# FINAL

# OPERABLE UNIT 2
# FEASIBILITY STUDY REPORT FOR
# LAVA CAP MINE SUPERFUND SITE
# NEVADA COUNTY, CALIFORNIA

**Prepared for:**

**Contract No. 68-W-98-225/WA No. 277-RICO-093Y**
**U.S. Environmental Protection Agency**
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# Acronyms and Abbreviations

| | |
|---|---|
| µg/L | micrograms per liter |
| °F | degrees Fahrenheit |
| AA | activated alumina |
| AHPA | Archaeological and Historic Preservation Act |
| ARAR | applicable or relevant and appropriate requirement |
| ARPA | Archaeological Resources Protection Act |
| As(III) | trivalent arsenic |
| As(V) | pentavalent arsenic |
| Basin Plan | *Water Quality Control Plan for the Sacramento River Basin and the San Joaquin River Basin* |
| bgs | below ground surface |
| CAA | Clean Air Act |
| CC | Clipper Creek |
| CDFG | California Department of Fish and Game |
| CERCLA | Comprehensive Environmental Response, Compensation, and Liability Act |
| CFR | Code of Federal Regulations |
| COC | contaminant of concern |
| CTR | California Toxics Rule |
| CWA | Clean Water Act |
| DTSC | California Department of Toxic Substances Control |
| ED | electrodialysis |
| ELCR | excess lifetime cancer risk |
| EPA | U.S. Environmental Protection Agency |
| ESA | Endangered Species Act |
| ET | evapotranspiration |
| Fe(II) | ferrous iron |

| | |
|---|---|
| Fe(III) | ferric iron |
| FS | feasibility study |
| ft/sec | feet per second |
| $ft^3$/sec | cubic feet per second |
| GFH | granular ferric hydroxide |
| gpm | gallons per minute |
| HHRA | human health risk assessment |
| HI | hazard index |
| $JT_{RV}$ unit | Jurassic to Triassic metamorphosed volcanic (metavolcanic) rocks |
| LCC | Little Clipper Creek |
| LGC | Little Greenhorn Creek |
| MCL | maximum contaminant level |
| Md unit | mine deposits |
| mg/kg | milligrams per kilogram |
| msl | mean sea level |
| NAAQS | National Ambient Air Quality Standards |
| NCP | National Contingency Plan |
| NF | nanofiltration |
| NHPA | National Historic Preservation Act |
| NID | Nevada Irrigation District |
| NMFS | National Marine Fisheries Service |
| NPL | National Priorities List |
| NPV | net present value |
| NRHP | National Register of Historic Places |
| O&M | operations and management |
| OU | operable unit |
| OU-1 | Operable Unit 1 |
| OU-2 | Operable Unit 2 |
| OU-2 RI Report | *Public Release Draft, Operable Unit 2 Remedial Investigation Report for the Lava Cap Mine Superfund Site* |

| | |
|---|---|
| Pms unit | Paleozoic to Upper Jurassic metamorphic rocks |
| Policy | *Policy for Implementation of Toxics Standards for Inland Surface Waters, Enclosed Bays, and Estuaries of California* |
| POU | point-of-use |
| RA | remedial action |
| RAO | removal action objectives |
| RI/FS | remedial investigation/feasibility study |
| RO | reverse osmosis |
| ROD | Record of Decision |
| SARA | Superfund Amendments and Reauthorization Act |
| SDWA | Safe Drinking Water Act |
| Site | Lava Cap Mine Superfund Site |
| STLC | soluble threshold limit concentration |
| SWRCB | State Water Resources Control Board |
| TBC | to-be-considered |
| TCLP | toxicity characteristic leaching procedure |
| TTLC | total threshold limit concentration |
| Tvb unit | Tertiary volcanic breccia |
| USC | United States Code |
| USFWS | U.S. Fish and Wildlife Service |
| $yd^3$ | cubic yard(s) |
| ZVI | zero valent iron |

SECTION 1

# Introduction

The U.S. Environmental Protection Agency (EPA) is conducting a remedial investigation/ feasibility study (RI/FS) to address groundwater contamination associated with the Lava Cap Mine Superfund Site (Site). The study is being conducted under the authority of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended. Lava Cap Mine is located southeast of Nevada City, California (see Figure 1-1) (figures are located at the end of the section in which they are first referenced). The Site was listed on the National Priorities List (NPL) in January 1999. Lava Cap Mine was a gold and silver mine that operated until 1943 and has since been inactive. The Site encompasses the mine property itself and all downgradient areas impacted by contamination from the Lava Cap Mine. The mine and downgradient areas have been impacted primarily by the release of tailings and seepage of water from the mine adit. The tailings and adit seepage contain arsenic that has impacted groundwater.

In July 2008, EPA issued its *Public Release Draft Operable Unit 2 Remedial Investigation Report, Lava Cap Mine Superfund Site* (OU-2 RI Report; EPA, 2008). That remedial investigation report was developed according to the EPA guidance document, *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (EPA, 1988). The OU-2 RI Report documents the results of data collection efforts conducted to characterize Site hydrogeologic conditions, determine the nature and extent of groundwater contamination, and support informed risk-management decisions regarding potential risks to human health and the environment from groundwater.

This feasibility study (FS) used information generated during the OU-2 RI to develop, screen, and provide detailed evaluations of alternative remedial actions (RA) for contaminated drinking water in the Lava Cap Groundwater operable unit. The term "operable unit" (OU) is used to define a discrete action that is an incremental step toward a comprehensive remedy. OUs may address certain geographic areas, specific media, initial phases of a remedy, or a set of actions over time. Because of the different issues presented by the various geographic areas and contaminated media at the Site, EPA has divided the Site into four OUs:

- **OU-1 –** (Mine Area OU) includes soil and surface water contamination on the mine property and along Little Clipper Creek downstream to Greenhorn Road
- **OU-2 –** (Groundwater OU) underlies the entire Superfund site (from the mine property to Little Greenhorn Creek)
- **OU-3 –** (Lost Lake OU) includes soil, sediment, and surface water contamination along Little Clipper Creek (LCC), Clipper Creek (CC), and Lost Lake, downstream from Greenhorn Road to Little Greenhorn Creek
- **OU-4 –** (Mine Residences OU) is a subset of OU-1, and specifically addressed RAs at two residences at the mine (the other two residences were demolished as part of the OU-1 RA)

The overall cleanup strategy for the Site has been to first address OU-1 and OU-4, then to develop cleanup alternatives for OU-2 and OU-3. Significant portions of the RAs have been completed in OU-1 and the OU-4 action is complete. OU-3 is in the RI/FS phase but is not as far along as OU-2.

The RI/FS process will lead to an Interim Record of Decision (ROD) for OU-2. In the Interim ROD, EPA will select environmental cleanup actions necessary to mitigate known risks to human health resulting from mine-related arsenic contamination in drinking water. According to the currently available data, no other environmental or ecological receptors are known to be directly impacted by exposure to arsenic-contaminated groundwater. The ROD will be an interim decision because uncertainties remain regarding the potential migration of mine-related arsenic contamination in groundwater and the future impact of potential discharges of mine-impacted groundwater to surface water. The extent of mine-related arsenic contamination will be refined through installation of additional monitoring wells during implementation of initial OU-2 RAs.

As described in more detail in Section 1.6, groundwater flowing beneath the Site ultimately discharges to Little Clipper Creek, Clipper Creek, Lost Lake, and Little Greenhorn Creek. Some of the groundwater reaching these surface water bodies now or in the future might contain mine-related arsenic contamination that could pose a potential risk to human and ecological receptors. However, the contribution of arsenic from groundwater discharges to surface water is estimated to be much smaller than existing loading of arsenic in these surface water bodies resulting from other sources in OU-1 and OU-3. Potential risks associated with surface waters at the Site are (or will be) addressed by the ongoing RAs in OU-1 and upcoming feasibility study and remedy implementation in OU-3; therefore, they are not evaluated in this FS.

The OU-1 RA will include treatment of the mine adit discharge water, which is currently the largest contributor of arsenic mass loading to surface water. Other recently completed OU-1 RAs, including capping the waste rock and tailings piles and constructing engineered channels to divert surface water around the mine wastes are also expected to reduce future arsenic loading to LCC.

Recommendations to further investigate groundwater contributions to surface water and associated arsenic loading are provided in Section 1.8. Recommendations should be implemented concurrently with implementation of RAs in OU-1 and OU-3 to allow accurate evaluation of potential risks to human and ecological receptors from groundwater discharging to surface water. If necessary, additional RAs will be evaluated for OU-2 and incorporated into a final OU-2 ROD.

## 1.1 Feasibility Study Purpose and Overview

The purpose of the FS is to develop and evaluate remedial alternatives that are appropriate to site-specific conditions, protective of human health and the environment, and comply with CERCLA. This FS is supported by information gathered during the RI and is designed to develop and evaluate remedial alternatives for mine-related arsenic contamination in drinking water in OU-2.

OU-2 is defined to include the groundwater beneath the entire Superfund site. EPA has published an FS for OU-1 and is currently implementing RAs. EPA will address cleanup alternatives for OU-3 in a separate FS. OU1 and OU-4 include the Lava Cap Mine property and the section of LCC that extends through the mine area downstream to Greenhorn Road. OU-3 includes contaminated tailings, soil, sediment, and surface water in portions of LCC, Clipper Creek (CC), and Lost Lake downgradient from Lava Cap Mine.

The development of this FS and evaluation of remedial alternatives were based on the guidelines set forth in the *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (EPA, 1988). The CERCLA compliance policy specifies that Superfund RAs must meet any federal standards, requirements, criteria, or limitations that are determined to be applicable or relevant and appropriate requirements (ARAR). State ARARs must be met as well if they are more stringent than federal requirements.

RA objectives (RAO) are medium-specific goals for protecting human health and the environment. RAOs were developed for OU-2, and then general response actions were identified for specific media to satisfy the RAOs. General response actions include treatment, containment, extraction, disposal, and institutional controls. Remedial technologies are the general categories of remedies under a general response action, such as chemical treatment, active capture, or active interception. Specific process options are developed for each remedial technology, and after screening, are combined to form remedial alternatives.

Pursuant to CERCLA RI/FS guidance (EPA, 1988), the remedial alternatives investigated in this FS were evaluated according to their ability to meet the following criteria:

1. Overall protection of human health and the environment
2. Compliance with ARARs
3. Long-term effectiveness and permanence of the RA to minimize risks
4. Reduction of toxicity, mobility, and volume through treatment
5. Ability to meet short-term remediation goals, including minimization of adverse health, safety, and environmental impacts during remedial activities
6. Technical viability, reliability, and implementability
7. Cost-effectiveness and economic feasibility

Alternatives will be evaluated against two additional criteria, state acceptance and community acceptance, after public comment on the FS and the proposed plan.

## 1.2 Report Organization

This Final Groundwater FS is organized as follows:

- **Section 1 – Introduction:** Provides historical background information for the Lava Cap Mine Site and summarizes the RI results.
- **Section 2 – Development of Preliminary Cleanup Goals:** Presents RAOs, ARARs, contaminants of concern (COC), and preliminary cleanup goals.

- **Section 3 – Identification and Screening of Remedial Technologies:** Identifies the general response actions, remedial technologies, and process options; screens the remedial technologies and process options on effectiveness, implementability, and cost.
- **Section 4 – Development of Remedial Alternatives:** Develops the remedial alternatives by combining remedial technologies and process options.
- **Section 5 – Detailed Analysis of Remedial Alternatives:** Presents an individual and comparative analysis of alternatives. The analysis is conducted using seven of the nine criteria specified in the CERCLA guidance.
- **Section 6 – Works Cited:** Lists the documents referenced in this FS report.
- **Appendix A – Extension of Nevada Irrigation District Water Pipeline Technical Memorandum:** Summarizes the conceptual design, assumptions, and estimated costs for providing treated water from the Nevada Irrigation District (NID) to residences with arsenic-contaminated drinking water at the Site.
- **Appendix B – Cost Estimates and Assumptions:** Includes detailed cost estimates used in the evaluation of remedial alternatives.

## 1.3 Site Background

This section provides a description of the Site and a brief history of the Lava Cap Mine. This section also provides a summary of investigations performed prior to EPA initiating the RI. Further details are provided in the OU-2 RI report (EPA, 2008).

### 1.3.1 Site Description

The Lava Cap Mine occupies approximately 30 acres in a rural residential area of the Sierra Nevada foothills. The mine is located approximately 5 miles southeast of Nevada City and 6 miles east of Grass Valley (see Figure 1-1) at 14501 Lava Cap Mine Road, Nevada City, California. The geographical coordinates are latitude 39°13′41.0″N, longitude 120°58′11.5″W, Township 16 N, Range 9 E, Section 28 of the Mount Diablo Base and Meridian.

Lava Cap Mine is located on the southern slope of Banner Ridge at an elevation of approximately 2,840 feet above mean sea level (msl). The elevation drops from approximately 2,870 feet above msl at the historical mine buildings to approximately 2,700 feet above msl at the base of the Rock Buttress, which is approximately 1,400 feet to the south.

The area surrounding the Site is covered with dense trees of the Sierra Nevada transition zone, with the predominant vegetation consisting of ponderosa pine. Numerous areas within the LCC and CC watersheds have undergone logging or land clearing activities.

Figure 1-2 shows features of the Site after completion of the primary OU-1 RA, which began in May 2006. Currently, there are several structures at the mine, including the former mill building, the former cyanide treatment building, several other old mine buildings, and two residences. As part of the OU-1 RA, two residential buildings were removed, the surface water drainage patterns were altered, the waste rock and tailings piles were capped or covered, some waste rock and tailings were removed, and the Log Dam was replaced with a Rock Buttress. The planned OU-1 RA is described in the *Mine Area OU-1 Phase 1 Primary Mine Area Remedial Design* (EPA, 2006a).

Areas encompassed by the Site are shown on Figure 1-3 and include the following:

- Lava Cap Mine
- Little Clipper Creek, which flows south from the mine
- Clipper Creek, downstream from the confluence with Little Clipper Creek
- Deposition Area, a large tailings deposit along Clipper Creek, above Lost Lake
- Lost Lake
- Clipper Creek, downstream from Lost Lake
- Little Greenhorn Creek (LGC), downstream from Lost Lake.

Elevated concentrations of arsenic in soil, sediment, and surface water indicate these areas have been impacted by the release of tailings from the Lava Cap Mine. Residences are located adjacent to areas of the Site impacted by mining activities. Approximately 15 residences are located within 500 feet of Little Clipper Creek, downstream from the Site. Ten to fifteen residences are located in the vicinity of Lost Lake, and 20 property parcels include a portion of Lost Lake or the Deposition Area. Four residences are located within 500 feet of Clipper Creek downstream from Lost Lake. As previously discussed, only arsenic-impacted drinking water at the Site is addressed in this FS. The surface conditions of the Site are considered part of either OU-1/OU-4 (RAs are underway or complete) or OU-3 that will be addressed in a separate FS.

In 1994, the estimated population within 1 mile of the Lava Cap Mine was 1,776; within 4 miles, the population was 24,091 (EPA, 1997). In 1998, the surrounding communities of Nevada City and Grass Valley, had populations of 2,880 and 9,475, respectively. The major regional population and industrial centers in the general vicinity of Grass Valley and Nevada City include Reno, Nevada (91 miles northeast), South Lake Tahoe, California (94 miles southeast), and Sacramento, California (60 miles southwest).

### 1.3.2 Site History

Various groups intermittently operated the Central and Banner Mines between 1861 and 1943. Gold and silver mining activities were initiated at the Lava Cap Mine (formerly known as the Central Mine) in 1861. The Banner Mine, approximately 1.5 miles north of the Lava Cap Mine, began operations in 1860. Starting in 1934, these two mines were operated jointly by the Lava Cap Gold Mining Corporation, and at that time, the Central Mine became known as the Lava Cap Mine. The *Public Release Draft, Remedial Investigation Report for the Lava Cap Mine Superfund Site* (EPA, 2001) provides a detailed chronology of mining operations at the Lava Cap Mine Site.

Relatively small-scale mining operations occurred during the initial operating period from 1860 to 1918. Approximately 20,000 tons of ore were mined from the Banner Mine and Central Mine between 1865 and 1890 (California Department of Toxic Substances Control [DTSC], 1991).

In the early years, the Central Mine was mined primarily for silver, using amalgamation to process the ore. This process uses mercury to recover the silver and gold from the ore. The process was not highly effective on Central Mine ore because of its high sulfide content.

Between 1861 and 1918, the amount of ore produced was greater at the Banner Mine; therefore, the majority of the ore processing, disposal of waste rock, and deposition of tailings (the waste products generated during the processing of ore) occurred at the Banner Mine.

The Banner and Central Mines were inactive from 1918 to 1934, after which mining activities resumed under the Lava Cap Gold Mining Corporation. A flotation plant was built to process the ore at the renamed Lava Cap Mine property. At some time after 1934, when the mines were reopened, the Banner and Lava Cap mines were connected underground by a 5,000-foot drift (tunnel). A schematic profile depicting the subsurface mine workings of the Lava Cap and Banner Mines is shown on Figure 1-4. Ore from the Banner portion of the mine was transported to the Lava Cap Mine central shaft and then to the surface, where it was processed in the Lava Cap Mill (California Journal of Mines and Geology, 1941).

After operations resumed in 1934, the Lava Cap Mine became one of the largest gold mines operating in California. The mine produced 300 to 400 tons of ore per day during 1934 (Vector Engineering, Inc., 1991). The primary mining method was cut and fill (California Journal of Mines and Geology, 1941), in which open stopes formed by mining were filled with waste rock after the ore was removed. This provided a more stable method than leaving the stopes open under weak rock conditions.

The Lava Cap Mill consisted of crushing and grinding circuits to reduce the particle size of ore. The ground ore was then subjected to flotation that separated the ore into a concentrate and tailings. The concentrate was the product that contained the gold and silver, and the tailings were the waste material from the processing. The primary gold-containing minerals were pyrite, arsenopyrite, and galena. The primary silver mineral was argentite. Silver was also reported to be contained in sphalerite (Engineering and Mining Journal, 1934). The gold recovery from this process is estimated at 93.5 percent (Holmes, 1985). The gold and silver concentrates from the flotation plant contained the majority of the sulfide minerals that were in the ore. The concentrates were shipped to two smelters: the Shelby Smelter near San Francisco, California, and a smelter in Tacoma, Washington (Vector Engineering, Inc., 1991).

In 1940, a cyanide plant was built to recover gold from the concentrates onsite, but this operation was relatively ineffective. From 1941 to 1943, the cyanide plant handled only the middlings and tailings from the flotation plant, and did not handle the higher-grade flotation concentrates. Middlings are an intermediate product that would normally be recycled in the mill to recover residual values. The middlings and tailings were ground to a very fine size and vat-leached with cyanide to remove residual gold and silver. The gold and silver were recovered in the cyanide plant using the Merrill Crowe zinc precipitation process.

From 1934 to 1943, the Lava Cap Mine produced 270,000 ounces of gold and 2.3 million ounces of silver from approximately 1 million tons of ore (Holmes, 1985). Because approximately 5 percent of the ore was recovered in the concentrate, the quantity of tailings would have been approximately 95 percent of the quantity of ore mined (Vector Engineering, Inc., 1991).

Tailings from flotation and cyanide processes were deposited in a ravine on the Lava Cap Mine property. A log dam, approximately 30-feet high, was built to hold the tailings in place where the ravine steepened and narrowed. The construction date of the log dam is not known, but it likely occurred shortly after mining operations resumed in 1934. The waste rock was deposited in two piles between the mine shaft and the tailings pond that formed above the log dam.

Lost Lake Dam was likely constructed as a mine tailings impoundment and created Lost Lake. Lost Lake is a private lake with a surface area of approximately 5 acres (Figures 1-3). Mine tailings were reportedly released into LCC, where they were transported to Lost Lake.

It was reported that a dam was built on "Greenhorn Creek" in 1938 to "stop tailings from polluting waters of Bear River" (Engineering and Mining Journal, 1938). It is possible that this is a reference to the dam at Lost Lake. A 1935 Lava Cap Gold Mining Corp. map shows the section of Clipper Creek from the confluence of Little Clipper Creek to LGC as "N. Fk. Little Greenhorn."

The dam located at Lost Lake was reported to be a "rock-core, earth filled dam meeting the then current requirements of the California Debris Commission. Water was then decanted in the tailings pond before being discharged into lower Clipper Creek" (Vector Engineering, Inc., 1991). Lost Lake Dam is approximately 50 feet high and approximately 1.25 miles downstream from Lava Cap Mine.

In 1943, the Lava Cap Mine closed because the federal government prohibited the production of non-strategic metals during World War II. An attempt was made to reopen the mine in the mid-1980s, but community opposition prevented the opening.

The adit to the Lava Cap Mine collapsed sometime between 1978 and 1984. Additionally, the main shaft into the mine has been filled with debris. No access to the underground workings from the Lava Cap Mine currently exists.

During a major winter storm in January 1997, the upper half of the log dam collapsed, releasing more than 10,000 cubic yards ($yd^3$) of tailings into LCC. This storm was estimated to be a 25-year event with a peak flow of approximately 120 cubic feet per second ($ft^3$/sec) at the log dam on LCC. In May 1997, staff from the DTSC, the California Department of Fish and Game (CDFG), and the Nevada County Environmental Health Department inspected the mine and downgradient areas. Extensive deposits of tailings were observed in LCC, in CC below the confluence with LCC, and in Lost Lake. The tailings were also observed in wetland areas contiguous with these water bodies, in some cases, reportedly covering the vegetation.

The DTSC issued an information sheet in June 1997 warning of potential hazards from contact with Lost Lake sediments. This information sheet was issued because March and April 1997 sampling results indicated the presence of arsenic in Lost Lake water at concentrations up to 28.4 micrograms per liter (µg/L) and in shoreline soils at concentrations up to 1,130 milligrams per kilogram (mg/kg).

In October 1997, the EPA Region 9 Emergency Response Office determined that conditions associated with the tailings release from the Lava Cap Mine met the National Contingency Plan (NCP) Section 300.415(b)(2) criteria for a removal action. The primary concern was the potential for additional releases of tailings from the tailings pile because of the high arsenic concentrations and the mobility of the extremely fine-grained tailings, which are easily suspended and transported in surface water (EPA, 1997).

During October and November 1997, 4,000 $yd^3$ of tailings were removed immediately upstream from the damaged log dam and stockpiled on the waste rock pile immediately north of the tailings area (see Figure 1-2). The stockpiled tailings were placed on a liner and covered with a liner, then covered with a clay cap and waste rock to help protect the liner and cap. The oversteepened slopes of the tailings pile immediately behind the dam were graded, and the entire tailings pile was covered with waste rock. Stream diversions were also constructed around the waste rock and tailings piles. In February 1998, EPA conducted additional work at the Site to stabilize another smaller tailings release and further improve drainage. In summer 1998, the emergency response action was completed. All work related to the action took place on the Lava Cap Mine property, at or above the log dam.

