaft. Both of these activities were completed in 1998 as part of phase II activities. Modifications were made as in 1999 as part of phase III activities. A detailed description of remedial activities is included in the phase II/III removal action completion report (CDM 2000c).

The surface water management system consists of approximately 1165 feet of surface water run-on diversions channel constructed up slope of the waste rock pile to divert water around the pile; 1260 feet of surface water run-off collection channels constructed around the perimeter of the waste rock pile to capture potentially impacted water; and two retention basins constructed to store collected water (Upper and Lower Adelaide Retention Basins, Figure 4). The basins were modified in 1999 to include concrete overflow weirs and riprap rundown channels. Approximately 66 lineal feet of rundown channel was provided in the upper basin and 20 lineal feet in the lower. The retention basins were sized to contain the 500-year storm event, the upper basin has a storage capacity of 21,344 ft^3 (0.49 acre-feet) and the lower basin 9,583 ft^3 (0.22 acre-feet). Overflow from the upper basin is routed to the lower basin and overflow from the lower basin is routed to Stray Horse Gulch. One piezometer (AUMW-01) was installed in 1999 to monitor ground water level downgradient of the upper basin.

2.2.2 Greenback Site

A surface water management system was constructed at the Greenback site in 1998 and 1999 as part of phase II and III activities. A detailed description of remedial activities is included in the phase II/III removal action completion report (CDM, 2000c). Portions of the Greenback embankment were stabilized in 2000 as part of phase IV activities. This work is described in the phase IV removal action completion report (CDM 2000d)

The surface water management system consists of approximately 805 feet of surface water run-on diversions channel constructed up slope of the waste rock pile to divert water around the pile; 285 feet of surface water run-off collection channels constructed around the perimeter of the waste rock pile to capture potentially impacted water; and a series of retention basins constructed to store collected water. The retention basins (Greenback Nos. 1, 2 and 3) were sized to contain the 500-year storm event and have capacities of 4,792 ft^3 (0.11 acre-feet); 20,473 ft^3 (0.47 acre-feet); and 2,178 ft^3 (0.05 acre-feet), respectively (Figure 3). Overflow from Greenback Nos.1 and 3 is routed to Greenback No. 2. Overflow from Greenback No. 2 has been directed into the Marian mineshaft since July 2000 – prior to this time overflow was directed into Stray Horse Gulch.

Slope stabilization of the steepest portion of the R.A.M./Greenback embankment above a 140-foot section of the Mineral Belt Bike Path was completed in 2000 (phase IV). The work included installation of a gabion wall and 6-inch perforated high density polyethelene (HDPE) drainage pipe. Drainage is routed directly into the Marian mineshaft. Two piezometers (GBMW-01 and GBMW-02) were installed in 1999 to monitor ground water level up and down gradient of the No. 2 basin.

2.2.3 Hamm's Tailing Impoundment

Time critical remedial activities completed at the site of Hamm's tailing impoundment include sediment control measures implemented in 1994, emergency removal actions conducted in 1995, and the consolidation of mine waste from Penrose on Hamm's tailing impoundment and regrading and covering of Hamm's tailings Impoundment in 1996 and 1997. Revegetation and drainage work were completed in 1998 (phase II) and additional surface water drainage rehabilitation was completed in 1999 (phase III). A detailed description of remedial activities is included in the phase II/III removal action completion report (CDM 2000c).

The ditch between Ash and 5th Streets was reconstructed with riprap (220 lineal feet) and a concrete inlet structure was installed at 5th Street in order to minimize flow of mud and water into 5th Street during summer thunderstorm events. This work was completed in 1998 (phase II). Revegetation of the Hamm's tailings impoundment was also completed in 1998.

Surface water drainage rehabilitation work completed in 1999 (phase III) consisted of demolition of approximately 1076 feet of existing drainage channel, construction of 1076 feet of riprap lined open channel, placement of 3 new inlet structures, modification of one existing inlet structure, and installation of 174 feet of reinforced concrete piping. Disturbed areas were revegetated.

2.2.4 Highland Mary Site

A surface water management system was constructed at the Highland Mary site in 1998 as part of phase II activities. Modifications were made to the retention basin in 1999. A detailed description of remedial activities is included in the phase II/III removal action completion report (CDM 2000c).

The surface water management system consists of approximately 75 feet of surface water run-on diversions channel constructed up slope of the waste rock pile to divert water around the pile; 810 feet of surface water run-off collection channels constructed around the perimeter of the waste rock pile to capture potentially impacted water; and a retention basin constructed to store collected water (Figure 4). This system was installed in 1998. In 1999, the retention basin was modified to include a concrete overflow weir and 10 lineal feet of riprap rundown channel.

The retention basin was sized to contain the 500-year storm event and has a capacity of 42,689 ft^3 (0.98 acre-feet). Overflow from the basin is directed into a natural drainage that is tributary to Stray Horse Gulch. One piezometer (HMMW-01) was installed in 1999 to monitor ground water level down gradient of the basin.

2.2.5 Mahala Site

The Mahala waste rock pile was consolidated and capped during the 1997 construction season (phase I). Waste rock along the perimeter of the pile was collected into a central area, compacted, shaped and graded, and capped with a composite liner. A detailed description of remedial activities is included in the phase

I removal action completion report (CDM 2000b).

The Mahala pile consists of 32,000 cubic yards of consolidated mine waste rock. Materials were collected from the source area by excavating to the original pre-mining ground surface. The source area boundary was delineated by materials having a lead concentration of 6700 parts per million (ppm) or less, a zinc concentration of 1000 ppm or less, and a soil pH of 5 or greater. A maximum of two feet of native materials (below original ground surface) as excavated based on lead and zinc concentrations or pH. Soils were tested in situ using a portable x-ray fluorescence (XRF) spectrum analyzer unit. Details of the soil testing results are presented in the report *Response Action Construction, Stray Horse Gulch, Maid of Erin, Wolftone, and Mahala Source Areas* (BOR 1998).

The consolidated pile was designed to replicate the appearance of historic piles in the area, which are typically steep sloped. Collected material was added to an existing pile and placed/compacted in one-foot thick horizontal lifts to create a final slope of 1:1.5V (horizontal to vertical). A liner consisting of 40-mil textured (one side) polyvinyl chloride (PVC) geomembrane was placed over the consolidated waste rock, smooth side down, then covered with a non-woven geotextile (Mirifi geofabric). Approximately 15 feet of dolomite and white porphyry rock fill (measured horizontally) was then placed over the geotextile on the sides of the pile, and 2 feet on the top of the pile. One gas vent was placed in the liner at the center and top of the pile.

In 1999, benches in the cap were re-graded to promote drainage and reduce erosion that had been developing channels. Riprap was placed in established channels to reduce future erosion. Rock piles that resemble mine dumps were placed on the cap to break up the uniform color of the dolomite and provide a more aesthetic appearance. Disturbed areas around the pile were revegetated in September 1999.

2.2.6 Maid of Erin Site

The Maid of Erin waste rock pile was consolidated and capped during the 1997 construction season (phase I). Waste rock along the perimeter of the pile and from Stray Horse Gulch Road was collected into a central area, compacted, shaped and graded, and capped with a composite liner. A detailed description of remedial activities is included in the phase I removal action completion report (CDM 2000b).

The Maid of Erin pile consists of 209,362 cubic yards of consolidated mine waste rock (including 5,940 cubic yards from the Stray Horse Gulch Road). Materials were collected from the source area by excavating to the original pre-mining ground surface. The source area boundary was delineated by materials having a lead concentration of 6700 ppm or less, a zinc concentration of 1000 ppm or less, and a soil pH of 5 or greater. A maximum of two feet of native material (below original ground surface) were excavated based on lead and zinc concentrations or pH. Soils were tested in situ using a portable XRF analyzer unit. Details of the soil testing results are presented in the report *Response Action Construction, Stray Horse Gulch, Maid of Erin, Wolftone, and Mahala Source Areas* (BOR 1998)

The consolidated pile was designed to replicate the appearance of historic piles in the area, which are typically steep sloped. Collected material was added to an existing pile and placed/compacted in one-foot thick horizontal lifts to create a final slope of 1:1.5 (horizontal to vertical). A liner consisting of 40-mil textured (one side) PVC geomembrane was placed over the waste rock, smooth side down, then covered with a non-woven geotextile (Mirifi geofabric). Approximately 15 feet of dolomite rock fill (measured horizontally) was then placed/compacted over the geotextile on the sides of the pile and two feet on the top of the pile. A series of gas vents were placed in the liner along the crest of the pile at a 100-ft spacing.

In 1999, benches in the cap were re-graded to promote drainage and reduce erosion that had been developing channels. Riprap was placed in established channels to reduce future erosion. Rock piles that resemble mine dumps were placed on the cap to break up the uniform color of the dolomite and provide a more aesthetic appearance. Disturbed areas around the pile were revegetated in September 1999.

2.2.7 Mikados Site

Remedial activities completed at the Mikados site include construction of a surface water management system and waste rock pile erosion protection. Both of these activities were completed in 1998 as part of phase II activities. The surface water management system was modified in 1999 as part of phase III activities. A detailed description of remedial activities is included in the phase II/III removal action completion report (CDM 2000c)

The surface water management system consists of approximately 754 feet of surface water run-on diversions channel constructed up slope of the waste rock pile to divert water around the pile; 1480 feet of surface water run-off collection channels constructed around the perimeter of the waste rock pile to capture potentially impacted water; and a retention basin constructed to store collected water (Figure 4). The position of the storm water run-off channel and berm around the Mikados pile had to be adjusted in order to avoid impacting historic cultural resources. The retention basin was modified in 1999 to include a concrete overflow weir and 20 lineal feet of riprap rundown channel. The retention basin was sized to contain the 500-year storm event and has a storage capacity of 24,829 ft^3 (0.57 acre-feet). Overflow from the basin is directed into Stray Horse Gulch.

A crib wall was constructed to retain material and provide erosion protection for the waste rock pile. The crib wall also provides protection from excessive erosion that may result from the placement of the collection ditch into the toe of the pile. One piezometer (MMW-01) was installed in 1999 to monitor ground water level down gradient of the basin.

2.2.8 Penrose Site

The Penrose mine waste pile was moved to the Hamm's tailing impoundment. The removal was initiated as a time critical activity in 1996 and completed in 1997. Additional material with elevated lead levels was excavated from the Penrose area and transported to the R.A.M. Sediment Repository in 1999 as part of phase III activities. Revegetation work was performed in 1998 and 1999 as part of phase II/III activities. A description of remedial activities conducted in 1998 and 1999 is included in the phase II/III removal action completion report (CDM 2000c).

The Penrose mine waste pile covered an area of about four acres and contained about 173,000 cubic yards of waste rock. Penrose consisted of two long narrow piles oriented in an east-west direction. The eastern pile was approximately 500 feet by 200 feet and the western pile was approximately 450 feet by 200 feet. Both piles were between 50 and 55 feet high. The ditches around the periphery of Penrose eventually flow into Starr Ditch.

In 1996, about half or the material in the Penrose mine waste pile was moved. The remaining material was moved in 1997. Materials were placed on the Hamm's tailing impoundment, which was being regraded at the same time. Material that was assumed to be on private land was left in place at this time. In general, the Penrose mine waste site was excavated to the pre-mining ground elevation. An action level of 3,500 ppm was established for lead and the final ground surface was confirmed to be less than this level by sampling and XRF testing. Confirmation sampling and XRF testing was performed by BOR and documented in the construction report (BOR 1998).

During the 1998 construction season, the Penrose site was vegetated with a seed mix to help control surface erosion. In 1999, under the direction of EPA, CDM Federal took 39 surface soil samples for XRF testing to determine if lead levels in the soil were above 3,200 ppm. Subsurface soil samples were also collected from three borings; Penrose-1 to 37 feet, Penrose-2 to 24 feet, and Penrose-3 to 29 feet. The soil inside the grid areas that had at least 3,200 ppm of lead was excavated down to 2 feet below ground surface. Approximately 700 cubic yards of mine waste/soil was excavated and moved to the R.A.M. Sediment Repository. The disturbed area was covered with clean material hauled from the Leadville silver and gold (LSG) borrow area and disturbed areas were revegetated.

2.2.9 Ponsardine Site

Removal actions have been proposed for Ponsardine including capping and surface water management. These plans have not been implemented to date. A demonstration project was completed in 1999 in an attempt to stabilize the pile.

2.2.10 Pyrenees Site

A surface water management system was constructed at the Pyrenees site in 1998 as part of phase II activities. Modifications were made to the system in 1999 as part of phase III activities. A detailed description of remedial activities is included in the phase II/III removal action completion report (CDM 2000c).

The surface water management system consists of approximately 1010 feet of surface water run-on diversions channel constructed up slope of the waste rock pile to divert water around the pile; 555 feet of surface water run-off collection channels constructed around the perimeter of the waste rock pile to capture potentially impacted water; and a retention basin constructed to store collected water (Figure 3). The retention basin was sized to contain the 500-year storm event and has a capacity of 12,632 ft^3 (0.29 acre-feet). Some of the run-on diversion is sent into Graham Park to a detention basin. A clay lens was identified within the Pyrenees and Mikados retention basins during construction. The clay lens was removed and used as Type II material (clay) for construction of the retention embankments. This clay may limit the infiltration capacity of these retention basins.

In 1999, a concrete overflow weir and 136 lineal feet of riprap rundown channel were added to the retention basin. Overflow was directed to the Greenback No. 2 retention basin by a pipeline placed through the Greenback crib wall, 990 feet of lined open channel, a concrete inlet structure, and 200 lineal feet of HDPE piping. Four piezometers (PMW-01 through PMW-04) were installed in 1999 to monitor ground water levels up and down gradient of the basin.

2.2.11 R.A.M. Site

A surface water management system was constructed at the R.A.M. site in 1998 and 1999 as part of phase II and III activities. A detailed description of remedial activities is included in the phase II/III removal action completion report (CDM Federal 2000c).

The surface water management system consists of surface water run-on diversion, surface water run-off diversion, and a retention basin. Approximately 250 feet of surface water run-on diversions channel was constructed up slope of the waste rock pile to divert water around the top of the pile. Run-on channels were constructed in 1998. Approximately 850 feet of surface water run-off collection channels were constructed around the perimeter of the waste rock pile to capture potentially impacted water, and a retention basin was constructed to store collected water and sediment (Figure 3). The retention basin includes a concrete overflow weir and 100 linear feet of riprap rundown channel. The run-off collection channels and retention basin were constructed in 1999.

The retention basin (R.A.M./Greenback retention basin) was sized to contain the 500-year storm event and has a capacity of 44,867 ft^3 (1.03 acre-feet). Overflow is directed to the Greenback No.2 retention basin. Three piezometers (RAMMW-01 through RAMMW-03) were installed in 1999 to monitor ground water levels up and down gradient of the basin.

2.2.12 Resurrection No. 1 / Fortune Site

A surface water management system was constructed at the Resurrection No. 1/Fortune site in 1998 and 1999 as part of phase II and III activities (Figure 2). A detailed description of remedial activities is included in the phase II/III removal action completion report (CDM 2000c).

The surface water management system consists of surface water run-off collection and a retention basin. Approximately 1200 feet of surface water run-off collection channel was constructed around the perimeter of the waste rock pile to capture potentially impacted water. Approximately 700 feet of unlined interim run-off channel was constructed in 1998 and approximately 990 feet of riprap lined collection channel was constructed in 1999. A temporary retention basin was constructed in 1998 and made permanent in 1999. The retention basin collects run-off and associated sediment and has a capacity of 129,809 ft^3 (2.98 acre-feet). The retention basin includes concrete inlet and overflow weirs. Overflow is directed under a road and into a natural drainage.

2.2.13 Starr Ditch

Previous remedial activities completed along Starr Ditch include conversion of ditches to culverts in 1990 (EPA 1995a), ditch re-establishment in the area of the Harrison Street slag piles in 1995 (EPA 1995b), and removal of sediment in 1996 (EPA 1996b). Additional rehabilitation of the ditch was completed in 1998 and 2000 (phase II and phase IV). Description of this work is included in the phase II/III removal action completion report (CDM, 2000c) and the phase IV removal action completion report (CDM 2000d).

The 1998 rehabilitation of Starr Ditch consisted of removing sediments from the ditch and disposal of the sediment at the R.A.M. sediment repository, backfilling to grade and shaping of the ditch profile. The ditch was rehabilitated to convey a 100-year, 24-hour flood event, be stable under a 500-year, 24-hour flood event, and minimize the release of mining waste under a 500-year flow. Rehabilitation work also included retaining wall construction, concrete and culvert work, and road and fence repair.

The 2000 rehabilitation work was implemented to allow Starr Ditch to convey the 100-year runoff storm event downstream from 3rd Street to its confluence with California Gulch. Work consisted of additional excavation and shaping of the channel profile, placing and securing erosion control fabric and riprap, and the placement of grade control structures, concrete flow structures and culverts. Areas disturbed by construction activity were revegetated.

2.2.14 Stray Horse Gulch

Previous activities associated with the rehabilitation of Stray Horse Gulch include the removal of contaminated rock within Stray Horse Gulch Road; placement of a culvert under the county road in 1997 (phase I); and removal of sediment, channel restoration, and detention basin construction in 1998 (phase II). Descriptions of these activities are included in the phase I removal action completion report (CDM 2000b) and the phase II/III removal action completion report (CDM 2000c).

Contaminated rock located within Stray Horse Gulch Road was excavated and placed in the Maid of Erin waste rock pile. Approximately 5900 cubic yards were moved. A culvert was installed to convey Stray Horse Gulch beneath and across the county road. The culvert was needed due to the lower elevation of the gulch following consolidation of waste rock from this area (phase I).

The rehabilitation of Stray Horse Gulch consisted of excavating and shaping the channel profile, placing and securing erosion control fabric, and placing riprap in the channel. Rocks and sediment were separated, the rock was used as a source of riprap and the sediment was taken to the R.A.M. sediment repository for disposal. Concrete and culvert work was also performed as part of the rehabilitation and a pipeline was constructed to direct flow in Stray Horse Gulch around the Mikados pile (phase II).

Detention basins were constructed in lower Stray Horse Gulch to detain the 100-year, 24-hour flood event. The basins were located at Adelaide Park (Nugget Gulch Road) and the Emmet waste rock pile. Basin work consisted of excavation and shaping of the basin, fill and compaction of the basin's embankment, and final shaping of the basin's profile. Concrete and culvert work was also performed at the basins. The Adelaide Park detention basin has a capacity of 161,172 ft^3 (3.70 acre-feet) and the Emmet detention basin has a capacity of 64,904 ft^3 (1.49 acre-feet).

2.2.15 5th Street Headwall

Emergency removal action in 1996 involved removing sediment from the 5th Street drainage ditch at its headwall to its confluence with California Gulch along Starr Ditch. The sediment was transported and stockpiled at Hamm's tailing impoundment.

In 1998, sediments from the 5th Street headwall were excavated and transported to the R.A.M. sediment repository. Three sediment basins at the base of the wall in Stray Horse Gulch were re-established by excavating and shaping the basins, filling and compacting the basin's embankments, and final shaping of the basin's profile. Concrete work was also performed at the basins (phase II).

2.2.16 Wolftone Site

The Maid of Erin waste rock pile was consolidated and capped during the 1997 construction season (phase I). Waste rock along the perimeter of the pile was collected into a central area, compacted, shaped and graded, and capped with a composite liner. A detailed description of remedial activities is included in the phase I removal action completion report (CDM 2000b).

The Wolftone pile consists of 95,000 cubic yards of consolidated mine waste rock. Materials were collected from the source area by excavating to the original pre-mining ground surface. The source area boundary was delineated by materials having a lead concentration of 6700 ppm or less, a zinc concentration of 1000 ppm or less, and a soil pH of 5 or greater. A maximum of two feet of native material (below original ground surface) were excavated based on lead or zinc concentrations or pH. Soils were tested in situ using a portable XRF analyzer unit. Details of the soil testing results are presented in the report *Response Action Construction, Stray Horse Gulch, Maid of Erin, Wolftone, and Mahala Source Areas* (BOR 1998).

The consolidated pile was designed to replicate the appearance of historic piles in the area, which are typically steeped sloped. Collected material was added to an existing pile and placed/compacted in one-foot thick horizontal lifts to create a final slope of 1:1.5 (horizontal to vertical). A liner consisting of 40-mil textured (one side) PVC geomembrane was placed over the waste rock, smooth side down, then covered with a non-woven geotextile (Mirifi geofabric). Approximately 15 feet of dolomite rock fill (measured horizontally) was then placed/compacted over the geotextile on the sides of the pile and two feet on the top of the pile. Two gas vents were placed in the liner along the crest of the pile.

In 1999, benches in the cap were re-graded to promote drainage and reduce erosion that had been developing channels. Riprap was placed in established channels to reduce future erosion. Rock piles that resemble mine dumps were placed on the cap to break up the uniform color of the dolomite and provide a more aesthetic appearance. Disturbed areas around the pile were revegetated in September 1999.

2.2.17 Revegetation

Revegetation of areas within OU6 disturbed by phase I, II, and III construction activities, as well as the work at Hamm's and Penrose sites, was completed near the end of each of the 1998 and 1999 construction seasons. Revegetation generally consisted of seed bed preparation to a 12-inch depth, incorporation of soil amendments (Biosol) at 1500 pounds per acre, placement of seed (mixed per specification) at a minimum of 40 pounds per acre, and addition of Summit Grow mulch cover at 40 cubic yards per acre. Selected areas received different application rates for seeds and amendments and erosion control matting.

Section 3
Evaluation of Effectiveness

No specific performance goals have been defined for the removal actions, however, information collected during and following construction can be used to assess the effectiveness of the removal actions. The following information has been collected and used in evaluating effectiveness:

- Surface water quality data (before, during, and following construction)
- Soil analytical data (during construction)
- Observations on cap performance
- Observations on vegetation performance
- Observations on surface water management performance

This information is used to evaluate the effectiveness of the removal actions in three ways:

- Examine how the actions meet the RAOs (Section 1.3)
- Evaluate the performance of structures based on observations made.
- Evaluate changes in surface water quality in Stray Horse Gulch.

These assessments of effectiveness are discussed in detail in the following sections. Photographs showing some of the work completed during the removal actions in OU6 are presented in Figures 5, 6, and 7.

3.1 Effectiveness Relative to Remedial Action Objectives

A summary of how the each of the removal actions have met have met specific each RAO is provided in the following paragraphs.

<u>Control direct contact with, ingestion of, and airborne transport of contaminated material</u>

- Waste rock piles at Mahala, Maid of Erin, and Wolftone sites have been consolidated and capped and the waste rock pile at Penrose was moved to the Hamm's tailing impoundment and both areas covered. The waste materials in these locations are now not directly accessible at the ground surface eliminating direct contact and ingestion pathways. Airborne transport of the waste materials at these locations is also no longer possible.
- Surface materials in the areas of the Mahala, Maid of Erin, and Wolftone meet the action level for lead (6700 ppm).
- Sediments have been excavated from Starr Ditch, Stray Horse Gulch, and the 5th Avenue headwall and placed in the Hamm's impoundment, the Maid of Erin waste rock pile or the R.A.M. sediment repository. These materials have also been removed from direct contact, ingestion and airborne transport.
- Disturbed areas have been revegetated. Revegetation provides stabilization and reduces the potential for erosion by wind.

<u>Maintain/preserve historic and cultural features</u>

- Historical features that have been preserved and or restored during removal actions include Hamm's ore bin, Mikados crib wall, Greenback crib wall, Finn Town structures no. 20, 24, and 35, IBEX hoist house, The Denver City headframe, Wright headframe, and the Pyrenees headframe.
- The regraded and capped piles at Mahala, Maid of Erin, and Wolftone sites were designed to be consistent with historic waste rock piles, cover materials were provided to achieve an aesthetic appearance.

<u>Control erosion of contaminated materials into local water courses</u>

- Erosion and transport of waste rock material at Mahala, Maid of Erin, Wolftone, Penrose, and tailing material at Hamm's has been eliminated through consolidation and capping.

- Surface water run-off from waste rock areas is collected at Adelaide/Ward, Greenback, Highland Mary, Mikados, Pyrenees, R.A.M sediment repository, and Resurrection No.1/Fortune locations. Collected water is routed to retention basins, collected sediments are not allowed to enter native surface water bodies.
- Erosion in disturbed areas has been reduced by revegetation.

Control leaching and migration of metals from contaminated materials into surface water

- Surface water run-off from waste rock areas is collected and water is routed to retention basins and allowed to infiltrate into the ground. Discharges to surface water bodies are minimized.

Control leaching and migration of metals from contaminated materials into ground water

- Surface water run-on to waste rock areas is diverted at Adelaide/Ward, Greenback, Highland Mary, Mikados, Pyrenees, R.A.M, and Resurrection No.1/Fortune. This water is routed around waste rock areas and is unable to leach and transport constituents from waste rock areas to ground water.
- Infiltration through waste rock, and subsequent constituent loading to ground water, has been eliminated at the Mahala, Maid of Erin, and Wolftone piles through the installation of the impermeable liner in the covers.

3.2 Observations on Performance

3.2.1 Stability of Consolidated and Capped Piles

A site visit was made to the consolidated and capped piles at Maid of Erin, Mahala, and Wolftone in 1998, one year after construction (PWT 1998). During this visit, tension cracks were observed in the outer edges of benches of the Maid of Erin and Wolftone piles. This cracking was observed to be limited to the portions of the fill that were not compacted during placement and does not indicate pile instability.

3.2.2 Revegetation Performance

Site visits were made in 1999 to assess the performance of the revegetation effort (CDM Federal 1999c; NRCS 1999). By the fall of 1999 the 1998 revegetation effort was judged to be performing moderately well with only a few steep slopes and localized patches not sustaining productive plant growth.