In 1998, EPA evaluated the Site to estimate potential risks to human health and the environment and to determine if it warranted listing on the NPL as a Superfund site. EPA formally listed the Site on the NPL in January 1999, allowing Superfund funding for investigation and cleanup.

In May 2006, the RA activities for OU-1 began in accordance with the *Mine Area OU-1 Phase 1 Primary Mine Area Remedial Design* (EPA, 2006a). The RA for OU-4 (mine area residences) began in September 2005 and is now complete. As a part of the OU-1 RA, several activities were required. Along LCC downstream from the mine near Tensy Lane, arsenic-contaminated soil was excavated and placed beneath the tailings pile cap. A Rock Buttress was constructed at the downstream end of the tailings pile to replace the Log Dam, LCC was diverted around the waste rock/tailings pile, and several smaller channels were constructed to control drainage. The waste rock piles and surrounding area were regraded and an 18-inch-thick vegetative soil cover was constructed using soil from an onsite borrow source. Contaminated soil and water were removed from within the mine buildings and the surrounding appurtenances, and the material was disposed of offsite.

Contaminated soil from areas surrounding the mine buildings was excavated and placed under the waste rock/tailings pile cap. The excavated areas were then backfilled with clean soil. The waste rock/tailings pile cap was constructed with geotextile and geomembrane layers, plus 18 inches of clean soil from the onsite borrow source. After removal of the southernmost residence, contaminated soil in the vicinity was covered with an 18-inch-thick vegetative soil cover near the residence or with a 12-inch layer of a clay/rock mix on the steeper surrounding slopes. All covered, capped, and disturbed areas were then hydroseeded. The primary mine access road and other access roads were armored with imported aggregate base.

## 1.4 Site Physical Characteristics

This section provides information from the OU-2 RI report (EPA, 2008), and includes a summary of the climate and hydrogeologic framework at the Site.

### 1.4.1 Climate

Generally, this area has warm, dry summers and mild, wet winters; most of the precipitation falls from November through April. Precipitation at the Grass Valley rain gauge located in Nevada County, approximately 5 miles west of the Site ranged from 15 to 95 inches per year between 1967 and 2006; the average precipitation is 52 inches per year. Precipitation at the Site is estimated to be approximately 10 percent greater than at the Grass Valley rain gauge because of orographic (i.e., elevation) effects.

The average temperatures in the eastern part of Nevada County range from 60 degrees Fahrenheit (°F) at the lower elevations to 55°F at higher elevations. Minimum temperatures are affected by local variations in the terrain. The January average minimum temperature ranges from 36°F at the lower elevations to 30°F at 4,500 feet above mean sea level (msl). Average maximum temperatures in July range from 98°F at the lower elevations to 92°F at the higher elevations.

The relative humidity during winter in Nevada County ranges from 90 percent at night to 70 percent during the day. In summer, average relative humidity ranges from 80 percent at night to 25 percent during the day (Natural Resources Conservation Service, 1993).

Prevailing winds in Nevada County are from a southwesterly direction most of the year, with an average wind speed of nearly 10 miles per hour. Thundershowers typically come from a south or southwesterly direction during summer and winter; at times they are accompanied by high winds. Most of the precipitation falls when a southwest wind is blowing. Winds from the north and east occasionally blow over the lower western slopes of the Sierra Nevada Mountains. In winter, these winds bring cold, dry weather; in spring and summer these winds are warm and dry. As a result, the wind quickly removes moisture from the soil surface and dries out vegetation.

Evapotranspiration (ET) is the vaporization of water to the atmosphere through evaporation (from plant, soil, and water surfaces) and transpiration (water uptake by plant roots). ET depends on the availability of water and energy to convert the water into vapor. The rate of ET varies spatially and temporally and depends on the weather (e.g., air temperature, relative humidity, and wind speed), solar radiation, vegetation (e.g., plant type, root depth, plant density, plant height, and stage of growth), and soil (e.g., soil moisture, texture, density, structure, and soil chemistry). Historical average monthly reference ET rates recorded in Grass Valley range from 0.64 inches in December to 6.34 inches in July, with an annual average of 3.16 feet per year (Goldhamer and Snyder, 1989).

### 1.4.2 Hydrogeologic Framework

Lava Cap Mine is located within the CC watershed, which is drained by CC and its tributaries. LCC is the dominant surface water drainage leading south, away from the mine. Lava Cap Mine is entirely within the LCC subwatershed. The upper reaches of LCC are seasonally dry (ephemeral), and the creek becomes perennial below the Rock Buttress, where it is fed by continuous discharge from the diverted adit water and flow from the base of the Rock Buttress.

Subsurface access to Lava Cap Mine during mining operations was possible through an adit connected to a horizontal tunnel that bisected the central mine shaft. After the mine ceased operations, the adit caved in, and it is no longer usable for mine access. Currently, water discharges continuously from the mine at the caved-in adit in the waste rock pile area.

The Site is underlain by the following five major hydrostratigraphic units (in order of increasing age) (Cole/Mills Associates, 1985):

- Naturally-occurring surficial deposits of Holocene age, including stream-channel alluvium, colluvium, and residual soils
- Mine deposits (Md unit), including waste rock and tailings that were removed from the underground mine workings and deposited on the ground surface outside of the mine (most commonly south and downhill of the mine entrance) since 1861
- Tertiary volcanic breccia (Tvb unit), commonly referred to as lava, with zones of conglomerates or gravels
- Cretaceous igneous intrusive rocks, including diorite and granodiorite
- Jurassic to Triassic metamorphosed volcanic (metavolcanic) rocks ($JT_{RV}$ unit)
- Paleozoic to Upper Jurassic metamorphic rocks (Pms unit), including argillite, slate, conglomerates, thin-bedded cherts, and other metasedimentary rock (metasediment)

Within the channel of LCC between the mine and Lost Lake, the surficial geology is dominated by alluvium and mine deposits, which are underlain by the Pms unit. The other rock units listed occur at the surface, north of the mine.

Numerous ancient fractures, joints, and inactive faults of the Foothills Fault System are present in the area of the Lava Cap Mine (Cole/Mills Associates, 1985). No known active faults are present on the mine property.

The residential groundwater supply throughout the Site is stored in primary pore spaces in the saturated overburden and in fissures, faults, and joints in the consolidated and crystalline rocks of the Pms unit. Inactive thrust faults and associated lineaments trend north-south to slightly northwest-southeast (Cole/Mills Associates, 1985), approximately parallel to the generally southward groundwater flow direction between Lava Cap Mine and Lost Lake.

Groundwater also occurs in the Tvb unit, which overlies the Pms unit north of the mine. The hydraulic conductivity of the Tvb unit is relatively high compared to the Pms unit. Groundwater is distributed throughout the Tvb unit. In contrast, in the Pms unit, groundwater primarily occurs within joints and fractures. Groundwater in the Tvb unit is most likely perched, with limited hydraulic interaction between the Tvb and the Pms units. Several springs are identified at the lithologic contact between the Tvb and Pms units.

Groundwater migrates from locations of recharge to locations of discharge. Precipitation recharges the groundwater system in the uplands, and groundwater discharges into the drainages (streams), springs, and seeps at lower elevations. Groundwater flows primarily from the ridges toward the deep drainages in the area, including CC, LCC, and LGC. In general, groundwater levels rise seasonally during winter and spring in response to increased rainfall, and decline in summer and fall when precipitation is minimal.

## 1.5 Nature and Extent of Contamination

This section describes the nature and extent of arsenic contamination in groundwater at the Site. Arsenic is the only identified contaminant of concern in the groundwater at the Site that contributes significant risk to human health. Other metals contribute to ecological risks from exposure to surface water, but those pathways are not addressed in this FS. As discussed in Section 1.4.2, interaction between groundwater and surface water is expected to occur at the Site; therefore, arsenic concentrations in surface water are also described in this summary of the nature and extent of groundwater contamination. Arsenic concentrations in groundwater and surface water samples are presented in more detail in the OU-2 RI (EPA, 2008); summary statistics are presented in Table 1-1.

Surface water and groundwater samples have been periodically collected and analyzed from creeks, lakes, monitoring wells, piezometers, and residential wells during the period from October 1999 through June 2007. In this section, the discussion is divided into the following geographic areas: Background Area, Source Area and Mine Area, Downgradient Area, and Lost Lake/Deposition Area. Water samples at the Site were collected from the following:

- Surface water sampling locations, including the mine adit, CC, LCC, LGC, and Lost Lake. Total (unfiltered) arsenic concentrations are generally reported for these locations.
- Site monitoring wells and piezometers. Dissolved (filtered) arsenic concentrations are generally reported for these locations.
- Site residential wells. Total arsenic concentrations are generally reported for these locations.

Generally, there is agreement between the filtered and unfiltered arsenic concentrations in groundwater samples from most areas of the site, indicating that most arsenic in Site groundwater occurs in the dissolved form. However, dissolved arsenic results from filtered surface water samples and filtered groundwater samples from wells screened in tailings were typically less (in many cases substantially less) than the associated total arsenic concentration (EPA, 2008), suggesting that a significant fraction of arsenic in these waters occurs in the particulate or colloidal forms.

### 1.5.1 Background Area

Figure 1-5 shows the sampling locations and the maximum arsenic concentrations detected in groundwater and surface water samples from the Background Area; summary statistics for arsenic concentrations are presented in Table 1-1. Results of chemical analysis for arsenic in samples obtained from the Background Area during the OU-2 RI included the following:

- Surface water upstream from the Source Area and Mine Area that feed LCC (Locations 1J and 1U) and the portion of CC upstream from the confluence with LCC (Location 2G) – total arsenic concentrations were less than 4 μg/L, with an average concentration of approximately 0.5 μg/L.
- Monitoring wells upgradient from the mine and the waste rock/tailings pile (Wells 1B and 1R) – these wells are screened in bedrock approximately 150 feet below ground surface (bgs), within the footprint of the Lava Cap Mine underground workings. Dissolved arsenic concentrations were between 1.2 and 24.2 μg/L. Dissolved arsenic concentrations remained above the maximum contaminant level (MCL) of 10 μg/L in samples from these wells (the average arsenic concentration was approximately 16 μg/L), except at Well 1B, where arsenic concentrations have been below 3 μg/L since 2006.

- Residential wells located on ridges above CC, upgradient from the confluence of LCC with CC (Wells 11AR and 11AW), and wells located more than 2,500 feet from LCC (Wells 11A3 and 11A5) – total arsenic concentrations were equal to or less than 1 µg/L.

In summary, arsenic concentrations in groundwater and surface water samples from the Background Area have generally been below the MCL for drinking water (10 µg/L), except for wells within the footprint of the mine workings. No discernible steadily increasing or decreasing trend in arsenic concentrations is apparent in the data during the period of record.

### 1.5.2 Source Area and Mine Area

Figure 1-5 shows the sampling locations and the maximum arsenic concentrations detected in groundwater and surface water samples from the Source Area and Mine Area; summary statistics are presented in Table 1-1. Results of chemical analysis for arsenic in samples obtained from the Source Area and Mine Area during the OU-2 RI included the following:

- Surface water discharging from the mine adit (Location 3A), the former tailings pile seep (Location 3B), the base of the former Log Dam (Location 4A), and the Rock Buttress (Location 4A2) in LCC – total arsenic concentrations ranged between 16.5 and 910 µg/L and exhibited seasonal concentration variations (all above the MCL of 10 µg/L). The highest total arsenic concentration was detected in a sample from the mine adit discharge. Samples from the former tailings pile seep (Location 3B) typically had the lowest arsenic concentrations in the Source Area, but were still well above the arsenic MCL. Arsenic concentrations in samples from the base of the former Log Dam (Location 4A) and the base of the Rock Buttress (Location 4A2) were similar to adit discharge concentrations (Location 3A) in the dry season and typically were significantly lower than adit discharge concentrations in the wet season because of dilution from storm water runoff. Arsenic concentrations in samples from Location 4A2 after the OU-1 RA were initially lower than historical concentrations detected at Location 4A (base of the former Log Dam) but increased by March 2007 to previous levels.

- Source Area monitoring Wells 5A, 5D, 5E, 5I, and 5J and Piezometers 5PZ-1, 5PZ-2, and 5PZ-3 (only Piezometer 5PZ-1 remains at the Site; the other wells and piezometers were properly destroyed during the OU-1 RA) – dissolved arsenic concentrations ranged between 0.43 and 871 µg/L. Dissolved arsenic concentrations at individual wells and piezometers fluctuated within one order of magnitude or less and were usually above the MCL, except at Piezometer 5PZ-1. Samples from Wells 5A and 5E and Piezometers 5PZ-2 and 5PZ-3 had the highest arsenic concentrations in the Source Area. Dissolved arsenic concentrations in samples from Well 5D fluctuated below and above the MCL. No steadily increasing or decreasing trend in dissolved arsenic concentrations is apparent in the data from most Source Area monitoring wells and piezometers during the period of record except the following:
  - Dissolved arsenic concentrations in samples from Well 5J steadily increased over the period of record until abandonment in 2006.

**TABLE 1-1**
Summary of Arsenic Concentrations Detected in Samples of Groundwater and Surface Water
*Feasibility Study Report for Operable Unit 2 Groundwater Lava Cap Mine Superfund Site, Nevada City, California*

| Location | Location Type | Minimum Arsenic Concentration (µg/L) | Maximum Arsenic Concentration (µg/L) | Median Arsenic Concentration (µg/L) | Average Arsenic Concentration (µg/L) | Standard Deviation | Number of Samples | Percent Detects |
|---|---|---|---|---|---|---|---|---|
| Background Area | | | | | | | | |
| 1J | SW | 0.22J | 0.9 | 0.30 | 0.39 | 0.27 | 10 | 80 |
| 1U | SW | 0.5U | 0.5U | NA | NA | NA | 1 | 0 |
| 2G | SW | 0.08J | 3.8 | 0.20 | 0.52 | 0.94 | 15 | 47 |
| 1B | MW | 1.2 | 24.2 | 13 | 13.4 | 6.05 | 15 | 100 |
| 1R | MW | 8.7 | 24 | 19.1 | 18.9 | 4.30 | 15 | 100 |
| 11AR | RW | 0.1J | 0.1J | NA | NA | NA | 1 | 100 |
| 11AW | RW | 0.21J | 0.41J | 0.21 | 0.24 | 0.12 | 4 | 75 |
| 11A3 | RW | 1U | 1U | NA | NA | NA | 4 | 0 |
| 11A5 | RW | 1 | 1 | NA | NA | NA | 1 | 100 |
| Summary | | 0.08J | 24.2J | 1.00 | 7.85 | 8.92 | 66 | 77 |
| Source Area and Mine Area | | | | | | | | |
| 3A | SW | 199 | 910 | 510 | 510 | 146 | 31 | 100 |
| 3B | SW | 27.2 | 383 | 50.6 | 95.4 | 101 | 14 | 100 |
| 4A/4A2 | SW | 16.5 | 532 | 130 | 168 | 114 | 30 | 100 |
| 5A | MW | 190 | 610 | 230 | 284 | 115 | 13 | 100 |
| 5D | MW | 3.5 | 29.3 | 13.3 | 15.5 | 10.3 | 16 | 100 |
| 5E | MW | 88.3 | 470 | 380 | 344 | 113 | 18 | 100 |
| 5I | MW | 11.8 | 181J | 40.0 | 53.6 | 45.8 | 17 | 100 |
| 5J | MW | 44.6 | 192 | 86.5 | 99 | 48.2 | 14 | 100 |
| 5PZ-1 | PZ | 0.43J | 9.4 | 1.70 | 4.27 | 4.67 | 5 | 80 |
| 5PZ-2 | PZ | 151 | 373J | 270 | 264 | 79.6 | 5 | 100 |
| 5PZ-3 | PZ | 501 | 871 | 764 | 725 | 147 | 6 | 100 |

**TABLE 1-1**
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| Location | Location Type | Minimum Arsenic Concentration (µg/L) | Maximum Arsenic Concentration (µg/L) | Median Arsenic Concentration (µg/L) | Average Arsenic Concentration (µg/L) | Standard Deviation | Number of Samples | Percent Detects |
|---|---|---|---|---|---|---|---|---|
| 5K-S | MW | 1.4 | 7.1 | 5.25 | 4.83 | 2.18 | 6 | 100 |
| 5K-D | MW | 8.2 | 33.8 | 15.2 | 18.1 | 10.7 | 6 | 100 |
| 5L-S | MW | 30.8 | 85.4 | 58.1 | 58.1 | 38.6 | 2 | 100 |
| 5L-D | MW | 21.3 | 30.2 | 25.8 | 25.8 | 6.29 | 2 | 100 |
| 10G | RW | 7.1 | 41.0 | 28.9 | 24.6 | 11.2 | 21 | 100 |
| 10H | RW | 2.5 | 31.7 | 20.4 | 19.0 | 8.85 | 19 | 95 |
| 10I | RW | 377 | 528 | 453 | 453 | 107 | 2 | 100 |
| 10J | RW | 41.9 | 56.8 | 49.0 | 49.1 | 6.9 | 5 | 100 |
| 10N | RW | 28.9 | 54.7 | 41.4 | 41.2 | 8.23 | 12 | 100 |
| Summary | | 0.43J | 910 | 73.0 | 178.0 | 207 | 244 | 99 |
| Downgradient Area | | | | | | | | |
| 12J | SW | 21.9 | 274 | 65.6 | 84.0 | 55.4 | 20 | 100 |
| 19M | SW | 1.8 | 11 | 4.40 | 5.38 | 2.71 | 18 | 100 |
| 11AL | RW | 18.7 | 90 | 33.6 | 37.0 | 13.4 | 22 | 100 |
| 11AS | RW | 2.1 | 270 | 105 | 110 | 61.3 | 16 | 100 |
| 11AT | RW | 0.2J | 1U | 0.20 | 0.24 | 0.12 | 7 | 43 |
| 11AU | RW | 1.4 | 5.7 | 2.85 | 2.98 | 1.02 | 16 | 100 |
| 11AV | RW | 3.5 | 890 | 28.7 | 87.9 | 216 | 16 | 100 |
| 11AY | RW | 0.98J | 1.5 | 1.15 | 1.20 | 0.22 | 4 | 100 |
| 11AZ | RW | 1.4 | 2.4 | 2.20 | 2.05 | 0.45 | 4 | 100 |
| 11A4 | RW | 0.84U | 2.1 | 2.00 | 1.63 | 0.80 | 4 | 75 |
| 11AF | RW | 0.89J | 1.9J | 1.45 | 1.47 | 0.34 | 12 | 100 |
| 11AJ | RW | 0.1J | 1UJ | 0.25 | 0.25 | 0.14 | 9 | 56 |

**TABLE 1-1**
Summary of Arsenic Concentrations Detected in Samples of Groundwater and Surface Water
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| Location | Location Type | Minimum Arsenic Concentration (µg/L) | Maximum Arsenic Concentration (µg/L) | Median Arsenic Concentration (µg/L) | Average Arsenic Concentration (µg/L) | Standard Deviation | Number of Samples | Percent Detects |
|---|---|---|---|---|---|---|---|---|
| 11AK | RW | 1.2 | 1.2 | 1.20 | 1.20 | 0.00 | 2 | 100 |
| 11AM | RW | 0.2U | 2U | 0.37 | 0.46 | 0.29 | 7 | 71 |
| 11AN | RW | 0.2U | 9.8 | 0.50 | 1.32 | 2.99 | 10 | 50 |
| 11AO | RW | 0.28 | 1UJ | 0.37 | 0.36 | 0.10 | 9 | 67 |
| 11AQ | RW | 0.25U | 1U | 0.35 | 0.33 | 0.18 | 5 | 40 |
| 11AX/11AX2 | RW | 0.54UJ | 3.5[a] | 0.60 | 1.22 | 1.22 | 7 | 57 |
| 11A1 | RW | 0.24J | 1U | 0.47 | 0.42 | 0.12 | 4 | 50 |
| Summary | | 0.1J | 890 | 2.90 | 30.6 | 76.8 | 192 | 86 |
| Lost Lake/Deposition Area | | | | | | | | |
| 16B | SW | 4.9 | 120 | 23.6 | 38.7 | 36.3 | 22 | 100 |
| 16C | SW | 11 | 430 | 33.9 | 57.0 | 86.8 | 22 | 100 |
| 19B | SW | 24 | 2200 | 98.5 | 238 | 450 | 22 | 100 |
| 14E | SW | 12.6 | 65.9 | 39.3 | 39.3 | 37.7 | 2 | 100 |
| 13Q | MW | 63.7 | 235 | 113 | 130 | 48.0 | 17 | 100 |
| 13R | MW | 529 | 2270 | 1320 | 1338 | 495 | 18 | 100 |
| 13S | MW | 2 | 6 | 3.70 | 3.92 | 1.05 | 17 | 100 |
| 13T | MW | 35.4 | 104 | 69.7 | 69.7 | 48.5 | 2 | 100 |
| 11AA | RW | 0.09U | 1U | 0.23 | 0.26 | 0.21 | 8 | 25 |
| 11AB | RW | 0.2J | 5U | 0.50 | 0.68 | 0.72 | 9 | 67 |
| 11AC | RW | 0.2U | 0.2U | NA | NA | NA | 2 | 0 |
| 11AD | RW | 0.1U | 0.6 | 0.30 | 0.27 | 0.16 | 9 | 78 |
| 11AE | RW | 0.1U | 1U | NA | NA | NA | 9 | 0 |
| 11AG | RW | 0.1U | 1U | NA | NA | NA | 8 | 0 |

**TABLE 1-1**
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| Location | Location Type | Minimum Arsenic Concentration (µg/L) | Maximum Arsenic Concentration (µg/L) | Median Arsenic Concentration (µg/L) | Average Arsenic Concentration (µg/L) | Standard Deviation | Number of Samples | Percent Detects |
|---|---|---|---|---|---|---|---|---|
| 11AH | RW | 0.1U | 1U | NA | NA | NA | 5 | 0 |
| 11AI | RW | 0.1U | 1U | NA | NA | NA | 9 | 0 |
| 11AP | RW | 0.2U | 5U | 0.28 | 0.64 | 0.87 | 7 | 29 |
| 11A2 | RW | 1U | 1U | NA | NA | NA | 4 | 0 |
| Summary | | 0.09U | 2270 | 15.1 | 177 | 432 | 192 | 73 |

[a]The 16.8 µg/L value from the October 2006 11AX sample is excluded.

Notes:

Results do not include field duplicates or laboratory split samples.

For median, average, and standard deviation calculations, one-half the reporting limit is used for values below the detection limit.