3.2.3 Performance of Surface Water Management System

Observations concerning the performance of the surface water collection systems and retention basins were made during phase III construction in 1999 and in a site visit in 2000 (CDM Federal 2000f). These observations have resulted in design changes and additional construction that have been summarized in previous sections. In general, the retention basins collect and store more water that was originally expected. This condition has resulted in the construction of overflow weirs and channels. Overflow from the Upper and Lower Adelaide, Mikados, and Highland Mary retention basins is directed into Stray Horse Gulch. Overflow from the Pyrenees, R.A.M. sediment repository/Greenback, and Greenback Nos. 1, 2, and 3 retention basins is directed into the Marian mineshaft. The surface water controls in Stray Horse Gulch appeared to be functioning properly. Silt accumulating in retention structures needs annual removal.

3.3 Effectiveness Relative to Surface Water Quality

Prior to and during the course of removal action activities numerous samples of surface and ground water were collected and analyzed. The subset of these data that were collected from areas that can be correlated with the removal action areas were examined for trends that may indicate effects of the removal actions. The following sections present a summary of pertinent sampling activities performed and an evaluation of the data collected.

3.3.1 Summary of Surface Water Sampling Activities

A large number of stations have been established within OU6 that are used on a continuing basis for surface and seepage sampling. For the purposes of this review, only data from the stations that are directly influenced by the removal actions in Stray Horse Gulch and Evans Gulch have been examined. A description of these sampling stations is presented in Table 1. A line diagram showing the hydrologic relationship between sampling stations and removal action areas is presented in Figure 8.

In Stray Horse Gulch, six surface water monitoring stations have been established on the main stem of the drainage (SHG-7, SHG-7A, SHG-8, SHG-9, SHG-9A, SH-10). In Starr Ditch, one location has been established that can be directly related to conditions in Stray Horse Gulch (SD-3). The sampling locations along Starr Ditch downstream of SD-3 include influences from the Apache tailings impoundment, and sampling locations further down stream include influences from the confluence with California Gulch and its tributaries. Due to the potential influences from sources other than Stray Horse Gulch, only the sampling locations SD-3 and above have been used in the evaluation of removal actions in Stray Horse Gulch.

In Evans Gulch, only one sampling station (EG-03) can be directly related to the removal actions conducted to date (Resurrection No. 1/Fortune), the next lower station (WE-02) has also been included even though it is below the confluence with South Evans Gulch.

The following surface water sampling efforts were conducted that included locations in Stray Horse Gulch and Evans Gulch:

- Spring 1995, includes multiple events of surface water sampling and hydrologic measurements in Stray Horse Gulch and Evans Gulch (BOR 1996a; RMC 1998)
- Spring 1996, continuation of 1995 program (BOR 1997a)
- Spring 1998, one synoptic sampling event (CDM Federal 1998b)
- Summer 1998, two storm water sampling events (CDM Federal 1998c)
- Spring 1999, two synoptic sampling events (CDM Federal 1999b; RMC 1999)
- Summer 1999, one storm water runoff sampling event (CDM Federal 2000e)
- Fall 1999, Pyrenees and Greenback retention pond sampling (CDM Federal 2000e)
- Spring 2000, two synoptic sampling events (RMC 2001) and three snow melt sampling events (CMC 2001)
- Summer 2000, five storm water sampling events (CMC 2001)
- Spring 2001, two synoptic sampling events and sampling of eight retention basins (CMC 2001)

In order to make an evaluation of surface water quality trends, samples must be collected from the same location and under similar conditions over a period of time. For comparative purposes, the following discussion is limited to the information collected during spring runoff events.

3.3.1.1 Spring 1995 Sampling

The BOR conducted a program of field sampling for the EPA Region VIII under an inter-agency agreement in 1995. One of the objectives of this work was to provide a detailed chemical and hydrologic description of a single season snowmelt runoff event based on weekly sampling from May 10 through July 26, 1995. Surface water samples and stream flow measurements were obtained from active stations in Stray

Horse Gulch and Evans Gulch. A comprehensive summary of the results of the program is presented in the *Phase I Feasibility Study, Water and Sediment Sampling and Hydrologic measurement Program Results and Findings, 1995 Spring Runoff for Operable Unit 6, California Gulch NPL Site, Leadville, Colorado* (BOR 1996a).

Sampling in Stray Horse Gulch was performed at four stations, SHG-7, SHG-8, SHG-9, and SHG-10. Flow measurements were conducted concurrently with sampling. Peak runoff was observed to occur on June 19, 1995 at all stations. Analytical results for a selected subset of parameters are presented in Table 3. RMC conducted a California Gulch loading analysis that included the Stray Horse Gulch stations. The analysis was conducted using data from May 30 to June 2, 1995 due to its completeness, however, the data was collected 17 to 19 days prior to peak runoff and can't be readily compared to later sampling events conducted at peak runoff. A summary of this analysis is also included in Table 2.

Sampling in Evans Gulch included the stations EB-03 and WE-02. Peak runoff was observed to occur on June 14, 1995 at EG-03 and on June 19, 1995 at WE-02. Analytical results for a selected subset of parameters are presented in Table 3.

3.3.1.2 Spring 1996 Sampling

Surface water sampling in the spring of 1996 was a continuation of the Bureau of Reclamation's sampling program that began in the spring of 1995. Surface water samples and stream flow measurements were obtained from active stations in Stray Horse Gulch and Evans Gulch over a seven week period from May 18 to June 25, 1996. A summary of the results of the program is presented in the *Environmental Geology of Operable Unit 6, Removal Action Design Data, California Gulch Superfund Site, Leadville, Colorado* (BOR, 1997a).

Sampling in Stray Horse Gulch was performed at five stations, SHG-7, SHG-7A, SHG-8, SHG-9, and SHG-10. Flow measurements were conducted concurrently with sampling. Peak runoff was observed to occur earlier (May 21, week 2) and the magnitude of runoff was less than in 1995. Analytical results for a selected subset of parameters are presented in Table 3.

Sampling in Evans Gulch included the stations EB-03 and WE-02. Analytical results for a selected subset of parameters are presented in Table 3.

3.3.1.3 Spring 1998 Sampling

Surface water samples were obtained from the active sampling stations within Stray Horse Gulch and Starr Ditch on May 20, 1998. This sampling event is documented and the results presented in the report *Synoptic Surface Water Sampling Results, May 20, 1998, Stray Horse Gulch/Starr Ditch* (CDM 1998b).

Sampling of stations along the main stem of Stray Horse Gulch and Starr Ditch was conducted as a synoptic sampling event. Flow measurements were conducted concurrently with sampling. Additional non-synoptic sampling was also conducted in locations off the main stem of the gulch. Flow measurements were conducted concurrently with sampling. The observed stream flows were significantly lower than expected, however, the position on the spring runoff hydrograph was not investigated. A complete set of results are presented in CDM Federal's report, results for a selected subset of parameters for stations on the main stem of Stray Horse Gulch and in Starr Ditch are presented in Table 2.

3.3.1.4 Spring 1999 Sampling

Surface water samples were obtained from the active sampling stations within Stray Horse Gulch in two separate sampling events conducted on May 14 and May 26, 1999. These sampling events are documented and the results presented in a memorandum *Synoptic Sampling of Stray Horse Gulch, Starr Ditch, and Lower California Gulch Performed on May 14 and 26, 1999* (RMC 1999).

The sampling of stations on the main stem of Stray Horse Gulch and on Starr Ditch was conducted as part of two separate synoptic sampling events. Additional non-synoptic sampling was also conducted in locations off the main stem of the gulch. Flow measurements were conducted concurrently with sampling. The May 14 sampling event represented one of the first days when snow melt runoff was observed at downstream stations of Stray Horse Gulch and Starr Ditch. The subsequent sampling event on May 26 was estimated to have occurred a few days after peak runoff. A complete set of results are presented in RMC's memorandum. (RMC 1999). Results for a selected subset of parameters for stations on the main stem of Stray Horse Gulch and in Starr Ditch are presented in Table 3. Results from both sampling events are included to demonstrate the variability that can occur over a short period of time.

During the spring runoff in 1999, water that was collecting in the Upper and Lower Adelaide retention basins was being siphoned into Stray Horse Gulch at a rate of approximately 5 gpm to reduce the possibility of overflow.

3.3.1.5 Spring 2000 Sampling

Surface water samples were obtained from the active sampling stations within Stray Horse Gulch in two separate sampling events conducted on May 4 and May 11, 2000. These sampling events are documented and the results presented in the report *Synoptic Sampling of Stray Horse Gulch, Starr Ditch, and Lower California Gulch (OU6), Spring 2000* (RMC 2001). A complete set of surface water samples were obtained from Evans Gulch during on May 22 and 23, 2000. These sampling events are documented and the results presented in the report *Site-Wide Water Quality, Summary of Events Completed by the Natural Resource Management Institute, 2000* (CMC 2000).

The sampling of stations on the main stem of Stray Horse Gulch and on Starr Ditch on May 4, 2000 and on May 11, 2000 was conducted as part of two separate synoptic sampling events. Additional non-synoptic sampling was also conducted in locations off the main stem of the gulch. Flow measurements were conducted concurrently with sampling. The May 4th sampling event was judged to be one to two days before peak runoff in upper Stray Horse Gulch (the May 11th event was thus five to six days after peak runoff). A complete set of results are presented in RMC's report (RMC 2001). Results for a selected subset of parameters for stations on the main stem of Stray Horse Gulch and in Starr Ditch are presented in Table 2. Results from both sampling events are included to demonstrate the variability that can occur over a short period of time.

The samples collected in Evans Gulch during a snow melting event on May 22 and 23, 2000. No stream flow measurements were collected during sampling. A complete set of results are presented in CMC's report (CMC 2000). Results for a selected subset of parameters are presented in Table 3.

During spring runoff in 2000, water that was collecting in the Greenback No. 2 Retention Basin was siphoned to Stray Horse Gulch to reduce the possibility of overflow. The diversion system to the Marion mine shaft had not been installed at this time.

3.3.1.6 Spring Sampling 2001

Surface water samples were obtained from active sampling stations within Stray Horse Gulch in two synoptic sampling events conducted on May 15, and May 23, 2001. Monitoring of flow conditions and field chemistry (pH and specific conductance) was performed on a near daily basis over the period from May 7 to May

25, 2001. Six retention ponds in Stray Horse Gulch (Adelaide/Ward, Highland Mary, Pyrenees, Greenback, R.A.M. sediment repository, and Mikados) were sampled on May 17 and June 3, 2001. Analytical results for the samples collected and documentation of the sampling activities has not yet been finalized. Preliminary results of the flow condition and field chemistry monitoring and retention pond sampling have been obtained from (CMC 2001).

3.3.2. Observed Trends in Surface Water Quality

3.3.2.1 Stray Horse Gulch

Stray Horse Gulch is an intermittent stream, only flowing during spring snowmelt runoff and thunderstorm events. Daily variations during spring runoff are high; flows are low or non-existent in the morning and increase in the afternoon as snow melting increases. The hydrology of the drainage changes during the course of spring runoff, a given reach may be either gaining or losing depending on the flow rate and time of year (position on the runoff hydrograph). The constituent load in surface water also varies considerably during the course of spring runoff events. This is evident in the difference in the results of sampling conducted on May 4 and May 11, 2000 (Table 1). The May 4th event was conducted 1 to 2 days prior to peak runoff and the May 11th event was conducted five to six days after peak runoff. As a result, sample results from various years are difficult to compare. Graphs of loading rates for selected analytical parameters for the sampling stations in Stray Horse Gulch are presented in Figures 9 through 15. A summary of the incremental loading changes between selected stations is provided in Table 4 and in Figures 16 through 20. A discussion of the information in these tables and figures follows.

Station SHG-7 is up gradient of any removal action and has the best water quality of any station in Stray Horse Gulch. There is some variability in the chemistry of the surface water samples collected over time but no trend in water quality is apparent.

Station SHG-7A was not established until 1996 when the location was sampled in early spring. In 1996, analytical results for surface water indicated that a significant increase in metal concentrations was occurring during spring runoff between SHG-7A and SHG-8. Spring runoff sampling results from 1999 and 2000 indicate an improvement in water quality from the 1998 results. The pH level increases from below 3 to above 5 and loading rates decrease for numerous constituents including total dissolved solids (TDS), sulfate, and zinc. This improvement may be due to the construction of surface water controls in Adelaide Park and at the Adelaide/Ward waste rock pile in the summer of 1998.

Surface water quality sample results from station SHG-8 change from being significantly lower in quality than those from station SHG-7A prior to 1999 to being similar to those in SG-7A in 1999 and 2000. The pH level increases from 2 in 1998 to above 5.5 in 1999 and 2000. Loading rates for zinc and cadmium are also lower in 1999 and 2000 than in 1998. This improvement may indicate that the construction of surface water controls at Mikados and Highland Mary was effective in improving surface water quality.

Station SHG-9 has historically had the highest median constituent concentrations in Stray Horse Gulch. In the drainage sub-basin between SG-9 and SG-8, removal actions have taken place at Mahala, Maid of Erin, and Wolftone in 1997, Pyrenees and R.A.M in 1998, and at Greenback and R.A.M in 1999. Surface water quality sample results do not show a clear trend. Measured pH values were similar to those at SHG-8 prior to 1999 and are significantly lower in 1999 and 2000, indicating the improvement in water quality at SHG-8 by 1999 but not at SHG-9.

Station SHG-9A includes some of the runoff from Hamm's tailing impoundment. Field chemistry measurements taken in the spring of 2001 indicate that the pH at

SHG-9A starts out at a relatively high pH of 7.3 and decreases as runoff progresses to less than 3.5. This decrease in pH during runoff indicates that dilution with higher quality surface water is occuring early in the spring runoff.

Station SHG-10 was established in the pipe outfall from Stray Horse Gulch into Starr Ditch and was utilized in 1995, 1996, and 1998. The station was not used following Starr Ditch rehabilitation in 1998. Data from this station is limited and generally cannot be used to assess the effectiveness of removal actions.

In the sub-basin between stations SG-9A and SD-3 removal actions have taken place at the Hamm's site between 1994 and 1997; at the 5th Street headwall in 1996 and 1998, and at Penrose in 1996. Results from water quality samples collected at SD-3 do not indicate improvements in water quality at this time, however, pH values are higher (above 3) in 1999 and 2000 as compared to 1998 (about 2).

3.3.2.2 Evans Gulch

There are only two sets of water quality sample results (spring 1995 and spring 2000) that can be compared that provide information regarding the effectiveness of the Resurrection No. 1/Fortune surface water management system constructed in 1998 and 1999. The 1995 samples were collected at peak runoff – flow rates were measured and constituent loading rates can be calculated. The 2000 samples were collected during spring snowmelt – flow rates were not measured and it is unknown exactly where this sampling event lies on the runoff hydrograph. As a result, only constituent concentrations can be compared.

Constituent concentrations measured at station EG-03 in the spring of 2000 are less than those measured in the spring of 1995. While the lower concentrations may be due to the remedial actions completed at Resurrection No. 1/Fortune, they are also typical of higher flow rates and associated dilution effects. Constituent concentrations measured at station WE-02 in the spring of 2000 are greater than those measured in the spring of 1995. Numerous sites in Evans Gulch, South Evans Gulch, and Lincoln Gulch contribute to the water quality at station WE-02. However, if flow rates were higher in 2000 than in 1995 a dilution effect would be expected. Since this is not observed, stream flows may not have been higher at the time samples were taken at both EG-03 and WE-02, and constituent loading may in fact be lower at EG-03 in 2000.

Section 4
References

The references that are listed in this section have been divided into two groups. References cited in this document are presented in Section 4.1 and other pertinent references are listed in Section 4.2. The alphabetical suffixes attached to the reference date (where more than one publication from one author were made in one given year) were made sequentially as if the reference list was unified.

4.1 References Cited

CET Environmental Services, Inc., 2000. *Work Plan for Greenback-R.A.M. Collection System, California Gulch NPL Site, Leadville, Lake County, Colorado.* June 24.

CDM Federal, 1997. *Engineering Evaluation/Cost Analysis for Stray Horse Gulch Operable Unit 6, California Gulch NPL Site, Leadville, Colorado.* June.

CDM Federal, 1998a. *Addendum to Engineering Evaluation/Cost Analysis for Stray Horse Gulch Operable Unit 6, California Gulch NPL Site, Leadville, Colorado.* May.

CDM Federal, 1998b. *Synoptic Surface Water Sampling Results, May 20, 1998, Stray Horse Gulch/Starr Ditch.* August, 1998.

CDM Federal, 1998c. *September 16 and 29, 1998, Storm Water Sampling Results.* Letter report to USEPA, December 17, 1998.

CDM Federal, 1999a *Addendum No. 2 to Engineering Evaluation/Cost Analysis for Stray Horse Gulch Operable Unit 6, California Gulch NPL Site, Leadville, Colorado.* May.

CDM Federal, 1999b. *Surface Water Sampling Data for Stray Horse Gulch.* Letter report to USEPA, August 13, 1999.

CDM Federal, 1999c. *Revegetation Field Evaluation and Species Survey Report for California Gulch NPL Superfund Site, Leadville, Colorado.* September.

CDM Federal, 2000a. *Revised Work Plan For California Gulch Superfund Site, Lake County, Colorado, Operable Unit 6.* February.

CDM Federal, 2000b. *Final Phase I Removal Action Completion Report for the California Gulch Superfund Site, Lake County, Colorado, Operable Unit 6.* December.

CDM Federal, 2000c. *Final Phase II/III Removal Action Completion Report for the California Gulch Superfund Site, Lake County, Colorado, Operable Unit 6.* December.

CDM Federal, 2000d. *Final Phase IV Removal Action Completion Report for the California Gulch Superfund Site, Lake County, Colorado, Operable Unit 6.* December.

CDM Federal,2000e. *1999 Surface Water Sampling Data at California Gulch OU6.* Memorandum to EPA dated January 18, 2000.

CDM Federal, 2000f. Stray Horse Gulch Site Visit, Communication regarding site visit on July 27, 2000 by Geoffrey McKenzie. July 28.

CDM Federal, 2000g. *1999 Soil Boring and Monitoring Well Installation Program, Draft Technical Memorandum.* Memorandum to EPA dated April 20, 1999.

CDM Federal, 2000h. *1999 Penrose Mine Waste Pile Removal, Draft Technical Memorandum.* Memorandum to EPA dated April 20, 1999.

CMC, 2000. *Site-Wide Water Quality, Summary of Events Completed by the Natural Resource Management Institute, 2000.* November, 14, 2000.

PWT, 1998. *Trip Report and Geotechnical Review, September 11, 1998 Site Visit, Stray Horse Gulch, California Gulch NPL Site Operable Unit 6, Leadville, Colorado.* September 29.

RMC, 1998. *California Gulch Loading Analysis,* Memorandum to CDHE dated January 12, 1998

RMC, 1999. *Synoptic Sampling of Stray Horse Gulch, Starr Ditch, and Lower California Gulch Performed on May 14 and 26, 1999,* Memorandum to CDHE dated January 12, 1998

RMC, 2000. *Synoptic Sampling of Stray Horse Gulch, Starr Ditch, and Lower California Gulch (OU6, Spring 2000.* January 2001

United States Department of Agriculture, Natural Resources Conservation Service, 1999. Summary of August 26, 1999 site visit and vegetation assessment. Correspondence from John Nelson (NRCS) to Michael Holmes (EPA), September 17 .

United States Department of the Interior, BOR 1996a. *Phase 1:Feasibility Study, Water and Sediment Sampling and Hydrologic Measurement Program, Results and Findings, 1995 Spring Runoff for Operable Unit 6, California Gulch NPL Site, Leadville, Colorado.* Prepared for the U.S. Environmental Protection Agency, November.

United States Department of the Interior, BOR, 1996b. *Value Analysis, Draft-Presentation Report, Project: California Gulch OU6 Removal Action Evaluation and Decision Phase, Leadville, Colorado.* April.

United States Department of the Interior, BOR, 1997a. *Draft Environmental Geology of Operable Unit 6, Removal Action Design Data, California Gulch Superfund Site, Leadville, Colorado.* (Includes Phase 2, mine waste pile sampling and analyses; and Phase 3 water and sediment sampling and analyses). Prepared for the U.S. Environmental Protection Agency. February.

United States Department of the Interior, BOR, 1997c. *Operable Unit 6 Removal Action Construction, California Gulch Superfund Site, Lake County, Colorado - Technical Specifications and Drawings.* May 30.

United States Department of the Interior, BOR, 1998a. *Draft - Final Construction Report, Tailings and Mine Waste Containment, Operable Unit 6, California Gulch Superfund Site, Leadville, Colorado.* Prepared for the EPA. April.

United States Department of the Interior, BOR, 1998b. *Draft - Final Response Action Construction, Stray Horse Gulch, Maid of Erin, Wolftone, and Mahala Source Areas, Operable Unit 6, California Gulch Superfund Site, Leadville, Colorado.* Prepared for the EPA. June, 12.

EPA, 2000. *United States Environmental Protection Agency Region VIII Action Memorandum - Amendment. Subject: Request for an Emergency Removal Action in the drainage northwest of the Greenback, RAM and Pyrenees Mine Waste Piles, a portion of Operable Unit 6 (OU6) of the California Gulch National Priorities List Site, Leadville, Colorado.* Ref: 8EPR-ER.

EPA, 1998a. *United States Environmental Protection Agency Region VIII Action Memorandum - Amendment. Subject: Request for Amendment to Action Memorandum dated June 24, 1997 which addressed Removal (Response) Actions at the California Gulch National Priorities List Site, Leadville, Colorado: ACTION MEMORANDUM for subsequent Non-Time Critical Removal Action for Source Control at Designated Mine Waste Piles. (Operable Unit 6).* Ref: 8EPR-SR. July 15.

EPA, 1998b. *United States Environmental Protection Agency Region VIII Action Memorandum. Subject: Request for Removal (Response) Actions at the California Gulch National Priorities List Site, Leadville, Colorado: ACTION MEMORANDUM for Non-Time Critical Removal Action for Water Management at the Resurrection #1 Tailings Pile at the upper end of Evans Gulch. (A portion of Operable Unit VI).* Ref: 8EPR-SR. October 26.

EPA, 1997. *United States Environmental Protection Agency Region VIII Action Memorandum. Subject: Request for Removal (Response) Actions at the California Gulch National Priorities List Site, Leadville, Colorado: ACTION MEMORANDUM for Non-Time Critical Removal Action for Source Control at Designated Mine Waste Piles. (Operable Unit VI).* Ref: 8EPR-SR. June 24.

EPA, 1996a. *United States Environmental Protection Agency Region VIII Action Memorandum -- Enforcement. Subject: Request for Removal (Response) Actions at the California Gulch National Priorities List Site, Leadville, Colorado: ACTION MEMORANDUM for Emergency Response Removal Action for the removal of sediments from the 5th Street Drainage Ditch and Starr Ditch, Operable Unit 6, (OU6).* Ref: 8EPR-SR. May 1.

EPA, 1996b. *United States Environmental Protection Agency Region VIII Action Memorandum. Subject: Request for Removal (Response) Actions at the California Gulch National Priorities List Site, Leadville, Colorado: ACTION MEMORANDUM for Time Critical Removal Actions for Hamm's Tailings Impoundment and the Penrose Mine Waste Pile.* Ref: 8EPR-SR. July 26.

EPA, 1996c. *Revised Plan for Removal Action, Stray Horse Gulch Drainage, Operable Unit 6, California Gulch Superfund Site, Leadville, Colorado.* December 16.

EPA, 1995. *United States Environmental Protection Agency Region VIII Action Memorandum. Subject: Request for Removal (Response) Actions at the California Gulch National Priorities List Site, Leadville, Colorado: ACTION MEMORANDUM for an Emergency Removal Action for Rehabilitation and Construction of Drainage and Sediment Control Features, Hamm's Tailing Impoundment.* Ref: 8HWM-SR. November 6.

EPA, 1989. *Phase II Remedial Investigation Technical Memorandum. Draft. California Gulch, Leadville,Colorado. Vols I-VI. 53-8129.0/DEN63786.R1.* Prepared by CH2MHill, Black and Veach, ICF, PRC, and Ecology and Environment. May.

4.2 Additional References

Alpine Archaeological Consultants, Inc., 1996. *Cultural Resource Inventory Report of a Proposed 15-Acre Borrow Area and Access Road, Operable Unit 6, California Gulch Superfund Site, Lake County, Colorado.* Prepared for the United States Department of the Interior, Bureau of Reclamation, June.

Alpine Archaeological Consultants, Inc., 1997a. *Cultural Resource Inventory of Two High Priority Survey Areas, California Gulch Superfund Site, Operable Unit 6, Lake County, Colorado.* Prepared for the United States Department of the Interior, Bureau of Reclamation, January.

Alpine Archaeological Consultants, Inc., 1997b. *Preliminary Draft Cultural Resource Inventory Report of Three Remediation Areas at the California Gulch Superfund Site, Operable Unit 6, Lake County, Colorado.* Prepared for the United States Department of the Interior, Bureau of Reclamation, January.

Alpine Archaeological Consultants, Inc., 1997c. *Preliminary Draft Cultural Resource Inventory Report of a Remediation Area at the California Gulch Superfund Site, Operable Unit 6, Lake County, Colorado.* Prepared for the United States Department of the Interior, Bureau of Reclamation, March.

Bigham, J.M., Schwertmann, U., and Carlson, L., 1992. *Mineralogy of Precipitates Formed by the Biogeochemical Oxidation of Fe(II) in Mine Drainage.* In Biomineralization Processess of Iron and Manganese Catena Supplement 21.

Emmons, S.F., Irving, J.D. Loughlin, G.F., 1927. *Geology and Ore Deposits of the Leadville Mining District, Colorado.* U.S. Geological Survey Professional Paper No. 14.

Fenneman, N.M., and Johnson, D.W., 1946. *Physical Divisions of the United States: U.S.Geological Survey, Scale 1:7,000,000.*

Golder Associates, Inc. 1996. *Hydrogeologic Remedial Investigation Report, California Gulch Site, Leadville, Colorado.* Prepared for ASARCO, Incorporated. May.

Lake County, 1996. *Draft Summary of Lake County Concerns, California Gulch OU6-Stray Horse Gulch Removal Action-Value Analysis,* October.

Roy F. Weston, Inc., 1991. *Preliminary Human Health Baseline Risk Assessment for the California Gulch NPL Site. Leadville, Colorado.* December.

Roy F. Weston, Inc., 1995a. *Baseline Human Health Risk Assessment for the California Gulch Superfund Site. Part C: Screening Level Soil Concentrations for Workers and Recreational Site Visitors Exposed to Lead and Arsenic.* February.

Roy F. Weston, Inc., 1995b. *Baseline Human Health Risk Assessment for the California Gulch Superfund Site. Part C: Evaluation of Worker Scenario.* April.

Roy F. Weston, Inc., 1995c. *Baseline Human Health Risk Assessment for the California Gulch Superfund Site. Part C: Evaluation of Recreational Scenarios.* April.

Roy F. Weston, Inc., 1995d. *Final Baseline Aquatic Ecological Risk Assessment for the California Gulch NPL Site.* September.

Roy F. Weston, Inc., 1996a. *Baseline Human Health Risk Assessment for the California Gulch Superfund Site. Leadville, Colorado. Part A - Risks to Residents from Lead.* January.

Roy F. Weston, Inc., 1996b. *Baseline Human Health Risk Assessment for the California Gulch Superfund Site. Leadville, Colorado. Part B - Risks to Residents from Contaminants Other than Lead.* January.

Roy F. Weston, Inc. and Terra Technologies, 1997. *Ecological Risk Assessment for the Terrestrial Ecosystem. California Gulch NPL Site. Leadville, Colorado.* January.

Tweto, O., Moench, R.H., and Reed, J.C., 1978. *Geologic Map of the Leadville 1? x 2? Quadrangle, Northwester Colorado, Miscellaneous Investigation Series Map I-999,* Scale 1:250,000.

United States Army Corps of Engineers, Hydrologic Engineering Center, 1991. *HEC-1,* software.

United States Army Corps of Engineers, Hydrologic Engineering Center, 1990. *HEC-2*, software.

United States Bureau of the Census, 1990.

United States Congress, *Comprehensive Environmental Response, Compensation, and Liability Act of 1980, as amended by the Superfund Amendments and Reauthorization Act of 1980,* Public Law 96-510, Title 42 U.S. Code 9608.

United States Department of the Interior, 1949. *Report of Investigations, The Leadville Drainage Tunnel.* August.

United States Department of the Interior, 1956. *Report of Investigations, The Leadville Drainage Tunnel Second Project.* December.

United States Department of the Interior, 1979. *Study of the Effect on Plugging the Leadville Drainage Tunnel.* September.

United States Department, BOR, 1997b. *Draft -Treatability Study, In-Situ Stabilization of Mine Waste Rock Piles, California Gulch Superfund Site, Operable Unit 6, Leadville, Colorado.* May 21.

United States EPA, 1993. *Final Screening Feasibility Study for Remediation Alternatives at the California Gulch NPL Site, Leadville, Colorado.* Region VIII, September.

United States EPA, 1990a. *National Priorities List Sites: Colorado.* Office of Solid Waste and Emergency Response, EPA/540/4-90/007, September.

United States EPA, 1990b. *National Oil and Hazardous Substances Pollution Contingency Plan,* Title 40 Code of Federal Regulations Part 300, 55 Federal Register 8666, March.

United States EPA, 1988. *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, Interim Final.* Office of Emergency and Remedial Response. EPA/540/G-89/004. October.

United States Geological Survey, 1975, *Lake County, Colorado, County Map Series (Topographic),* Scale 1:50,000.

Woodward-Clyde Consultants, 1994a. *Mine Waste Piles Remedial Investigation Report, California Gulch Site, Leadville, Colorado,* January.

Woodward-Clyde Consultants, 1994b. *Tailings Disposal Area Remedial Investigation Report, California Gulch Site, Leadville, Colorado,* January.

TARGET SHEET

EPA REGION VIII

SUPERFUND DOCUMENT MANAGEMENT SYSTEM

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DOCUMENT DATE: 09/01/2002

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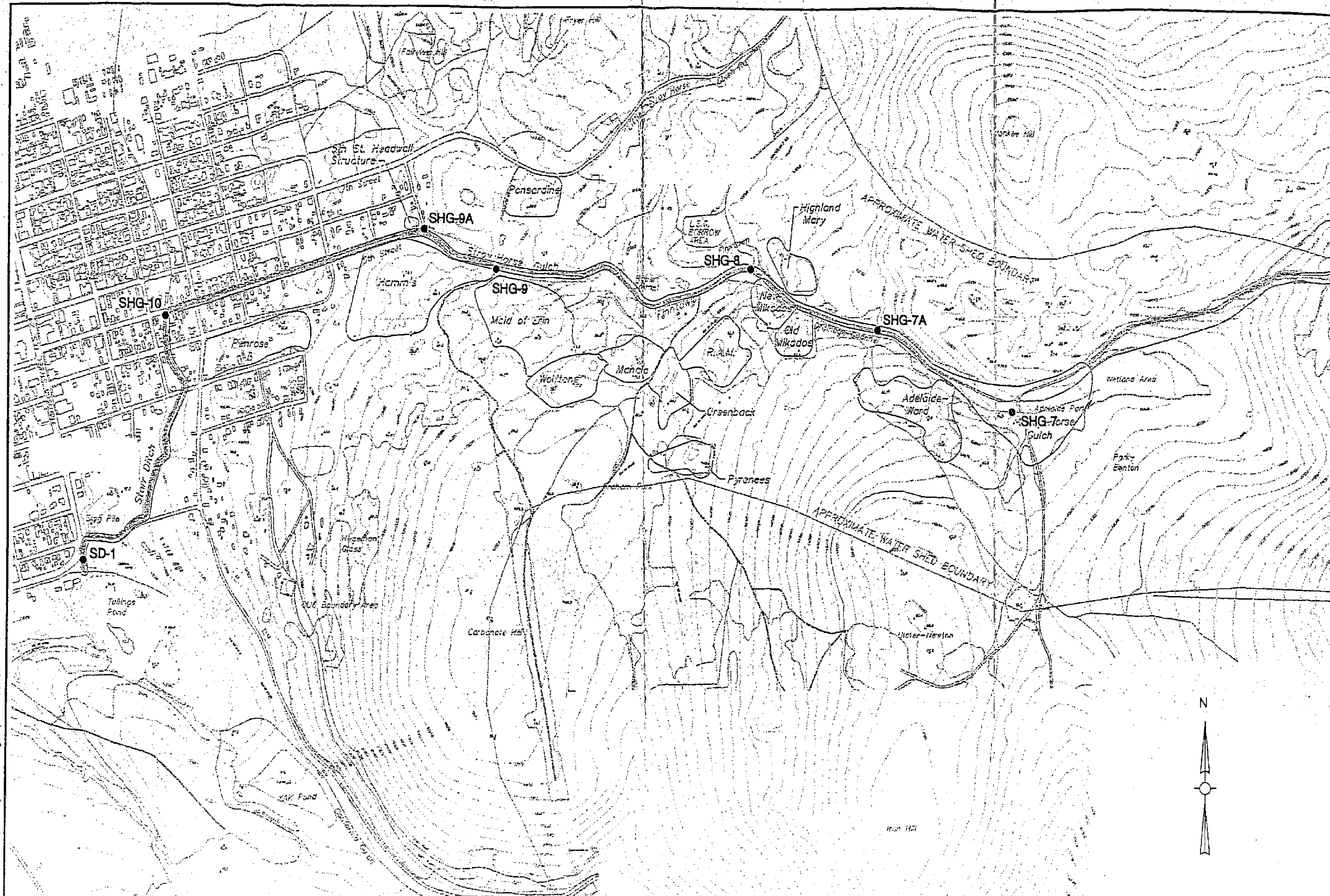

LEGEND

- SURFACE WATER SAMPLING STATION
- WORK AREA BOUNDARIES

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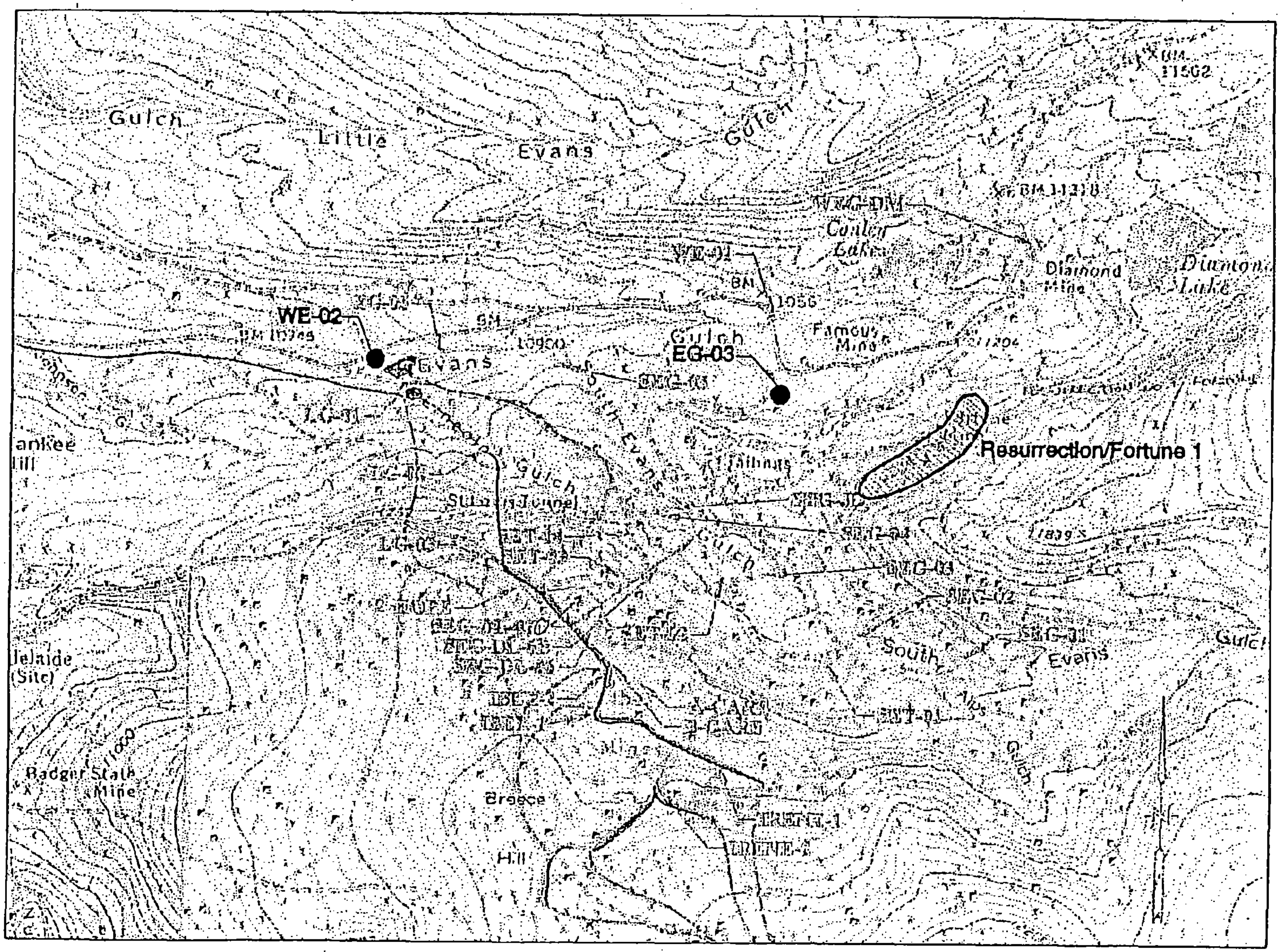
Figure 1
Location of Removal Action Areas and Surface Water Sampling Stations, Stray Horse Gulch
California Gulch Superfund Site
Lake County, Colorado



Location of Removal Action Areas and Surface Water Sampling Stations, Evans Gulch

California Gulch Superfund Site
Lake County, Colorado

Figure 2

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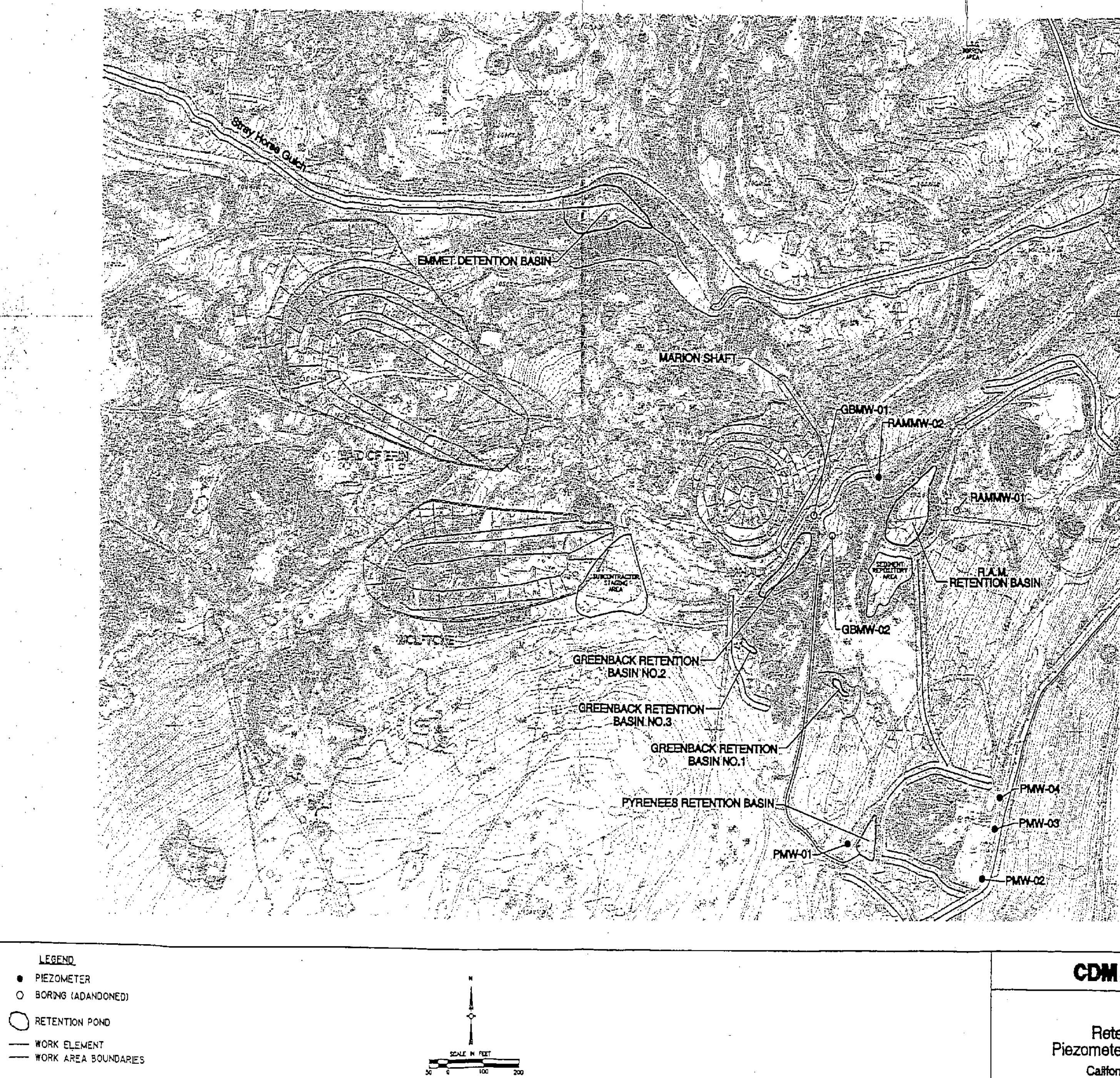

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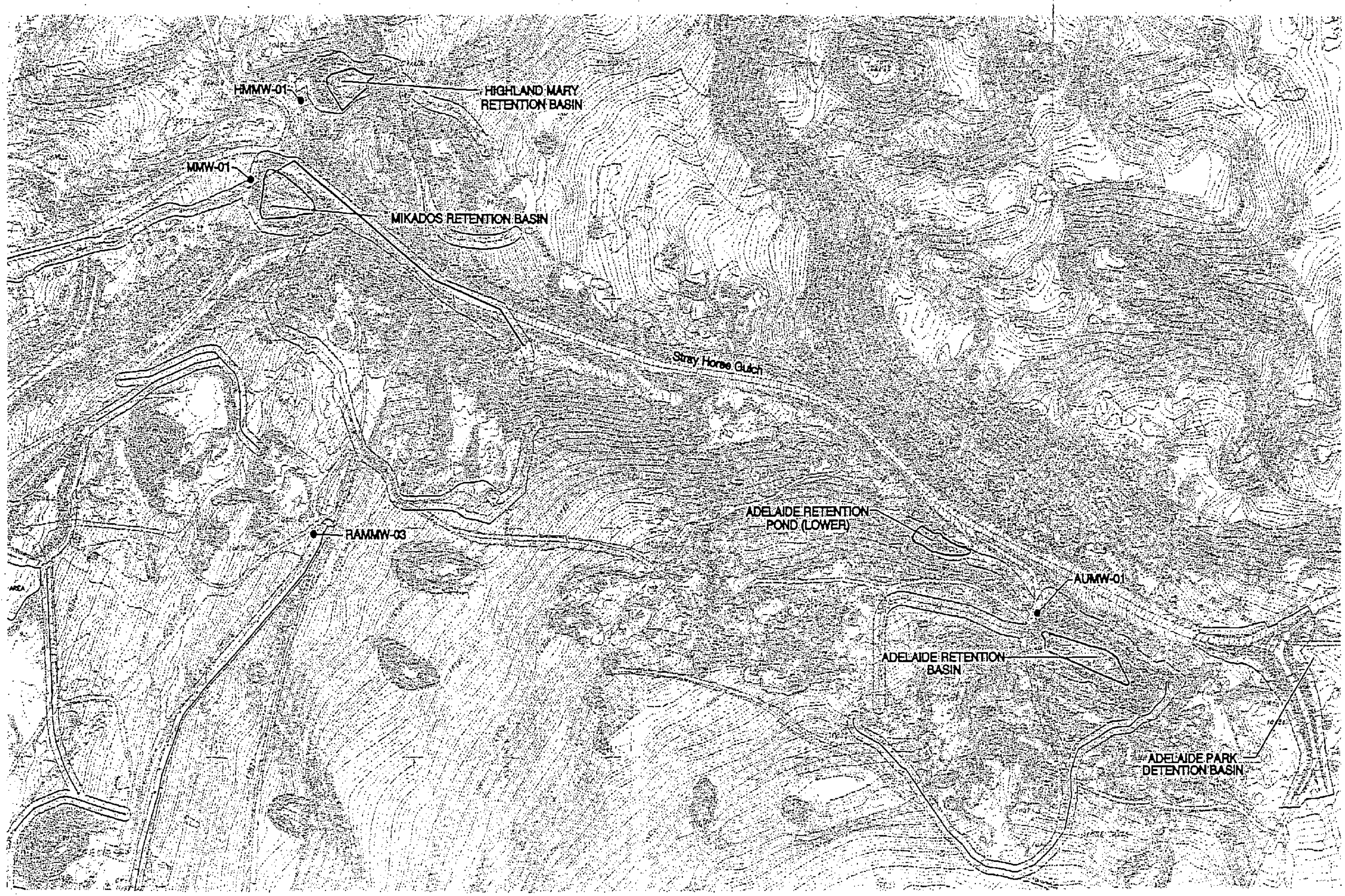
Figure 3
Retention Pond and
Piezometer Location Map, West
California Gulch Superfund Site
Lake County, Colorado



LEGEND
- PIEZOMETER
- RETENTION POND
- WORK ELEMENT
- WORK AREA BOUNDARIES

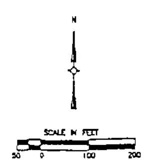


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Figure 4
Retention Pond and
Piezometer Location Map, East
California Gulch Superfund Site
Lake County, Colorado

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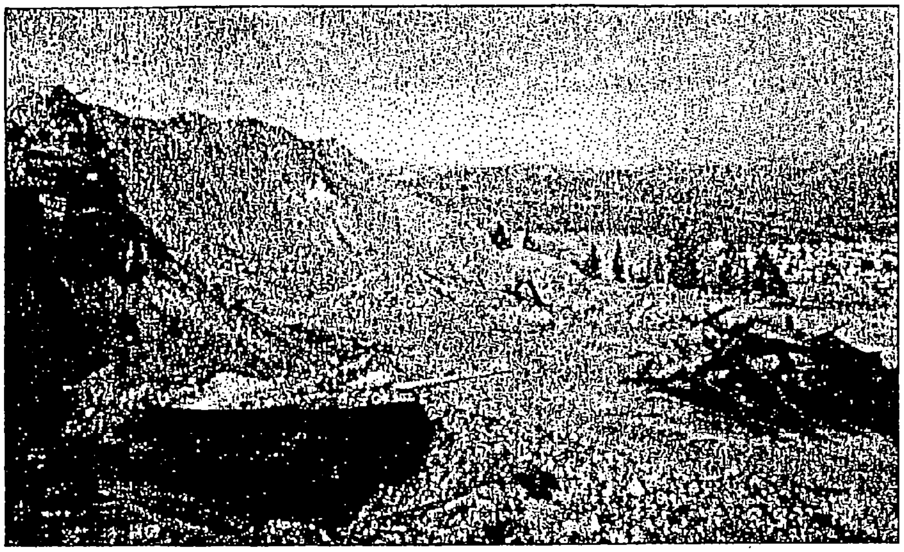
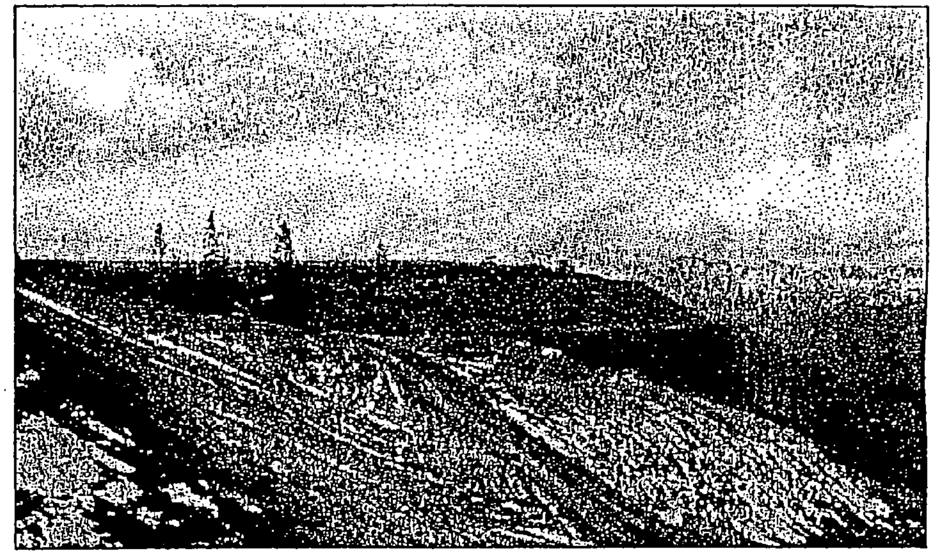


View of Maid of Erin site before capping (looking west.)



View of Maid of Erin site after capping (looking west.)

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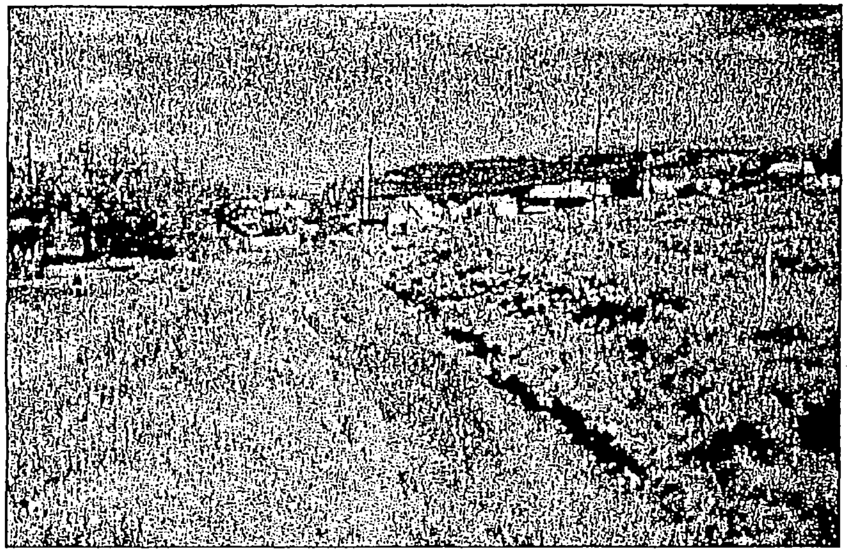
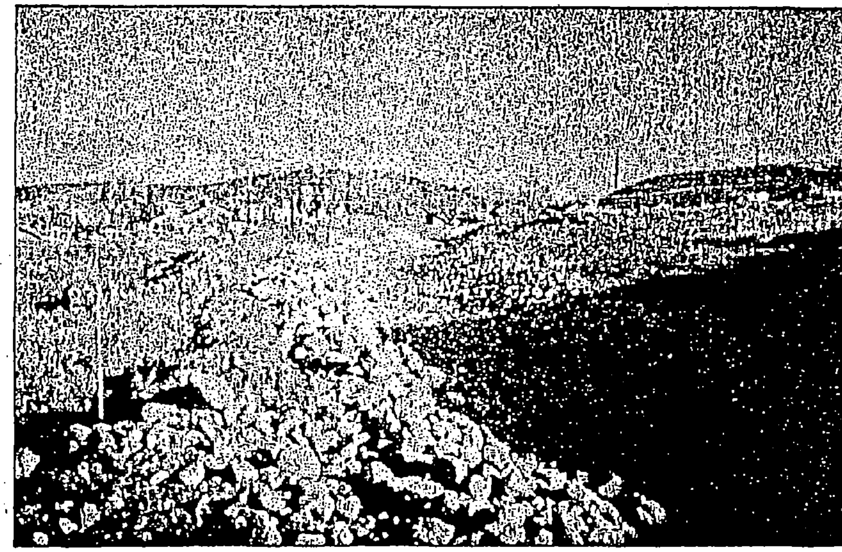
Site Photographs

California Gulch Superfund Site
Lake County, Colorado

Figure 5



Starr Ditch near Monroe Street and 3rd Avenue before rehabilitation.