J = estimated value
NA = not applicable
MW = monitoring well
PZ = piezometer
RW = residential well
SW = surface water
U = nondetect at the specified concentration, which is equal to the reporting limit

  - Dissolved arsenic concentrations in samples from Well 5I showed a minor decrease from 2000 through early 2002, with concentrations remaining between 11.7 and 58.5 µg/L over the remaining period of record until the well was abandoned in 2006.

- Mine Area monitoring wells located on the ridges southwest of the waste rock/tailings pile (shallow/deep Well Pairs 5K-S/5K-D and 5L-S/5L-D) – dissolved arsenic concentrations ranged between 1.4 and 85.4 µg/L. Dissolved arsenic concentrations in groundwater from these wells were usually above the MCL, except at Well 5K-S. No discernible steadily increasing or decreasing trend in dissolved arsenic concentrations is apparent in the data from the Mine Area monitoring wells during the period of record, except for Well 5K-D, where arsenic concentrations have consistently declined since well installation in 2005 and dropped below the MCL by March 2007.

- Mine Area residential wells (Wells 10G, 10H, 10I, 10J, and 10N), which are screened in bedrock northwest and west of the waste rock/tailings pile – total arsenic concentrations ranged between 2.5 and 528 µg/L. Total arsenic concentrations in samples from Wells 10G and 10H sometimes fluctuated seasonally (above and below the MCL). Total arsenic concentrations in samples from Wells 10J and 10N fluctuated very little over the period of record. Well 10I has only two recorded sample results from late 1999 (528 µg/L) and early 2000 (377 µg/L); both are significantly above the MCL. Because of the location and depth of this well and the high arsenic concentrations detected, it appears that Well 10I might be partially completed in the mine workings. Well 10I is used for irrigation but not for residential purposes.

In summary, surface water and groundwater arsenic concentrations in the Source Area and Mine Area are typically significantly higher than background concentrations and are usually above the MCL (except at Well 5K-S and Piezometer 5PZ-1). The highest arsenic concentrations (over 100 µg/L) occur in water discharging from the mine adit and in groundwater samples from wells screened within waste rock, tailings, or mine workings. Arsenic concentrations are typically lower (less than 100 µg/L) in wells screened in bedrock on the ridges northwest, west, and southwest of the waste rock/tailings pile. Arsenic concentrations detected in the different geologic units in and below the waste rock/tailings pile (waste rock, tailings, basal gravel, and underlying bedrock) are typically similar.

### 1.5.3 Downgradient Area

Figure 1-6 shows sampling locations and the maximum reported arsenic concentrations detected in groundwater and surface water samples from the Downgradient Area; summary statistics are presented in Table 1-1. Results of chemical analysis for arsenic in samples obtained from the Downgradient Area during the OU-2 RI included the following:

- Surface water in LCC between the mine and Lost Lake, immediately upstream from the confluence with CC (Location 12J) – total arsenic concentrations ranged between 21.9 and 274 µg/L at Location 12J; these concentrations were typically one-half of the total arsenic concentrations in samples of LCC surface water from the base of the former Log Dam and current Rock Buttress (Location 4A/4A2) and all are above the MCL.

- Residential wells along the LCC drainage below the mine and above Greenhorn Road (Wells 11AL, 11AS through 11AV, 11AY, 11AZ, and 11A4) and south of Greenhorn Road and north of Lost Lake (Wells 11AF, 11AJ, 11AK, 11AM through 11AO, 11AQ, 11AX, 11AX2, and 11A1) – total arsenic concentrations ranged between nondetect and 890 µg/L in samples collected from Downgradient Area wells north of Greenhorn Road. Total arsenic concentrations have only been detected up to 9.8 µg/L in samples from wells south of Greenhorn Road. Total arsenic concentrations in Downgradient Area residential wells were below the MCL, except at Wells 11AL, 11AS, and 11AV. Total arsenic concentrations in samples from Downgradient Area wells are consistent over their periods of record (typically with concentrations fluctuating less than an order of magnitude at individual wells), except at Wells 11AS and 11AV. At these wells, total arsenic concentrations detected in samples varied by two orders of magnitude (mostly above the MCL, but a few samples had arsenic concentrations below the MCL). No discernible steadily increasing or decreasing trend in total arsenic concentrations is apparent in the data from Downgradient Area groundwater during the period of record.

- Surface water in LGC downstream from the confluence with CC (Location 19M, approximately 1.5 miles downstream from Lost Lake) – total arsenic concentrations ranged between 1.8 and 11 µg/L in LGC downstream from the confluence with CC below Lost Lake, but generally are below the MCL. Arsenic concentrations detected in LGC at this location have no discernible steadily increasing or decreasing trend in total arsenic concentrations during the period of record.

In summary, the concentrations of arsenic in groundwater samples from the Downgradient Area are typically less than the MCL, except at residential wells AL, AS, and AV, which are located adjacent to the Mine Area.

### 1.5.4 Lost Lake/Deposition Area

Figure 1-7 shows sampling locations and the maximum reported arsenic concentrations detected in groundwater and surface water samples from the Lost Lake/Deposition Area; summary statistics are presented in Table 1-1. Results of chemical analysis for arsenic in samples obtained from the Lost Lake/Deposition Area during the OU-2 RI included the following:

- Surface water in CC, immediately south of the confluence with LCC and immediately north of Lost Lake (Location 14E) – total arsenic concentrations ranged between 12.6 and 65.9 µg/L at Location 14E, all above the MCL. These concentrations are slightly lower than concentrations detected in samples collected in LCC upstream from the confluence with CC (Location 12J).

- Surface water in Lost Lake (Locations 16B and 16C) and at the base of the Lost Lake Dam (Location 19B) – total arsenic concentrations ranged between 4.9 and 2,200 µg/L; most detections were above the MCL. The highest total arsenic concentration (2,200 µg/L at Location 19B) was associated with a dissolved arsenic concentration of only 13 µg/L. This large difference indicates that suspended solids contributed to the elevated total arsenic concentrations (a preliminary USGS investigation of the orange-colored iron bacteria that occur at Location 19B indicated that the bacteria is very high in arsenic and other metals). Seasonal variations occur in Lost Lake water, with concentration peaks in the wet season and concentration lows in the dry season.

- Monitoring wells in the Deposition Area screened within the tailings deposits along CC, immediately upstream from Lost Lake (Wells 13Q and 13R) and in the underlying bedrock (Wells 13S and 13T) – dissolved arsenic concentrations ranged between 2 and 2,270 µg/L in samples from these wells. Arsenic concentrations were above the MCL for all samples from these wells, except in Well 13S (a bedrock well). Dissolved arsenic concentrations within the Deposition Area tailings (Wells 13Q and 13R) remained high (between 63.7 and 2,270 µg/L), particularly in the samples from Well 13R. Dissolved arsenic concentrations in groundwater samples from bedrock Well 13S remained less than the MCL. Samples from the newly installed bedrock well (Well 13T), which is screened at a similar depth as Well 13S, had dissolved arsenic concentrations of 104 µg/L and 35 µg/L when it was sampled in March and June 2007, respectively. Arsenic concentrations in Well 13R appear to be decreasing over time, while the concentrations at Wells 13Q and 13S remain relatively constant. There were insufficient data to determine a trend at Well 13T; however, a significant drop occurred in arsenic concentrations between March and May 2007 at this well. Additional sampling is needed to further evaluate the concentration trend at this well. Significant drops in arsenic concentrations were also detected in other bedrock monitoring wells (e.g., Wells 5I and 5K-D) during their first year of monitoring. This could indicate that arsenic concentrations at new monitoring well installations can take time to equilibrate to natural conditions after drilling.
- Residential wells north, east, and west of Lost Lake (Wells 11AA through 11AE, 11AG through 11AI, 11AP, and 11A2) – total detected arsenic concentrations were less than 1 µg/L in Lost Lake/Deposition Area residential wells. The highest detected arsenic concentration (0.64 µg/L) was in the May 2000 sample from Well 11AA. No discernible steadily increasing or decreasing trend in total arsenic concentrations is discernable at residential wells in the Lost Lake/Deposition Area during the period of record.

In summary, elevated groundwater arsenic concentrations in groundwater samples from the Lost Lake/Deposition Area are limited to monitoring wells within the Deposition Area tailings deposited during the 1997 log dam failure. This includes the surface water in LCC, groundwater within the tailings pile, surface water in Lost Lake, and surface water at the base of the Lost Lake Dam. The seep at the base of Lost Lake Dam will be addressed as part of OU-3. Groundwater from residential wells and the older bedrock monitoring well (Well 13S) had low arsenic concentrations, less than 6 µg/L.

## 1.6 Contaminant Fate and Transport

Past mining activities and the ongoing presence of associated mine waste and tailings have impacted arsenic concentrations in groundwater at the Site and in downstream areas. The following sections summarize information from the RI report (EPA, 2008) regarding the sources, transport, and fate of arsenic in the study area.

### 1.6.1 Sources of Arsenic in Groundwater

Arsenic is often found at varying concentrations in a variety of common rock-forming minerals, but is particularly common in sulfide minerals, including pyrite and arsenopyrite (Smedley and Kinniburgh, 2002), which are found in relative abundance at the Site. The extent of arsenic contamination at mine sites is typically very limited, as geochemical conditions in most aquifers are not conducive to arsenic mobility. However, a small fraction of arsenic that dissolves or desorbs from iron oxides could produce elevated arsenic concentrations in groundwater. Dissolution of iron oxides, which commonly contain both surface-bound (sorbed) and co-precipitated arsenic, or exposure of arsenic-containing sulfide ores to oxygen during mining operations can concentrate arsenic in the dissolved phase (Smedley and Kinniburgh, 2002). Known and suspected sources of arsenic contamination to groundwater at the Lava Cap Mine Site include the following:

- Waste rock and tailings in the Source Area and Lost Lake/Deposition Area. As part of the OU-1 RA, surface water from the mine adit and Rock Buttress drain (if necessary) will be treated, significantly reducing arsenic loading from this source.
- Remaining tailings deposits in LCC, CC, and Lost Lake. Future RAs in OU-3 will likely mitigate adverse impacts of tailings in these areas.
- Subsurface mine workings beneath the Mine Area.
- Naturally occurring arsenic not associated with mining activities (natural ore bodies).

### 1.6.2 Transport of Arsenic Concentrations in Groundwater

Several factors influence migration of arsenic contamination in groundwater. These factors include fracture flow, groundwater use (pumping), potential unmapped subsurface ore bodies containing arsenic, geochemical reactions, adsorption, dilution, and travel times. Groundwater chemical conditions downgradient from the mine generally indicate oxidizing conditions, which favor the less mobile forms of arsenic. The abundance of iron oxide minerals in the aquifer matrix suggests that the aquifer materials have a significant capacity for adsorption of arsenic, limiting its mobility in the aquifer.

Groundwater flowpath analysis using the Lava Cap Mine Groundwater Flow Model indicates that groundwater flowing from the surficial deposits of mine tailings and waste rock is confined to a narrow area within the Source Area, Lost Lake/Deposition Area, LCC, and CC (EPA, 2008). Groundwater in these areas travels toward the creeks and typically discharges to the creeks within a relatively short distance from the Source Area, as shown on Figures 1-8 and 1-9.

Groundwater flowpaths from the deeper mine workings are longer than those from the surficial deposits and shallow mine workings, and some flowpaths might extend as far as LGC. This does not mean that arsenic is present in groundwater along each of these flowpaths; furthermore, it is possible that arsenic concentrations attenuate (decrease) during migration. The model-derived flowpaths from the mine workings and mine-waste are areas shown on Figures 1-8 and 1-9 where arsenic transport in groundwater is possible under certain geochemical conditions. The limited data available for the Site indicate that arsenic has not been detected at elevated concentrations (greater than 10 μg/L) in the bedrock aquifer downgradient from the Mine and Source Areas except at three residential wells (Wells 11AV, 11AS, and 11AL) and three monitoring wells (Wells 5K-D, 5L-S, and 5L-D), all located within 0.5 mile south of the Mine Area. Arsenic is also present in monitoring wells screened in shallow tailings deposits adjacent to CC, LCC, and Lost Lake, but the source of this arsenic is likely the deposits themselves. The apparent limited extent of contamination in the bedrock aquifer suggests that arsenic that is transported in groundwater from the Mine and Source Areas is attenuated to concentrations below the MCL (10 µg/L) by geochemical processes, dilution, and dispersion. However, groundwater movement in the bedrock aquifer at the Site occurs primarily via fracture flow, which is difficult to characterize using available data. It is possible that other flowpaths exist that have not yet been evaluated. Recommendations for additional investigation are provided in Section 1.8 to improve knowledge of groundwater flowpaths and the extent of arsenic contamination at the Site.

Several residential wells in the Mine Area, Downgradient Area, and Lost Lake/Deposition Area are present within the model-derived flowpaths leading from the surficial mine deposits (gold-colored areas on Figure 1-8). Of these wells, only those in the Source Area and Mine Area and 11AL have elevated arsenic concentrations potentially related to releases from surficial mine deposits.

Residential Wells 11AS and 11AV also have elevated arsenic concentrations. Monitoring wells located upgradient from these residential wells and outside of the flowpaths leading from surficial mine deposits have had groundwater samples with arsenic concentrations above the MCL. This indicates that elevated arsenic concentrations in this area might be associated with subsurface and upgradient sources of arsenic other than the surficial mine wastes or adit water. However, given the elevated arsenic concentrations in groundwater at Wells 10G and 1R, which are both proximal to the Source Area, one cannot rule out the possibility that past mining activities are responsible for elevated arsenic concentrations in groundwater upgradient from residential Wells 11AV, 11AS, and 11AL. These contaminated wells are within the potential flowpath area simulated from the shallow mine workings (blue-colored areas on Figure 1-8). The shallow mine workings flowpath area also encompasses several residential wells that do not have elevated arsenic concentrations. The low hydraulic conductivity of the Pms unit is likely associated with longer travel times for potential migration of arsenic-impacted groundwater in this flowpath area.

### 1.6.3 Summary of Conceptual Site Model for Groundwater

By using available data, groundwater flow modeling results, and professional judgment, the following observations were made regarding groundwater flow at the Site. Groundwater north of the Source Area and Mine Area is reportedly perched on the contact between the Tvb and Pms units and discharges to the surface as springs upgradient from the mine. This water eventually discharges to LCC, which flows southward toward the mine. North of the mine, LCC is ephemeral and the water has low arsenic concentrations (less than 1 µg/L). Groundwater samples from Background Area wells that are upgradient from the mine deposits and adit but within the footprint of the mine workings have considerably higher arsenic concentrations (up to 24.2 µg/L) than LCC upstream from the mine.

In the Source Area and Mine Area, elevated arsenic concentrations (up to 910 µg/L) have been detected in the perennial adit discharge and seeps and groundwater in the tailings pile and underlying bedrock. Samples from wells in the Source Area and the adit discharge have a more pronounced sulfate presence than most of the surrounding wells sampled for the RI. This sulfate signature persists in downstream samples from LCC, but does not appear to persist in groundwater away from the mine, suggesting limited mine-related impacts on local groundwater. Groundwater within the tailings pile had a downward hydraulic gradient to the underlying bedrock according to data collected prior to the OU-1 RA. The RA will significantly reduce infiltration into the tailings pile; however, some groundwater will likely continue to flow along the historical LCC drainage, into the northern portion and out from the southern portion of the tailings pile. This will likely result in some leaching of arsenic from the tailings pile. Groundwater discharging from the tailings pile and the underlying Pms unit occurs as dam underflow and drain outflow from the Rock Buttress that feeds LCC. Some groundwater impacted by tailings and waste rock in the Source Area likely continues to flow in the aquifer to the south. This groundwater would be confined within the LCC canyon and eventually discharge into LCC.

LCC south of the Rock Buttress currently collects flow from the LCC diversion around the tailings pile (low arsenic concentration), the adit diversion (high arsenic concentration until the adit discharge treatment is implemented), and water discharged at the base of the Rock Buttress (currently has elevated arsenic concentrations but they will potentially decline over time as conditions continue to stabilize following the OU-1 RA construction). Historically, tailings were transported by LCC from the mine to Lost Lake, which was constructed as a tailings impoundment. Naturally occurring sediments in LCC and CC are sparse; the only areas of significant sedimentation are in deposition areas upstream from Lost Lake that are dominated by tailings carried downstream during past releases from the Source Area.

The OU-1 RA removed tailings in LCC south of the Rock Buttress and north of Greenhorn Road. LCC and CC have gaining and losing reaches upstream from Lost Lake, but the relationship between surface water in these creeks and the Pms unit groundwater is less certain because of the lack of groundwater elevation and land-surface elevation data or surface water flow volume and mass flux changes at regular intervals. Groundwater flow model results indicate that approximately 0.05 $ft^3$/sec (22 gallons per minute) of baseflow enters LCC between the Rock Buttress and the Deposition Area. However, because of uncertainties in the groundwater model, this number could be considerably different. Arsenic concentrations in LCC currently decrease by about one-half between the Rock Buttress and CC in summer. Arsenic in surface water is diluted south of the confluence of LCC and CC according to sampling results. In the Lost Lake/Deposition Area, the initial water elevation data indicate that CC seasonally alternates as a gaining and losing stream at this location. The OU-3 FS will address potential surface water contamination in LCC and CC downstream from Greenhorn Road.

The large tailings deposit in the Lost Lake/Deposition Area contains impacted groundwater. Elevated dissolved arsenic concentrations are consistently detected in groundwater samples from wells screened within the Deposition Area tailings (up to 2,270 μg/L). The vertical hydraulic gradient is typically downward from the tailings to the bedrock. The low dissolved arsenic concentrations in bedrock suggest that overlying groundwater in the tailings does not significantly impact the underlying bedrock (Pms unit) water quality. However, additional monitoring of the newer bedrock monitoring well (Well 13T) is needed to verify this conclusion. The groundwater flow model indicates that groundwater in this area discharges to Lost Lake or to LGC, south of Lost Lake.

Groundwater flowing from northwest of Lost Lake likely discharges to Lost Lake at its northwestern shoreline, and a small amount of water seeps under the dam along its southeastern shoreline. Total arsenic concentrations in Lost Lake range from 4.9 to 430 μg/L. Although some tailings deposits have been observed in CC and LGC south of Lost Lake, surface water in LGC 1.5 miles downgradient from Lost Lake has relatively low arsenic concentrations (1.8 to 11 µg/L, with a median of 4.4 µg/L). Mine-impacted groundwater is predicted to discharge to LGC. Mine-impacted groundwater from the Lost Lake/Deposition Area has not caused any residential wells in this area to exceed the MCL for arsenic. Surface water in the vicinity of Lost Lake will be addressed as part of OU-3.

## 1.7 Risk Assessment

The baseline human health and ecological risk assessments were prepared for the entire Site, including the mine area and downgradient areas. The baseline human health and ecological risk assessments (Appendices E and F, respectively, in the Lava Cap Mine RI Report [EPA, 2001]) indicate that many areas at and downgradient from the mine pose a significant potential risk to human and ecological receptors. These areas have been impacted by mine-related contamination and contain elevated levels of inorganic constituents, particularly arsenic. Groundwater at the Site is not considered to have a complete pathway for ecological exposure, except for potential discharges to creeks and as springs. The ecological risks from these surface water expressions will be evaluated as part of the OU-3 FS work.

The human health risk assessment (HHRA) (EPA, 2001) concluded that arsenic is the primary risk driver in impacted areas and is the only constituent that contributes significantly to the estimated risks. The HHRA evaluated potential risks to mine workers, mine residents, residents/recreational users along LCC below the mine, residents and recreational users around Lost Lake, recreational users of the Deposition Area, and recreational users of CC below Lost Lake. In the HHRA, six exposure units at the mine and in downgradient areas were identified for estimating potential risks:

- **Exposure Unit 1 –** a mine worker scenario with exposure through incidental soil ingestion, dermal contact with soil, and inhalation of particulate matter in fugitive dust.
- **Exposure Unit 2 –** residents near Lost Lake, including those who use Lost Lake for recreation.
- **Exposure Unit 3 –** residents at Lava Cap Mine.
- **Exposure Unit 4 –** residents living along LCC, below Lava Cap Mine and above the Deposition Area who use LCC for recreation.
- **Exposure Unit 5 –** recreational users in the Deposition Area, above Lost Lake.
- **Exposure Unit 6 –** two recreational exposure scenarios along CC below Lost Lake. The first set of recreational users (Recreational Scenario I) consists of infant through adult receptors. The second set of recreational users (Recreational Scenario II) consists of school-age children through adult users of the area.

Risks posed by contaminated groundwater were evaluated for Exposure Units 2, 3, and 4. Exposure to contaminated groundwater is not expected to occur in Exposure Units 1, 5, and 6. The results of the baseline risk assessment for these three exposure units indicate that potential cancer risks for current or future hypothetical receptors exceed EPA's risk management range of $10^{-6}$ to $10^{-4}$ in Exposure Unit 4 (only for the high arsenic well dataset) and Exposure Unit 3. The total estimated cancer risk in Exposure Unit 3 was $5.8 \times 10^{-3}$, and in Exposure Unit 4 it was 1.6 x $10^{-3}$. The groundwater component (primarily driven by ingestion of groundwater) of these total estimated cancer risks was 1.3 x $10^{-3}$ in Exposure Unit 3 and 1.1 x $10^{-3}$ in Exposure Unit 4. Note that these risk assessments assume long-term exposure to untreated, arsenic-contaminated groundwater from impacted residential wells. These risks are referred to as an excess lifetime cancer risk (ELCR) because they would be in addition to the risks of cancer individuals face from other causes. Noncancer risks are evaluated using the hazard index (HI). Hazard index values greater than 1 indicate that site-related exposures might present a risk to human health. The HI estimates for all exposure units were greater than 1 (HI estimates ranged from 1.6 to 91) and nearly all exceeded their respective background HI estimates. The HI values specifically related to groundwater exposure in Exposure Units 2, 3, and 4 ranged from 3 to 7. The risk driver for both cancer and noncancer estimates was arsenic.

An update to the HHRA was presented in the RI report (EPA, 2008). As previously mentioned, the baseline risk assessment had already established that arsenic-contaminated groundwater at the Site represented a significant risk to receptors. Accordingly, the HHRA update focused solely on summarizing arsenic MCL exceedances detected in residential wells at the Site using the entire dataset from 1999 through 2007. Several additional residential wells had been sampled near the site since the original HHRA was completed in 2001.

None of the groundwater samples from residential wells in the Background Area and the Lost Lake/Deposition Area exceed the MCL for arsenic. Three residential wells (Wells 11AL, 11AS, and 11AV) in the Downgradient Area (along LCC, below the mine and above Greenhorn Road) had many exceedances of the arsenic MCL. At Well 11AL, all 22 samples exceeded the MCL; the maximum detected concentration was 90 µg/L. At Well 11AS, 15 of the 16 samples collected exceeded the MCL; the maximum detected concentration was 270 µg/L. At Well 11AV, 13 of the 16 samples collected exceeded the MCL; the maximum detected concentration was 890 µg/L.