Starr Ditch after rehabilitation.

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Site Photographs

Ca[illegible]rnia Gulch Superfund Site
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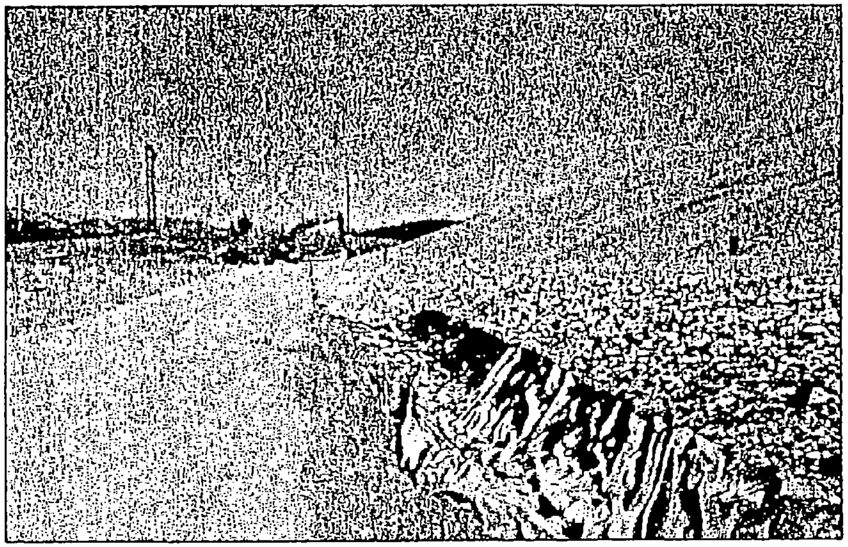
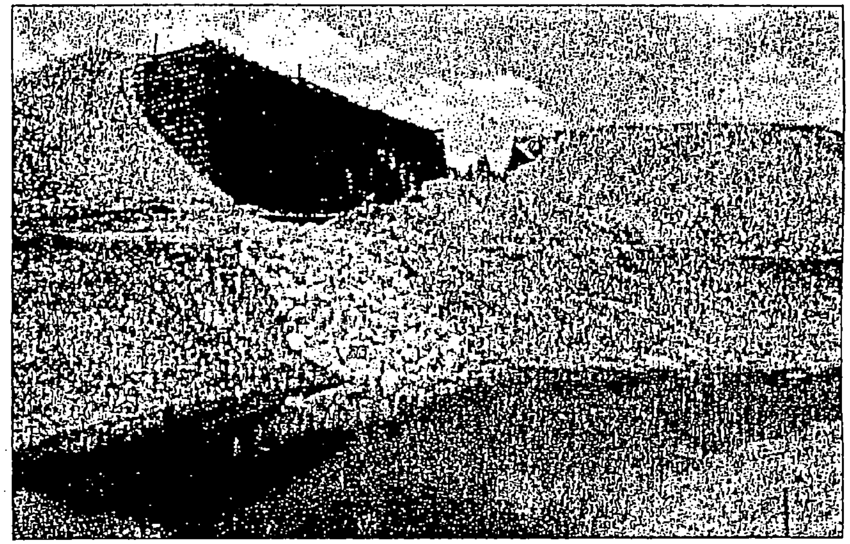


Run off collection at the Hamms tailing impoundment



Greenback No. 2 retention basin. Inlet from the Pyrenees retention basin overflow, and the Greenback crib wall.

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Site Photographs

California Gulch Superfund Site
Lake County, Colorado

Figure 7

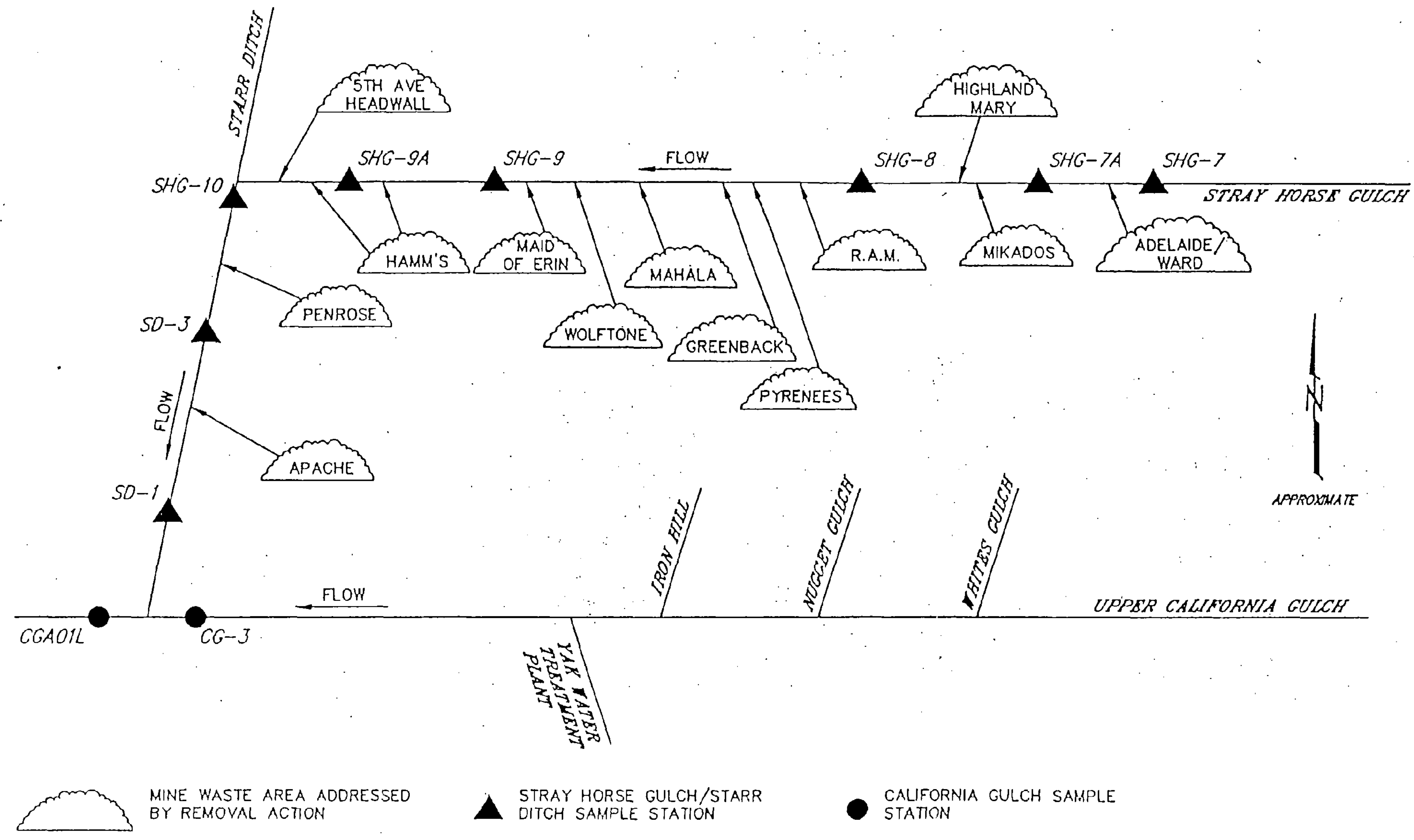

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Diagram Showing Surface Water Collection Sequence and Relationship with Sampling Stations in Stray Horse Gulch and Starr Ditch

California Gulch Superfund Site
ake County, Colorado

Fig 8

TARGET SHEET

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SUPERFUND DOCUMENT MANAGEMENT SYSTEM

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APPENDIX A FIGURES 9 through 20

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APPENDIX B
Technical Memoranda

APPENDIX B
Technical Memorandum 1

Colorado Mountain College
Natural Resource Management Institute

TECHNICAL MEMORANDUM November 28, 2001
*Includes requested changes to October 18, 2001 TM

TO: Ken Napp, HDR; Mike Holmes, EPA;
From: Jord Gertson, CMC/NRMI

CC: Stan Christensen, EPA; Mike Wireman, EPA;
Orville Kiehn, EPA; Karmen King, CMC/NRMI
Subject: Marion Shaft Watershed Calculations

This technical memorandum is a presentation of the volume estimates for the Marion Watershed based on the precipitation approach and orifice flow measurements.

I. Precipitation Estimation

A. Snow Water Equivalent (SWE) data collection

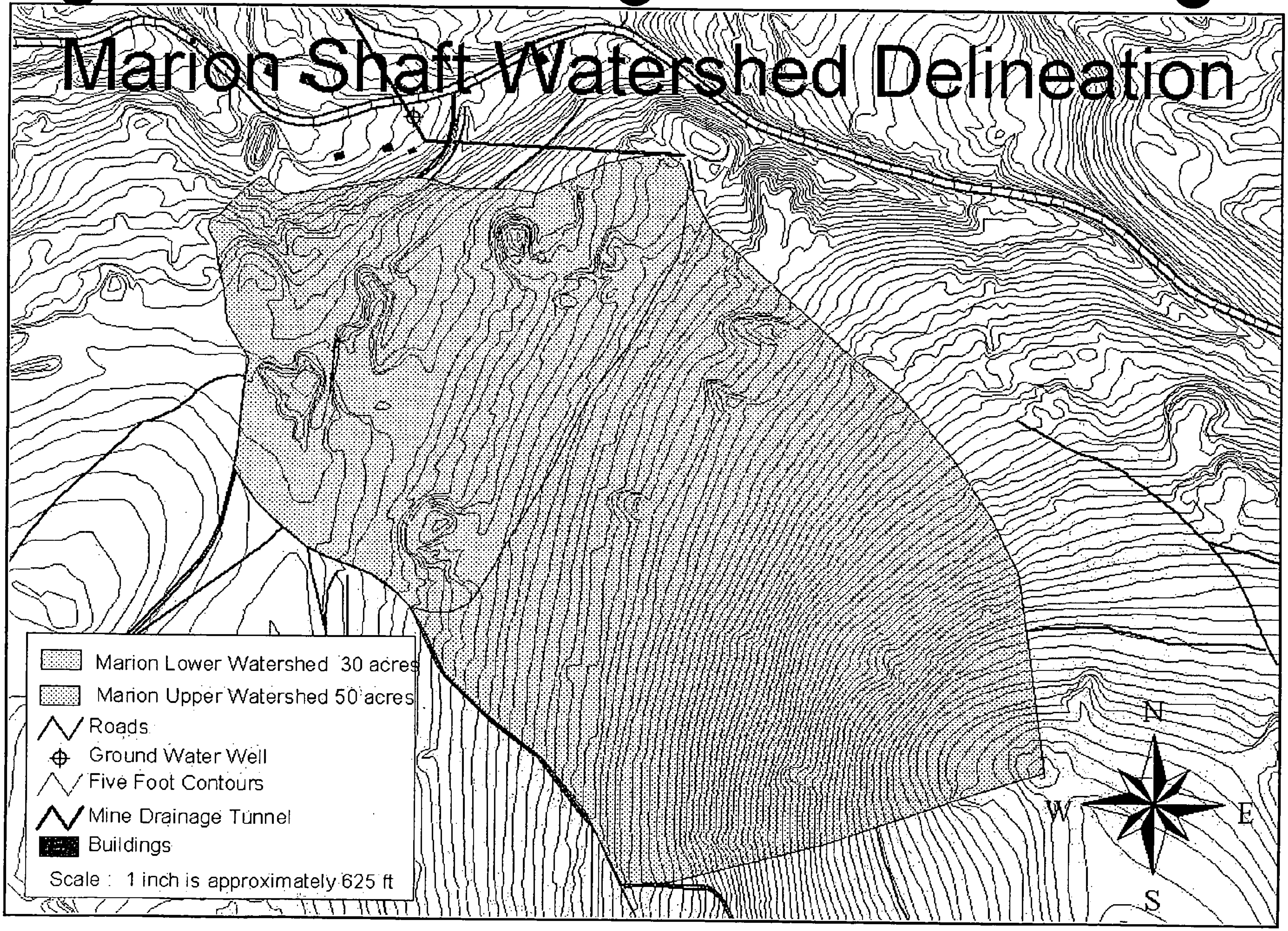
Snow water equivalent data was collected by the Colorado Mountain College, Natural Resource Management, GEY 210-Hydrology class. Students were tasked to estimate the average amount of water on the watershed surface as snow using two Federal Snow Samplers on the 21st of March. The average SWE on the 21st of March 2001 is estimated as 5.3 inches. To estimate the amount of additional precipitation accumulated between the 21st of March and the 1st of May local Sno-Tel data was analyzed. Fremont Pass Sno-Tel site was used to estimate the amount of snow fallen since the 21st of March. Fremont Pass Sno-Tel data indicated that there was 13.8 inches of water on the 21st of March. On May 1st the SWE measurement on Fremont Pass was 18.1 [in], a difference of 4.3 inches of water. Thus, the estimate of SWE on the 1st of May is the sum of 5.3 inches (March 21st Measurement Marion Watershed) and 4.3 inches (The difference in SWE @ Fremont Pass, March and May), which equates to 9.6 inches of SWE. It is important to note that Fremont Pass is 1000 feet higher in elevation than the Marion Watershed, which indicates that more precipitation is likely to fall on Fremont Pass. Therefore the estimation of SWE is considered qualitatively conservative.

B. Rainfall Estimation

The monthly rainfall estimations were derived from two sources, the Leadville Airport and the installation of several Tru-Chek rain gauges distributed around California Gulch Superfund Site by CMC NRMI employees. The following table summarizes the rainfall distribution from May to August.

	Leadville Airport [inches]	**Tru-Chek Gauges [inches]**
May	1.37	no data
June	0.56	no data
July	1.99	no data
August	3.52	3.33
Total	7.25	no data

Figure 1



Marion Shaft Watershed Delineation
Marion Lower Watershed 30 acres
Marion Upper Watershed 50 acres
Roads
Ground Water Well
Five Foot Contours
Mine Drainage Tunnel
Buildings
Scale : 1 inch is approximately 625 ft
N
W
E
S

II. Watershed Volume Calculations

A. Data collection parameters

To calculate the watershed area for the Marion Shaft two factors were considered. Watershed topography and a clean water diversion ditch were the determining factors for estimating the area of influence. Field observations during the 2001 spring snowmelt indicated that the clean water ditch is less than 100 percent effective at diverting water around the contamination features. Therefore, two watershed areas were used to compute a range of flows from precipitation within the Marion Watershed. If you were to assume that the clean water diversion ditch is 100 percent effective, than the Marion watershed is 30 acres. If you assume that the Clean Water ditch is non-existent, the watershed area is 80 acres. The Figure 1 depicts the watershed areas of interest. The Marion Watershed volume calculations were estimated using the May 1st SWE estimation and local rainfall data distributed over the area of influence. It's important to note that no losses were accounted for in the volume estimation. These losses can range from 2% - 60 % of precipitation depending on several environmental factors. The volume estimate was split into a range to account for variable watershed areas and the two main sources of precipitation, snow and rain.

B. Calculations

Snowmelt

May 1st SWE = 9.6 inches = 0.8 feet

$0.8\text{ft} * 80\text{ acres} * 43560\ \text{ft}^2/\text{acre} * 7.48\ \text{gal}/\text{ft}^3 \approx 21{,}000{,}000$ gal, 64 acre-ft

$0.8\text{ft} * 30\text{ acres} * 43560\ \text{ft}^2/\text{acre} * 7.48\ \text{gal}/\text{ft}^3 \approx 8{,}000{,}000$ gal, 24 acre-ft

Snowmelt + Rainfall [May & June]

Total snowmelt plus rainfall for May and June = 11.52 inches = 0.96 feet

$0.96\text{ft} * 80\text{ acres} * 43560\ \text{ft}^2/\text{acre} * 7.48\ \text{gal}/\text{ft}^3 \approx 25{,}000{,}000$ gal, 77 acre-ft

$0.96\text{ft} * 30\text{ acres} * 43560\ \text{ft}^2/\text{acre} * 7.48\ \text{gal}/\text{ft}^3 \approx 9{,}400{,}000$ gal, 29 acre-ft

Rainfall

Total rainfall for May, June, July, and August = 7.25 inches = 0.60 feet

$0.6\text{ft} * 80\text{ acres} * 43560\ \text{ft}^2/\text{acre} * 7.48\ \text{gal}/\text{ft}^3 \approx 16{,}000{,}000$ gal, 48 acre-ft

$0.6\text{ft} * 30\text{ acres} * 43560\ \text{ft}^2/\text{acre} * 7.48\ \text{gal}/\text{ft}^3 \approx 6{,}000{,}000$ gal, 18 acre-ft

III. Flow Volume Calculations [Pressure Transducer]

A. Data collection parameters

The parameters required for data collection include, specific gravity, orifice size, and head elevation above the orifice. These parameters were used to estimate the volume to flow into the Marion Orifice. The following hydrologic equation was used to estimate the rate of flow into the Marion orifice (Hann, Barfield, and Hayes Design Hydrology and Sedimentology pg. 150,151, 1981).

$Q = C' A (2gH)^{(1/2)}$ equation 1.0

Where:

Q = [ft^3/sec]
C'= weir coefficient [unit less]
A = orifice area [ft^2]
g = gravitational acceleration [ft/sec^2]
H = elevation head above orifice [ft]

B. Calculations

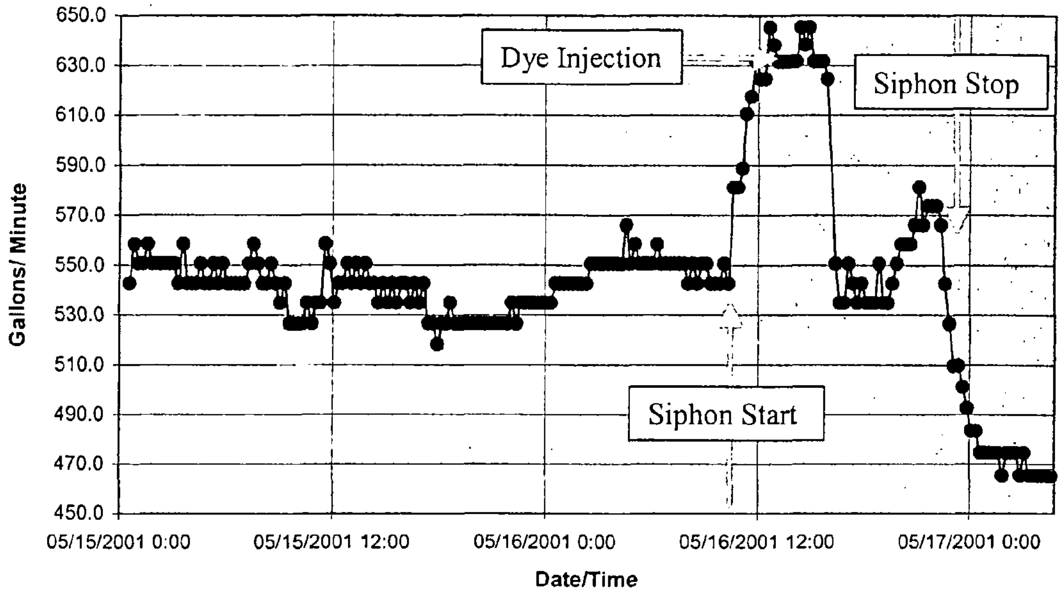
The volume of water that passed through the Marion shaft is a combination of snowmelt and rainfall. It is difficult to distinguish one from the other with this type of measurement technique. It is assumed that base flow for the two different types of precipitation overlap significantly. The total volume estimated using the pressure transducer to measure the head elevation on the orifice is approximately 38,000,000 gallons or 117 acre-ft.

C. Peak Flow Calculations

The peak flow into the Marion orifice was measured on May 17th 2001 during a dye injection when the Ram Retention pond was draw off into the Greenback Retention Pond to overflow into the Marion orifice via a riprap channel. The peak flow estimate of approximately 650 gpm was measured using equation 1.0, ten days after installation and calibration of the pressure transducer. A graph summarizing the data is presented in figure 2. This measurement includes several sources of flow; anthropogenic forces had constructed a siphon, which was discharging into the Greenback Retention Pond; the Greenback RP captures several tiny springs and overflow from the Pyrenees RP; several other springs are also captured with an additional rip-rap channel that direct flows to the Marion orifice from the east, north of the Greenback RP. Prior to siphoning the Ram RP into the Greenback RP, i.e. native flows, the peak flow into the Marion orifice was approximately 550 gpm (Figure 2).

Figure 2

Marion Shaft Flow During 2nd Dye Injection



D. Limitations and Uncertainties

There are two main variables that were not addressed accordingly to accurately estimate the volume discharged into the Marion Shaft from the pressure transducer data. The specific gravity was measured during the initial installation of the pressure transducer. Due to the dissolution of metals and salts into solution the specific gravity changed drastically throughout the summer. Due to the metal chemistry changes onsite there was also deposition of solids on the edge of the orifice, which changed the orifice elevation by 12 mm. Weekly measurements should have been taken to update the specific gravity and clean the orifice rim of the Marion collection system. Both of these factors combined create an inaccuracy a month after calibration and installation that may alter the volume estimates by 60 percent. It is not advised to use the long-term volume estimates quantitatively.

IV. Conclusions

The volume approximations are considered conservative approximations based on the approach and variables used. The SWE from March 21st to May 1st estimated within the Marion Watershed was derived from the Fremont Pass Sno-tel site, which is 1000 [ft] higher in elevation. This equates to a significant hidden safety factor when considering the snow water equivalent evaluation of volume. The combined flows generated from snowmelt and rainfall (May - August) without considering any losses from the hydrologic cycle is estimated to be approximately 112 [acre-ft] (80 acre watershed) - 42 [acre-ft] (30 acres watershed). This estimate was derived from limited data and should be considered highly uncertain for long-term prediction.

APPENDIX B
Technical Memorandum 2

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 8
999 18TH STREET - SUITE 500
DENVER, CO 80202-2466

January 30, 2002

Subject: California Gulch NPL Site Operable Unit 6

This technical memorandum summarizes an evaluation and conclusions in the review of available Leadville, CO Superfund site records, historical reports, current reports and pertinent personal conversations with technical specialists in the field for the subject Superfund OU6 site.

(1) Under current conditions, both the ASARCO Yak and USBOR Leadville Mine Drainage Tunnel Water Treatment Plant (LMDTWTP) process trains are capable of treating the OU6 water quality.

(2) Both item (1) water treatment plants can process at least 50 gallons/minute OU6 water. However, a 50 gallons/minute treatment rate of OU6 water for both plants will reduce their water treatment capacity for that water quality normally treated.

(3) Referencing the 11/26/01 verbal advice of Mr. Robert Elder, Mining Engineer, Vice President Leadville Silver and Gold, the volume of the mine pool above the Leadville Mine Drainage Tunnel (LMDT) invert elevation at the Emmet shaft is estimated to be approximately 750 million gallons. Below the Emmet shaft invert elevation the volume of the mine pool is unknown but Mr. Elder believes it to be "significant".

The extent of the blockages creating the mine pool is unknown. Thus, the potential for a blowout or surge of water, potentially impacting the lower reach of the LMDT and the LMDTWTP is uncertain.

Consequently, the use of the LMDT (in its present condition) to convey OU6 surface water for a long term remedy is not practical even though ongoing tracer studies currently demonstrate that waters from the Emmet shaft reach the treatment plant.

(4) Referencing the USBM RI 5284, after the Leadville drainage adit was driven, an approximate 2200-2300 gallons/minute of water flowed out of the tunnel at it's discharge or collar, circa 1952. Since then, some of the tunnel has caved, reducing the tunnel flow to approximately 400 gallons/minute at the tunnel portal or collar, causing a rise in the water column in the Emmet shaft that appears to have stabilized at a level approximately 140 feet above the invert elevation. Were the mine to be pumped so as to reduce the approximate 140 foot invert elevation hydraulic head at an approximate 3000 gallons/minute pumping rate (with an approximate 2250 gallons/minute rechage), it would require approximately 2 years for the draw-down.

(5) Referencing a 7/25/01 memorandum from the USBOR LMDTWTP supervisor, Mr. Brad Littlepage, he advised that plant equipment operating constraints placed the maximum plant capacity (for plant design specification influent water quality) at about 1800-1900 gallons/minute. The chemical analysis of both Emmet shaft mine pool water (one sample) and several OU6 water samples including what has been discharged down the Marion shaft, are significantly higher in dissolved metals (referencing the plant design specification for influent water quality), effectively limiting treatment in the LMDTWTP as per item (2) above (to approximately 50 gallons/minute) plus dilution tunnel waters, the sum of which equals a total flow of 1000 to 1500 gallons/minute of tunnel, formation and surface OU6 waters.

(6) Capacity to treat OU6 water in the LMDTWTP could be increased if water entering the LMDT from below the mining district were not treated in the plant (from the portal upgradient to USBM Station 60 + 00, approximately 6,000 feet back). This water does not travel through metal sulfide-bearing mineralized rock and thus should not need water treatment. If the water from the non-metal sulfide-bearing mineralized reach of the tunnel was no longer treated, not only would there be increased capacity to treat OU6 water but the LMDTWTP operation costs could be reduced.