All of the residential wells in the Source Area and Mine Area (Wells 10G, 10H, 10I, 10J, and 10N) had exceedances of the MCL. At Well 10G, 19 of the 21 samples collected exceeded the MCL; the maximum detected concentration was 41 µg/L. At Well 10H, 15 of the 19 samples collected exceeded the MCL; the maximum detected concentration was 31.7 µg/L. At Wells 10I, 10J, and 10N, all samples (2, 5, and 12, respectively) exceeded the MCL; the maximum detected concentrations at these wells were 528, 56.8, and 54.7 µg/L, respectively.

## 1.8 Recommendations for Additional Investigation

The OU-2 RI Report (EPA, 2008) contains several recommendations for additional data collection that attempt to balance Site access difficulties, cost, and value for reducing uncertainty in future groundwater evaluations. EPA anticipates implementing these recommended additional data collection activities concurrently with the remedial design phase of the selected drinking water remedy. High priority recommendations include the following:

- Continue routine monitoring of all active residential wells that exceed the arsenic MCL (Wells 10G, 10H, 10N, 11AL, 11AS, and 11AV).

- Continue semiannual monitoring and maintenance of existing EPA-maintained residential wellhead treatment systems.
- Install stream weirs at (1) Location 12J on LCC, immediately upstream from the confluence with CC, (2) Location 19A, upstream from LGC, and (3) LGC, where it exits the watershed. Stream discharge measurements from these weirs would provide insights into the groundwater/surface-water interactions and water budget calculations for the watershed. These data would also provide additional constraints on aquifer property estimates for the Pms unit and improve the CSM and predictive capabilities of the Lava Cap Mine Groundwater Flow Model. Surface water samples should be collected at least quarterly from the new weir locations and from stream gauge Location 12B; the samples should be analyzed for total and dissolved arsenic for use in the mass load calculations.
- Collect at least two additional groundwater samples for dissolved arsenic from Well 13T to determine if the arsenic concentration in this well will stabilize below the MCL.
- Collect a surface water sample for total arsenic analysis from LGC, within the area projected to potentially have mine-impacted groundwater discharge (near elevation 2,350 feet msl). The travel times from the mine area to this LGC discharge location are likely extremely long (i.e., many hundreds of years).
- Continue bimonthly water level measurements through December 2008 in Site monitoring wells, piezometers, and staff gauges.
- Continue stream discharge monitoring through December 2008 to complete an annual cycle and to validate and correct existing streamflow data.

The following are lower priority recommendations:

- Resample the wells sampled in October 2006 for arsenic speciation to evaluate whether arsenic speciation trends are a result of field or laboratory quality control problems, seasonal fluctuations, or a combination of both.
- Install new monitoring wells in the Source Area to help evaluate how groundwater elevations and arsenic concentrations have changed as a result of the OU-1 RA.
- Perform depth-discrete groundwater sampling in Well 5L-D to determine the depth of the greatest arsenic concentrations. This information could aid in the placement of new monitoring wells as part of the OU-2 FS.
- Collect surface water samples from tributaries upstream from Lost Lake, LGC upstream from the confluence of CC, and LGC to verify the assumption of low arsenic concentrations in these waters.
- Perform a reach-specific stream discharge analysis in LCC between the Rock Buttress and Lost Lake (collect accurate stream discharge measurements with a current meter in LCC at several distances from the Rock Buttress). This should include sampling and analysis for total and dissolved arsenic in surface water at each discharge measurement location to help evaluate arsenic concentrations and groundwater/surface water interactions along LCC.

- Incorporate any new information into the Lava Cap Mine Groundwater Flow Model.

Incorporate any new information into the Lava Cap Mine groundwater flow model. In addition to the ongoing and recommended investigation and evaluation efforts previously listed, a significant expansion of the Site monitoring well network is proposed under most of the remedial alternatives developed for this FS. Proposed locations for monitoring wells and frequencies for sampling are described in Section 4.

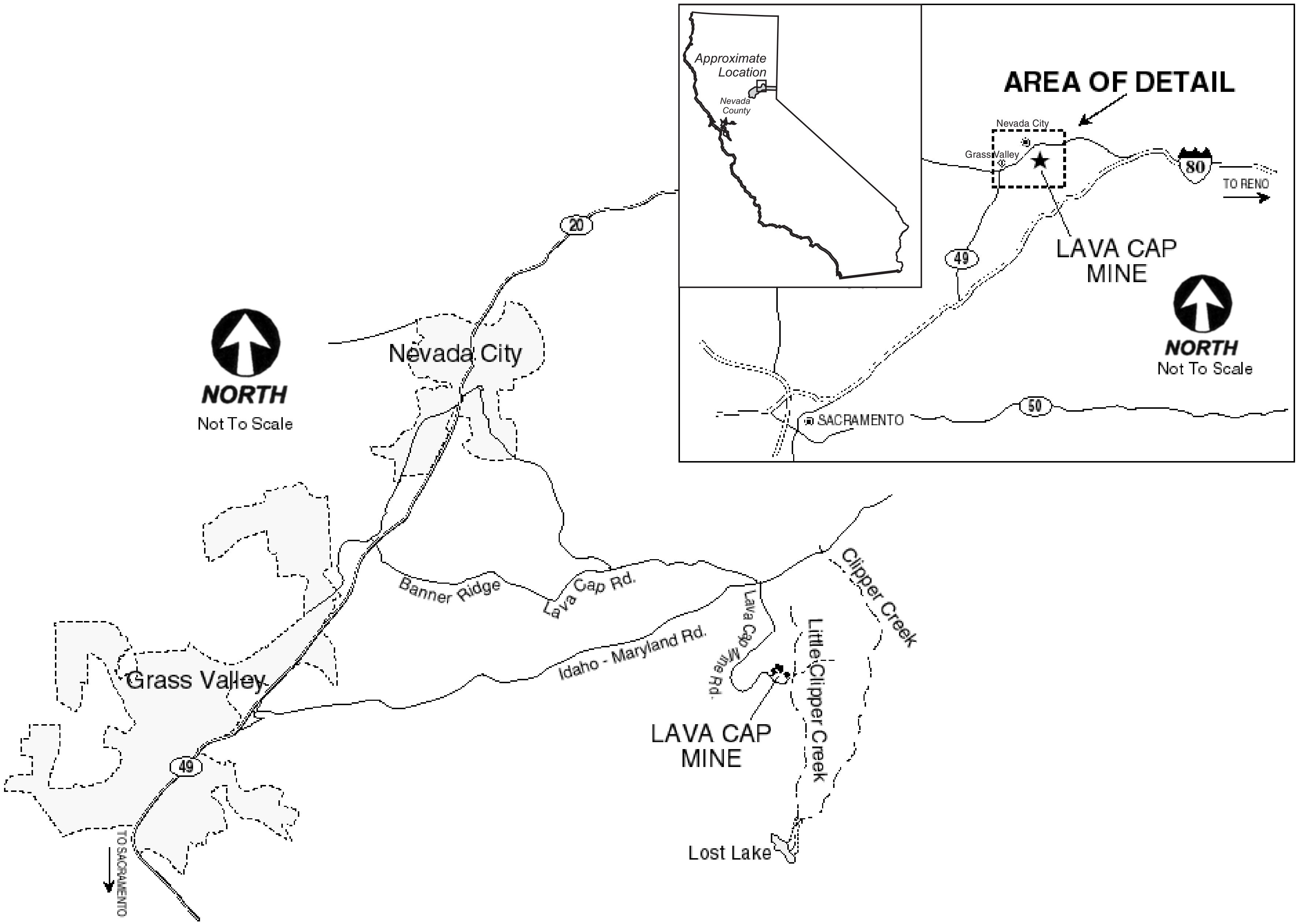


**FIGURE 1-1**
**LOCATION OF LAVA CAP MINE SITE**
OPERABLE UNIT 2 FEASIBILITY STUDY REPORT
LAVA CAP MINE

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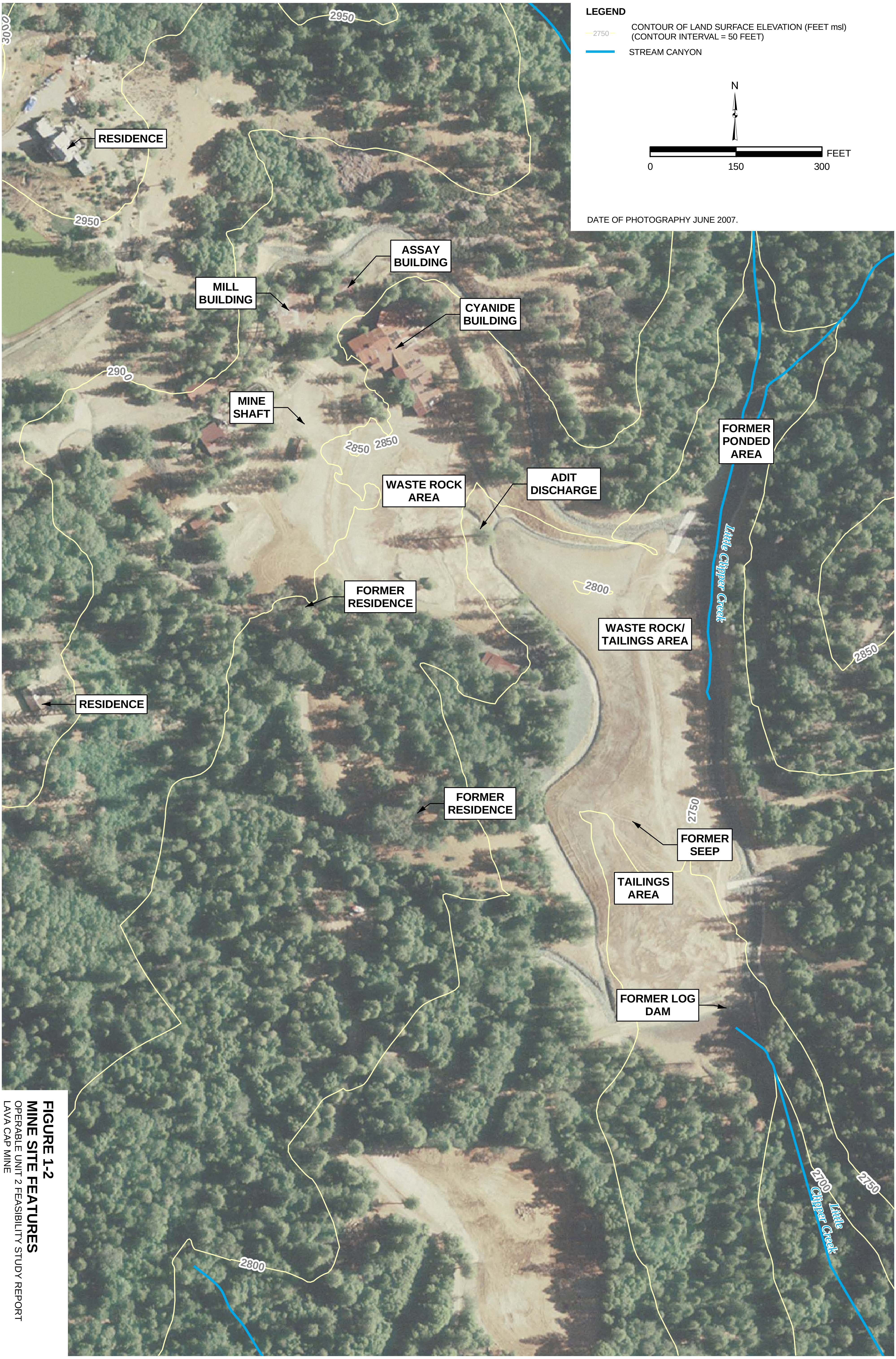


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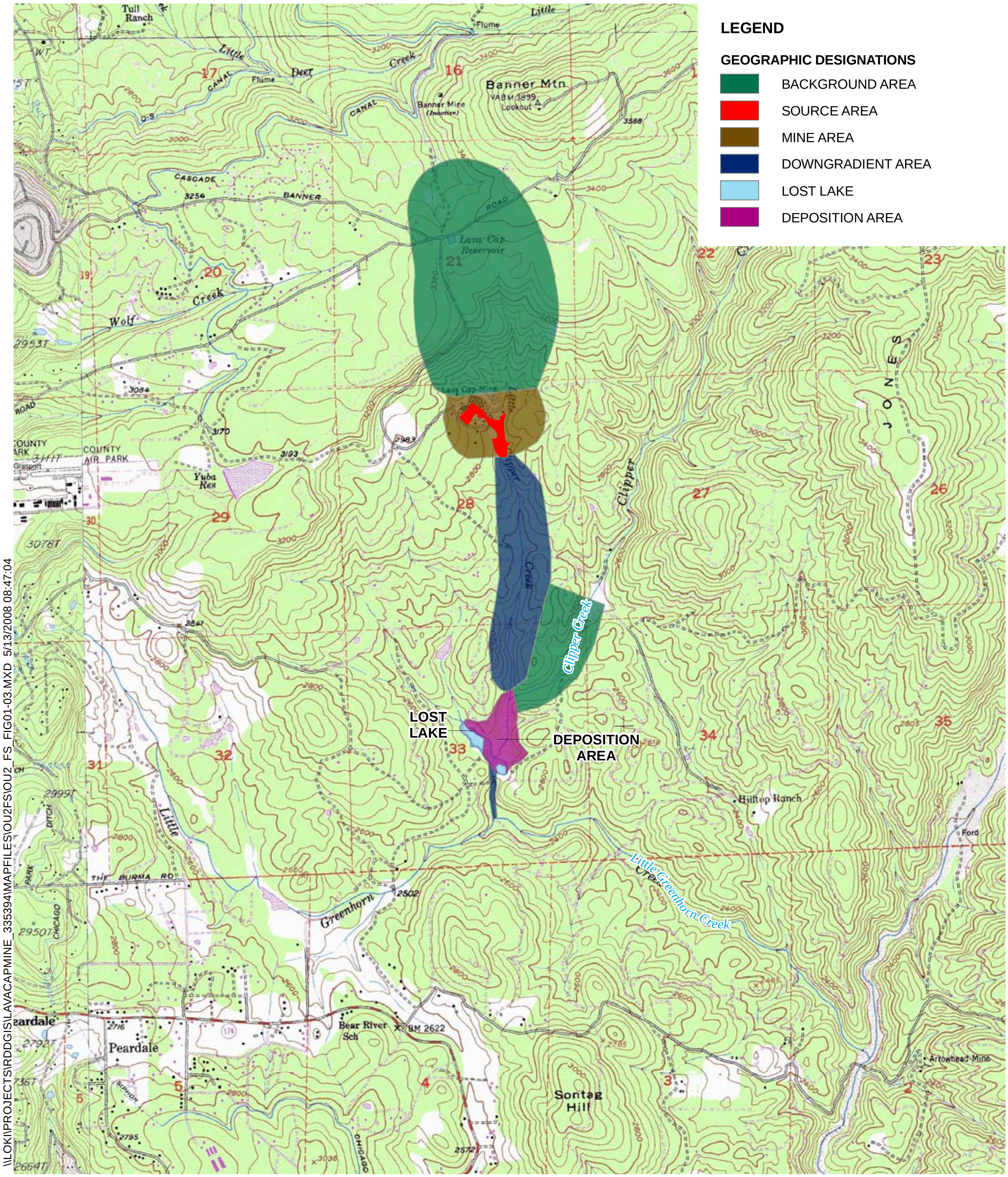
**FIGURE 1-2**
**MINE SITE FEATURES**
OPERABLE UNIT 2 FEASIBILITY STUDY REPORT
LAVA CAP MINE



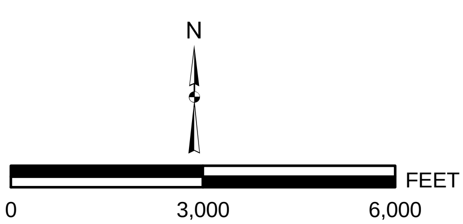




**FIGURE 1-3**
**GEOGRAPHIC DESIGNATIONS IN THE LAVA CAP MINE AREA**
OPERABLE UNIT 2 FEASIBILITY STUDY REPORT
LAVA CAP MINE