Subsequently, with increased capacity, a capacity lost to tunnel caving problems, a LMDTWTP strategy to treat both OU6 water (on a seasonal campaign basis) and additional mine pool water continuously, in addition to that mine pool water presently not treated, within the constraints of the existing LMDTWTP design (or its future modification), could be devised.

Orville A. Kiehn

EPA Environmental Engineer

APPENDIX C
Costing

Remedial Alternative Costing

Cost estimates developed at the detailed analysis of alternatives phase of the FS should have accuracy ranges of -30% to +50% (EPA, 2000). These cost estimates are used to compare alternatives and support remedy selection. Cost estimates at this stage are intended to provide a measure of total resource costs over time associated with any given alternative.

The types of costs that are assessed include the following:

- Capital costs, including both direct and indirect costs;
- Annual operations and maintenance costs; and
- Net present value of capital and O&M costs.

EPA guidance (EPA, 2000) requires the use of a 7% discount factor when calculating net present value of capital, operation and maintenance costs for all non-Federal Facilities. However, EPA also suggests using current discount rates published by the Office of Management and Budget (OMB) for Federal Facility Sites. The OMB recommends a discount rate of 3.9% for projects with durations exceeding 30-years. This lower discount rate (reflecting real interest rates on treasury notes and bonds) would result in a significantly higher present worth cost for alternatives with relatively higher, long-term operational costs such as for water treatment under Alternative 2. However, OU6 is not a federal facility and so the 7% discount rate is used.

Alternative 2 – ARD Conveyance, Storage and Treatment Options

Alternative 2 includes five options that involve variations on storage, conveyance and treatment of ARD collected in OU6. The options are:

- Alternative 2a - Pressurized pipeline conveying ARD to the Yak Tunnel.
- Alternative 2b - Gravity pipeline conveying ARD to the Yak water treatment plant surge pond with storage impoundment.
- Alternative 2e - Gravity pipeline conveying ARD to existing extraction well along LMDT.
- Alternative 2g - Plug LMDT and dewater impounded mine pool with gravity pipeline to BOR water treatment plant.
- Alternative 2h - Gravity pipeline to dedicated water treatment plant

Section 1: Design Controls and Assumptions: For all six alternatives, it was assumed that the pipe trenching and installation of all gravity line pipes was in rippable soil. For any vertical boring options, it was assumed that the material was mostly rock. All pipe sizing was based on Cameron Hydraulic Data calculations. By replacing the PVC material used in the alignments with Schedule 80 Cast Iron Pipe, it more closely simulates the true average roughness of the interior of the pipe over its design life. For the pump in Alternative 2a, a pH level of 1.8 was assumed for material compatibility. For the pump in Alternative 2g (mine pool dewatering), a pH level of 3.0 was assumed. Peak flow rates (for ARD) annual ARD quantities are discussed in Section 7.3.2.

Section 2: Conceptual Alignment Layouts

2.1: Alternative No. 2a: Force Main Line: This alternative would construct a pump house with a Stainless Steel ANSI 811 Centrifugal pump or equal to pump water through a 12" PVC pipe directly from the Greenback Pond at elevation 10,560 to a location just upstream from the bulkhead on the YAK Tunnel, 4,277 feet away at an elevation of 10,900. From here, a vertical pipe would then direct the flow approximately 600 feet down into the YAK tunnel. The average grade for force main portion of alignment would be 7.95%.

2.1.1: Alignment location reasoning: Two additional alignments were analyzed for this alternative. Both systems used a combination of a force main system and gravity system. The first option was to construct a gravity line from the Greenback pond heading south down the ravine between Carbonate Hill and Iron Hill and then pumping up Iron Hill, parallel to the YAK tunnel to the point just above the bulkhead. From here, the same vertical pipe, as described above, would direct the flow into the YAK tunnel. This option was abandoned for a number of reasons. First, the total dynamic head would increase by approximately 80 ft, possibly requiring a larger pump or decreasing the expected life of the pump used for the selected alternative. Secondly, the length of pipeline was approximately 1600 ft. longer, adding more cost to the system. Thirdly, in general, a system utilizing a combination of gravity lines and force main lines is more costly than a single system. Lastly, a lengthy bore and oversized trench, similar to that used in Alternative 2c, would have to be used on the first portion of the alignment. This would add significant cost to this alignment. The second option was to construct a force main line from the Greenback pond up Iron Hill to a height to get a reasonable drop in a gravity line for the remainder of the alignment. This option was abandoned for the same reasons as noted above. The head was approximately 50 ft. more, the pipe length was about 500 ft. longer, and the use of a combination system would be more costly than a single system.

2.1.2: Technical Data: Based on a flow rate of 1000 GPM, and a pipe diameter of 12", the velocity in the pipe is estimated to be 3.16 fps with a friction loss of 0.263 ft. per 100 ft. These numbers are based on the Darcy formula for a 12" Diameter Schedule 80 steel pipe. The total dynamic head is then:

Static Head = 10,900-10,560 =	340 ft	
Friction Loss =	12 ft	(based on 12" Diameter Schedule 80 steel for conservative values)
Minor loss =	2 ft	(approx. 10% of friction loss)

Total Dynamic Head= 354 ft.

2.1.3: Cost Estimate: Using *2001 RSMeans Building Construction Cost Data* values along with estimates from qualified engineers, the following cost estimate was developed:

Alternative 2a					
Item	Quantity	Units	Unit Cost	Total Cost	Ref.
12" PVC Pipe System	4277	LF	$33.00	$141,141.00	1
Pump System/Housing	1	LS	$25,000.00	$25,000.00	4
Air vac vaults	5	EACH	$5,000.00	$25,000.00	5
Drain vaults	3	EACH	$5,000.00	$15,000.00	5
Inlet/Outlet Structures	1	LS	$50,000.00	$50,000.00	6
Vertical pipe to YAK tunnel	600	LF	$180.00	$108,000.00	12
Overhead powerlines and transformers	3100	LF	$10.00	$31,000.00	13
			SUBTOTAL:	$395,141.00	
Contingency	1	LS	25% of subtotal	$98,785.25	17
Remedial Design	1	LS	8% of subtotal	$31,611.28	17
Project Management	1	LS	5% of subtotal	$19,757.05	17
Construction Management	1	LS	6% of subtotal	$23,708.46	17
Mobilization/Demobilization	1	LS	15% of subtotal	$59,271.15	5
Total O&M Present Value	1	LS		$1,303,374.01	
			TOTAL:	$1,931,648.20	

2.1.5: Benefits

-No storage facility required
-Direct, short pipe length

2.1.6: Drawbacks

-Force Main System costly
-More O&M cost in comparison to a gravity line

2.2: Alternative No. 2b: Gravity Line to YAK Surge Pond: This alternative would construct a 12" PVC gravity line from the Greenback pond at elevation 10,560 to the YAK Surge Pond at elevation 10,200. The alignment would be routed along the west side of Carbonate Hill for a total length of approximately 7,128 feet. The average grade would be 5.05%. At some point along the alignment a 10 MG impoundment would need to be constructed. An energy dissipation structure would also be constructed on the outlet of the pipe prior to flowing into the YAK surge pond.
2.2.1: Alignment location reasoning: Another alignment for this alternative was looked at and abandoned. This alignment was routed around the other side of Carbonate Hill down to the YAK Surge Pond. This option was abandoned because it required a lengthy bore and an oversized trench at the beginning of the alignment, similar to Alternative 3, which added significant cost.

2.2.2: Cost Estimate: Using *2001 RSMeans Building Construction Cost Data* values along with estimates from qualified engineers, the following cost estimate was developed:

Alternative 2b					
Item	Quantity	Units	Unit Cost	Total Cost	Ref.
12" PVC Pipe System	7128	LF	$33.00	$235,224.00	1
48" Dia. Manholes	22	EACH	$3,500.00	$77,000.00	5
Impoundment	1	LS	$542,747.00	$542,747.00	11
Connections	1	LS	$10,000.00	$10,000.00	5
Inlet Structure	1	LS	$25,000.00	$25,000.00	
Outlet Energy Dissipation structure	1	LS	$25,000.00	$25,000.00	7
			SUBTOTAL:	$914,971.00	
Contingency			25% of direct	$228,742.75	17
Remedial Design	1	LS	8% of subtotal	$73,197.68	17
Project Management	1	LS	5% of subtotal	$45,748.55	17
Construction Management	1	LS	6% of subtotal	$54,898.26	17
Mobilization/Demobilization	1	LS	15% of subtotal	$137,245.65	5
Total O&M Present Value	1	LS		$2,203,820.27	
			TOTAL:	$3,658,624.16	

2.2.3: Benefits

-No vertical drilling into YAK tunnel

2.2.4: Drawbacks

-Requires storage facility

2.3: Alternative No. 2c: Gravity Line to Underground Mine Workings: This alternative would construct a 12" PVC gravity line from the Greenback pond at elevation 10,560 to the underground mine workings south of the YAK Tunnel. The alignment would be constructed by boring from the pond for 1000 ft. to elevation 10,555 to the ravine between Carbonate Hill and Iron Hill. From this point, the pipe would be placed in an oversize trench for 1426 ft. to elevation 10,540. Then the pipe would be in regular trench for 5125 ft. to the mine workings at elevation 10,500. From here, the water would drain into the mine workings and theoretically lead into the YAK Tunnel. The average grade for the bored portion of the alignment is 0.50%. For the oversize trench, the average grade is 1.05% and for the remainder of the alignment the grade is 0.78%.

2.3.1: Alignment location reasoning: This was the only feasible general location for this alternative. Routing around the other side of Iron Hill wasn't feasible due to the steep incline for the majority of the route. A force main system would have to be utilized for this option to work.

2.3.2: Cost Estimate: Using *2001 RSMeans Building Construction Cost Data* values along with estimates from qualified engineers, the following cost estimate was developed:

Alternative 2c

Item	Quantity	Units	Unit Cost	Total Cost	Ref.
12" PVC Pipe System, regular trench	5125	LF	$33.00	$169,125.00	1
48" Dia. Manholes	20	EACH	$3,500.00	$70,000.00	5
Connections	1	LS	$10,000.00	$10,000.00	5
Boring	1000	LF	$1,500.00	$1,500,000.00	10
12" PVC Pipe System w/ large trench	1426	LF	$98.00	$139,748.00	3
Inlet/Outlet Structures	1	LS	$50,000.00	$50,000.00	
			SUBTOTAL:	$1,938,873.00	
Contingency			25% of direct	$484,718.25	17
Remedial Design	1	LS	8% of subtotal	$155,109.84	17
Project Management	1	LS	5% of subtotal	$96,943.65	17
Construction Management	1	LS	6% of subtotal	$116,332.38	17
Mobilization/Demobilization	1	LS	15% of subtotal	$290,830.95	5
Total O&M Present Value	1	LS		$1,064,363.63	
			TOTAL:	$4,147,171.70	

2.3.3: Benefits

-No vertical drilling into YAK tunnel
-No storage facility required

2.3.4: Drawbacks

-Extensive tracer studies to be performed to prove connection to YAK Tunnel
-Boring and oversize trench – expensive and ripping up excess land

2.4: Alternative No. 2d: Gravity Line to Bureau of Reclamation (BOR): This alternative would construct a 12" PVC gravity line from the Greenback pond at elevation 10,560 to the BOR for 11,458 feet to elevation 9,965. The average grade over the entire alignment would be 5.19%.

2.4.1: Alignment location reasoning: There are a number of different alignment options for this alternative, but all with similar characteristics. The specific routing for this alternative can be altered to avoid conflicts (right of ways, abandoned mines, utilities, etc.)

2.4.2: Cost Estimate: Using *2001 RSMeans Building Construction Cost Data* values along with estimates from qualified engineers, the following cost estimate was developed:

Alternative 2d					
Item	Quantity	Units	Unit Cost	Total Cost	Ref.
12" PVC Pipe System	11458	LF	$33.00	$378,114.00	1
48" Dia. Manholes	32	EACH	$3,500.00	$112,000.00	5
Impoundment	1	LS	$542,747.00	$542,747.00	11
Connections	1	LS	$10,000.00	$10,000.00	5
Inlet/Outlet Structures	1	LS	$50,000.00	$50,000.00	
			SUBTOTAL:	$1,092,861.00	
Contingency			25% of direct	$273,215.25	17
Remedial Design	1	LS	8% of subtotal	$87,428.88	17
Project Management	1	LS	5% of subtotal	$54,643.05	17
Construction Management	1	LS	6% of subtotal	$65,571.66	17
Mobilization/Demobilization	1	LS	15% of subtotal	$163,929.15	5
Total O&M Present Value	1	LS		$2,203,820.27	
			TOTAL:	$3,941,469.26	

2.4.3: Benefits

-No vertical drilling into LMDT tunnel

2.4.2: Drawbacks

-Length of alignment
-Requires storage facility

2.5: Alternative No. 2e: Gravity Line to extraction well on LMDT Tunnel: This alternative would construct a 12" PVC gravity line from the Greenback pond at elevation 10,560 to the extraction well for 9,821 feet to elevation 10,108. The flow would then drop into the well and utilize the existing LMDT tunnel to get to the BOR. The average grade over the entire alignment would be 4.60%.

2.5.1: Alignment location reasoning: There are a number of different alignment options for this alternative, but all with similar characteristics. The specific routing for this alternative can be altered to avoid conflicts (right of ways, abandoned mines, utilities, etc.)

2.5.2: Cost Estimate: Using *2001 RSMeans Building Construction Cost Data* values along with estimates from qualified engineers, the following cost estimate was developed:

Alternative 2e					
Item	Quantity	Units	Unit Cost	Total Cost	Ref.
12" PVC Pipe System	9821	LF	$33.00	$324,093.00	1
48" Dia. Manholes	27	EACH	$3,500.00	$94,500.00	5
Impoundment	1	LS	$542,747.00	$542,747.00	11
Connections	1	LS	$10,000.00	$10,000.00	5
Inlet/Outlet Structures	1	LS	$50,000.00	$50,000.00	
			SUBTOTAL:	$1,021,340.00	
Contingency			25% of direct	$255,335.00	17
Remedial Design	1	LS	8% of subtotal	$81,707.20	17
Project Management	1	LS	5% of subtotal	$51,067.00	17
Construction Management	1	LS	6% of subtotal	$61,280.40	17
Mobilization/Demobilization	1	LS	15% of subtotal	$153,201.00	5
Total O&M Present Value	1	LS		$2,203,820.27	
			TOTAL:	$3,827,750.87	

2.5.3: Benefits

-No vertical drilling into LMDT tunnel

2.5.4: Drawbacks

-Length of alignment
-Requires storage facility

2.6: Alternative No. 2g: Gravity Line from new extraction well on LMDT Tunnel to BOR: This alternative would install a concrete plug in the LMDT Tunnel at the location shown and construct an extraction well just upstream and pump the flow through a lineshaft pump up to the surface at elevation 10,377. The flow would then go through a 18" PVC pipe, gravity flow for 7,287 feet to the BOR at elevation 9,965. The average grade over the alignment of the gravity line would be 5.65%

2.6.1: Alignment location reasoning: There are a number of different alignment options for this alternative, but all with similar characteristics. The specific routing for this alternative can be altered to avoid conflicts (right of ways, abandoned mines, utilities, etc.)

2.6.2: Cost Estimate: Using *2001 RSMeans Building Construction Cost Data* values along with estimates from qualified engineers, the following cost estimate was developed:

Alternative 2g

Item	Quantity	Units	Unit Cost	Total Cost	Ref.
18" PVC Pipe System	7287	LF	$51.00	$371,637.00	2
48" Dia. Manholes	20	EACH	$3,500.00	$70,000.00	5
Connections	1	LS	$10,000.00	$10,000.00	5
Shaft and Tunneling	1	LS	$1,100,000.00	$1,100,000.00	8
Concrete plug	1	LS	$140,000.00	$140,000.00	8
Pump system	1	LS	$490,000.00	$490,000.00	9
Outlet Structure	1	LS	$25,000.00	$25,000.00	
Overhead powerlines and transformers	3100	LF	$10.00	$31,000.00	13
			SUBTOTAL:	$2,237,637.00	
Contingency			25% of direct	$559,409.25	17
Remedial Design	1	LS	8% of subtotal	$179,010.96	17
Project Management	1	LS	5% of subtotal	$111,881.85	17
Construction Management	1	LS	6% of subtotal	$134,258.22	17
Mobilization/Demobilization	1	LS	15% of subtotal	$335,645.55	5
Total O&M Present Value	1	LS		$1,448,195.95	
			TOTAL:	$5,006,038.78	

2.6.3: Benefits

-Shorter length of newly constructed line

2.6.4: Drawbacks

-Costly pump system
-Electricity costs for pumping

2.7: Alternative No. 2h: Dedicated Water Treatment Plant: This alternative would install a 12" PVC pipe system from the Greenback Pond to a location nearby, estimated to be 500 ft away, at which would be constructed a dedicated 321 hp water treatment plant. A 1 MG equalization basin would be constructed between the pond and the plant to regulate the flow coming into the plant. The system would be a lime softening filtration system.

2.7.1: Alignment location reasoning: The location of the proposed plant is near the Greenback Pond to decrease the length of pipe required.

2.7.2: Cost Estimate: Using *2001 RSMeans Building Construction Cost Data* values along with estimates from qualified engineers, the following cost estimate was developed:

Alternative 2h					
Item	Quantity	Units	Unit Cost	Total Cost	Ref.
12" PVC Pipe System	500	LF	$33.00	$16,500.00	1
48" Dia. Manholes	2	EACH	$3,500.00	$7,000.00	5
Equalization Basin	1	LS	$80,474.00	$80,474.00	14
Inlet/Outlet Structures	1	LS	$50,000.00	$50,000.00	
Overhead powerlines and transformers	3100	LF	$10.00	$31,000.00	13
Plant equipment costs	1	LS	$1,500,000.00	$1,500,000.00	16
Plant installation (30% of equipment)	1	LS	$450,000.00	$450,000.00	15
			SUBTOTAL:	$2,134,974.00	
Contingency			25% of direct	$533,743.50	17
Remedial Design	1	LS	8% of subtotal	$170,797.92	17
Project Management	1	LS	5% of subtotal	$106,748.70	17
Construction Management	1	LS	6% of subtotal	$128,098.44	17
Mobilization/Demobilization	1	LS	15% of subtotal	$320,246.10	5
Total O&M Present Value	1	LS		$4,803,376.46	
			TOTAL:	$10,332,959.12	

2.7.3: Benefits

-Shorter length of pipe

2.7.4: Drawbacks

-Sludge removal cost
-Electricity costs

REFERENCES

1 See 12" Pipe Costing (attached)
2 See 18" Pipe Costing (attached)
3 See Oversize Pipe Trench Costing (attached)
4 Average from Bomareto Pumps (John, October 2001) and Griswold Pumps (Rick, October 2001) estimates
5 Adjusted from HDR Costing for DIA Cargo ADF Management Project, (Mike Middleton, HDR, November 2001)
6 Adjusted from HDR Costing for City of Broomfield Airport Booster Pump Station, (Mike Middleton, HDR, April 1998)
7 Adjusted from HDR Costing for City of Broomfield Interlocken 6MG Storage Reservoir, (Mike Middleton, HDR, April 1997)
8 TSS Tunnel a Shaft Sealing Ltd. Document to Brad Littlepage, U.S. Bureau of Reclamation (March 30, 2000)
9 Estimate from Layne-Western (Neil Parsons, October 2001)
10 Estimate from Trainor (Dave Emm, October 2001)
11 See estimate from Impoundment Costing Spreadsheet (attached), developed by Craig Habben, HDR
12 Estimate from Layne-Western (Dennis, October 2001)
13 Estimate from Excel Energy (Jim Steck, December 2001)
14 Estimate from Equalization Basin Costing Spreadsheet (attached), developed by Craig Habben, HDR
15 Estimate from USFilter (Kevin Warheit, December 2001)
16 US Filter, Technical and Cost Proposal, November 20, 2001
17 EPA A Guide to Developing and Documenting Cost Estimates During the Feasibility Study, July 2000

O&M Present Worth Details

Alternative 2a

Direct Operation and Maintenance Costs

	Unit	Unit Cost	Each	Each/Year	$/year	Years	Present Worth	Ref
Pump Replacement	lump	$25,000	4	N/A	N/A	100	$8,673	1
Pump maintenance	hour	$40	8	4	$1,280	100	$18,265.60	4
Pump parts	year	$350	1	1	$350	100	$4,994.50	1
Major pump parts	lump	$5,000	1	0.1	$500	100	$7,135.00	1
Electrical Costs	year	$9,669	1	1	$9,669	100	$137,976.63	2
Muck existing ponds	CY	$130	425	1	$55,250	100	$788,417.50	7
Total Direct O&M Present Worth							$965,462.23	

Indirect Operation and Maintenance Costs

		Present Worth	Ref
Administration	5% of direct O&M	$48,273.11	4
Misc. Fees	5% of direct O&M	$48,273.11	4
Reserve	25% of direct O&M	$241,365.56	4
Total Indirect O&M Present Worth		$337,911.78	
Total O&M Present Worth		$1,303,374.01	

Alternative 2b

Direct Operation and Maintenance Costs

	Unit	Unit Cost	Each	Each/Year	$/year	Years	Present Worth	Ref
Muck out impoundment	CY	$318	186	1	$59,148	100	$844,042	3
Muck existing ponds	CY	$130	425	1	$55,250	100	$788,417.50	7
Total Direct O&M Present Worth							$1,632,459	

Indirect Operation and Maintenance Costs

		Present Worth	Ref
Administration	5% of direct O&M	$81,622.97	4
Misc. Fees	5% of direct O&M	$81,622.97	4
Reserve	25% of direct O&M	$408,114.87	4
Total Indirect O&M Present Worth		$571,360.81	
Total O&M Present Worth		$2,203,820.27	

Alternative 2c

Direct Operation and Maintenance Costs

	Unit	Unit Cost	Each	Each/Year	$/year	Years	Present Worth	Ref
Muck existing ponds	CY	$130	425	1	$55,250	100	$788,417.50	7
Total Direct O&M Present Worth							$788,417.50	

Indirect Operation and Maintenance Costs

		Present Worth	Ref
Administration	5% of direct O&M	$39,420.88	4
Misc. Fees	5% of direct O&M	$39,420.88	4
Reserve	25% of direct O&M	$197,104.38	4
Total Indirect O&M Present Worth		$275,946.13	
Total O&M Present Worth		$1,064,363.63	

Alternative 2d

Direct Operation and Maintenance Costs

	Unit	Unit Cost	Each	Each/Year	$/year	Years	Present Worth	Ref
Muck out impoundment	CY	$318	186	1	$59,148	100	$844,042	3
Muck existing ponds	CY	$130	425	1	$55,250	100	$788,417.50	7
Total Direct O&M Present Worth							$1,632,459	

Indirect Operation and Maintenance Costs

Administration	5% of direct O&M	$81,622.97	4
Misc. Fees	5% of direct O&M	$81,622.97	4
Reserve	25% of direct O&M	$408,114.87	4
Total Indirect O&M Present Worth		$571,360.81	
Total O&M Present Worth		$2,203,820.27	

Alternative 2e

Direct Operation and Maintenance Costs

	Unit	Unit Cost	Each	Each/Year	$/year	Years	Present Worth	Ref
Muck out impoundment	CY	$318	186	1	$59,148	100	$844,042	3
Muck existing ponds	CY	$130	425	1	$55,250	100	$788,417.50	7
Total Direct O&M Present Worth							$1,632,459	

Indirect Operation and Maintenance Costs

Administration	5% of direct O&M	$81,622.97	4
Misc. Fees	5% of direct O&M	$81,622.97	4
Reserve	25% of direct O&M	$408,114.87	4
Total Indirect O&M Present Worth		$571,360.81	
Total O&M Present Worth		$2,203,820.27	

Alternative 2g

Direct Operation and Maintenance Costs

	Unit	Unit Cost	Each	Each/Year	$/year	Years	Present Worth	Ref
Pump replacement	lump	$490,000	4	N/A	N/A	100	$169,989	1
Pump maintenance	hour	$40	8	4	$1,280	100	$18,265.60	4
Pump parts	year	$350	1	1	$350	100	$4,994.50	1
Major pump parts	lump	$5,000	1	0.1	$500	100	$7,135.00	1
Electrical Costs	year	$5,882	1	1	$5,882	100	$83,936.14	2
Muck existing ponds	CY	$130	425	1	$55,250	100	$788,417.50	7
Total Direct O&M Present Worth							$1,072,738	

Indirect Operation and Maintenance Costs

Administration	5% of direct O&M	$53,636.89	4
Misc. Fees	5% of direct O&M	$53,636.89	4
Reserve	25% of direct O&M	$268,184.44	4
Total Indirect O&M Present Worth		$375,458.21	
Total O&M Present Worth		$1,448,195.95	

Alternative 2h

Direct Operation and Maintenance Costs

	Unit	Unit Cost	Each	Each/Year	$/year	Years	Present Worth	Ref
Plant Replacement Cost	lump	$1,950,000	4	N/A	N/A	100	$676,487	6
Chemical Consumption	year	$5,000	1	1	$5,000	100	$71,350.00	5
Sludge Disposal	year	$34,593	1	1	$34,593	100	$493,642.11	5
Plant Staff	year	$86,400	1	1	$86,400	100	$1,232,928.00	3
Electrical Costs	year	$20,689	1	1	$20,689	100	$295,232.03	2
Muck existing ponds	CY	$130	425	1	$55,250	100	$788,417.50	7
Total Direct O&M Present Worth							$3,558,057	
Indirect Operation and Maintenance Costs								
Administration			5% of direct O&M				$177,902.83	4
Misc. Fees			5% of direct O&M				$177,902.83	4
Reserve			25% of direct O&M				$889,514.16	4
Total Indirect O&M Present Worth							$1,245,319.82	
Total O&M Present Worth							$4,803,376.46	