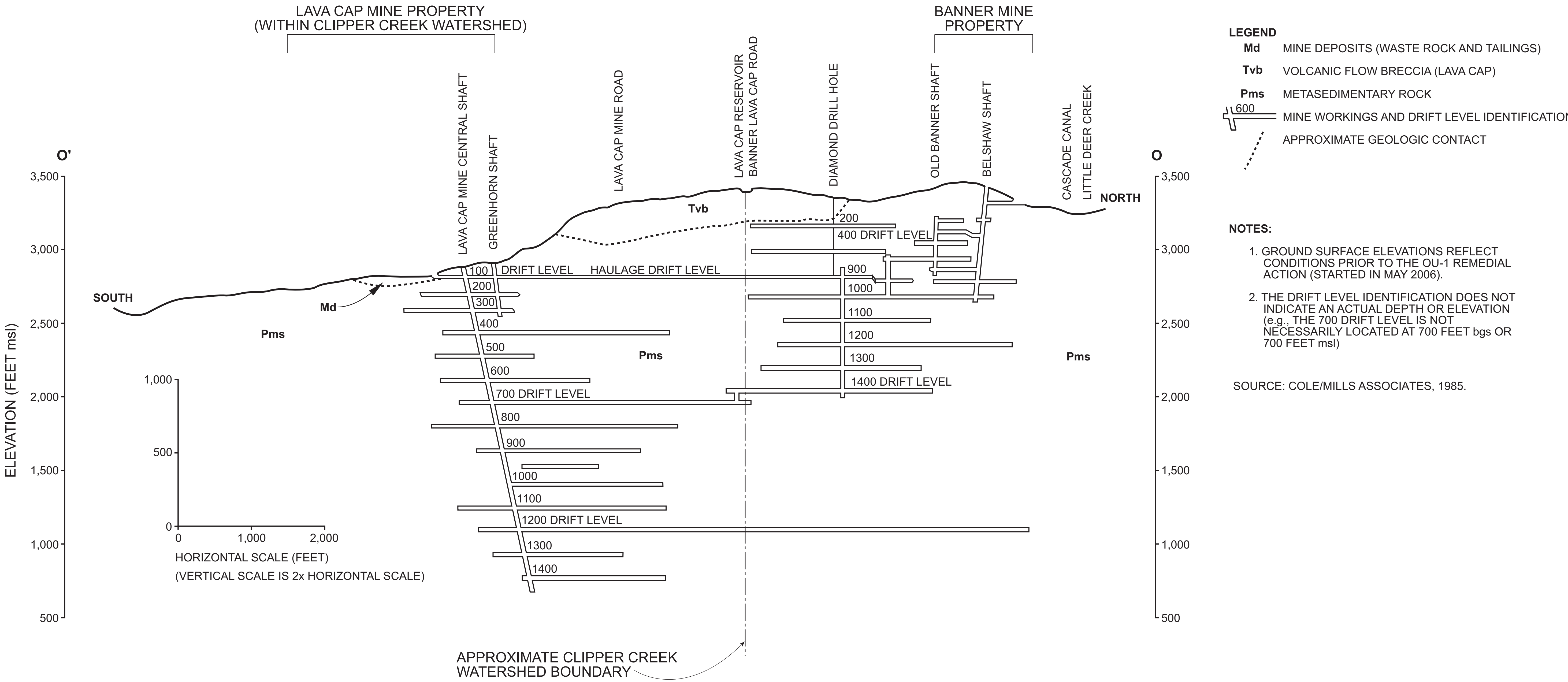



**FIGURE 1-4**
**SCHEMATIC PROFILE OF SUBSURFACE MINE WORKINGS**
OPERABLE UNIT 2 FEASIBILITY STUDY REPORT
LAVA CAP MINE

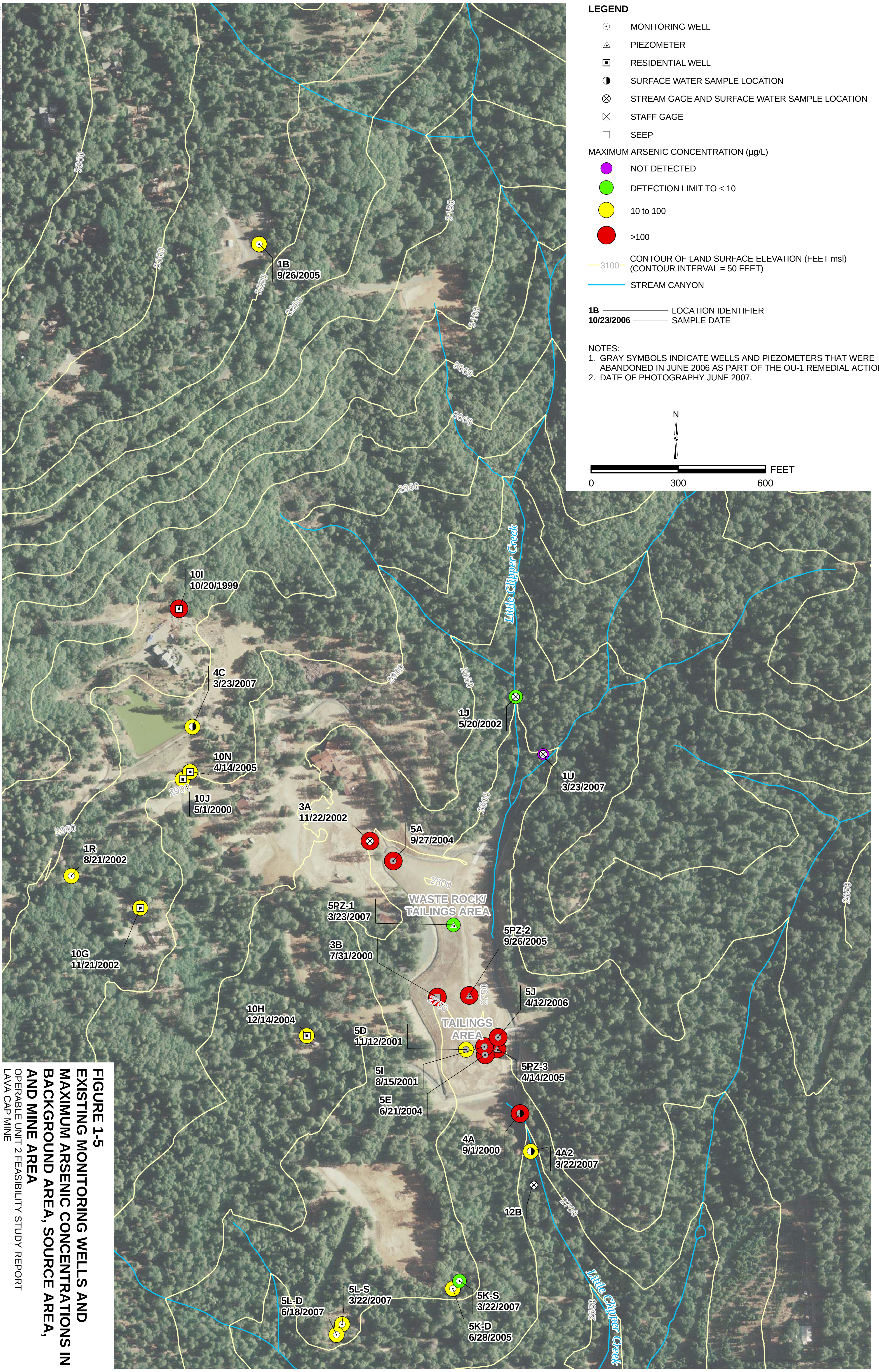
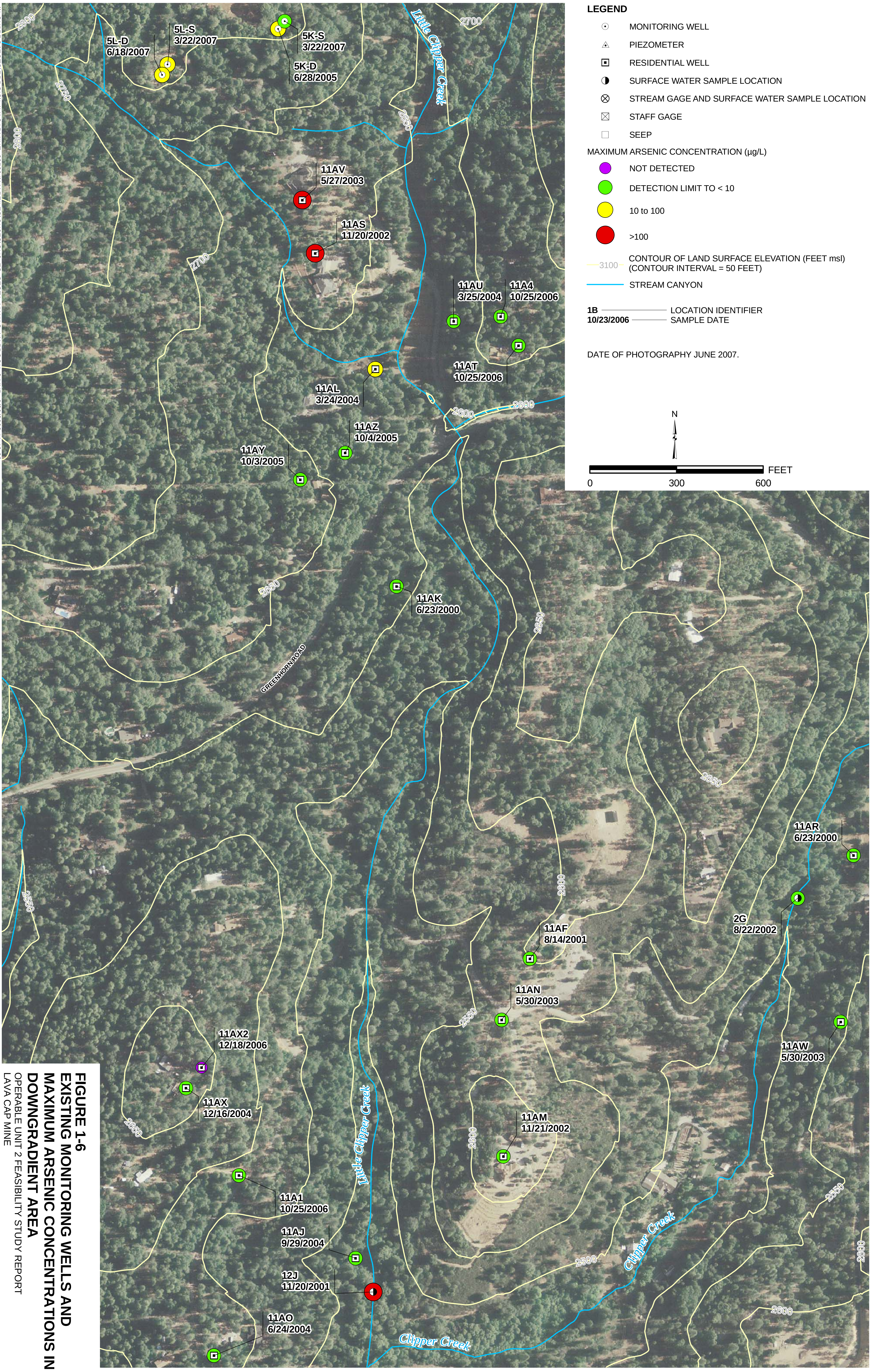



**FIGURE 1-5**
**EXISTING MONITORING WELLS AND MAXIMUM ARSENIC CONCENTRATIONS IN BACKGROUND AREA, SOURCE AREA, AND MINE AREA**
OPERABLE UNIT 2 FEASIBILITY STUDY REPORT
LAVA CAP MINE




**LEGEND**

- MONITORING WELL
- PIEZOMETER
- RESIDENTIAL WELL
- SURFACE WATER SAMPLE LOCATION
- STREAM GAGE AND SURFACE WATER SAMPLE LOCATION
- STAFF GAGE
- SEEP

MAXIMUM ARSENIC CONCENTRATION (µg/L)

- NOT DETECTED
- DETECTION LIMIT TO < 10
- 10 to 100
- >100

3100 CONTOUR OF LAND SURFACE ELEVATION (FEET msl) (CONTOUR INTERVAL = 50 FEET)

STREAM CANYON

1B — LOCATION IDENTIFIER
10/23/2006 — SAMPLE DATE

DATE OF PHOTOGRAPHY JUNE 2007.

N

0 300 600 FEET

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**FIGURE 1-6**
**EXISTING MONITORING WELLS AND MAXIMUM ARSENIC CONCENTRATIONS IN DOWNGRADIENT AREA**
OPERABLE UNIT 2 FEASIBILITY STUDY REPORT
LAVA CAP MINE

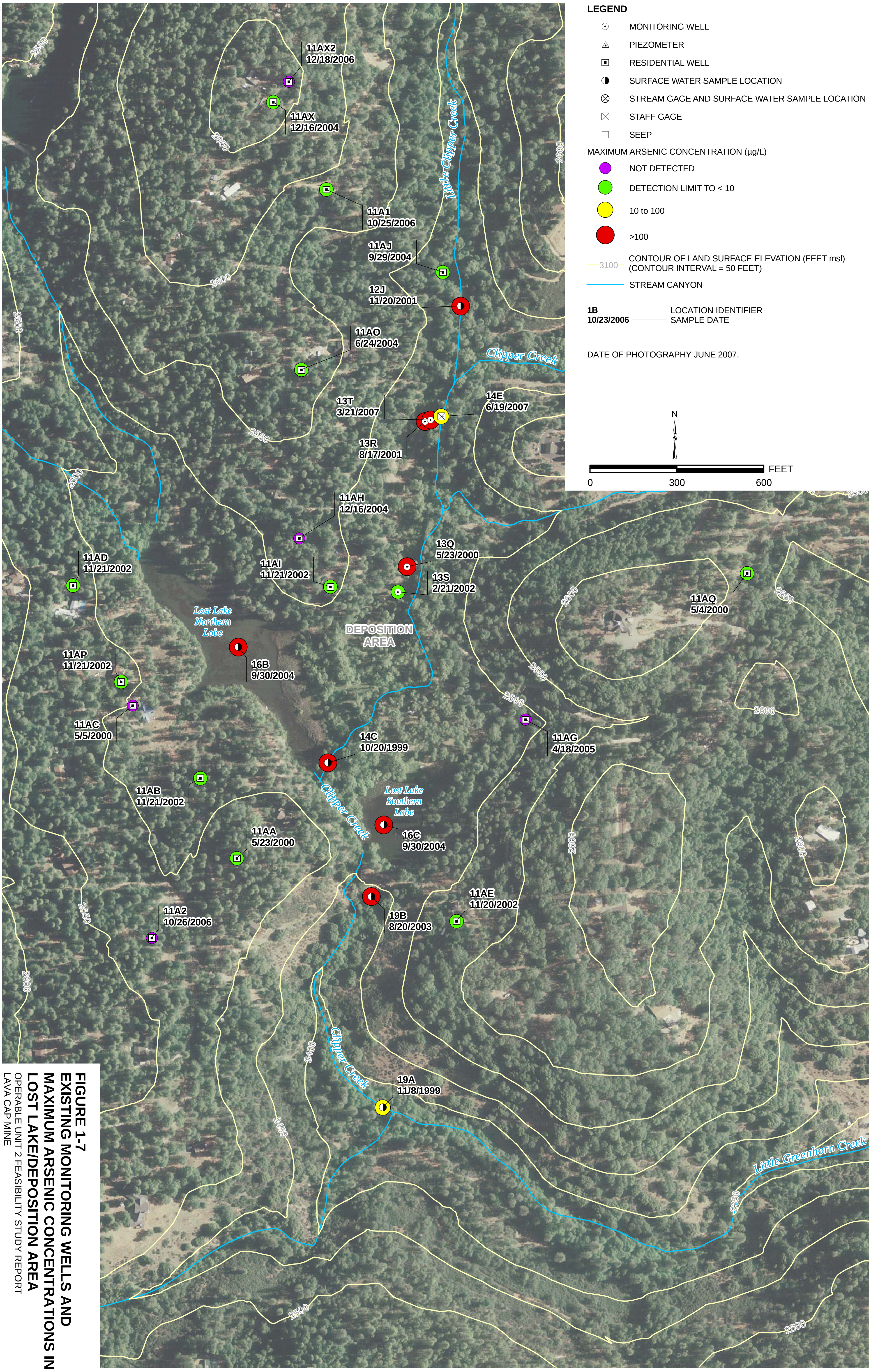


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**FIGURE 1-7**
**EXISTING MONITORING WELLS AND MAXIMUM ARSENIC CONCENTRATIONS IN LOST LAKE/DEPOSITION AREA**
OPERABLE UNIT 2 FEASIBILITY STUDY REPORT
LAVA CAP MINE

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**LEGEND**

- MONITORING WELL
- PIEZOMETER
- RESIDENTIAL WELL
- SURFACE WATER SAMPLE LOCATION
- STREAM GAGE AND SURFACE WATER SAMPLE LOCATION
- STAFF GAGE
- SEEP
- ESTIMATED PROJECTION OF SUBSURFACE MINE WORKINGS
- STREAM CANYON
- PARCELS
- ESTIMATED AREA OF GROUNDWATER FLOW FROM MINE WASTE AREAS (FLOWPATH SET 1)
- ESTIMATED AREA OF GROUNDWATER FLOW FROM MINE WORKINGS OF THE 600 DRIFT LEVEL AND ABOVE (FLOWPATH SET 2)

NOTES:

1. FLOWPATH SET 1 AREA DERIVED BY STARTING PARTICLES AT THE SIMULATED WATER TABLE BENEATH SURFICIAL AREAS WITH MINE WASTES AND TRACKING THEM DOWNGRADIENT.
2. FLOWPATH SET 2 AREA DERIVED BY STARTING PARTICLES AT THE ESTIMATED DEPTHS OF MINE WORKINGS OF THE 600 DRIFT LEVEL AND ABOVE AND TRACKING THEM DOWNGRADIENT.
3. SEE FIGURE 1-4 FOR SCHEMATIC PROFILE OF MINE WORKINGS.
4. DATE OF PHOTOGRAPHY JUNE 2007.

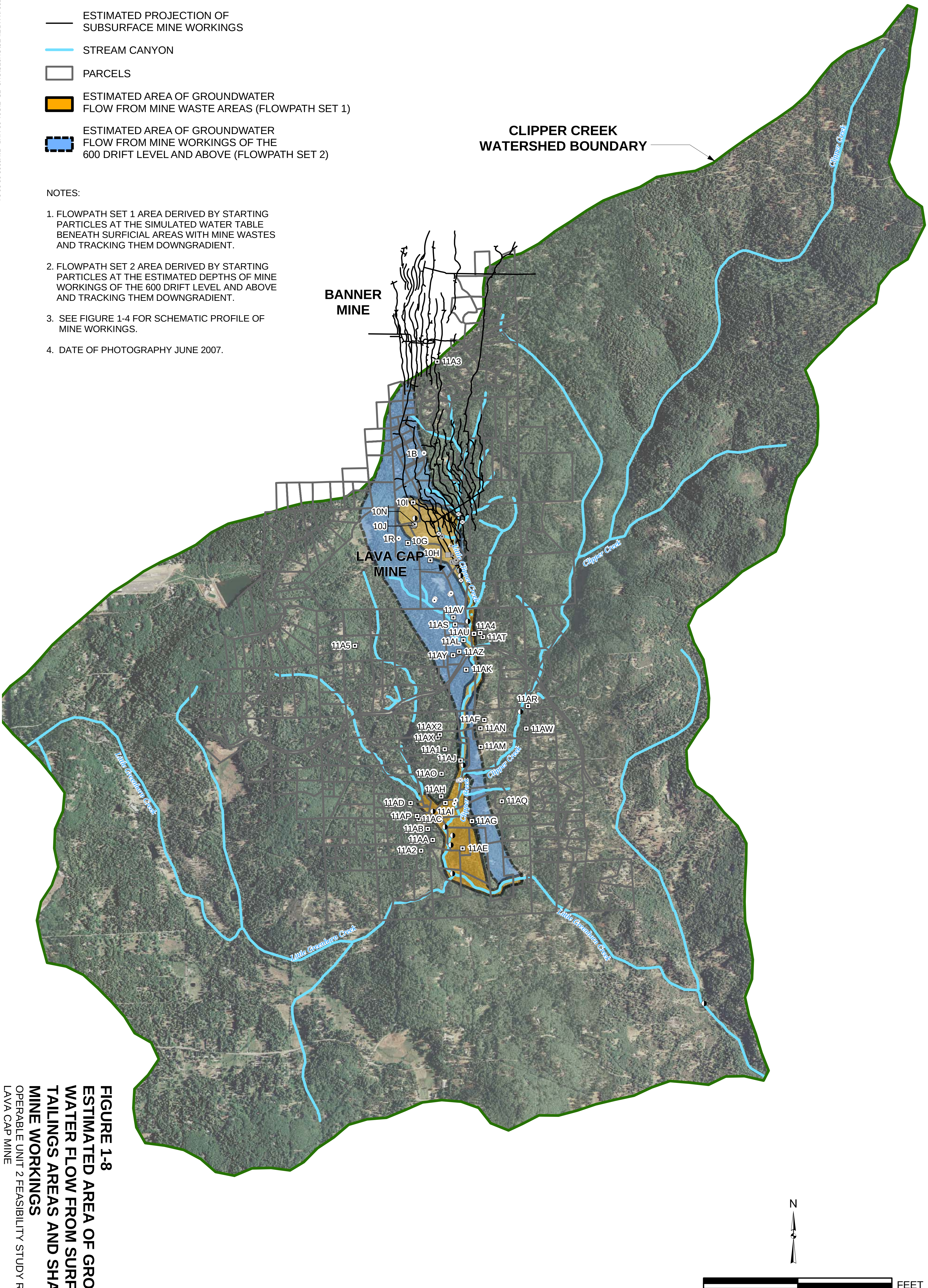


**FIGURE 1-8**
**ESTIMATED AREA OF GROUND-WATER FLOW FROM SURFICIAL TAILINGS AREAS AND SHALLOW MINE WORKINGS**
OPERABLE UNIT 2 FEASIBILITY STUDY REPORT
LAVA CAP MINE

**LEGEND**

- MONITORING WELL
- PIEZOMETER
- RESIDENTIAL WELL
- SURFACE WATER SAMPLE LOCATION
- STREAM GAGE AND SURFACE WATER SAMPLE LOCATION
- STAFF GAGE
- SEEP
- ESTIMATED PROJECTION OF SUBSURFACE MINE WORKINGS
- STREAM CANYON
- PARCELS
- ESTIMATED AREA OF GROUNDWATER FLOW FROM MINE WORKINGS OF THE 700 DRIFT LEVEL AND BELOW (FLOWPATH SET 3)

NOTES:

1. FLOWPATH SET 3 AREA DERIVED BY STARTING PARTICLES AT THE ESTIMATED DEPTHS OF MINE WORKINGS OF THE 700 DRIFT LEVEL AND BELOW AND TRACKING THEM DOWNGRADIENT.
2. SEE FIGURE 1-4 FOR SCHEMATIC PROFILE OF MINE WORKINGS.
3. DATE OF PHOTOGRAPHY JUNE 2007.

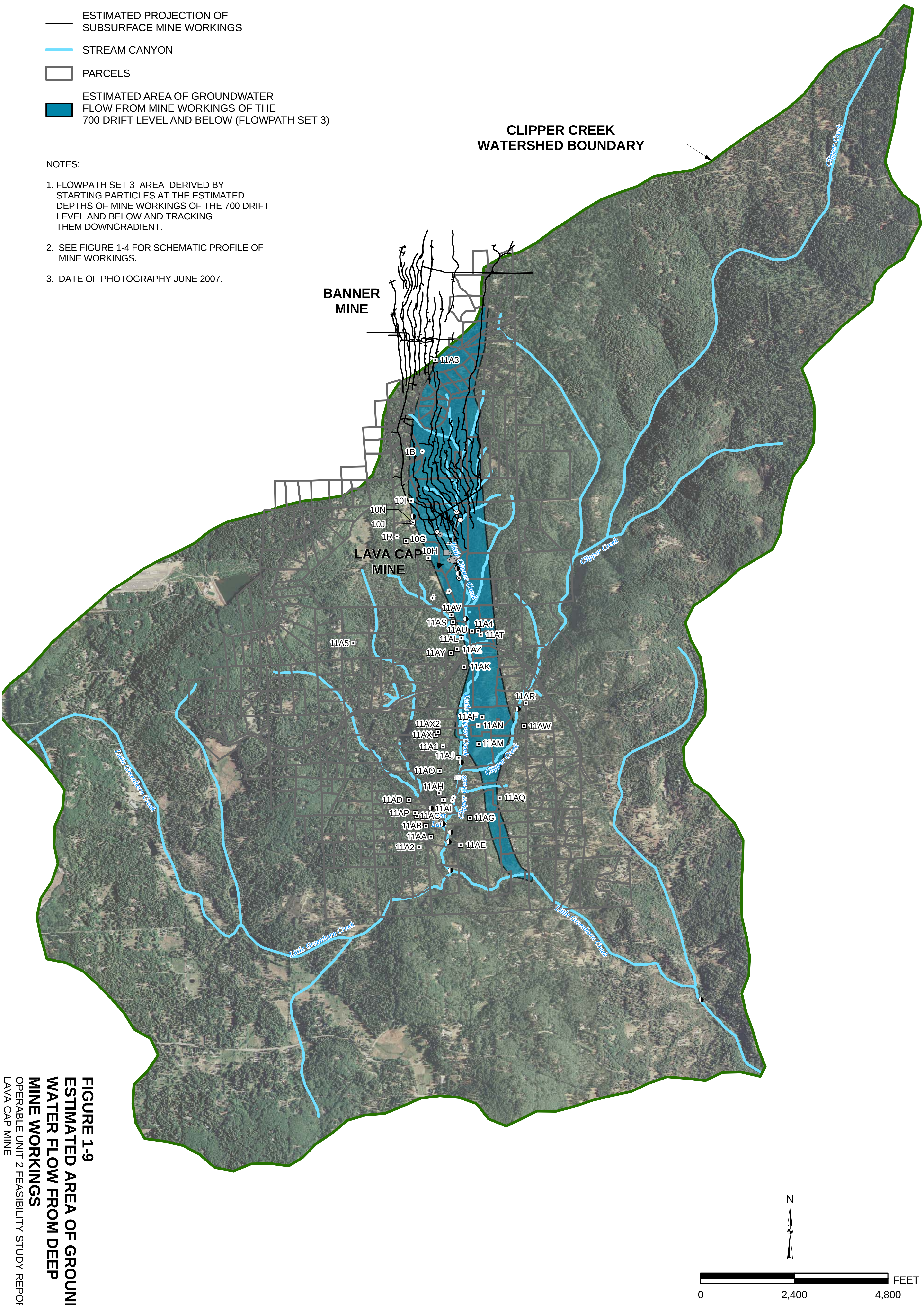


**FIGURE 1-9**
**ESTIMATED AREA OF GROUND-WATER FLOW FROM DEEP MINE WORKINGS**
OPERABLE UNIT 2 FEASIBILITY STUDY REPORT
LAVA CAP MINE

SECTION 2

# Development of Preliminary Cleanup Goals

This section describes the development of preliminary cleanup goals for arsenic-contaminated groundwater at the Site. Preliminary cleanup goals establish a basis for the remedial alternatives and are developed based on the RAOs and ARARs. Preliminary cleanup goals are generally set at the lowest of the following values:

- Numerical cleanup criteria established by the ARARs
- Levels determined to be protective of human health
- Levels determined to be protective of ecological receptors

## 2.1 Remedial Action Objectives

RAOs are statements defining the extent that Site cleanup is required to protect human health and the environment. They take into consideration the COCs, routes of exposure and receptors, and acceptable contaminant concentrations for each impacted media at the Site. Preliminary RAOs for the Site are presented in the following sections. They are listed in order from those generally applicable to all CERCLA sites to those more specific to the Site.

### 2.1.1 General Remedial Action Objectives

Generally applicable RAOs include the following:

- Protect human health and the environment by reducing the potential for exposure to contaminants
- Expedite site cleanup and restoration
- Use permanent solutions to the maximum extent possible
- Consider innovative technologies to reduce the duration and cost of RAs
- Use solutions that support existing and proposed land uses
- Achieve compliance with ARARs
- Be compatible with other actions
- Be flexible to respond to reuse priorities and changes in reuse priorities

### 2.1.2 Specific Remedial Action Objectives

Specific RAOs developed for OU-2 of the Lava Cap Mine include the following:

- Protect against exposure to groundwater contaminated with mine-related arsenic that presents an unacceptable risk to human health. According to the OU-2 RI, arsenic is the risk driver at the Site. In general, EPA uses the arsenic MCL (10 µg/L) as the cleanup goal that is protective of human health and of the environment and preserves the beneficial use of the aquifer as a drinking water supply. This is considered an immediate objective, which is possible to achieve using a variety of readily implementable technical approaches. This remedial objective is the primary focus of this FS and is the principal driver for development of the remedial alternatives described in Section 4.

The following RAOs will be addressed in a subsequent FS addendum for OU-2. The addendum would be followed by a final OU-2 ROD.