References

1 Estimate from Pete Green, McLamar Pumps, November 2001
2 E-mail from Orville Kiehn (EPA) to Ken Napp (HDR) and Mike Kuyper (HDR) on 10/28/2001
3 2001 RSMeans Building Construction Cost Data, see attachment
4 Upper California Gulch Feasibility Study OU4. January 1997
5 Hwy. 36 SafetyKleen (Establishment of site wide repository will significantly reduce sludge disposal costs)
6 US Filter, Technical and Cost Proposal, November 20, 2001
7 2001 RSMeans Building Construction Cost Data and CSI/Waste Management Facility, Bennett, CO, see attachment

<u>**Costing Calculations for pipe installation – Alternative 2a-2h**</u>

1.)Typical pipe section (12")

Area of pipe = $\frac{\pi(1\text{ ft.})^2}{4} = 0.785\text{ ft}^2$

Cubic yards per linear foot of pipe = 0.785 ft^3/LF = 0.029 CY/LF

Area of bedding = (3 ft.)(2 ft.) – Area of pipe = 5.215 ft^2
Cubic yards per linear foot of bedding = 5.22 ft^3/LF = 0.1933 CY/LF

Area of backfill = (6 ft.)(3 ft.) + 2(½(6 ft.)(6 ft.)) = 54 ft^2
Cubic yards per linear foot of bedding = 54 ft^3/LF = 2.00 CY/LF

Costs per linear foot:

Pipe: [2530-780-2160][1] = $12.20/LF — $12.20/LF
Bedding: [2315-130-0050] [1] + [2315-130-0500] [1]
= $26.00/CY + $4.00/CY = $30.00/CY
$30.00/CY * 0.1933 CY/LF = $5.80/LF — $5.80/LF
Trenching: [2315-900-0090/0500] [1] = $4.80/CY
$4.80/CY * (2.00 CY/LF + 0.1933 CY/LF + 0.029 CY/LF) = $10.70/LF
Backfill: [2315-100-2200] [1] = $2.15/CY
$2.15/CY * 2.00 CY/LF = $4.30/LF — <u>$4.30/LF</u>

Total: $33.00/LF

2.)Typical pipe section (18")

Area of pipe = $\frac{\pi(1.5\text{ ft.})^2}{4} = 1.77\text{ ft}^2$

Cubic yards per linear foot of pipe = 1.77 ft^3/LF = 0.0656 CY/LF

Area of bedding = (3.5 ft.)(2.5 ft.) – Area of pipe = 6.98 $ft^2 \approx 7.0\ ft^2$
Cubic yards per linear foot of bedding = 7.0 ft^3/LF = 0.259 CY/LF

Area of backfill = (6 ft.)(3.5 ft.) + 2(½(6 ft.)(6 ft.)) = 57 ft^2
Cubic yards per linear foot of bedding = 57 ft^3/LF = 2.11 CY/LF

Costs per linear foot:

Pipe: [2530-780] [1] (interpolated) = $27.00/LF — $27.00/LF
Bedding: [2315-130-0050] [1] + [2315-130-0500] [1]
= $26.00/CY + $4.00/CY = $30.00/CY
$30.00/CY * 0.259 CY/LF = $7.80/LF — $7.80/LF

Trenching: [2315-900-0090/0500] [1] = \$4.80/CY
\$4.80/CY * (2.11 CY/LF + 0.259 CY/LF + 0.0656 CY/LF) = \$11.70/LF
Backfill: [2315-100-2200] [1] = \$2.15/CY
\$2.15/CY * 2.11 CY/LF = \$4.50/LF — \$4.50/LF

Total: \$51.00/LF

3.)Typical oversize trench

Area of pipe = $\frac{\pi(1 \text{ ft.})^2}{4} = 0.785 \text{ ft}^2$

Cubic yards per linear foot of pipe = 0.785 ft^3/LF = 0.029 CY/LF

Area of bedding = (5 ft.)(2 ft.) – Area of pipe = 9.22 ft^2
Cubic yards per linear foot of bedding = 9.22 ft^3/LF = 0.342 CY/LF

Area of backfill = (5 ft.)(14 ft.) + (25 ft.)(8 ft.) + 2(½(8 ft.)(8 ft.)) = 334 ft^2
Cubic yards per linear foot of bedding = 334 ft^3/LF = 12.37 CY/LF

Costs per linear foot:

Pipe: [2530-780-2160] [1] = \$12.20/LF	\$12.20/LF
Bedding: [2315-130-0050] [1] + [2315-130-0500] [1]	
= \$26.00/CY + \$4.00/CY = \$30.00/CY	
\$30.00/CY * 0.342 CY/LF = \$10.26/LF ≈ \$10.30/LF	\$10.30/LF
Trenching: [2315-900-1310] [1] = \$2.80/CY	
\$2.80/CY * (0.342 CY/LF + 2.963 CY/LF) = \$9.30/LF	\$9.30/LF
Scraping: [2315-430] [1] = \$4.00/CY	
\$4.00/CY * 9.78 CY/LF = \$39.20/LF	\$39.20/LF
Backfill: [2315-100-2200] [1] = \$2.15/CY	
\$2.15/CY * 12.37 CY/LF = \$26.60/LF	\$26.60/LF

Total: \$98.00/LF

[1] 2001 RSMeans Building Construction Cost Data

Mucking Cost Estimate

Muck New Impoundment

Excavation: [2315-400-1000][1] + [2315-400-4200][1] +[2315-400-0020]= $8.80/CY + 15% = $10.12/CY

Hauling: (To Hwy. 36 SafetyKleen)[2] = $307.50/CY

Total: $318/CY

Muck Existing Ponds

Excavation: [2315-400-1000][1] + [2315-400-4200][1] +[2315-400-0020] [1] = $8.80/CY + 15% = $10.12/CY

Hauling: (To CSI in Bennet, CO) Disposal Cost[3] = $23.00/CY
Hauling [2320-200] [1] (interpolated) + [2320-200-1300] [1] = $96.00/CY
= $126.00/CY

Total: $130/CY

[1] 2001 RSMeans Building Construction Cost Data
[2] Estimate from Gary Slifka of ASARCO (December, 2001)
[3] Estimate from Marie Lopez, CSI/Waste Management, Bennett, CO (February, 2002)

Impoundment Sizing - Alternatives 2b, 2d, 2e

Single Underlined Represents Variables

Dimensional Data

Vertical Slope up North/South Side	3.00	to 1	a
Vertical Slope up East/West Sides	3.00	to 1	b
Bottom Dimension East/West Sides	200.00	feet	c
Bottom Dimension North/South Sides	300.00	feet	d
Storage Portion Depth	16.00	feet	e
Top of Storage Portion East/West Side	296.00	feet	
Top of Storage Portion North/South Si	396.00	feet	

Storage Volume

Volume of One Cell Storage	1,393,152	cubic feet
Volume of One Cell Storage	10,420,777	gallons
Number of Cells	1	each
Total Storage Volume	10,420,777	gallons

Overall Pond Dimensional Data

Top of Berm Height	18.00	feet	f
Required Top of Storage Height	16.00	feet	
Free Board	2.00	feet	g
Bottom of Pond Datum	0.00	feet	
Total Depth of Pond	18.00	feet	
Top of East/West Side Dimension	308.00	feet	
Top of Pond Short Dimension	408.00	feet	

Overall Pond Volumes

Total Volume One Cell	1,635,984	cubic feet
Number of Cells	1	each
Overall Total Volume	1,635,984	cubic feet
Overall Total Volume	60,592	cubic yards
Overall Total Volume	12,237,160	gallons

Excavation Quantities

Elevation Rock Begins	0.00	feet	(If no rock, enter the "Bottom of Pond Elevation")	h
Depth of Rock Excavation	0.00	feet		
Volume of Rock Excavation	0	cubic yards		
Remaining Excavation	60,592	cubic yards		

HDPE Data

Height Liner Begins	18.00	feet		i
Slope Length North/South Side	56.92	feet		
Slope Length East/West Side	56.92	feet		
Additional Liner Required at top of line	7.00	feet	(North/South Side)	j
Additional Liner Required at top of line	7.00	feet	(East/West Side)	k
Length at height liner begins	408.00	feet	(North/South Side)	
Length at height line begins	308.00	feet	(East/West Side)	
HDPE Quantity Required	79,240	sq. ft.		

Over Excavation

Over Exc. Depth (Rock)	0.00	feet	Enter 0.00 if no rock	m
Over Exc. Depth (Normal) =	2.50	feet		n

Concrete

Bottom	0.00	sq. feet
Ramp width	0.00	feet
Ramp length	0.00	feet
Concrete thickness	0.00	inches

Costs

Cost Item	Quantity	Unit	Unit Price	Cost
Rock Over Excavation	0	CY	$15.00	$0.00
Rock Excavation	0	CY	$15.00	$0.00
Total Rock Excavation	0			$0.00
"Normal" Over Excavation	12,140	CY	$6.30	$76,480.25
"Normal" Remaining Excavation	60,592	CY	$6.30	$381,729.60
Total Normal Excavation	72,732			$458,209.85
HDPE Required	79,240	SF	$0.50	$39,619.97
Fill required for over excavation	12,140	CY	$3.70	$44,916.97
Concrete	0	CY	$350.00	$0.00
Total				$542,746.79

Equalization Basin Sizing - Alternative 2h

Single Underlined Represents Variables

Dimensional Data

Vertical Slope up North/South Side	3.00	to 1	a
Vertical Slope up East/West Sides	3.00	to 1	b
Bottom Dimension East/West Sides	100.00	feet	c
Bottom Dimension North/South Sides	100.00	feet	d
Storage Portion Depth	8.50	feet	e
Top of Storage Portion East/West Side	151.00	feet	
Top of Storage Portion North/South Si	151.00	feet	

Storage Volume

Volume of One Cell Storage	135,720	cubic feet
Volume of One Cell Storage	1,015,182	gallons
Number of Cells	1	each
Total Storage Volume	1,015,182	gallons

Overall Pond Dimensional Data

Top of Berm Height	10.50	feet	f
Required Top of Storage Height	8.50	feet	
Free Board	2.00	feet	g
Bottom of Pond Datum	0.00	feet	
Total Depth of Pond	10.50	feet	
Top of East/West Side Dimension	163.00	feet	
Top of Pond Short Dimension	163.00	feet	

Overall Pond Volumes

Total Volume One Cell	185,042	cubic feet
Number of Cells	1	each
Overall Total Volume	185,042	cubic feet
Overall Total Volume	6,853	cubic yards
Overall Total Volume	1,384,110	gallons

Excavation Quantities

Elevation Rock Begins	0.00	feet	(If no rock, enter the "Bottom of Pond Elevation")	h
Depth of Rock Excavation	0.00	feet		
Volume of Rock Excavation	0	cubic yards		
Remaining Excavation	6,853	cubic yards		

HDPE Data

Height Liner Begins	10.50	feet		I
Slope Length North/South Side	33.20	feet		
Slope Length East/West Side	33.20	feet		
Additional Liner Required at top of line	5.00	feet	(North/South Side)	j
Additional Liner Required at top of line	5.00	feet	(East/West Side)	k
Length at height liner begins	163.00	feet	(North/South Side)	
Length at height line begins	163.00	feet	(East/West Side)	
HDPE Quantity Required	20,725	sq. ft.		

Over Excavation

Over Exc. Depth (Rock)	0.00	feet	Enter 0.00 if no rock	m
Over Exc. Depth (Normal) =	2.50	feet		n

Concrete

Bottom	0.00	sq. feet
Ramp width	0.00	feet
Ramp length	0.00	feet
Concrete thickness	0.00	inches

Costs

Cost Item	Quantity	Unit	Unit Price	Cost
Rock Over Excavation	0	CY	$15.00	$0.00
Rock Excavation	0	CY	$15.00	$0.00
Total Rock Excavation	0			$0.00
"Normal" Over Excavation	2,693	CY	$6.30	$16,968.58
"Normal" Remaining Excavation	6,853	CY	$6.30	$43,176.35
Total Normal Excavation	9,547			$60,144.93
HDPE Required	20,725	SF	$0.50	$10,362.63
Fill required for over excavation	2,693	CY	$3.70	$9,965.68
Concrete	0	CY	$350.00	$0.00
Total				$80,473.24

Water Plant Staff Costs – Alternative 2h

-Assume (1) full time employee each shift, 3 shifts, 90 days/yr.
-Assume employee cost of $40/hr.

$40/hr * 8 hrs. * 3 shifts * 90 days/yr = **$86,400/yr.**

Electricity Costs for pipeline pumps

For Alternative 2a:

150 hp centrifugal pump

-Assume pump runs 24 hrs./day for 60 days/yr.
-Use conversion of 0.746 kW/hp [1]
-Use conversion of $0.06/kWh [1]

150 hp * 0.746 kW/hp * 60 days/yr * 24 hrs./day
= 161,136 kWh/yr

Annual Cost:
161,136 kWh/yr * $0.06/kWh
= **$9,669/yr**

For Alternative 2g:

15 hp lineshaft pump

-Assume pump runs 24 hrs./day for 365 days/yr.
-Use conversion of 0.746 kW/hp [1]
-Use conversion of $0.06/kWh [1]

15hp * 0.746 kW/hp * 365 days/yr. * 24 hrs./day
= 98,025 kWh

Annual Cost:
98,025 kWh * $0.06/kWh
= $5,882/yr

For Alternative 2h:

321 hp Water Plant

-Assume pump runs 24 hrs./day for 60 days/yr.
-Use conversion of 0.746 kW/hp [1]
-Use conversion of $0.06/kWh [1]

321 hp* 0.746 kW/hp * 60 days/yr. * 24 hrs./day
=344831 kWh

Annual Cost:
344831 kWh *$0.06/kWh
=**$20,689/yr**

[1] E-mail from Orville Kiehn (EPA) to Ken Napp (HDR) and Mike Kuyper (HDR) on 10/28/2001

ANNUAL AND 100-YEAR PRESENT WORTH WATER TREATMENT COSTS AND WATER PLANT REPLACEMENT COSTS

I. Yak Treatment Plant:

Alternatives 2a, 2b and 2c assume that OU6 ARD is treated at the Yak Water Treatment Plant.

Treatment Cost:

- Unit cost (treatment and sludge disposal) - $0.04/gallon (ASARCO, 2001)
- Annual Quantity - 10,000,000 gallon
  - Annual Cost - $400,000
  - 100-year present worth - $5,708,000

Treatment Plant Replacement Cost:

- Assume 20-year plant life
- Plant constructed in 1991 at a cost of $12M (Gary Slifka, personal communication, 2001)
- Assume OU6 ARD requires 37% of existing plant capacity (EPA Memorandum).
  - Adjusting the 1991 plant capital cost to 2001, assuming 5% inflation = $19.54M
  - The OU6 financial obligation for plant replacement is 37% or $7.23M in 2001.
  - Assuming full plant replacement in year 2011 and every 20-years thereafter until 2091, the present worth cost of plant replacement = $4.95M

II. BOR Treatment Plant

Alternatives 2d, 2e, 2f and 2g assume that OU6 ARD is treated at the BOR Water Treatment Plant.

Alternative 2d, 2e and 2f Treatment Cost:

- Unit cost (treatment and sludge disposal) - $0.01/gallon (BOR Actual 2001 treatment costs for Marion Shaft Discharge)
- Annual Quantity - 10,000,000 gallon
  - Annual Cost - $100,000
  - 100-year present worth - $1,400,000

Alternative 2g Treatment Cost:

- Unit cost (treatment and sludge disposal) - $0.01/gallon (BOR Actual 2001 treatment costs for Marion Shaft Discharge)
- Annual Quantity - 26,280,000 gallons (assumes 50gpm continuous discharge)

  - Annual Cost - $262,800
  - 100-year present worth - $3,750,156

Treatment Plant Replacement Cost:

Not Available. Therefore, the replacement costs for the Yak Plant is used in this case.

Alternative 5 – Consolidate and Cap Waste Piles

This alternative would consolidate the remaining, uncapped piles into larger, but fewer piles to be determined in design. An assumed over excavation depth of 1 ft. depth will be assumed sufficient to remove the majority of the contaminants. The consolidated piles would then be covered with a geomembrane and ultimately covered with crushed dolomite rock. The old footprints of the piles would then be amended, stabilized and revegetated.

Alternative 5- Consolidate and cap waste piles									
WORK STATEMENT:									
DIRECT CAPITAL COSTS									
Item		Unit	Unit Cost	Quantity	Total Cost	Ref			
Waste rock pile excavation and consolidation		cu-yd	$2.25	742100	1,669,725.00	2			
Over excavation under piles (1 ft. depth)		cu-yd	$2.25	109537	246,458.25	2			
Amend soil and revegetation of old pile footprints		acre	$8,100.00	68	550,800.00	1			
Dust control		M gal	$21.25	2468	52,445.00	2			
Sediment control		lf	$5.75	5685	32,688.75	2			
Geomembrane		sy	$11.20	154199	1,727,028.80	2			
Dolomite rockfill		cy	$30.00	320196	9,605,880.00	5			
White porphyry rockfill		cy	$3.75	13334	50,002.50	2			
Mixed rockfill		cy	$4.09	7515	30,736.35	2			
Gas vents		lump	$2,710.00	1	2,710.00	2			
Capping mine shafts		ea	$3,800.00	23	87,400.00				
Subtotal construction						14,055,874.65			
Contingency	25% of direct				3,513,968.66	3			
Subtotal						17,569,843.31			
INDIRECT CAPITAL COSTS									
Mobilization/Demobilization	18% of direct				3,162,571.80	2			
Remedial design	8% of direct				1,405,587.47	3			
Project management	5% of direct				878,492.17	3			
Construction management	6% of direct				1,054,190.60	3			
Subtotal indirect capital costs						6,500,842.03			
Total capital costs							24,070,696.34		
POST REMEDIATION SITE CONTROL COSTS									
Item		Unit	Unit Cost	Each	Each/year	$/year	Years	Present Worth	Ref
DIRECT OPERATION AND MAINTENANCE COSTS									
Inspection		hour	40.00	8	4	$1,280.00	100	$18,265.60	4
Erosion repair (old pile site)		lump	$136,000	1	1	$136,000	5	$557,600.00	3
Vegetation repair (old pile site)		lump	$170,000	1	1	$170,000	5	$697,000.00	3
Cap maintenance and repair		lump	$17,361	1	1	$17,361	5	$71,180.88	3
Total direct O&M present worth								$1,344,046.48	
Item		Unit	Unit Cost	Quantity	Total Cost				
INDIRECT OPERATION AND MAINTENANCE COSTS									
Administration	5% of direct O&M							$67,202.32	4
Misc. fees	5% of direct O&M							$67,202.32	4
Reserve	25% of direct O&M							$336,011.62	4
Total indirect operation and maintenance costs								$470,416.27	
Total operation and maintenance present worth									$1,814,462.75
Grand total									$25,885,159.08
1	Draft Addendum to Engineering Evaluation/Cost Analysis for Stray Horse Gulch OU6 California Gulch NPL Site Leadville Colorado. December 1997								
2	Final Phase I Removal Action Completion Report for the California Gulch Superfund Site Lake County, Colorado OU6. December 2000								
3	EPA A Guide to Developing and Documenting Cost Estimates During the Feasibility Study. July 2000								
4	Upper California Gulch Feasibility Study OU4. January 1997								
5	Dolomite costs from Dan Hindes, Frontier Contractors (November, 2001). $12/ton, 1.5 ton/yd + haul cost 10 miles(2001 RSMeans Building Construction Cost Data)								

Alternative 6 – Excavate, Transport, and on-site disposal

This alternative would excavate all of the uncapped piles including one foot of over excavated soil into a large repository, assumed at a location 4 miles from the site. The repository would be lined on both the top and the bottom to completely encapsulate the waste so no stormwater runoff will come in contact with the waste. 10 monitoring wells approximately 100 ft. deep would be placed throughout the new repository site and quarterly sampling and alalysis would be conducted to measure TAL Metal concentrations. The old pile footprints and the top of the repository would then be amended, stabilized, and revegetated.

Alternative 6- Excavate, transport, and on-site disposal										
WORK STATEMENT:										
DIRECT CAPITAL COSTS										
Item			Unit	Unit Cost	Quantity	Total Cost	Ref			
Excavate, Load and haul waste rock/soil			cu-yd	9.50	742100	7,049,950.00	1			
Over Excavation under piles (1 ft. depth)			cu-yd	9.50	109537	1,040,601.50	1			
Repository Excavation			cu-yd	3.50	62230	217,805.00	5			
Top/Bottom soil cover placement			cu-yd	2.00	61860	123,720.00	5			
Topsoil placement and haul			cu-yd	10.35	10580	109,503.00	5			
Vegetate repository			acre	2000.00	12.5	25,000.00	4			
Amend soil and revegetation of old pile footprints			acre	8100.00	68	550,800.00	4			
60 mil HDPE liner, top and bottom, complete in place			sf	0.50	1113472	556,736.00				
Install Monitoring wells			lf	27.00	1000	27,000.00	7			
Dust control			M gal	21.25	2468	52,445.00	2			
Sediment control			lf	5.75	5685	32,688.75	2			
Capping mine shafts			ea	$3,800.00	23	87,400.00	2			
Subtotal construction							9,873,649.25			
Contingency		25% of direct				2,468,412.31	3			
Subtotal							12,342,061.56			
INDIRECT CAPITAL COSTS										
Mobilization/Demobilization		18% of direct				2,221,571.08	2			
Remedial design		8% of direct				987,364.93	3			
Project management		5% of direct				617,103.08	3			
Construction management		6% of direct				740,523.69	3			
Subtotal indirect capital costs							4,566,562.78			
Total capital costs								16,908,635.34		
POST REMEDIATION SITE CONTROL COSTS										
Item			Unit	Unit Cost	Each	Each/year	$/year	Years	Present Worth	Ref
DIRECT OPERATION AND MAINTENANCE COSTS										
Inspection			hour	40.00	8	4	$1,280.00	100	$18,265.60	3
Erosion repair (old pile site)			lump	$136,000	1	1	$136,000	5	$557,600.00	3
Vegetation repair (old pile site)			lump	$170,000	1	1	$170,000	5	$697,000.00	3
Erosion repair (repository)			lump	$25,000	1	1	$25,000	5	$102,500.00	3
Vegetation repair (repository)			lump	$31,250	1	1	$31,250	5	$128,125.00	3
Groundwater Monitoring (repository)										
Analytical			lump	$3,449	1	4	$13,796.00	100	$196,868.92	6
Labor & Misc. Equipment			lump	$2,235	1	4	$8,940.00	100	$127,573.80	6
Total direct O&M present worth									$1,827,933.32	
Item			Unit	Unit Cost	Quantity	Total Cost				
INDIRECT OPERATION AND MAINTENANCE COSTS										
Administration		5% of direct O&M							$91,396.67	4
Misc. fees		5% of direct O&M							$91,396.67	4
Reserve		25% of direct O&M							$456,983.33	4
Total indirect operation and maintenance costs									$639,776.66	
Total operation and maintenance present worth										$2,467,709.98
Grand total										**$19,376,345.32**
1	Value Analysis California Gulch OU6 Removal Action Evaluation and Decision Phase Leadville Colorado. April 1996									
2	Final Phase I Removal Action Completion Report for the California Gulch Superfund Site Lake County, Colorado OU6. December 2000									
3	EPA A Guide to Developing and Documenting Cost Estimates During the Feasibility Study. July 2000									
4	Upper California Gulch Feasibility Study OU4. January 1997									
5	2001 RSMeans Building Construction Cost Data									
6	CDM Final Focused Feasibility Study for Groundwater in Operable Unit 2, Midvale, Utah, May 2002									
7	2001 RSMeans Environmental Remediation Cost Data									

Repository Sizing - Alternative 6

Total Waste Volume	851637 CY		Volume available with design below	852923 CY	
			Excess Cover Material %	0.3 %	
x above	245 Yards	for 1:3 slopes	Excess Space for waste %	0.2 %	
y above	245 Yards	for 1:3 slopes			
z above	**40.90** Yards	Manually Adjust			
Volume	821015 CY				
x below	245 Yards	variable slope			
y below	245 Yards	variable slope			
z below	**3.09** Yards	Manually Adjust			
Excavated volume available	**62028** CY				
Surface Area above grade	63479 SY				
Top Cover Volume (1/2 yard depth)	31739 CY				
Surface Area below grade	60240 SY				
Bottom Cover Volume (1/2 yard depth)	30120 CY				
Total Cover Volume Needed(above and below)	**61859** CY				
Footprint	60221.2 SY				
Footprint	12.4 Acres				
Total Surface Area of Liner Needed	123719 SY				
	1113470.37 SF				

APPENDIX D
Technical and Cost Proposal to Plug LMDT

TSS Tunnel & Shaft Sealing Ltd.

Our File: 00-146.1

March 30, 2000

U.S. Bureau of Reclamation
749 Highway 91 North
Leadville, CO 80461

Mr. Brad Littlepage

Rehabilitation of Leadville Drainage Tunnel

Dear Mr. Littlepage:

Please find attached some rough cost comparisons and preliminary recommendations regarding rehabilitation of the Leadville Drainage Tunnel. You indicated you were going to send a second package of documents relating to the recent hydrogeology studies but I did not receive it. Nonetheless, I have proceeded on the basis of some assumptions and I think most of my comments should be applicable. My comments are provided without the benefit of having carried out a complete review of all the historical data or having been to the site. As such, they should be treated accordingly, and serve only to guide the direction of future engineering work at the site.

I have also proposed a small budget for myself to visit the site in order to develop a better understanding of the problem and to assist the Bureau of Reclamation in developing a scope of work for future engineering studies.

Project Understanding

I recently completed a review of the historical documents you provided that relate to the construction and performance of the Leadville Drainage Tunnel. The work to date on the Leadville Drainage Tunnel is summarized chronologically in the Table 1.

41717 Cottonwood Road
Box 489 Brackendale, B.C.
Canada V0N 1H0

tel (604) 608-3230
fax (604) 608-3230
www.tunnelseal.com

Table 1 Leadville Drainage Tunnel History

1943-1946	The Leadville Drainage Tunnel was constructed by the U.S. Bureau of Mines between 1943 and 1945 to drain a number of mines in the Leadville area. The tunnel was driven 9.5 feet wide x 10.5 feet high at a grade of 0.2%. The portal was collared in Evans Gulch at approximately the 9960 ft elevation. The tunnel was driven to 6600 ft where poor ground was encountered.
1950-1957	Tunnel extended to Hayden and Emmet Shafts. Main tunnel advanced 4,698 feet and 571 feet of crosscuts were driven.
1959	Tunnel ownership transferred from Bureau of Mines to Bureau of Reclamation
1975	EPA orders Bureau of Reclamation to bring tunnel effluent into compliance with established limits.
1976	Secretary of Interior authorized by Law to rehabilitate first 1000 ft of tunnel.
1979-1980	Rehabilitation of first 1000 feet of tunnel undertaken
1990	First 400 ft of tunnel rehabilitated and dam/bulkhead constructed to channel water into pipeline feeding water treatment plant.

The first 650 feet of the tunnel is in water bearing unconsolidated gravel. Between 650 and approximately 2100 ft from the portal, the tunnel is in relatively weak, weathered shale. At about Station 21+00, the tunnel entered unconsolidated material again and a bypass had to be driven starting at Station 16+81. Progress was slow until about Station 40+00. The plans show that the tunnel was driven through competent Pre-Cambrian granite from approximately 4000 to 6300 feet. The granite is overlain by a shallow dipping sequence of shale, quartzite and dolomite, which the tunnel passes through between 6600 ft and 9600 feet. Poor ground conditions were reported between 6600 and 7700 feet and between 7800 and 8000 feet. At Station 84+80, a crosscut is driven from the main tunnel to the Ponsardine Raise, the first connection to the mine workings.

Sulfide mineralization was encountered in rocks between 7120 and 8600 feet from the portal. If the tunnel was completely sealed, it is reasonable to expect that the remaining tunnel discharge would not require treatment.

Based on the geology and tunneling conditions described in the various reports, and the location of sulphide bearing rocks, the most suitable location for a concrete plug is within the Pre-Cambrian granite between 4000 and 6300 feet from the portal. Previous studies have suggested a site at approximately Station 50+00 as being geotechnically favourable.

Timber support was used in much of the first phase of the tunnel with the inside dimension being 9 feet wide and 10.5 feet high. During the second phase, the inside dimension was reduced to 7.5 feet wide by 8.75 ft high. Based on the tunnel dimensions and the difficulty in providing enough ventilation for diesel equipment, it has been assumed in these cost comparisons that the rehabilitation would be carried out with rail-mounted mucking machines and locomotives rather than trackless equipment.

Current Problem:

The head measured on the bulkhead 400 feet in the tunnel is 20 feet, while at the Emmet Shaft 9,995 feet into the tunnel, the head is 141 feet. It must be assumed from the numerous sinkholes that have developed that a series of natural blockages have developed within the tunnel. Water is impounded behind this blockage and there are two problems associated with this. There is a risk that the blockage may release the water suddenly and it is not known if the existing bulkhead has been designed to handle this pressure. A sudden release would pose a risk to anyone near the entrance to the mine, and may threaten buildings and infrastructure outside the portal. Secondly, the ARD threatens to drain to surface at other sites if the water level is too high. It is understood that the groundwater would move in the direction of California Gulch.

The risk of a sudden release of the blockage and failure of the bulkhead is considered low. It is likely that the tunnel is completely filled over some distance resulting in head loss. Any piping or erosion of the blockage is likely to be filled by more material flowing into the tunnel. Furthermore, any pressure on the bulkhead would quickly dissipate since the natural water table is less than 70 feet above the bulkhead and water in the tunnel between the bulkhead and Station 6+50 would escape into the surrounding gravel.

Although the risk of failure is low in the short term, the situation should not be allowed to persist for the long term. The Bureau of Reclamation should be aware that natural blockages cannot be relied on to impound water of any great depth. I am aware of two case histories involving sudden release of water from blockages in tunnels. The first occurred at the Britannia Mine in 1974 after the mine had been closed for two years. The mine is drained by the 4100 Tunnel located just above Highway 99 and a major rail corridor. The head impounded by the water is not known but the sudden release of water did do some damage to structures downstream of the portal. This uncontrolled release necessitated the construction of a concrete plug (with flow through piping) in the tunnel.

A similar event occurred while trying to remotely seal the Marcopper Tunnel in 1996. Before we could get in the tunnel to construct a permanent concrete plug, we attempted to construct a temporary plug remotely in the flowing tunnel through drill holes drilled into the tunnel from surface about 200 m above. A temporary plug was grouted in using a combination of cement grout, bitumen, and concrete. The lower 2/3 of the tunnel was covered with unconsolidated tailings and rock. A head of 50 m was developed for a few days but piping occurred through the underlying tailings, which eventually eroded through the seal releasing the water. Fortunately the situation was being monitored and there was no risk to workers, only environmental damage. A second attempt finally sealed it and that allowed us to go in and construct the concrete plug. What I have taken from this experience is 1) do not rely on the temporary blockage like the one you have in the Leadville Tunnel and 2) Installing a plug remotely is very expensive and unreliable unless the tunnel is very close to surface.

Remediation Alternatives

Four options for rehabilitation the Leadville Drainage Tunnel have been assessed. Other options exist, however these four are considered to be the most credible alternatives. In developing these options, it is assumed that it is not simply enough to construct a tunnel to stop the water and allow the mine workings to flood. It is understood that the elevated groundwater levels may be contributing to increased metal loading measured elsewhere around Leadville. Therefore, the drainage must be maintained through the plug or be pumped from one of the shafts. A second assumption that has been made is that it is not safe to begin rehabilitation of the existing Leadville Drainage Tunnel without lowering the water level at the Emmet shaft to near tunnel elevation.

Option A: Sink Shaft/Plug Tunnel/Pump from Tunnel

In this option, a shaft is drilled at approximately Station 50+00 down to about 30 ft below the tunnel invert elevation and about 20 feet to the side of the tunnel. A temporary plug will be placed remotely by pumping concrete through short drill holes to the tunnel drilled off of the shaft. When the temporary plug is in place, a 20 ft tunnel will be driven off the shaft to connect to the Leadville Drainage tunnel downstream of the temporary plug. The permanent plug will be constructed and then the temporary bulkhead will be breached to permit flooding. When flooding reaches the maximum allowable flooding level (El. 10,100 is assumed), pumping through the shaft will commence. A pipeline will carry the flow from the top of the shaft to the treatment plant.

Table 1 Option A Construction Sequence

1	Mobilize drilling and grouting contractor.
2	Grout unconsolidated gravel along shaft alignment
3	Mobilize shaft boring rig and contractor and site preparation
5	Liner fabrication
6	Bore 8 ft diameter shaft through unconsolidated gravel
7	Lower liner, and grout base into rock
8	Resume boring smaller diameter (2.2 m) in rock to 30 ft m below tunnel 20 ft to side of tunnel
9	Demobilize shaft boring rig and erect temporary sinking hoist
10	Drill 4 inch holes from shaft to tunnel
11	Pump concrete and grout to create temporary seal
12	Breakthrough into tunnel downstream of temporary seal
13	Clean out and rehabilitate tunnel for 50 ft downstream
14	Begin pumping water from shaft bottom with submersible pumps
15	Construct 20 ft long concrete plug with 10 ft long sand/bentonite plug upstream
16	Construct HDPE pipeline to water treatment plant
17	After concrete is sufficiently strong and contact grouting completed, withdraw pumps and allow flooding in shaft to acceptable level (say 100 m)
18	When safe level is achieved (i.e. no leakage to other locations), lower pumps and pump to treatment plant

Table 2 Option A Capital Cost ($US)

Grouting Contractor Mob/Demob	25,000
Grouting	200000
Shaft Contractor Mob/Demob/Setup	200,000
Sink 2.4 m diameter shaft (375 ft) with steel liner through gravel section	800000
Crosscut to Tunnel (20 feet)	40,000
Temporary Plug	40,000
Permanent Concrete Plug	100,000
Pump (stainless steel wetted parts and Controls)	100,000
Pipeline	50,000
Engineering, Procurement & Construction Management (EPCM) (20%)	311,000
Total	1,866,000

Table 3 Option A Annual Operating Cost

Power (based on $3 ft^3/s$, $0.07/kwh)	60,000
Pipeline, Pump Maintenance	40,000
Total Annual Operating Cost	100,000

In the above cost estimate, it has been assumed that there are no access or land costs for the shaft and pipeline. It is also assumed that power is available from a reasonably close distance. I have spoken to a shaft drilling contractor to confirm that the shaft drilling cost is reasonable.

The most obvious criticism of this option is the long-term cost of pumping. However, comparing the net present value (NPV) of pumping to the NPV of rehabilitating the tunnel, the pumping option is more favourable (Table 13).

With the plug in place it may be possible to direct any remaining groundwater seepage into the tunnel into Evans Gulch or back into the ground, thereby reducing the amount of water handled by the treatment plant. This option also permits backfilling of the drainage tunnel with flowable fill over the first 650 of tunnel in order to prevent further sinkholes (not included in cost estimate).

Option B Continuously Pump

This option involves drilling dewatering wells or rehabilitating Robert Emmet Shaft as necessary for protection of a pump and pipeline. The condition of the shaft is not know so we have made an allowance of $500,000 for 400 ft of rehabilitation work from surface 10,500 ft to El 10,100. A single, submersible pump with stainless steel wetted parts would be installed in Emmet Shaft to maintain water at safe elevation (El. 10,100 ft assumed). A pipeline will be constructed from Emmet Shaft to the water treatment plant. The route of this pipeline is probably more complex than Option A as it is closer to the town of Leadville and there may be some political/legal obstacles that will be difficult to overcome. The pumping height is higher through the Emmet shaft than for Option A. For the well pumping option, it is recommended that a diamond drill be used with a directional survey and steering tool to help the hole intersect the tunnel. The holes could then be reamed to sufficient size to install a pump. Based on our experience trying to intersect tunnels at depth, not all holes will be successful and so three drill holes are budgeted.

Table 4 Option B Continuous Pumping/No Plug

1	Rehabilitate Robert Emmet Shaft sufficiently to protect submersible pumps or Drill dewatering wells
2	Construct Pipeline from Shaft to Water Treatment Plant
3	Install Pumps and Pipeline
4	Pump shaft down to safe level (El.10,100 ft has been assumed for pumping costs)

Table 5 Option B Capital Cost ($US)

	Dewatering Wells	Shaft Dewatering
Mob/Demob Contractor	50,000	50000
Rehab Shaft	0	500000
Drilling/Casing/Reaming/down Hole Surveying	225,000	0
Pumps (stainless steel wetted parts and Controls)	200000	100,000
Pipeline	500000	500,000
Engineering, Procurement & Construction Management (EPCM) (20%)	195,000	230,000
Total	1,170,000	1,380,000

Table 6 Option B Annual Operating Cost

	Dewatering Wells	Shaft Dewatering
Power (assuming 1.5 ft^3/s is pumped)	40000	40000
Pipeline, Pump Maintenance	40000	40,000
Shaft Maintenance		40000
Total Annual Operating Cost	80000	120,000

The pumping height is greater through the Emmet shaft than for Option A resulting in a higher annual operating cost. Water treatment must be carried out year round because water will still drain from the Leadville Drainage Tunnel. Pumping may be carried out on a seasonal basis.

Option C Pump out from Emmet Shaft/Rehabilitate Tunnel Install Plug

This option involves pumping down the water in the mine to the Leadville Drainage Tunnel, followed by rehabilitation of the tunnel between Station 4+00 and Station 50+00. A plug would be constructed at approximately Station 50+00 and a stainless steel pipe and valve arrangement would pass water through the plug.

Table 7 Option C Pump Down Emmet Shaft / Rehabilitate Tunnel / Install Permanent Plug

1	Rehabilitate Emmet Shaft sufficiently for temporary pump down
2	Install Pipeline to water treatment plant
2	Install pumps and pump water down to Tunnel Elevation
3	Mobilize Tunneling Contractor
4	Rehabilitate Tunnel to 5000 feet.
5	Install Plug with pipeline through it and valve, perform contact grouting
6	Close valve on plug and flood mine to "safe" level (El 10,100 ft assumed)
7	Open valve and begin water treatment

Table 8 Option C-2 Capital Cost ($US)

Dewatering Contractor Mob/Demob	25,000
Dewater Emmet Shaft	1,000,000
Tunneling Contractor Mob/Demob	100,000
Rehabilitation of Tunnel 400 ft unconsolidated gravel and fault zones	1,200,000
Tunnel Rehabilitation (3200 ft poor to fair rock)	1,600,000
Tunnel Rehabilitation – 1000 ft good rock	300,000
Permanent Concrete Plug	110,000
Pipeline	500,000
Engineering, Procurement & Construction Management (EPCM) (20%)	1,007,000
Total	5,842,000

Table 9 Option C-1 Annual Operating Cost

Tunnel Maintenance	50,000
Total Annual Operating Cost	50,000

The cost of the initial dewatering of the shaft to the tunnel elevation could not be estimated from the reports provided however we have assumed a cost of 1,000,000 for the purposes of this comparison.

Option D

This option involves pumping down through the Emmet Shaft and then completely rehabilitating the Leadville Drainage Tunnel to the Robert Emmet Shaft. A plug would not be constructed for this option.

Table 10 Option D Pump Down Emmet Shaft / Rehabilitate Tunnel / Install Permanent Plug

1	Rehabilitate Tunnel Sufficiently for Temporary Pump Down
2	Install Temporary Pipeline to Water Treatment Plant
3	Install Pumps and Pump water down to Tunnel Elevation
4	Mobilize Tunneling Contractor
5	Rehabilitate Tunnel to Emmet Shaft feet.

Table 11 Option D Capital Cost ($US)

Dewatering Contractor Mob/Demob	25,000
Dewater Emmet Shaft	1,000,000
Tunneling contractor mob/demo	100,000
Rehabilitation of Tunnel 400 ft unconsolidated gravel and fault zones	1,200,000
Tunnel Rehabilitation (5555 ft poor to fair rock)	2,778,000
Tunnel Rehabilitation – 4000 ft good rock	1,200,000
Pipeline	500,000
Engineering, Procurement & Construction Management (EPCM) (20%)	1,360,600
Total	8,163,600

Table 12 Option D Annual Operating Cost

Tunnel Maintenance	70000
Total Annual Operating Cost	70000

Recommendations

Based on my first impressions of the project obtained from discussions with yourself and from the previous reports it is believed that Options A and B represent the best alternatives from the following standpoints:

- Lowest Net Present Cost (based on 50 year analysis)
- Best long term viability
- Minimal engineering risk

As you can appreciate, there are likely to be other factors such as access to the Emmet Shaft, pipeline routing, political, and legal considerations that I cannot properly assess at this time.

The Net Present Value of Options A and B have significantly lower NPV's than the tunnel rehabilitation options. Option A provides the additional benefit of reducing the overall flow of water treated by the water treatment plant since the water draining into the tunnel from behind the plug will likely meet water quality guidelines. For the purposes of the comparison, we have assumed the quantity of water treated is the 3 gallons per second for all options.

Clearly however, this assessment shows that options involving rehabilitation of the drainage tunnel is not a cost effective solution to this site and my recommendation would be to not spend any more time or money assessing those options.

Table 13 Net Present Value Comparison (50 years)

Option	NPV (\$US. millions)
Option A: Shaft Access/Plug Tunnel/Pump from Shaft	-2.86
Option B-1: Continuous Pumping – Dewatering Wells	-1.99
Option B-2: Continuous Pumping – Dewater Emmet Shat	-2.64
Option C: Pump Down Emmet Shaft/Rehabilitate Tunnel/Install Flow Through Plug	-5.98
Option D: Pump Down Emmet Shaft/Rehabilitate Tunnel over Entire Length/Maintain Tunnel	-8.35

Further Work

TSS would be pleased to provide the Bureau of Reclamation with a formal cost proposal to carry out the engineering and construction management aspects of this project. It would be helpful however if I was to visit Leadville to get a better understanding of the physical layout of the site and surrounding infrastructure. A 3-day site visit (including travel) would be adequate in helping me prepare an accurate scope of work and cost estimate for the required work. My charge-out rate for this reconnaissance-type work is US\$500/day plus travel expenses.

We trust this information is useful to the Bureau of Reclamation. I am attaching two additional items that may be of interest. The first is a copy of a paper I presented last year to the International Mine Water Association annual conference. The second item is an excerpt from one of the reports done for the Marcopper tunnel sealing project, which has some similarities to this project. If TSS is selected to carry out the detailed engineering work, we could assemble many of the same key people who worked on the Marcopper Project. I have also included CV's for my associate Mr. Peter White, P.Eng. and myself.

Please call if you have any additional questions.

Yours truly,
TSS TUNNEL & SHAFT SEALING LTD.

Brennan Lang, P.Eng.
President

APPENDIX E
Technical and Cost Proposal for Dedicated water Plant

INFLUENT CHEMISTRY

Marion Shaft (T_{rec}) µ/L

	4/26/2001	5/1/2001	5/8/2001	5/14/2001
Al	590	690	1,300	2,090
As	<5	7.5	9.8	44.9
Cd	955	381	1,398	1,840
Cu	1,219	629	1,776	3,559
Fe	14,650	24,530	23,920	251,100
Pb	398	247	498	520
Mn	60,700	16,300	47,000	66,500
Hg	<0.25	<0.25	<0.25	<0.25
Se	<5	<5	<5	<5
Ag	6	4	13	17
Zn	80,500	31,200	141,700	149,300

Data from CMC, 2001b.

EFFLUENT CHEMISTRY

COMPARISON OF EFFLUENT LIMITS

	YAK INTERIM		LMDT	
	Daily Max.	30-Day Avg.	Daily Max.	30-Day Avg.
Flow, MGD	Rpt	Rpt	Rpt	Rpt
PHSU	6.0-9.0	6.0-9.0	6.5-9.0	Rpt
Oil & mg/l	10.0	Rpt	10.0	Rpt
Total Calcium mg/l	Rpt	Rpt	--	--
Total Mag. mg/l	Rpt	Rpt	--	--
Hardness mg. Eq.	Rpt	Rpt	--	--
TSS mg/l	30	20	45	30
TSS lbs/day	360	240	--	--
Al, As, µg/l	Rpt	Rpt	--	--
Al, As, lbs/day	Rpt	Rpt	--	--
As (total Rec. µg/l)	Rpt	Rpt	50	50
As (total Rec. lbs/day)	Rpt	Rpt	--	--
Cd (total Rec. µg/l)	100	50	4.4 Dissolved	1.4 Dissolved
Cd (total Rec. lbs/day)	Rpt	Rpt	--	--
CU (TR) µg/l	300	150	19 Dissolved	13 Dissolved
CU (TR) lbs/day	Rpt	Rpt	--	--
Cr (TR) µg/l	Rpt	Rpt	--	--
Cr (TR) lbs/day	Rpt	Rpt	--	--
Fe (TR) µg/l	Rpt	Rpt	Rpt	1000
Fe (TR) lbs/day	Rpt	Rpt	--	--
Pb (TR) µg/l	500	300	112	4.5
Pb (TR) lbs/day	Rpt	Rpt	--	--
Mn (TR) µg/l	Rpt	Rpt	Rpt	1000
Mn (TR) lbs/day	Rpt	Rpt	--	--
Hg (TR) µg/l	2	1	Rpt	0.01
Hg (TR) lbs/day	Rpt	Rpt	--	--
Sc (TR) µg/l	Rpt	Rpt	10	Rpt
Sc (TR) lbs/day	Rpt	Rpt	--	--
Ag (TR) µg/l	Rpt	Rpt	2.4 Dissolved	0.09 Dissolved
Ag (TR) lbs/day	Rpt	Rpt	--	--
Zu (TR) µg/l	1500	750	127	Rpt
Zu (TR) lbs/day	Rpt	Rpt	--	--

INFLUENT CHEMISTRY

Marion Shaft (T_{rec}) µ/L

	4/26/2001	5/1/2001	5/8/2001	5/14/2001
Al	590	690	1,300	2,090
As	<5	7.5	9.8	44.9
Cd	955	381	1,398	1,840
Cu	1,219	629	1,776	3,559
Fe	14,650	24,530	23,920	251,100
Pb	398	247	498	520
Mn	60,700	16,300	47,000	66,500
Hg	<0.25	<0.25	<0.25	<0.25
Se	<5	<5	<5	<5
Ag	6	4	13	17
Zn	80,500	31,200	141,700	149,300

Data from CMC, 2001b.

TECHNCIAL AND COST PROPOSAL

USFilter

Industrial Wastewater Systems
181 Thorn Hill Road
Warrendale, PA 15086
Phone: 724-772-0044
Fax: 724-772-1360

February 13, 2002

Mr. Jeff Glover
HDR Engineering, Inc.
2202 North West Shore Boulevard - Suite 250
Tampa, Florida 33607
Phone No. 813-282-2322
Fax No. 813-282-2430
Via Email: jglover@hdrinc.com

Reference: Leadville, Colorado Superfund Site

Subject: Rough Order of Magnitude Revised Proposal
Acid Waste Neutralization System

USFilter, IWS Proposal No. SRK-0111-01-SYS-A

Dear Mr. Glover:

USFilter, IWS is pleased to offer this revised ballpark quotation for an acid waste neutralization system for the Leadville, Colorado Superfund site. As requested in your quotation request, the base system being quoted utilizes USFilter's Memtek microfiltration system. As an alternate, we quoted a clarifier/multimedia filter combination.

After reviewing the influent data sent in by you with the original request and comparing the loading to the anticipated effluent requirements sent to us on December 10, 2001, it is our feeling that if bench scale pilot testing is not possible, the Memtek microfilter would be our system of choice. This is due to the following:

- The effluent limits are very tight for a number of the heavy metals.
- In addition, the influent load fluctuates significantly for a number of these metals. This makes removal of suspended solids a critical issue. Equalizing the flow will help, however there still is a potential for a major change in the ratio of the constituents of the feed over time.
- A clarifier sand filter installation will typically put out 1 to 2 ppm of TSS. A varying proportion of that would be heavy metals depending on the particular composition of the feed. Since the microfilter is rated at 0.1 micron nominal, it would put out essentially no TSS. This would allow the system to be much more reliable in the face of swings in the concentration of suspended (precipitated) metals in the treated feed.

If at all possible we would still like to do lab scale work to ensure that the iron co-precipitation technology proposed reduces all of the soluble metal levels low enough to meet the required limits.

If you would still want a clarifier/multimedia type system, extensive on-site pilot work would be required to verify that the effluent limits could be met under the wide variety of influent conditions. For anticipated effluent limits, see table appended.

Since no information on the site is available, equipment only is being quoted. Due to the large size of the system, it is not feasible for us to provide this equipment on a rental basis.

ORIGINAL BASIS FOR DESIGN

Parameter	*Feed (Average)*	*Feed (Maximum)*
Flow, gpm	650	700
pH, standard units	2.8	3.67
Aluminum, mg/L	17.6	144.5
Arsenic, mg/L	0.043	0.165
Cadmium, mg/L	1.23	6.8
Copper, mg/L	4.11	18.1
Iron, mg/L	114.9	720.0
Lead, mg/L	0.479	1.21
Manganese, mg/L	90.4	367.5
Mercury, mg/L	0.017	0.120
Selenium, mg/L	0.0058	0.0165
Silver, mg/L	0.0114	0.028
Zinc, mg/L	151.15	805.00

The average and maximum values are abstracted from Leadville Stray Horse Gulch Water Quality Results 1999, 2000 and 2001, Maximum and Mean Values for All Ponds.

Since the water analysis is not complete, we are using the estimates generated by Mr. Lutz for chemical consumption which are as follows:

- Lime Consumption 1,060 mg/L
- Solids Generation 1,300 mg/L

The basis for design listed above contains the Customer/USFilter best available influent waste stream characteristics and effluent requirements at the time of this proposal. The wastewater treatment system design is based on the information contained in the basis for design. Variations in the influent conditions (concentrations or unspecified parameters) may invalidate any warranties (performance or other) offered by USFilter.

PROCESS DESCRIPTION

The microfilter design replaces a typical clarifier/filter system functions, and includes design redundancy into one unit operation. Fluctuations in loading and water temperature in the feed to a clarifier/filter system interferes with critical coagulation, flocculation and settling processes in a clarifier such that reliable control of downstream filtration processes are very difficult. Consistency of the solids removal process is much easier to guarantee when both processes occur within the microfiltration process.

♦ **Lime Softening Filtration System**

The lime softening filtration system consists of six 20 percent capacity lime softening filtration trains that perform the function of both the clarifier and the filtration system typically used for this type of treatment.

The system consists of:

- One two-stage reaction tank system with a bridge-supported dual rotor mixer. Water from the pond is delivered to the first reaction tank where lime and air are added to the feed water to raise the pH to 6.0 minimum while oxidizing the divalent iron present. The adjusted water flows upward into the second reaction compartment where air and lime are added to pH 9.5 to precipitate the metals present as the hydroxide. Other chemicals (such as sulfide) may be added if lower metals are required. The treated water slurry exits the reaction tank via a top mounted weir box where it flows by gravity to the microfilter feed tank.

- One feed concentration tank with a bridge-supported single rotor mixer. This tank will serve as a pump surge tank for the downstream microfiltration units and will include float switches in a stilling well to monitor levels in the feed concentration tank. Water exiting this tank is pumped to each of five 20 percent microfiltration systems online. Since the microfiltration systems operate in a "crossflow" mode, water is constantly being returned from the microfilter back to the feed tank. The slurry concentration in the tank increases as the filtrate leaves the process. Some of the slurry is directed to a thickener and then to filter presses when the sludge concentration approaches 3 to 5 percent concentration by weight.