- To the extent technically and economically feasible, limit the potential migration of mine-impacted groundwater that poses a threat to beneficial uses of groundwater or surface water. At present, this RAO is considered a longer-term objective to be evaluated as more data become available during the next several years. Arsenic concentrations at the Site generally appear to be stable, suggesting that high concentrations of arsenic in groundwater are not migrating in a downgradient (southward) direction. However, the period of data availability is limited and data gaps exist in the monitoring network, particularly as they relate to potential deeper, long-term migration pathways. To determine whether additional RAs are necessary to achieve this RAO, supplemental RI activities are planned (see Section 1.8), including installation of additional groundwater monitoring wells. Because the applicability of this RAO is uncertain at this time, and the risks resulting from further contaminant migration would not be immediate and could potentially be mitigated with other measures, this RAO will be addressed in a future FS addendum.
- To the extent technically and economically feasible, limit discharge of mine-impacted groundwater at concentrations that cause streams to exceed the preliminary cleanup goal for arsenic. As noted in Section 1, the contribution of arsenic from groundwater discharges to surface water is estimated to be much smaller than existing loading of arsenic to these surface water bodies resulting from other sources in OU-1 and OU-3. Known risks associated with surface waters at the Site are (or will be) addressed by the ongoing RAs in OU-1 and upcoming feasibility study and remedy implementation in OU-3. Potential future risks from groundwater discharges to surface water will be evaluated as RA work progresses in OU-1 and OU-3. A future FS addendum will address groundwater discharges to surface water. Recommendations to further investigate groundwater contributions to surface water and associated arsenic loading are provided in Section 1.8.

## 2.2 Applicable or Relevant and Appropriate Requirements

Section 121(d) of CERCLA, 42 United States Code (USC) § 9621(d) requires that RAs at CERCLA sites attain (or justify the waiver of) any federal or state environmental standards, requirements, criteria, or limitations that are determined to be legally applicable or relevant and appropriate requirements (ARAR). Federal ARARs may include requirements promulgated under any federal environmental laws. State ARARs may only include promulgated, enforceable environmental or facility-siting laws of general application that are more stringent or broader in scope than federal requirements and that are identified by the state in a timely manner.

An ARAR may be either "applicable," or "relevant and appropriate," but not both. If there is no specific federal or state ARAR for a particular chemical or RA, or if the existing ARARs are not considered sufficiently protective, then other guidance or criteria to be considered (TBC) may be identified and used to ensure the protection of public health and the environment. The NCP, 40 CFR Part 300, defines "applicable," "relevant and appropriate," and "TBC" as follows:

- **Applicable requirements** are those cleanup standards, standards of control, or other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, RA, location, or other circumstances found at a CERCLA site. Only those state standards that are identified by a state in a timely manner and that are more stringent than federal requirements may be applicable.
- **Relevant and appropriate requirements** are those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that, while not "applicable" to a hazardous substance, pollutant, contaminant, RA, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site. Only those state standards that are identified in a timely manner and that are more stringent than federal requirements may be relevant and appropriate.
- **TBCs** consist of advisories, criteria, or guidance that EPA, other federal agencies, or states developed that may be useful in developing CERCLA remedies. The TBC values and guidelines may be used as EPA deems appropriate. Once a TBC is adopted, it becomes an enforceable requirement.

ARARs are identified on a site-specific basis from information about the chemicals at the site, the RAs contemplated, the physical characteristics of the site, and other appropriate factors. ARARs include only substantive, not administrative, requirements and pertain only to onsite activities. Section 121(e) of CERCLA, USC 9621(e), states that no federal, state, or local permit is required for RAs conducted entirely onsite. Offsite activities, however, must comply with all applicable federal, state, and local laws, including both substantive and administrative requirements, that are in effect when the activity takes place. There are three general categories of ARARs:

- **Chemical-specific ARARs** are health- or risk-based concentration limits, numerical values, or methodologies for various environmental media (i.e., groundwater, surface water, air, and soil) that are established for a specific chemical that may be present in a specific media at the site, or that may be discharged to the site during remedial activities. These ARARs set limits on concentrations of specific hazardous substances, pollutants, and contaminants in the environment. Examples of this type of ARAR include federal and state drinking water standards.
- **Location-specific ARARs** restrict certain types of activities based on site characteristics. Federal and state location-specific ARARs are restrictions placed on the concentration of a contaminant or the activities to be conducted because they are in a specific location. Examples of special locations possibly requiring ARARs include floodplains, wetlands, historical sites, and sensitive ecosystems or habitats.

- **Action-specific ARARs** are technology- or activity-based requirements that are triggered by the specific type of remedial activities. Examples of this type of ARAR include the Resource Conservation and Recovery Act regulations for waste treatment, storage, or disposal.

CERCLA Section 121(d)(4), 42 USC 9621(d)(4), provides that under certain circumstances EPA may waive an ARAR. The waivers include the following criteria: interim measures, greater risk to health and the environment, technical impracticability, equivalent standard of performance, inconsistent application of state requirements, and fund balancing.

## 2.2.1 Potential Chemical-specific ARARs

Potential chemical-specific ARARs for OU-2 were identified on the basis of the COCs at the Site and the media impacted. The only COC identified in groundwater at the Site was arsenic.

Potential ARARs and TBC criteria for drinking water include only the Safe Drinking Water Act (SDWA) and the California Safe Drinking Water Act. These are discussed in the following sections. Potential chemical-specific ARARs are summarized in Table 2-1.

### 2.2.1.1 Safe Drinking Water Act

The Safe Drinking Water Act establishes national primary drinking water standards (i.e., MCLs) to protect the quality of water in public water systems. MCLs are enforceable standards and represent the maximum concentrations of contaminants permissible in a public water system. MCLs are generally relevant and appropriate when determining acceptable exposure limits for waters that are a current or potential source of drinking water (40 CFR 300.430(e)(2)(i)(B). Because MCLs are enforced at the point where water is delivered to the public, they are rarely applicable to RAs at Superfund sites (55 Federal Register 8750). However, because this FS has remedial alternatives that include direct drinking water treatment, MCLs are considered applicable. In the case of inorganic compounds, the natural background concentrations are also considered when developing preliminary cleanup goals (e.g., in cases where the background concentrations are greater than MCLs) because it is not required or expected that RAs achieve cleanup criteria that are less than the existing background concentrations. The California drinking water MCLs are, in some cases, more stringent than the federal MCLs, and, in other cases, they are less stringent. The more stringent limit would be determined on a chemical-by-chemical basis. For arsenic, the California MCL is less stringent, so the federal MCL of 10 µg/L is a potential ARAR for drinking water quality.

## 2.2.2 Potential Location-specific ARARs

Location-specific ARARs are requirements that relate to the geographical position or physical condition of the site. These requirements may limit the type of RA that can be implemented or may impose additional constraints on some remedial alternatives. RA alternatives for drinking water at the Site include institutional controls, alternate water supply, and water treatment. The major location-specific ARARs that could affect RAs are categorized and briefly described in the following sections. Potential location-specific ARARs for the site are summarized in Table 2-2.

**TABLE 2-1**
Potential Chemical-specific ARARs
*Feasibility Study Report for Operable Unit 2 Groundwater Lava Cap Mine Superfund Site, Nevada City, California*

| Standard, Requirement, Criterion, or Limitation | ARAR Status | Description | Comment |
|---|---|---|---|
| National Drinking Water Standards MCLs<br>40 CFR 300.430(e)(2)(I)(B)<br>Safe Drinking Water Act | Applicable | Establishes national primary drinking water standards, MCLs, to protect the quality of water in public water systems. MCLs represent the maximum concentrations of contaminants permissible in a water system delivered to the public. MCLs are generally relevant and appropriate when determining acceptable exposure limits for current or potential sources of drinking water. | National primary drinking water standards are health-based standards for public water systems (i.e., MCLs). The NCP defines MCLs as relevant and appropriate for water determined to be a current or a potential source of drinking water in cases where MCL goals are not ARARs. |
| California Safe Drinking Water Standards (MCLs)<br>State MCLs found in 22 CCR 64435 and 64444.5 | Applicable | Establishes primary MCLs for contaminants that cannot be exceeded in public water systems. In some cases the California drinking water standards are more stringent than the federal MCLs. However, this is not the case for arsenic. | Like federal MCLs, state MCLs are applicable as cleanup goals for waters determined to be a current or a potential source of drinking water. |

Note:

SWRCB = State Water Resources Control Board

**TABLE 2-2**
Potential Location-specific ARARs
*Feasibility Study Report for Operable Unit 2 Groundwater Lava Cap Mine Superfund Site, Nevada City, California*

| Citation | Summary of Requirement | Evaluation |
|---|---|---|
| National Historic Preservation Act (16 USC 470 et seq.; 36 CFR 800; 40 CFR6.301(b); Executive Order 11593); National Historic Landmarks Program (36 CFR 65); National Register of Historic Places (36 CFR 60) | Federal agencies must identify possible effects of proposed remedial activities on historic properties (cultural resources). If historic properties or landmarks eligible for, or included in, the National Register of Historic Places exist within remediation areas, remediation activities must be designed to minimize the effect on such properties or landmarks. | Potentially applicable |
| Archaeological and Historical Preservation Act (16 USC 469 et seq.; 40 CFR 6.301(c)) | Establishes procedures to provide for preservation of historical and archeological data that might be destroyed through alteration of terrain as a result of federal construction project or a federally licensed activity or program. Presence or absence of such data on the site must be verified. If historical or archaeological artifacts are present in remediation areas, the RAs must be designed to minimize adverse effects on the artifacts. | Potentially applicable |
| Archaeological Resources Protection Act of 1979 (16 USC 470aa-ii; 43 CFR 7) | Steps must be taken to protect archaeological resources and sites that are on public and Indian lands and to preserve data. Investigators of archaeological sites must fulfill professional requirements. Presence of archaeological sites are to be identified. | Potentially applicable |
| Endangered Species Act, 16 USC 1531 et seq.; 50 CFR 402; 40 CFR 6.302(h) | Protects endangered or threatened species and their habitat. If endangered or threatened species are in the vicinity of remediation work, USFWS must be consulted and the remediation activities must be designed to conserve endangered or threatened species and habitats. | Potentially applicable |
| Fish and Wildlife Conservation Act (16 USC 2901 et seq.; 50 CFR 83) | Federal departments and agencies required to use their statutory and administrative authority to conserve and promote conservation of nongame fish and wildlife and their habitats. Nongame fish and wildlife are defined as fish and wildlife that are not taken for food or sport, that are not endangered or threatened, and that are not domesticated. | Potentially applicable |
| Fish and Wildlife Coordination Act (16 USC 661 et seq.; 40 CFR 6.302(g)) | Requires consultation with USFWS (and CDFG) when any federal department or agency proposes or authorizes any modification of stream or other water body greater than 10 hectares; requires adequate provisions for protection of fish and wildlife resources). Certain remedies might result in the temporary or permanent modification of naturally occurring water bodies and might require the construction of mitigated wetlands in other areas. | Potentially applicable |
| Fish and Game Code Section 1600 and 1603 | Requirements for construction by, or on behalf of any state or local agency or public utility that will change the natural flow or use material from the beds or result in disposal into designated waters. | Potentially applicable |
| Protection of Floodplains (Executive Order 11988; 40 CFR 6.302(b); 40 CFR 6, Appendix A) | Requires federal agencies to evaluate the potential effects of actions they take in a floodplain to avoid the adverse impacts associated with direct and indirect development of a floodplain. | Potentially applicable for activities that occur within the 100-year floodplain |
| Protection of Wetlands (Executive Order 11990; 40 CFR 6.302(a); 40 CFR 6, Appendix A) | Requires federal agencies to take action to avoid adversely affecting wetlands, to minimize wetlands destruction, and to preserve the value of wetlands. | Potentially applicable if wetlands are identified |

Note:

USFWS = U.S. Fish and Wildlife Service

#### 2.2.2.1 National Historic Preservation Act, National Historic Landmarks Program, and National Register of Historic Places

The National Historic Preservation Act (NHPA), 16 USC 470, requires federal agencies to take into account the effect of any federally assisted undertaking or licensing on any district, site, building, structure, or object that is included in or eligible for inclusion in the National Register of Historic Places (NRHP). Criteria for evaluation are included in 36 CFR 60.4. The Site has not been designated as having historic value to warrant inclusion in the NRHP. If an eligible structure were encountered, the procedures for protection of historic properties set forth in Executive Order 11,593 "Protection and Enhancement of the Cultural Environment" and in 36 CFR 63, 36 CFR 800, and 40 CFR 6.301(c) are potentially applicable.

#### 2.2.2.2 Archaeological and Historic Preservation Act and Archaeological Resources Protection Act

The Archaeological and Historic Preservation Act (AHPA), 16 USC 469, and the Archaeological Resources Protection Act (ARPA), 16 USC 470, established procedures to preserve and protect archaeological resources. AHPA provides for preservation of historical and archaeological data that might be destroyed through alteration of terrain as a result of a federal construction project or a federally licensed activity or program. The ARPA prescribes steps taken by investigators to preserve data. If remedial activities would cause irreparable loss or destruction of significant scientific, prehistoric, historical, or archaeological data, mandatory data recovery and preservation activities would be necessary. The implementing regulations (40 CFR 6.301(c) and 43 CFR 7) would be potentially applicable if eligible structures were identified.

#### 2.2.2.3 Endangered Species Act

The Endangered Species Act (ESA), 16 USC 1531, et seq., requires consultation with the resource agencies for RAs that may affect these species. Section 7 of the ESA requires that federal agencies consider whether their actions will jeopardize the existence of species that are listed as threatened or endangered by the USFWS or the National Marine Fisheries Service (NMFS). EPA is complying with the consultation provisions of the ESA, and is proposing selection of a RA that will provide the necessary level of protection for affected species. The ESA would be considered to be potentially applicable.

#### 2.2.2.4 Fish and Wildlife Conservation Act and Fish and Wildlife Coordination Act

The Fish and Wildlife Conservation Act, 16 USC 2901, requires federal agencies to use their authority to conserve and promote conservation of non-game fish and wildlife. The Fish and Wildlife Coordination Act, 16 USC 661–666, requires federal agencies involved in the control or structural modification of any natural stream or body of water to take action to protect fish and wildlife resources that may be affected by the selected RA. The Fish and Wildlife Conservation Act and the Fish and Wildlife Coordination Act and their implementing regulations (50 CFR 83 and 40 CFR 6.302(g)) are potentially applicable to site remediation activities.

#### 2.2.2.5 Clean Water Act

Section 404 of the Clean Water Act (CWA), 33 USC 1344, requires a permit for the discharge of dredged or fill material into waters of the United States. CC, LCC, and Lost Lake are waters of the United States. Substantive CWA requirements are potentially applicable to remedial alternatives proposed in this FS.

Activities associated with a selected remedy that might trigger Section 404 requirements include pipeline construction within the banks of CC or LCC. The *Guidelines for Specification of Disposal Sites for Dredged or Fill Material* (40 CFR 230, Section 404(b)(1)) define requirements that limit the discharge of dredged or fill material into the aquatic environment or aquatic ecosystems. These guidelines specify consideration of alternatives that have fewer adverse impacts and prohibit discharges that would result in exceedance of surface water quality standards, exceedance of toxic effluent standards, or jeopardize threatened or endangered species. Actions that can be taken to minimize potential adverse impacts of the discharge on the aquatic ecosystem are specified in Subpart H of 40 CFR 230, and include the following:

- Confining the discharge's effects on aquatic biota
- Avoiding disruptions of periodic water inundation patterns
- Selection of disposal site and method of discharge
- Minimizing or preventing standing pools of water

#### 2.2.2.6 Executive Order on Floodplain Management

The Executive Order on Floodplain Management, Executive Order 11,988, requires that federal agencies evaluate the potential effects of activities in a floodplain to avoid, to the extent possible, adverse effects associated with direct and indirect development. EPA's regulations to implement Executive Order 11,988 are provided in 40 CFR 6.302(b). In addition, EPA has developed guidance, the *Policy on Floodplains and Wetlands Assessments for CERCLA Actions* (EPA, 1985b). The requirements of this regulation are potentially applicable if any remedial activities affect the floodplain at the Site.

#### 2.2.2.7 Executive Order on Protection of Wetlands

The Executive Order on Protection of Wetlands, Executive Order 11,990, requires that federal agencies avoid, to the extent possible, adverse impacts associated with the destruction or loss of wetlands and to avoid support of new construction in wetlands if a practicable alternative exists. EPA's regulations to implement Executive Order 11,990 are provided in 40 CFR 6.302(a). In addition, EPA has developed guidance, the *Policy on Floodplains and Wetlands Assessments for CERCLA Actions* (EPA, 1985b). If wetlands are encountered at the Site, these requirements would be potentially applicable.

### 2.2.3 Potential Action-specific ARARs

Action-specific ARARs are requirements that define acceptable containment, treatment, storage, and disposal criteria and procedures. These ARARs generally set performance, design, or other similar action-specific controls or restrictions on particular kinds of activities. These requirements are activated by the particular RAs selected to accomplish a remedy. The action-specific requirements do not in themselves determine the remedial alternative; rather, they indicate how, or to what level, a selected alternative must achieve the requirements.

RA alternatives for drinking water at the Site include institutional controls, alternate water supply, and water treatment. Potential action-specific ARARs are summarized in Table 2-3.

#### 2.2.3.1 RCRA Subtitle C Hazardous Waste Identification and Generator Requirements

The RCRA requirements for identification and listing of hazardous waste can be found in 22 CCR, Division 4.5, Chapter 11. A hazardous waste is a RCRA hazardous waste if it exhibits any of the characteristics of ignitability, corrosivity, reactivity, or toxicity identified in 22 CCR 66261.21, 66261.22(a)(1). 66261.22(a)(2), 66261.23, and 66261.24(a)(1) or if it is listed as a hazardous waste in Article 4 of Chapter 11. Under the California RCRA program, wastes can be classified as non-RCRA, state-only hazardous wastes if they exceed the soluble threshold limit concentration (STLC) or the total threshold limit concentration (TTLC) values listed in 22 CCR 66261.24(a)(2). It will be necessary to determine which wastes at the site are hazardous to determine the group classification of the wastes under the Water Code Section 13172.

In addition, if wastes are generated at the Site (e.g., wastes from installation of pipelines or treatment additives) and they exhibit characteristics of a hazardous waste, the requirements of Title 22 would be applicable to those wastes.

#### 2.2.3.2 Air Quality Requirements

RAs at Lava Cap Mine will require control of particulates. Under the Clean Air Act (CAA), EPA has set forth National Ambient Air Quality Standards (NAAQS), which define levels of air quality necessary to protect public health (40 CFR 50). Lava Cap Mine is located in the Northern Sierra AQMD. The district is required by state law to achieve and maintain the federal and state ambient air quality standards. Potentially applicable air regulations to this site and proposed RAs include Rule 205, which prohibits discharges of air contaminants that cause a nuisance, and Rule 225, which requires reasonable precautions to prevent dust emissions.

#### 2.2.3.3 CERCLA Offsite Rule

Although they are not specifically ARARs, CERCLA Section 121(d)(3) and EPA regulations establish independently applicable requirements regarding offsite disposal of hazardous substances. This rule and these regulations would apply to soil generated during pipeline installation that needs to be shipped offsite for disposal.

## 2.3 Preliminary Cleanup Goals

Preliminary cleanup goals are established to provide a chemical concentration for drinking water that will achieve the level of protection specified in the RAOs. In consideration of the RAOs and ARARs, the preliminary cleanup goal for arsenic in drinking water in OU-2 is the federal MCL of 10 µg/L. This preliminary cleanup goal should not be considered a final remediation goal or cleanup level to be achieved by the RA; it provides a basis for delineating the extent of contaminated drinking water. The preliminary cleanup goal is needed during development of RAs and when remedial alternatives are being evaluated and compared within the CERCLA FS process.

**TABLE 2-3**
Potential Action-specific ARARs
*Feasibility Study Report for Operable Unit 2 Groundwater Lava Cap Mine Superfund Site, Nevada City, California*

| Citation | Summary of Requirement | Evaluation |
|---|---|---|
| Hazardous Waste Control Act, California Health and Safety Code Division 20 chapter 6.5 – 22 CCR 66261.4(b)(7) | | |
| Hazardous Waste Control Act, California Health and Safety Code Division 20 chapter 6.5 – Hazardous Waste Identification and Generator Requirements (22 CCR, Division 4.5, Chapters 11 and 12) | A solid waste is hazardous if it exhibits any of the characteristics of a hazardous waste; (i.e., ignitability, corrosivity, reactivity, and toxicity) as determined by a TCLP. If a waste is deemed to be hazardous, then substantive requirements of 22 CCR 66262 (Generator Requirements) are applicable. | Potentially applicable to any hazardous waste generated at the site |
| Northern Sierra AQMD Rules 205 (nuisance) and 225 (dust control). | Rule 205 prohibits discharges of air contaminants that cause a nuisance.<br>Rule 225 states that remedial activities will be designed to take all reasonable precautions to prevent particulate matter from becoming airborne including, but not limited to, as appropriate, the use of water or chemicals as dust suppressants, the covering of trucks, and the prompt removal and handling of excavated materials. | Potentially applicable |
| Fish and Game Code Section 5650 | Provides, among other prohibitions, that “It is unlawful to deposit in, permit into, or place into the waters of this state …substance or material deleterious to fish, plant life, or bird life.” | Potentially applicable |
| Clean Water Act (Section 404) – Dredge or Fill Requirements (33 USC 1251-1376; 40 CFR 230) | Establishes requirements that limit the discharge of dredged or fill material into waters of the United States. EPA guidelines for discharge of dredged or fill materials in 40 CFR 230 specify consideration of alternatives that have fewer adverse impacts and prohibit discharges that would result in exceedance of surface water quality standards, exceedance of toxic effluent standards, and jeopardy of threatened or endangered species. Special consideration required for “special aquatic sites” defined to include wetlands. | Potentially applicable |

Notes:

AQMD = Air Quality Management District

TCLP = toxicity characteristic leaching procedure

RCRA = Resource Conservation and Recovery Act

As an alternative to using the federal MCL for arsenic as the preliminary cleanup goal for drinking water, the background concentration of arsenic in groundwater in OU-2 was also considered, and rejected. The background concentration for arsenic in groundwater was established by statistical analysis of arsenic detections in the Background Area. A discussion of the methodology for determining background levels for groundwater is provided in Appendix F of the FS (EPA, 2004). The background value for arsenic calculated in that FS was 18 µg/L; however, that concentration is not considered representative of background conditions throughout the Site, as demonstrated by the lack of arsenic in downgradient residential wells below Greenhorn Road. There appears to be a different background condition in the Downgradient Area that is below 10 µg/L. Selecting an arsenic cleanup goal of 18 µg/L would allow exposure to mine-impacted groundwater in residential wells that exceeds the MCL. Therefore, although naturally-occurring arsenic plays an important role at the Site, the background value of 18 µg/L determined in the 2004 FS is not used in this FS as a preliminary cleanup goal.

**SECTION 3**

# Identification and Screening of Remedial Technologies

As defined in the *EPA Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (EPA, 1988), general response actions are medium-specific actions that satisfy the RAOs. General response actions considered for remediation of contaminated drinking water at the Site (OU-2) include the following:

- No Action – required under CERCLA
- Institutional Controls – reduce potential future human exposure to contaminants by limiting installation of new wells in contaminated areas
- Alternative Water Supply – replace contaminated drinking water with potable water from another source, which reduces the current and potential future human exposure to contaminants in groundwater
- Monitoring – provide information regarding the quality of groundwater, which helps reduce potential future human exposure to contaminated drinking water
- Treatment – reduce the toxicity, mobility, or volume of contaminated drinking water

Except for the no action alternative, each general response action can be achieved by several remedial technologies and process options. Remedial technologies are defined as the general categories of remedies under a general response action. For example, ex situ chemical treatment is one of the remedial technologies evaluated under the general response action of treatment. Process options are specific categories of remedies within each remedial technology. The process options are used to implement each remedial technology. For example, the remedial technology of ex situ chemical treatment could be implemented using one of several types of process options (e.g., chemical oxidation or ion exchange).

General response actions, remedial technologies, and process options deemed to be potentially applicable for drinking water remediation at OU-2 were identified and screened. Screening was conducted on the basis of effectiveness (primarily), implementability, and relative cost.

Effectiveness was evaluated by considering the following factors:

1. The potential effectiveness of a process option to address the estimated areas or volumes of contaminated drinking water and meet the goals identified in the RAOs
2. The potential impacts to human health and the environment during the construction and implementation phases
3. Reliability and success of the process with respect to the types of contamination and Site conditions that will be encountered

Implementability was evaluated by considering factors such as the ability to obtain necessary permits (if any); the availability and capacity of treatment, storage, and disposal services; and the availability of the equipment and workers to implement the technology.

Cost was evaluated by considering relative capital and operating costs rather than detailed estimates. The costs for a process option relative to other process options of the same technology type were assessed based on engineering judgment and experience.

When multiple process options or configurations were considered effective, implementable, and cost-effective, a representative process option was chosen to be used in the development and analysis of RAs (see Sections 4 and 5). However, representative process options assumed for development of RAs can be replaced during the subsequent remedial design process if additional data become available that support a change.

Table 3-1 summarizes the general response actions, remedial technologies, and process options identified for OU-2 drinking water. The table presents process option descriptions, screening decisions retained or removed from further consideration), and major screening comments.

General response actions, remedial technologies, and selected process options identified in Table 3-1 are discussed in the following sections.

## 3.1 No Action

The no action general response action is required by the *EPA Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (EPA, 1988) as a baseline for comparison with other remedial alternatives. The no action option does not include active remediation or monitoring.

## 3.2 Institutional Controls

Institutional controls involve technical and administrative controls that limit access, and thereby potential future exposure, to contaminated drinking water. Institutional controls are divided into two technologies, restrictions and notifications.

Access and use restrictions, including groundwater use restrictions or, can limit human exposure to contaminants in drinking water. A ban on new residential supply wells in potentially contaminated areas was considered but was removed from further consideration because of the limited and inconsistent occurrence of contaminated groundwater.

Access and use notifications would inform potential receptors of the risks, but would not eliminate activities that could result in exposure to contaminated groundwater. For example, anyone applying for a domestic well drilling permit within the footprint of potential current or future mine-impacted groundwater area could be notified by the Nevada County Environmental Health Department regarding arsenic contamination in the area. The notifications could describe the likelihood of contamination, alternative water supply options, and water testing procedures. Access and use notifications are less stringent than access and use restrictions. Access and use notifications were retained for use in remedial alternatives.

## 3.3 Groundwater Monitoring

Monitoring groundwater that is potentially impacted by mine-related arsenic would provide information regarding contaminant levels and an early warning of impending changes in water quality at residential wells. Groundwater monitoring would be performed using a combination of monitoring wells and residential wells. Access agreements with residents would be required to include residential wells in a monitoring program. Monitoring of groundwater at monitoring wells and residential wells was retained for use in remedial alternatives.

## 3.4 Alternative Water Supply

An alternative water supply could be provided to residential properties where drinking water or irrigation wells are impacted by mine-related arsenic contamination. Three alternative water supply process options were considered: water from NID, new (individual) residential wells, and new (shared) production wells.

The NID option would require expanding the NID water distribution system to supply potable water to residences within the area potentially impacted by groundwater contamination from the mine (now and in the future). Cost sharing for this expansion and possibly compensation for higher rates for water would need to be considered. This process option was retained and is described in greater detail in Appendix A.

The new well options would require installation of replacement wells for residents already affected by arsenic from Lava Cap Mine. This could potentially be achieved by either installing replacement wells in uncontaminated portions of each impacted parcel, or by constructing a smaller number of higher-yield supply wells that would yield sufficient water for several parcels. These replacement well options were dropped from further consideration because of the uncertainty regarding the extent of contamination and the significant likelihood that the replacement wells would ultimately become contaminated. Furthermore, the yield and reliability of potential replacement wells in a fractured-bedrock aquifer might be insufficient to meet the needs of residents.

## 3.5 Ex Situ Treatment

Treatment technologies for contaminated drinking water at the Site would be designed to reduce the toxicity or mobility of the sole contaminant of concern, arsenic. There are typically two general categories of remedial technologies evaluated under the treatment general response action: in situ treatment and ex situ treatment. However, because this FS is specifically evaluating drinking water impacts, in situ treatment options are not considered.

The ex situ treatment technologies that were evaluated include point-of-use (POU) and wellhead treatment for groundwater produced by residential wells.

### 3.5.1 Point-of-Use and Wellhead Treatment

POU devices treat water intended for direct consumption (drinking and cooking), typically at a single tap or limited number of taps. Wellhead treatment devices are installed to treat all water entering a single home, business, school, or facility. Treatment technologies used for both POU and wellhead treatment can be identical, the difference being the size and design flow rate. POU treatment units treat small flows (typically 0.5 to 5 gallons per minute [gpm]); wellhead treatment units treat larger flows (typically 5 to 30 gpm).

POU and wellhead treatment systems are readily available "off-the-shelf," and can be easily installed and serviced by many plumbers. POU units are normally installed under the kitchen sink for convenience in supplying drinking and cooking water. Wellhead treatment units are typically installed at the water service entrance to the house or next to a domestic well. POU and wellhead units consist of a set of tanks or vessels connected by piping. The most commonly used technologies for treating water in these systems are adsorption and reverse osmosis (RO). These systems may also include pre-treatment and post-treatment, including solids filtration or charcoal adsorption (for organic contaminants or chlorine, where these are a concern). Adsorptive media such as activated alumina and RO have been identified as small system compliance technologies by EPA for arsenic treatment (EPA, 2006b). Details regarding chemical and physical treatment processes are discussed in the following sections.

### 3.5.2 Ex Situ Chemical Treatment

The full range of ex situ chemical treatment process options considered for ex situ chemical treatment of arsenic in drinking water is summarized in Table 3-1. The most applicable process options include a co-precipitation process (coagulation) and adsorption processes (activated alumina, granular ferric hydroxide, and zero valent iron). Ex situ chemical oxidation, while probably not an effective option for stand-alone treatment of groundwater, was retained for possible use in conjunction with the coagulation process.

#### 3.5.2.1 Coagulation

Coagulation, as used here, refers to the addition of a ferric iron salt, such as ferric chloride, to groundwater to remove arsenic. Ferric iron (Fe(III)) is generally insoluble in water with neutral or higher pH and precipitates primarily as ferric hydroxide. Arsenic adsorbs to and co-precipitates with the ferric iron floc. Although both trivalent arsenic (As(III)) and pentavalent arsenic (As(V)) will adsorb to and co-precipitate with ferric oxyhydroxides, As(V) is known to sorb more strongly than As(III).

Implementation of the coagulation process for wellhead treatment of extracted groundwater at the Site would likely consist of a pre-aeration or pre–oxidation step, ferric chloride addition and rapid mixing, and one or more solid/liquid separation processes. In addition, pH adjustment might be needed if the influent pH is less than approximately 6.7. The purpose of pre-aeration is to provide oxygen for oxidation of ferrous iron (Fe(II)) contained in the groundwater (thereby reducing the ferric chloride chemical requirement), and to prevent reduction of the added ferric iron. If the influent groundwater pH is less than 6.7, it would be adjusted upward to accelerate Fe(II) oxidation. Alternatively, rather than pre-aeration, pre-oxidation could be employed, if necessary, to enhance arsenic removal because this would result in oxidation of As(III) as well as Fe(II). After ferric chloride addition, the iron solids and co-precipitated arsenic would be separated from the effluent water by sedimentation and filtration. The effectiveness of this treatment process for arsenic removal has been demonstrated in full-scale applications. In addition, laboratory testing of this process has shown it to be potentially effective for treating Lava Cap Mine adit discharge water (CH2M HILL, 2002). Consequently, this ex situ treatment process option was retained for potential use in remedial alternatives. However, it is a more complicated process than is likely necessary for wellhead treatment.

The general approach considered for implementation of the coagulation process described here is an active approach. A semipassive approach may be more cost effective for higher flow rates, but is not appropriate for a drinking water well. The active approach could consist of the follow unit operations:

- Pre-aeration/oxidation in a mixed reactor with air sparging (with pH adjustment if necessary) or with chemical oxidant addition (such as hydrogen peroxide).
- Ferric chloride addition in a small rapid-mix tank.
- Clarification in a gravity clarifier.
- Filtration of clarifier overflow (supernatant) using either granular media filters or a microfiltration system. The choice of filtration process depends on the particle size that needs to be removed to achieve arsenic discharge requirements in the filtrate.
- Thickening and dewatering of clarifier underflow (sludge), and sludge disposal.

The coagulation process, coupled with microfiltration, was selected as the representative process option for treatment of mine adit discharge in the OU-1 ROD (EPA, 2004)

#### 3.5.2.2 Adsorptive Processes

In general, an adsorptive media system would consist of a vessel containing the adsorption media along with any support media. Contaminated drinking water is passed through a solids removal process (such as a sand or pea gravel bed) to remove large solids to reduce fouling of the sorptive media, and then through the adsorptive media bed, where arsenic is removed. When the media bed becomes saturated with arsenic and any other interfering contaminants in the water, the spent media are removed and replaced with fresh media. Potential sorptive media include activated alumina (AA), granular ferric hydroxide (GFH) and zero valent iron (ZVI). The adsorptive media processes are amenable to use as semipassive treatment systems and, therefore, offer the potential advantages of simplicity, lower operations and management (O&M) requirements, and lower costs. However, the cost effectiveness of these processes is directly related to their arsenic removal capacity and the associated frequency of media exhaustion and replacement.

Batch isotherm tests were conducted to evaluate whether an adsorptive process could be more cost effective than coagulation coupled with microfiltration for treating Lava Cap Mine adit discharge water for arsenic removal. The results are documented in *Lava Cap Mine Discharge Water - Isotherm Test Results* (CH2M HILL, 2005). The treatment media evaluated were: (1) Granular Ferric Hydroxide™ adsorbent, distributed by US Filter, (2) Bayoxide® E33 adsorbent, distributed by Severn Trent, (3) ZVI, distributed by Connelly-GPM, and (4) ion exchange medium distributed by US Filter. ZVI had the greatest capacity for arsenic removal and the lowest cost by more than an order of magnitude. Therefore, additional study of ZVI was performed.

The results of the ZVI onsite pilot testing are documented in the *Lava Cap ZVI Onsite Pilot Test Results Technical Memorandum* (CH2M HILL, 2006). Results of the study indicated that several auxiliary pre- and post-ZVI unit processes were needed to provide effective treatment of arsenic, iron, and manganese. These auxiliary processes included aeration and filtration prior to and after the ZVI reactor. Because of this increased complexity and associated cost of these auxiliary processes, ZVI was no longer considered a feasible alternative to ferric chloride coagulation. Similar pre- and post-treatment processes are likely to be required for other adsorptive media processes; therefore, most were dropped from further consideration, although GFH was tentatively retained to represent a possible semipassive treatment process option. Treatment for iron and manganese is not likely to be required for wellhead systems.

### 3.5.3 Ex Situ Physical Treatment

All process options considered for ex situ physical treatment are summarized in Table 3-1, and include clarification, passive aeration, aerobic settling pond, granular media filtration, microfiltration, sludge thickening/dewatering, RO, electrodialysis (ED), and nanofiltration (NF). The first six options listed are not stand-alone treatment processes, but are process options that could be used in conjunction with another arsenic removal process such as coagulation (see previous discussion). These are not likely practical for wellhead treatment units. The last three process options listed – RO, ED, and NF – are semipermeable membrane-based technologies with the potential for treating arsenic-contaminated drinking water. RO, in particular, is well demonstrated to be effective for removal of arsenic and is widely used for removing dissolved constituents from water. All of these process options have relatively high capital and operating costs, generate a concentrated stream, and have relatively high O&M requirements. ED and NF are not commonly used in wellhead-type applications. Consequently, these two process options were removed from further consideration. RO was retained for further consideration in POU or wellhead treatment, where flow rates are low and waste volumes generated are more easily managed (see previous discussion).

### 3.5.4 Ex Situ Biological Treatment

Two ex situ biological treatment process options, phytoremediation and constructed wetland; both were considered but dropped from further consideration because their effectiveness and reliability are not well demonstrated for arsenic removal (see Table 3-1), and they are not appropriate for wellhead treatment application.

**TABLE 3-1**
Screening of Drinking Water Remedial Technologies and Process Options
*Feasibility Study Report for Operable Unit 2 Groundwater Lava Cap Mine Superfund Site, Nevada City, California*

| General Response Action | Remedial Technology | Process Option | Description | Screening Comments |
|---|---|---|---|---|
| No Action | None | None | No action. | Retained for further consideration. Evaluate per EPA guidance. |
| Institutional Controls | Access and use restrictions | Groundwater use restrictions | Groundwater use restrictions would be issued to restrict groundwater use and minimize contact with contaminated groundwater. This could include restricting installation of domestic wells. | Removed from further consideration. Unnecessarily restrictive. |
| | | Fencing | Fences would restrict access to surface water that is impacted by contaminated groundwater. | Removed from further consideration. Surface water contamination will be addressed by the OU-1 and OU-3 RAs. |
| | Access and use notifications | Groundwater use notifications | Notifications of risks would be issued to well owners and any person who applies for domestic well permits. | Retained for further consideration. Requires coordination with Nevada County Environmental Health Department. |
| Monitoring | Groundwater monitoring | Monitoring wells | Groundwater potentially migrating away from the Site will be monitored to evaluate contaminant levels and migration. | Retained for further consideration. Potentially effective in reducing risk to receptors (in conjunction with other response actions) by providing early warning of groundwater quality changes. |
| | | Residential wells | Groundwater will be monitored to evaluate contaminant levels and migration and to evaluate the risk to human receptors. | Retained for further consideration. Potentially effective in reducing risk to receptors (in conjunction with other response actions) by providing information about the potability of groundwater. |
| Alternative Water Supply | Supply water from an outside source | NID water supply | Extend NID pipelines to the Site and provide NID water to affected properties. | Retained for further consideration. Would provide a safe, reliable source of potable water. |
| | Alternative groundwater supply | New residential wells | Install replacement residential wells (at a different location or depth than existing wells) on parcels affected by mine-related groundwater contamination. | Removed from further consideration. Substantial uncertainty exists regarding the extent of arsenic-contaminated groundwater and the reliability of well yields in this area. |
| | | New production wells | Install a limited number of replacement production wells that would supply potable water to be shared by affected property owners. | Removed from further consideration. Substantial uncertainty exists regarding the extent of arsenic-contaminated groundwater and the reliability of well yields in this area. |
| Treatment | Ex situ chemical treatment | Point-of-use treatment | In-home, under-sink treatment units remove the arsenic at the point of use. | Retained for further consideration. |
| | | Wellhead treatment | Wellhead treatment used to remove arsenic at the wellhead. | Retained for further consideration. |
| | | Coagulation | Ferric chloride added to extracted groundwater to co-precipitate arsenic with Fe(III). This option would be combined with pre-aeration/oxidation and a post solids/liquid separation process. | Retained for further consideration. Proven technology for removing arsenic from water. Treatability testing has demonstrated this technology's effectiveness for treating arsenic in Lava Cap adit water to concentrations below the MCL. |
| | | Chemical oxidation | Hydrogen peroxide, chlorine, or other oxidant added to extracted groundwater to oxidize Fe(II) and adsorb/co-precipitate arsenic with Fe(III). Furthermore, direct oxidation of arsenic from As(III) to As(V), which adsorbs more strongly to iron and manganese oxyhydroxides. | Retained for further consideration. Not a stand-alone technology unless water contains enough iron relative to arsenic for effective treatment (probably not the case for Lava Cap groundwater). However, it may be used in conjunction with addition of a ferric salt to enhance the co-precipitation process. |
| | | Ion exchange | Ion exchange removes arsenic anions from the aqueous phase by exchange of counter ions on the exchange medium. Strong base anion exchange resins are used for arsenic removal. Spent resin is normally regenerated with a brine solution, and used regenerant is either disposed of or treated with ferric chloride to remove arsenic. | Removed from further consideration. Sulfate and other dissolved anions compete with arsenic for exchange sites and reduce resin capacity for removal of arsenic. Relatively large volumes of waste are produced. Higher cost than coagulation. |
| | | Lime softening | Lime addition raises the water pH and precipitates dissolved calcium as calcium carbonate. (Dissolved magnesium can also be removed by softening, but it is likely that selective calcium removal would be employed by using a lime dosage that limits the pH increase to approximately 10). Dissolved iron is also precipitated by softening under aerobic conditions. Arsenic is co-precipitated with ferric and calcium floc. Pre-aeration, solids/liquid separation, and post-treatment pH adjustment would be required. | Removed from further consideration. Poorly dewatered sludge is produced. Overall costs are higher than coagulation. |
| | | AA | Water is passed through a packed bed reactor containing aluminum oxide media, where arsenic becomes sorbed to the solid alumina. Exhausted media reportedly can be regenerated with sodium hydroxide. Regenerant must be treated and disposed of, and spent media must eventually be disposed of and replaced. | Retained for further consideration. Considered likely to be effective for wellhead systems, although at a higher cost than RO. |
| | | Iron oxide-coated sand | Water is passed through a bed of sand grains coated with ferric hydroxide, where arsenic becomes sorbed to the ferric coating. Spent media must be disposed of and replaced. Sand grains coated with ferric hydroxide would be used in fixed bed reactors to remove dissolved metal species. The metal ions would be exchanged with the surface hydroxides. | Removed from further consideration. Process not widely used for this type of application. Coated sand production and regeneration facility are not available on a commercial scale. |
| | | Sulfur-modified iron | Finely divided metallic iron, powdered sulfur, and an oxidizing agent is thoroughly mixed and then added to the contaminated groundwater. The oxidizing agent converts As(III) to As(V) and Fe(0) to Fe(III); arsenic co-precipitated with ferric iron. The slurry is then mixed and settled. | Removed from further consideration. The technology is still experimental. |

**TABLE 3-1**
Screening of Drinking Water Remedial Technologies and Process Options
*Feasibility Study Report for Operable Unit 2 Groundwater Lava Cap Mine Superfund Site, Nevada City, California*

| General Response Action | Remedial Technology | Process Option | Description | Screening Comments |
|---|---|---|---|---|
| | | Photo-oxidation | In the presence of light and naturally occurring light-absorbing materials, the oxidation rate of As(III) by oxygen can be increased 10,000 fold. As(V) is less toxic than As(III), and oxidation might be required for some chemical treatment options. With the process, As(III) would be preferentially oxidized in the presence of excess dissolved Fe(II), in contrast to conventional chemical oxidation in which excess dissolved Fe(II) represents an extra chemical oxidant demand. | Removed from further consideration. The technology is still experimental. |
| | | Granular ferric hydroxide | Water is passed through GFH in a fixed bed reactor where arsenic becomes sorbed to the media. Spent media must be disposed of and replaced. This is a more passive treatment option than conventional coagulation/filtration with lower capital costs. | Retained for further consideration. Laboratory treatability testing conducted on adit discharge water indicated that the arsenic removal capacity of GFH was modest and the media unit cost was relatively high. Would require pilot testing to confirm effectiveness and capacity for treating drinking water. |
| | | Zero valent iron | Water is passed through a bed of ZVI filings mixed with sand where arsenic sorbs to Fe(III) formed from corrosion (oxidation) of the Fe(0). This process requires pre-aeration/oxidation of the influent water, and post-treatment to remove dissolved iron and manganese. | Removed from further consideration. Pilot-testing for treatment of adit drainage at the Site showed that high costs for pre- and post-treatment made this less cost effective than coagulation. |
| Treatment | Ex situ physical treatment | Clarification | Quiescent tank that allows retention time for sedimentation of suspended solids. Circular gravity clarifiers are most common, but inclined tube (lamella) clarifiers are also used where space is limited. Clarified supernatant (overflow) is discharged directly or filtered prior to discharge. Sludge (underflow) is normally withdrawn continuously or at frequent intervals, and requires disposal, usually after dewatering. | Retained for further consideration. Solid/liquid separation process that might be used in conjunction with a chemical treatment process, such as coagulation. |
| | | Passive aeration | Water flows through a passive aeration structure, such as a cascade system, riffles, or trays, to aerate the water and strip excess carbon dioxide (raises pH slightly). This promotes oxidation of Fe(II) and possibly some As(III). Arsenic co-precipitates with ferric floc. | Retained for further consideration. Not a stand-alone technology unless water contains enough iron relative to arsenic for effective treatment (probably not the case for Lava Cap groundwater). However, it may be used in conjunction with addition of a ferric salt to enhance the coagulation process. |
| | | Aerobic settling pond | Quiescent pond that provides retention time for sedimentation of suspended solids. Can also provide time for Fe(II) oxidation following an aeration process. In semipassive systems, clarified supernatant is discharged directly, or after polishing in a wetland. Sludge is normally allowed to accumulate in the pond bottom for several years between cleanout (via dredging or other mechanical removal method). Sludge requires proper disposal, often after dewatering. | Removed from further consideration. Solid/liquid separation process that may be used in conjunction with a chemical treatment process, such as coagulation. Not applicable for residential drinking water treatment. |
| | | Granular media filtration | Water is filtered through granular media (sand, or multimedia typically consisting of layers of garnet, sand, or anthracite) to remove suspended solids. Granular media filtration units are backwashed periodically to clean the media, and spent backwash water must be managed (often with gravity thickening, recycling of supernatant, and disposal of sludge). Applicable for treating raw water for TSS removal or treated water for removal of precipitated iron and arsenic. Equipment options include gravity and pressure filters. | Retained for further consideration. Solid/liquid separation process that may be used in conjunction with a chemical treatment process, such as coagulation, to increase removal efficiencies. Minimum particle size removed by granular media filtration is larger than for microfiltration. |
| | | Microfiltration | Treated water is passed across a microfiltration membrane under pressure to remove particulate and colloidal solids as small as approximately 0.1 micrometer. Microfiltration generates a clean filtrate (permeate) stream that is discharged directly, and a reject stream containing removed solids, which must be managed (often with gravity thickening, recycling of supernatant, and disposal of sludge). | Retained for further consideration. Solid/liquid separation process that may be used in conjunction with a chemical treatment process, such as co-precipitation, to increase removal efficiencies. Microfiltration removes smaller particle size solids than granular media filtration, which may result in higher removal efficiencies (important if water stream contains colloidal material). |
| | | Sludge thickening/dewatering | Thickening is accomplished by gravity settling of a solids-containing stream to increase the percent solids of sludge. Dewatering processes remove additional water from sludge, thereby increasing the percent solids and reducing the sludge volume and cost of sludge disposal. Dewatering processes include filter presses (e.g., belt or plate-and-frame), centrifuges, and drying beds. Thickening and dewatering are potentially applicable to streams such as clarifier underflow, granular media filter backwash, and microfiltration reject. | Retained for further consideration. Process options may be used in conjunction with chemical treatment, such as coagulation, to reduce volume of waste requiring disposal. |
| | | RO | Water under very high pressure is passed across a RO membrane that rejects dissolved contaminants. RO produces a clean permeate stream, which is discharged directly, and a concentrate stream containing arsenic and other ions. The concentrate stream must be disposed of, often after evaporation to reduce the volume. Pre-treatment is usually required to remove suspended solids and in some cases, scale-forming constituents. As(V) is rejected more effectively than As(III). | Retained for further consideration. Considered reliable and cost effective for wellhead and point-of-use systems. |
| | | ED | Electrical-potential driven membrane process in which ions are transferred through membranes that are selectively permeable toward cations or anions. Contaminant removal is comparable to that for RO. | Removed from further consideration. Relatively high cost and O&M requirements. |
| | | NF | Water under high pressure is passed across a NF membrane to remove particulate and colloidal arsenic down to less than 0.01 micrometer. | Removed from further consideration. High cost and O&M requirements. Removal efficiency for dissolved arsenic is uncertain. Nanofiltration is more prone to fouling than microfiltration. |