- One USFilter microfiltration system consisting of six 20 percent capacity microfilter skids. Each microfilter skid includes a feed/recirculation pump, microfilter membrane modules, chemical cleaning tank, water flush tank, cleaning pump, instrumentation and controls. Each microfilter module consists of ten 1-inch diameter PVDF microfilter tubes with an average pore size of 0.1 micron.

PROCESS DESCRIPTION (Continued)

Lime Softening Filtration System (Continued)

The filtration system will operate as follows:

- Low level in the filtered water storage tank will open filtrate valves from each microfilter skid in sequence as required to satisfy the demand.

- The feed and concentrate return flows from each microfilter skid will be monitored with magnetic flow meters. The filtrate flow is calculated by difference; when the filtrate flow drops below the design rate, the microfilter skid is removed from service for cleaning.

- Flow to each train of the filtration system is controlled by levels in the microfilter feed/concentration tank. As the level in this tank drops below a setpoint, the system feed valve is opened to deliver more water to the reaction tank. As additional water is delivered to the tank, lime is pumped to their appropriate reaction compartments. Lime feed is metered by a pinch valve which is controlled by reaction tank pH.

- Provisions will be made for optional feeding of up to 50 ppm of ferric chloride to the reaction tank. Ferric chloride addition is helpful as a means of reducing the frequency of microfilter membrane cleaning if slime and algae in the feed is significant.

- Normal frequency of microfilter cleaning is one to three times per month. When a microfilter membrane skid is cleaned, the feed/recirculation pump for that skid is shut down and water from the flush water tank is used to displace the high solids slurry back to the feed tank. During normal cleaning, dilute (2 to 5 percent) HCl is then recirculated from the cleaning tank through the membrane modules and back to the cleaning tank for 30 to 60 minutes. In this case, because of the use of pond water, normal cleaning will be with 10 percent NaOCl with an occasional HCl cleaning. However, with the pond water, cleaning frequency may be more frequent. For that reason, the cleaning cycle will be automatic. After recirculation, the cleaning chemicals are neutralized and sent back to the pond (by others).

- Excess solids removal from the microfiltration tank will be controlled much the same as for reactor/clarifier softeners. During start-up, the frequency and duration of sludge withdrawal will be established and will be paced to the totalized filtrate flow in order to maintain a solids concentration in the feed tank in the 3 to 5 percent solids range. Once per shift the operator should measure the solids concentration by comparing the settled solids volume in a graduated cylinder after 5 minutes of settling to a preset volume that represents the desired operating range.

Filtrate from the lime softening filtration system will be pH adjusted with sulfuric acid to ensure the final effluent is in spec on pH. Depending on the effluent limits, this step may be eliminated.

PROCESS DESCRIPTION (Continued)

♦ **Optional Equipment**

For comparison, USFilter is offering a lamella type clarifier and multimedia filter system as a deduct to replace the microfilter. The equipment is described in the Optional Equipment List.

EQUIPMENT LIST

ITEM NO.	DESCRIPTION
1	Two Stage Reaction Tank
	* Two 120-inch diameter by 134-inch high, heavy-duty, FRP constructed reaction tanks * Two heavy-duty mixers * Two pH monitor/controllers * Reaction system catwalk for access to tanks, probes and metering pumps
2	Microfiltration System (2 Required) USFilter Model No. EFC-108-108
	* Heavy-duty, FRP concentration tank * Process recirculation pump * Set of membrane filtration modules * Piped-in-place membrane cleaning system * Air-operated, double-diaphragm pump for solids removal
3	Concentrate Blowdown Thickener
	* 22,000-gallon capacity, vertical, cylindrical, FRP tank * 144-inch diameter by 264-inch high * Conical bottom * 2 HP mixer * Internal baffles * Overflow nozzle * Flanged bottom nozzle
4	Flow Monitor/Transmitter
	* 0 to 800 gpm * 6-inch flow control valve

EQUIPMENT LIST (Continued)

ITEM NO.	DESCRIPTION

5 Lime Slurry Pinch Valves (2 Required)

* 1/4-inch 3-way, electrically-operated solenoid valve
* 3/8-inch air-operated, rubber-lined pinch valve
* 1/4-inch steel pipe and union connection between valves
* 3/8-inch NPT slurry line connection

6 Lime Silo

* 2,045 cu ft capacity welded steel silo
* 12 ft diameter by 33 ft high
* Exterior chemical-resistant epoxy paint
* Skirted bottom
* 4-inch diameter fill pipe
* Exterior steel ladder and cage
* Roof handrail
* Dust filter
* Lime bin activator
* Three level indicators
* Feed screw discharge assembly
* Top manway
* Manual discharge slide gate
* Electrical control panel

7 Lime Slurry Feed Tank

* 510-gallon capacity, vertical, cylindrical, FRP tank
* Agitator
* Agitator mounting bracket
* Partial cover and exhaust collar
* Flanged suction nozzle

Recirculation Pumps

* Two air-operated diaphragm pumps
* Cast iron construction
* Neoprene elastomers
* 55 gpm capacity at 100 psi
* 1-1/2-inch NPT suction connection
* 1-1/4-inch NPT discharge connection

EQUIPMENT LIST (Continued)

ITEM NO.	DESCRIPTION
8	Final pH Adjustment Tank USFilter Model No. ROPT-2000 * 3,760-gallon capacity, FRP constructed tank * Heavy-duty, gear-driven mixer * pH monitor/controller
9	Filter Press Feed Pumps * Three air-operated diaphragm pumps * Cast iron construction * Neoprene elastomers * 200 gpm capacity at 100 psi * 3-inch NPT suction connection * 3-inch NPT discharge connection
10	Filter Press * 125 cu ft filter cake capacity * 1.26-inch cake thickness * 100 psi filtration capacity * Center feed * Four corner filtrate discharge connection * Painted steel skeleton * Woven polypropylene filter cloth * Automatically operated closure * Plate shifter Acid Wash System
11	Coagulant Storage Tank * One vertical cylindrical, flat bottomed, open top tank * One piece molded linear polyethylene construction * 2,100-gallon capacity * 6 ft diameter by 10 ft high * Ultrasonic level control

EQUIPMENT LIST (Continued)

ITEM NO.	DESCRIPTION

Metering Pump

* One positive displacement metering pump
* 0 to 18 gph output capacity
* Polypropylene head, check valves and diaphragm
* Suction hose and strainer
* Totally enclosed drive
* Anti-siphon valve
* Dial-knob capacity adjustment

12 93% H_2SO_4 Storage Tank

* One vertical cylindrical, flat bottomed, open top tank
* One piece molded linear polyethylene construction
* 2,100-gallon capacity
* 6 ft diameter by 10 ft high
* Ultrasonic level control

Metering Pump

* One positive displacement metering pump
* 0 to 18 gph output capacity
* Polypropylene head, check valves and diaphragm
* Suction hose and strainer
* Totally enclosed drive
* Anti-siphon valve
* Dial-knob capacity adjustment

13 Air Blower
As manufactured by Roots

* Voltage - 460/3/60
* 600 scfm at 6 psig
* Motor speed - 1,750 rpm
* Rotary lobe type
* Pressure relief valve
* Inlet and discharge silencers
* Flexible connectors

OPTIONAL EQUIPMENT

ITEM NO.	DESCRIPTION
O-1	Flash Mix Floc Tank and Parallel Plate Separator

Flash Mix Floc Tank

* Carbon steel fabrication
* Chemical-resistant paint (exterior)
* Coal tar interior coating
* Flash mix compartment
* Flocculation compartment
* Flash mix and flocculation tank mixers
* Flanged effluent connection
* Operator platform with access ladder

Parallel Plate Separator

* Carbon steel fabrication
* Chemical-resistant paint (exterior)
* Coal tar epoxy coating
* FRP constructed settling plates
* 2,880 sq ft of settling surface area
* Flanged sludge withdrawal connection
* Flanged effluent connection
* Effluent weir trough

ITEM NO.	DESCRIPTION
O-2	Polymer Feeder

* 10 to 100 gph dilute polymer feed rate
* 0.01 to 1.0 gph neat polymer feed rate
* Manually adjustable feed rates
* Static in-line mixers
* Rotometers
* Neat polymer feed pump

OPTIONAL EQUIPMENT (Continued)

ITEM NO.	DESCRIPTION

O-3 Duplex Multimedia Sand Filter
USFilter Model No. AMM-09660

* Two 96-inch diameter by 60-inch high carbon steel tanks
* 100 psi ASME code tanks
* Automatic operation
* NEMA-12 enclosure
* Plasite lining
* Differential pressure switch
* Interconnecting piping
* Finish paint
* Air scour

O-4 Multimedia Filter Lift Pumps

* Duplex, 316 stainless constructed, horizontal, centrifugal pumps
* 700 gpm capacity
* Pump level controls
* High level alarm
* 230/460-VAC, 3-Phase, TEFC motors

O-5 Multimedia Filter Backwash Pump

* Simplex, 316 stainless constructed, horizontal, centrifugal pump
* 700 gpm capacity
* Pump level controls
* High level alarm
* 230/460-VAC, 3-Phase, TEFC motors

Note: Unless otherwise specified herein, ventilation, interconnecting piping, wiring, conduit, supports, fittings, valves, etc. between USFilter equipment items and/or customer equipment is to be provided by others.

If you require installation prices for the above listed equipment, we would be happy to submit a proposal for the complete installation of this equipment.

POWER COST

- Running Load 276 HP
- Total Connected Load 321 HP

SLUDGE GENERATION

- 10,140 pounds dry solids at 2% to 5% with thickener filter press - 35% cake or 343 cu ft/day of sludge

ESTIMATED CHEMICAL CONSUMPTION

Chemical	*Cost Per Pound*	*Pounds Per Day*	*Cost Per Day*
Acid - 37% HCl	$0.70	312	$22.00
Lime - 93% $Ca(OH)_2$	$0.05	8,268	$413.40
$FeCl_3$ - 40% $FeCl_3$	$0.07	195	$13.65
Cleaning Chemicals (Microfilter)			$55.00
Total			$504.05

TREATABILITY STUDIES

As you know, we have not had the opportunity to analyze and process representative samples of your waste in our treatability laboratory. While we have ample reason to believe that the proposed system will provide satisfactory treatment, USFilter reserves the right to perform such tests prior to formal acceptance of your order. If you wish, we can perform the treatability work immediately for a fee of $2,500.00, which would be credited against your purchase order for the proposed system.

ENGINEERING SERVICES

- USFilter would prepare the following equipment arrangement drawings:

  Reaction Tanks
  Microfilter
  Lime Silo

  Each equipment arrangement drawing would show overall equipment dimensions, access and maintenance clearance requirements, shipping and operating weights, equipment coatings or lining specifications, anchoring details, piping connections and utility requirements.

- Piping and Instrumentation Diagram(s) - This drawing is a flow schematic illustrating the proposed treatment equipment. Equipment is shown with the instrumentation, valves, pipe line sizes and materials of construction.

- Operating and maintenance manuals would be provided. These manuals would include installation instructions, operating procedures, maintenance instructions and vendor manuals for the equipment furnished.

Notes: All copies described above are in triplicate. Additional copies may be obtained at cost.

All drawings and documentation would be submitted for information only.

START-UP SERVICES

USFilter's field service technician would perform checks to certify that the equipment installation and operation are satisfactory.

There would be three phases to equipment start-up which are:

- Mechanical/electrical pre-start-up checkout/troubleshooting and water testing of all equipment

- Supervision of system process start-up with customer operating personnel

- Instruction of operating personnel in system maintenance and operation and field instruction which includes equipment operation, test procedures and equipment maintenance

START-UP SERVICES (Continued)

USFilter has allotted 10 man-days (2 trips) for start-up and operator training services on a portal-to-portal basis.

Additional on-site supervision is available at our standard per diem rate of $860.00 per 8-hour workday (Monday through Thursday) on a portal-to-portal basis, plus all out-of-pocket travel and living expenses which would be invoiced as a separate item at net cost plus a 15 percent handling charge.

The workday is based upon 8 hours per day, 5 days per week.

BALLPARK PRICE

USFilter would supply the microfilter equipment as described in this proposal for approximately ONE MILLION FIVE HUNDRED THOUSAND DOLLARS . . $1,500,000.00.

The price for the clarifier sand filter equipment would be $1,100,000.00 (F.O.B. job-site).

TERMS AND CONDITIONS OF SALE

The attached USFilter "Terms and Conditions of Sale" would be applicable.

EQUIPMENT WARRANTY

USFilter would warrant all equipment for a maximum period of 12 months from date of shipment. This warranty would cover all defects in materials or workmanship.

The pH/ORP electrodes are warranted for 30 days from the start-up date, or 6 months from the shipping date, whichever occurs first.

SHIPPING SCHEDULE

Shipment of equipment is quoted F.O.B. shipping point of manufacture and is anticipated to be ready for shipment 24 weeks following return of approval drawings. Approval drawings would be issued approximately 4 to 6 weeks after acceptance of a purchase order.

Freight would be prepaid and invoiced at time of equipment shipment.

Mr. Jeff Glover - HDR Engineering, Inc.
[Leadville, Colorado Superfund Site]
USFilter, IWS Proposal No. SRK-0111-01-SYS-A
February 13, 2002

CONFIDENTIALITY AGREEMENT

This proposal is confidential and contains proprietary information. It is not to be disclosed to a third party without the written consent of USFilter.

We thank you for the opportunity to quote the acid waste neutralization equipment described in this budgetary proposal. If you have any questions or comments regarding this proposal, please do not hesitate to contact me at 724-772-1265.

Sincerely,

Stanley R. Karrs

Stanley R. Karrs
Technical Director

cc:

USFilter
Sophia O'Halloran
Kim Lukens

APPENDIX F
Technical and Cost Proposal for In-Situ Chemical Stabilization

Denver Grouting
A Division of Hayward Baker
11575 Wadsworth Blvd.
Broomfield, Colorado 80020
303.469.1136
Fax 303.469.3581

HAYWARD BAKER
A Keller Company

December 7, 2001

Mr. Mike Holmes
Remediation Project Manager,
U.S. Environmental Protection Agency, Region 8
999 18th Street, Suite 300
Denver Colorado 80202-2466

Technical Memorandum: Ponsardine Mine Waste Dump In-situ Neutralization, Leadville Mining District, Colorado

HBI file D010755

Dear Mr. Holmes,

In response to your request, Hayward Baker, Inc. (HBI) is pleased to present this technical memorandum and proposal for demonstration of **in-situ mine waste neutralization** at the Ponsardine waste pile in Leadville Colorado. This technical proposal is based on our site visit on 28-Nov-01, the chemical and topographic information you provided, and our experience with existing chemical injection technology currently in use in our specialty ground-modification work.

Hayward Baker has several decades of experience in chemical injection of soils and waste. While most projects of this nature are designed to chemically modify clay soils to prevent swelling, the technology can be readily adapted to chemically modify various forms of granular waste materials. Hayward Baker Environmental has used the approach to chemically modify contaminated acid-producing soils at several environmental remediation projects. The in-situ technique involves injecting and dispersing buffering amendments into the waste mass so that a final equilibrium is reached that inhibits or prevents acid generation. The attached papers and project case histories give examples of the use of this approach, quantification of results, and the types of equipment involved.

We are proposing to use injection techniques and equipment to demonstrate an in-situ placement of neutralizing amendments directly into the existing Ponsardine waste dump. The neutralizing amendments will be proportioned to result in significant reduction of acid production and subsequent metals transport from the Ponsardine waste pile, while maintaining general overall integrity of the waste dump for cultural and historic aesthetics. We will investigate the feasibility of several types of reagents, including lime, Mg products, and some proprietary materials we have developed.

SCOPE OF WORK

At your request, we have outlined a demonstration injection program to address approximately 15,000 cubic yards of mine waste. Tasks to accomplish the demonstration project are as follows:

Phase I

1.) Characterize the waste pile and develop a detailed Project Implementation Plan (PIP).

A. Drill and sample the waste pile to determine chemistry and acid production potential of various stratified materials in the pile.

B. Use chemical analysis data to test and determine appropriate neutralization reagent, reagent proportions, and injection hole spacing to treat pile.

C. Determine physical properties of the various strata in the pile, including permeability, porosity, and size gradations.

D. Use physical properties to select appropriate drilling and injection equipment. Injection techniques could include permeation in some strata where permeability is appropriate, combined with "soil-fracture grouting" to force lenses of neutralizing agents into less permeable, clayey materials.

E. Write detailed demonstration project implementation plan describing materials, equipment, and methods, and final construction budget.

Phase II

2.) Modify existing drilling and injection equipment for specific nature of mine waste

A. Modify specialty-drilling equipment to provide proper single-pass stroke length and appropriate drilling technique (rotary rock drill, augers, etc.)

B. Modify neutralizing agent mixing and pumping equipment as necessary to address site and job specifics (pump type, pressures, mixing capacities etc.)

3.) Conduct field demonstration of In-situ Waste Neutralization

A. Mobilize equipment and materials to jobsite.

B. Conduct pilot drilling and injection testing in a small area to fine-tune injection spacing, drilling techniques, and injection pressures.

C. Conduct production drilling and injection of neutralizing reagent into pile.

D. Demobilize and clean up site.

Project Schedule

We anticipate Phase I project work could commence in late June 2002 after snowmelt and runoff. Hayward Baker provides complete turnkey project design, management and execution. HBI crews conduct drilling and sampling, with oversight provided by an experienced mining geologist. A detailed Project Implementation Plan will be written for approval by EPA Region 8.

Following approval of the plan and a Phase II budget, HBI acquires bulk reagent materials, and modifies existing drilling and mixing/pumping equipment.

Mobilization to the jobsite is followed by preliminary pilot testing. Full-scale production injection work is estimated to require 4 to 6 weeks to complete, during summer 2002.

Preliminary Budget Estimate

As requested, we are providing a preliminary budget estimate, based mostly on our experience with similar injection projects. This estimate assumes approximate waste volume of 15,000 cubic yards, a conservative material void ratio, and approximate reagent costs. Estimated costs are shown in the table below.

PRELIMINARY BUDGET ESTIMATE, PONSARDINE PILE IN-SITU NEUTRALIZATION DEMONSTRATION PROJECT

Task	Description	Estimated Cost Low	High
Phase I			
1A	Drill and sample pile	$ 4,000.00	$ 6,000.00
1B	Chemical analysis of waste, develop neutralization formulation	$ 7,000.00	$ 9,000.00
1C	Determine physical properties of waste (lab work)	$ 2,000.00	$ 3,000.00
1D & 1E	Develop drilling and injection criteria, write Project Implementation Plan	$ 2,000.00	$ 3,500.00
	Subtotal, Phase I	$ 15,000.00	$ 21,500.00
Phase II			
2A&2B	Modify drilling and injection equipment	$ 20,000.00	$ 25,000.00
3A-3D	Conduct field demonstration (Staged injection of approx 400,000 gallons of reagent through 80 to 100 holes)	$ 125,000.00	$ 150,000.00
	Subtotal, Phase II	$ 145,000.00	$ 175,000.00
	Estimated Grand Total	$ 160,000.00	$ 196,500.00

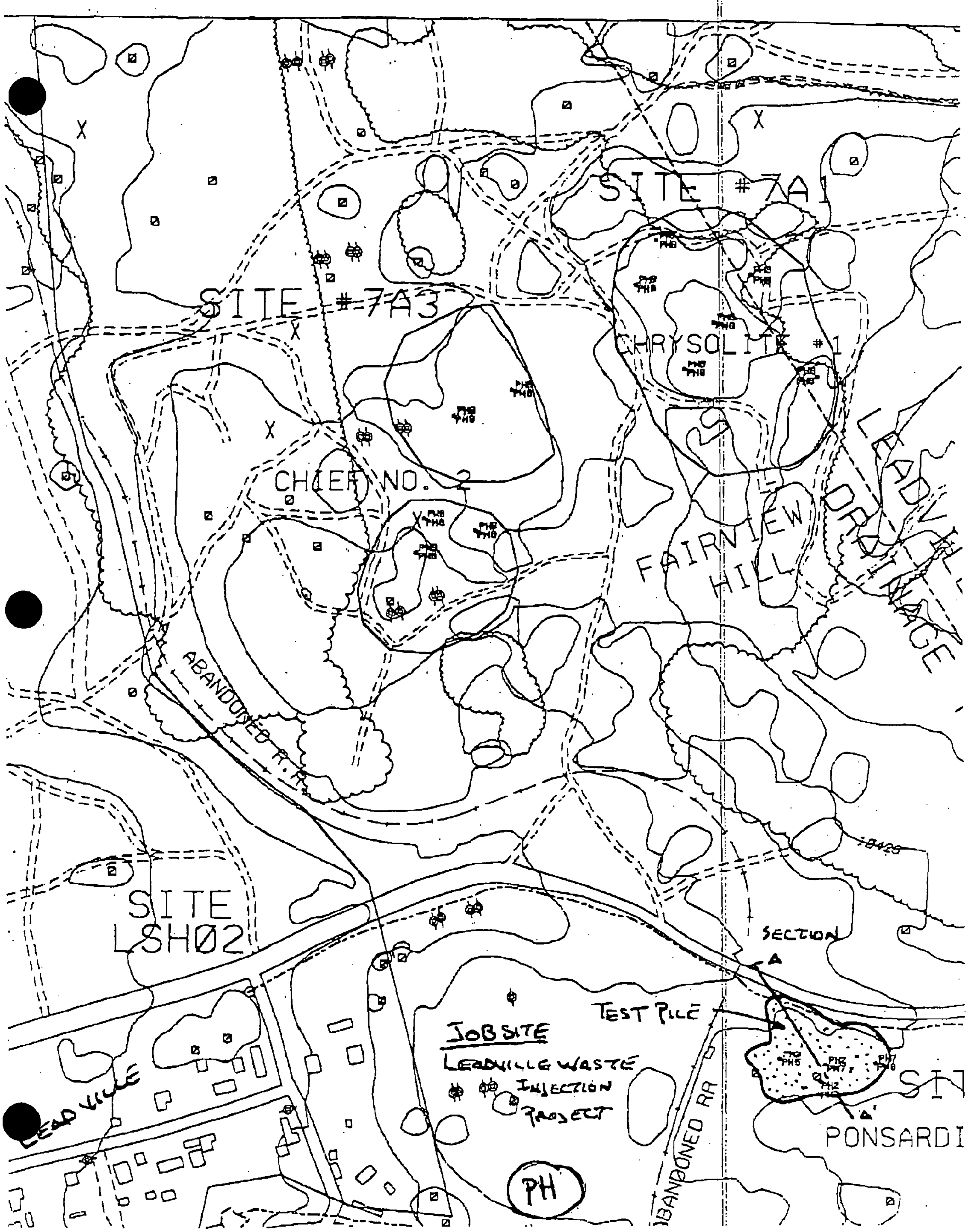
Please note that actual costs will depend on many factors determined after the waste pile has been fully characterized in Phase I. The reagent chosen, as well as the quantity needed to achieve the appropriate level of buffering capacity, will largely affect final project cost.

We trust this Technical Memorandum and preliminary proposal meets your current project requirements, and we look forward to being of service. If we can be of any assistance in clarifying any points in this proposal, please contact us at 303.469.1136.

Sincerely,
HAYWARD BAKER INC.

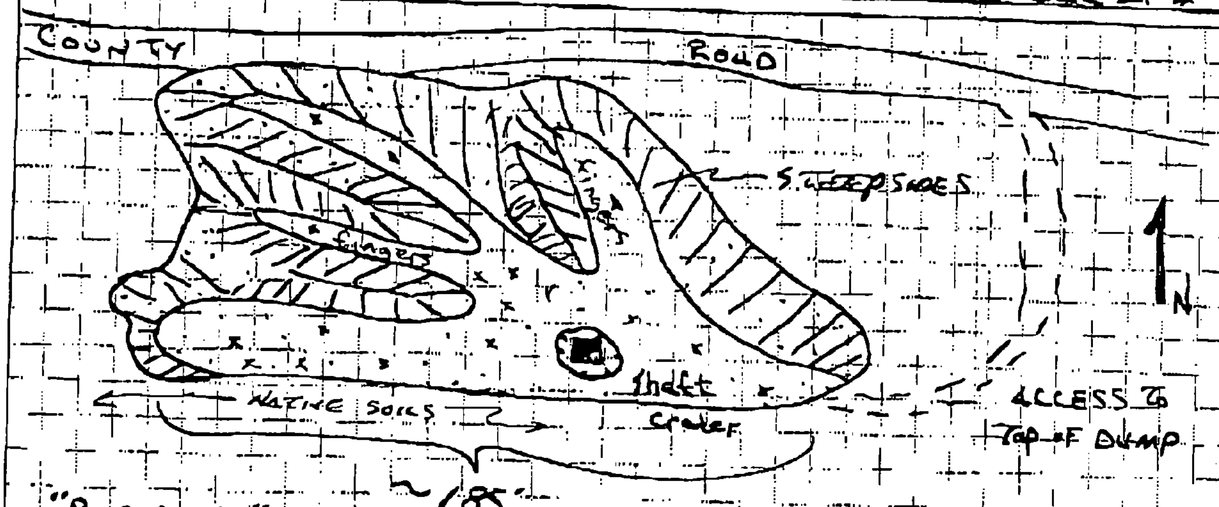
Bruce K. Stover
Mining Services Project Manager

Enclosures


SITE #7A1
SITE #7A3
CHRYSOLITE #1
CHIEF NO. 2
FAIRVIEW HILL
ABANDONED R.R.
SITE LSH02
SECTION A
A'
TEST PILE
JOB SITE
LEADVILLE WASTE INJECTION PROJECT
LEADVILLE
ABANDONED RR
PONSARDI
PH

DENVER GROUTING
A Division of Hayward Baker

JOB NO.	BY BKS	SHEET NO. 1
PROJECT PONILLE MINE WASTE INJECTION		DATE 3-DEC-2K1



"PONSARDINE"
MINE DUMP NTS 15,000 yds^3

pH 2 TO pH 7

MAX DEPTH = 22-25'

SIDESLOPES = ∡ OF REPOSE ≈ 45° MAX