**TABLE 3-1**
Screening of Drinking Water Remedial Technologies and Process Options
*Feasibility Study Report for Operable Unit 2 Groundwater Lava Cap Mine Superfund Site, Nevada City, California*

| General Response Action | Remedial Technology | Process Option | Description | Screening Comments |
|---|---|---|---|---|
| Treatment | Ex situ biological treatment | Phytoremediation | Water is passed through a plantation of appropriate plant species selected for their ability to uptake arsenic through roots and translocate/accumulate contaminants in plant shoots and leaves. | Removed from further consideration. This process is not a proven technology and is not appropriate for residential drinking water treatment. |
| | | Constructed wetland | The constructed wetland-based treatment technology uses natural geochemical and biological processes inherent in an artificial wetland ecosystem to accumulate and remove metals from influent waters. Removal mechanisms potentially include filtration, precipitation, and plant uptake. Aerobic wetlands may remove arsenic by iron oxidation and co-precipitation if the influent water contains sufficient dissolved iron relative to arsenic (not likely to be the case for Lava Cap groundwater). | Removed from further consideration because this process is not applicable for residential drinking water treatment. |
| Disposal | Treated water discharge | Discharge to surface water | Treated water would be discharged to surface water onsite. | Retained for further consideration. |
| | Treatment residuals disposal | Onsite disposal | Treatment residuals would be buried onsite in an engineered disposal cell. | Removed from further consideration. Treatment residuals for wellhead or point-of-use systems are expected to be minimal. |
| | | Offsite disposal | Treatment residuals would be transported to an offsite disposal facility. | Retained for further consideration. Treatment residuals for wellhead or point-of-use systems are expected to be minimal. |

ED = electrodialysis
NF = nanofiltration
RO = reverse osmosis

SECTION 4

# Development of Remedial Alternatives

In accordance with the *EPA Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* (EPA, 1988), remedial alternatives have been developed by assembling remedial technologies and representative process options identified and screened in Section 3. The remedial alternatives vary primarily in the method contact with arsenic is prevented. The alternatives include a no action alternative, two residential well water treatment alternatives, and an alternative that provides water from the NID. The objective of developing alternatives is to provide an appropriate range of potential RAs and sufficient information to adequately compare them in Section 5. The results of the analysis will be presented to decision makers as part of the remedy selection process.

The alternatives are listed in order of increasing level of protectiveness active remediation. Names are given to alternatives to highlight major components or differences in them and are not intended to capture the full extent of the alternatives. Specific details presented as part of the conceptual design or component description were developed for the evaluation, cost, and comparison of alternatives only, and are not meant to serve as a true design or specific recommendation of technologies or process options.

Table 4-1 summarizes the remedial alternatives. Table 4-2 summarizes the components of each remedial alternative. Table 4-3 provides a cost summary for each remedial alternative, including capital cost, O&M costs, and the total 50-year net present value (NPV). A preliminary cost estimate and the assumptions used in the cost estimate are described in Appendix B.

## 4.1 Alternative 1 – No Action

Consideration of a no action alternative is required by the *EPA Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* (EPA, 1988) as a baseline for comparison with other remedial alternatives. The no action alternative does not include active remediation or monitoring. No cost is associated with this alternative. Although this alternative does not include any active remediation or monitoring, there are selected activities that are likely to continue regardless of whether any action is taken in OU-2. The existing POU and wellhead treatment units installed by EPA and private residents will likely continue to operate (with maintenance costs borne by the homeowner), although this is not certain. Also, in the absence of an adequate OU-2 monitoring program, a performance monitoring program would be required for the OU-1 remedy that would involve focused surface water and shallow groundwater monitoring. Similarly, there would potentially be a surface water monitoring program associated with the OU-3 remedy that EPA will select in the future.

**TABLE 4-1**
Description of Remedial Alternatives for Groundwater
*Feasibility Study Report for Operable Unit 2 Groundwater Lava Cap Mine Superfund Site, Nevada City, California*

| Alternative | Components | Description |
|---|---|---|
| 1 | No action | No active remediation or monitoring |
| 2 | • Point-of-use treatment<br>• Monitoring<br>• Land use notifications | • Installation and O&M of POU treatment systems at key locations (typically under kitchen sinks) in homes that receive their water supply from residential wells contaminated by mine-impacted groundwater currently or potentially in the future. POU treatment systems are currently being used at several homes in the Lava Cap Mine area to remove arsenic.<br>• Monitor arsenic in groundwater.<br>• Work with Nevada County to implement a notification process for domestic well drilling permit applicants in areas potentially impacted by mine-related groundwater contamination to inform the applicant of potential arsenic contamination. |
| 3 | • Wellhead treatment<br>• Monitoring<br>• Land use notifications | • Installation and O&M of wellhead treatment systems at residential wells contaminated by mine-impacted groundwater currently or potentially in the future.<br>• Same monitoring as Alternative 2.<br>• Same land use notification process as Alternative 2. |
| 4 | • Replacement water supply from NID<br>• Monitoring<br>• Land use Notifications | • Expand NID treated water municipal supply system to properties within the Source Area and Mine Area and Downgradient Area that are currently impacted by arsenic contamination, with a provision to extend the supply south of Greenhorn Road if downgradient properties became impacted in the future.<br>• Same monitoring as Alternative 2.<br>• Same land use notification process as Alternative 2. |

**TABLE 4-2**
Remedial Alternatives for Groundwater
*Feasibility Study Report for Operable Unit 2 Groundwater Lava Cap Mine Superfund Site, Nevada City, California*

| General Response Action | Component | Remedial Alternatives 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| No Action | No action | X | | | |
| Institutional Controls | Land use notifications | | X | X | X |
| Monitoring | Groundwater monitoring | | X | X | X |
| Alternative Water Supply | NID water supply | | | | X |
| Hydraulic Control | Pump-and-treat barrier | | | | |
| Treatment | Point-of-use treatment | | X | | |
| | Wellhead treatment | | | X | |

**TABLE 4-3**
Cost Summary of Remedial Alternatives
*Feasibility Study Report for Operable Unit 2 Groundwater Lava Cap Mine Superfund Site, Nevada City, California*

| | Alternative | Capital Cost ($) | Annual O&M and Monitoring Costs ($) | 50-Year NPV of Annual Cost[a] ($) | Total 50-Year NPV[a] ($) |
|---|---|---|---|---|---|
| 1 | No action | 0 | 0 | 0 | 0 |
| 2 | Point-of-use treatment | 12,000 | 47,000 | 1,172,000 | 1,184,000 |
| 3 | Wellhead treatment | 176,000 | 56,000 | 1,378,000 | 1,554,000 |
| 4 | NID water supply | 3,208,000 | 43,000 | 1,055,000 | 4,263,000 |
| | Optional NID extension | 1,891,000 | 0 | 0 | 0 |

[a]NPV estimates use a real discount rate of 3.2 percent (see Appendix B).

Note: All costs are rounded to the nearest $1,000.

# 4.2 Alternative 2 – Point-of-use Treatment

Alternative 2 is designed to protect human receptors by minimizing ingestion of arsenic in groundwater. The components of Alternative 2 include land use notifications, monitoring of groundwater, and installation and maintenance of POU treatment systems.

## 4.2.1 Treatment

POU treatment is intended to minimize ingestion of arsenic-contaminated groundwater. Homes served by residential wells within the modeled footprint of potential migration pathways of mine-impacted groundwater (see Figures 1-8 and 1-9) that produce groundwater exceeding the MCL would have a POU treatment system installed. As is shown on Figures 1-8 and 1-9, the footprint of potential mine-related contamination extends from the Mine Area downgradient, beyond Lost Lake to LGC. However, as previously described, most of the potential flow paths contained within the shaded areas on the figures have only a remote possibility of transporting arsenic contamination that would impact a residential well.

The treatment system would be a commercial POU system based on RO technology. The unit would be mounted under the kitchen sink of affected residences with a RO vessel, pre- and post-filtration vessels, interconnecting tubing, instruments, and controls in a packaged unit. The unit would be installed so that any water entering the faucet would pass through the POU unit.

There are four existing POU treatment systems and one wellhead treatment system currently installed at and immediately downgradient from the mine. Two of these POU systems were installed by EPA (Wells 10G and 11AL at the guest house) and two were installed by the residents without consulting EPA (Wells 10N and 11AL at the main house). The wellhead system at Well 11AV was also installed by the resident. For cost estimating, this FS assumes that up to seven additional POU treatment systems will be installed in the future. It is assumed that six of these additional systems would be installed at existing homes with residential wells that become impacted by mine-related contamination in the future, but they could potentially be installed in new homes supplied by new or existing wells within mine-impacted areas. The seventh new POU treatment system is assumed to replace the existing system currently treating water from Well 11 AL. This POU treatment system is having operational difficulties and likely will require replacement in the future. The new and existing POU treatment systems require routine maintenance (including replacement of adsorption media) to provide reliable treatment of arsenic. Cost estimates assume maintenance for 10 POU systems. This maintenance would be triggered by supplier and manufacturer recommendations of membrane and filter cartridge or media replacement frequencies. Analysis of influent and effluent samples from each treatment system is included in annual maintenance costs for these systems. Disposal of spent treatment membranes or filter media is not expected to be a concern and it is assumed that residents would dispose of membranes and filter cartridges or media as municipal solid waste. The small amount of brine waste generated by the treatment units would be disposed of in the home septic system with other household wastewater.

### 4.2.2 Monitoring

Existing residential wells that are currently monitored by EPA and selected existing monitoring wells will be periodically sampled to track migration of mine-related groundwater contamination towards residential wells. Continued monitoring is required to identify potential future changes in contaminant distribution that may require changes to the remedy (e.g., new releases from the Source Area or migration of contamination towards additional residential wells) and to evaluate whether remedial alternatives are adequately protecting human health.

As discussed in Section 1.8, additional investigations are required to fill data gaps. However, this additional investigation will be conducted separately from implementation of the remedial alternatives described in this FS. An assumed monitoring program has been developed to prepare annual monitoring costs (see Appendix B). This conceptual program includes semiannual monitoring at selected locations and either annual or biannual monitoring at most locations; the samples would be analyzed for arsenic as well as a few additional metals and general chemistry parameters.

### 4.2.3 Land Use Notifications

To limit potential human exposure to contaminated groundwater, a land use notification process would be developed in conjunction with the Nevada County Environmental Health Department for parcels within the footprint of potential flowpaths emanating from Lava Cap Mine. The specific number of parcels that would require notifications has not been determined but it is in the range of 30 to 50 parcels. EPA will provide maps of parcels in potentially impacted areas to Nevada County. However, existing wells in most of these areas are currently clean. It is assumed that the Nevada County Environmental Health Department would notify EPA and the resident when a well permit is requested for a potentially impacted parcel. Details of the land use notification process will be developed during the remedial design. Cost estimates assume that a small annual cost would be incurred for providing maps and coordinating with Nevada County. Annual costs were estimated to include inspections of residential wells and updates to the notification maps and associated fact sheets if arsenic conditions change.

## 4.3 Alternative 3 – Wellhead Treatment

Alternative 3 is intended to protect human receptors by preventing contact with arsenic in groundwater. The components of Alternative 3 include installation and maintenance of wellhead treatment units, expanded monitoring of groundwater, and land use notifications.

### 4.3.1 Treatment

Wellhead treatment is intended to eliminate exposure to arsenic-contaminated groundwater. Where the POU treatment described for Alternative 2 would only treat water at one sink in a residence, wellhead treatment would treat all water extracted from the impacted residential well, including landscaping and irrigation water. Residential wells that produce groundwater exceeding the arsenic MCL and are within the modeled footprint of potential migration pathways of mine-impacted groundwater (see Figures 1-8 and 1-9) would be equipped with a wellhead treatment system. In this FS, it is assumed that the wellhead treatment systems will use RO technology, similar to the POU treatment systems described for Alternative 2 (but capable of treating larger discharge rates).

There are currently five impacted residential wells that provide drinking water (Wells 10G, 10H, 10N, 11AL, and 11AV). Homes supplied with groundwater from Wells 10G, 10H, 10N, and 11AL are currently equipped with POU treatment (see Section 4.2.1); Well 11AV is equipped with wellhead treatment. In addition, there are two wells contaminated with arsenic that are not currently treated because they are used only for outdoor irrigation purposes (Wells 10I and 11AS). Cost estimates assume that these seven existing residential wells would each have a new wellhead treatment system installed. In addition to these seven systems, this FS assumes that up to five additional wellhead treatment systems would be installed in the future. It is assumed that these additional systems would be installed at existing homes with residential wells that become impacted by mine-related contamination in the future, but they could potentially be installed at new wells within mine-impacted areas. These wellhead treatment systems require routine maintenance to provide reliable treatment of arsenic (including changeout of adsorption media). Maintenance requirements would be based on system vendor recommendations and breakthrough of arsenic at the wellhead. Influent and effluent samples from each treatment system are included in the annual costs for system maintenance. For cost estimates, treatment residuals are expected to be non-hazardous and appropriate for disposal as municipal solid waste. Brine wastes would be disposed of in the home septic system with other household wastewater.

### 4.3.2 Monitoring

Monitoring would be the same as described for Alternative 2.

### 4.3.3 Land Use Notifications

Land use notifications would be the same as described for Alternative 2.

## 4.4 Alternative 4 – NID Water Supply

The intent of Alternative 4 would be to provide a reliable municipal water supply to replace well water at properties where existing wells are affected by mine-related arsenic contamination in groundwater. The local municipal water supplier would be the Nevada Irrigation District (NID). Residences with wells that are impacted by mine-related arsenic contamination would be connected to the NID treated water supply.

### 4.4.1 Replacement Water Supply from NID

NID does not currently have distribution pipelines along Greenhorn Road, south of the mine. However, NID operates the Elizabeth George water treatment plant located northwest of Lava Cap Mine. The NID distribution system is on the top of a ridge north of the mine, along Banner Lava Cap Road.

This alternative would provide an NID water connection to homes where residential wells produce groundwater that exceeds the arsenic MCL and are within the modeled footprint of potential migration pathways of mine-impacted groundwater (see Figures 1-8 and 1-9). Although the footprint of potential mine-related contaminant migration pathways extends from the Mine Area downgradient beyond Lost Lake to LGC, there are currently no arsenic impacts to residential well groundwater south of Greenhorn Road. Cost estimates assume that a new 8-inch-diameter ductile iron pipe would be installed from Banner Lava Cap Road (above the mine) down to Greenhorn Road (below the mine) (see Figure 4-1 and Appendix A). The cost estimate for this alternative assumes that connections would be made from the new pipeline to 10 locations that correspond to existing residential wells (Wells 10I, 10J, 10N, 10H, 10G, 11AV, 11AS, 11AL, 11AZ, and 11AY) located north of Greenhorn Road.

As a contingency to address potential future migration south of Greenhorn Road, estimated costs have also been developed to extend the pipeline to selected parcels between Greenhorn Road and the Deposition Area. This contingency component includes connecting the water pipeline to five additional locations that are currently served by existing wells (Wells 11AK, 11AF, 11AX, 11AX2, and 11AM) south of Greenhorn Road (see Figure 4-1).

No O&M costs are included in this alternative because it is assumed that this new pipeline will become part of the NID water supply system, and they would provide maintenance. The residential well owners would pay NID directly for their water consumption.

### 4.4.2 Monitoring

Monitoring would be the same as described for Alternative 2.

### 4.4.3 Land Use Notifications

Land use notifications would be the same as described for Alternative 2.

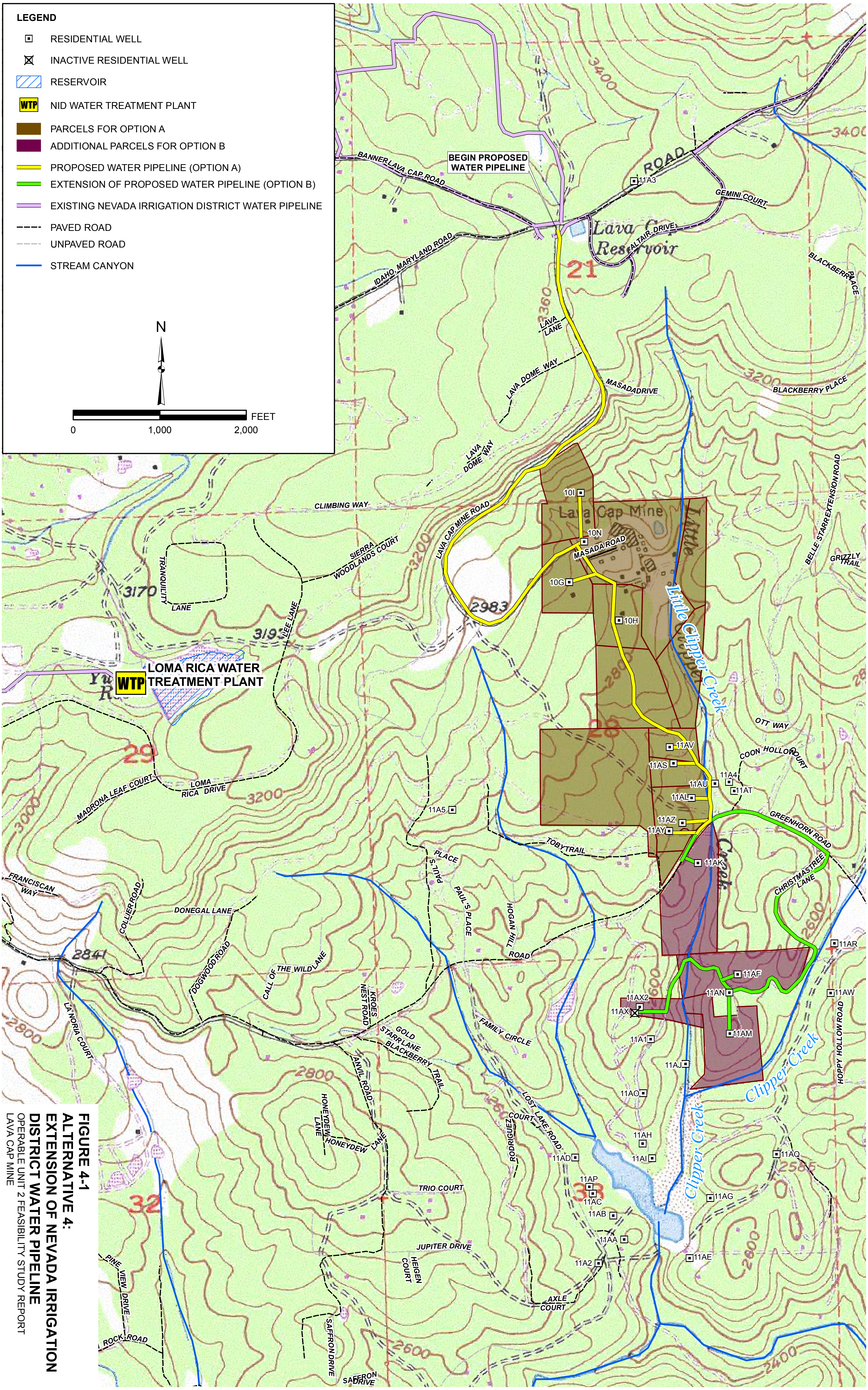


**FIGURE 4-1**
**ALTERNATIVE 4:**
**EXTENSION OF NEVADA IRRIGATION DISTRICT WATER PIPELINE**
OPERABLE UNIT 2 FEASIBILITY STUDY REPORT
LAVA CAP MINE

SECTION 5

# Detailed Analysis of Remedial Alternatives

This section provides a detailed analysis of remedial alternatives developed for drinking water at Lava Cap Mine. The remedial alternatives described in Section 4 are evaluated against the criteria specified in the *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (EPA, 1988). The alternatives are evaluated individually against each criterion, and then are compared to determine specific strengths and weaknesses that must be balanced. The results of the detailed analysis support the selection of a RA and the foundation for the ROD.

The nine CERCLA evaluation criteria include the following:

1. Overall protection of human health and the environment
2. Compliance with ARARs
3. Long-term effectiveness and permanence
4. Reduction of toxicity, mobility, or volume through treatment
5. Short-term effectiveness
6. Implementability
7. Cost
8. State acceptance
9. Community acceptance

The NCP (40 CFR 300.430(e)(9)(iii)) categorizes these nine criteria into three groups: (1) threshold criteria, (2) primary balancing criteria, and (3) modifying criteria. Each type of criteria has its own weight when it is evaluated.

Threshold criteria are requirements that each alternative must meet to be eligible for selection as the preferred alternative, and include overall protection of human health and the environment and compliance with ARARs (unless a waiver is obtained).

Primary balancing criteria are used to weigh effectiveness and cost tradeoffs among alternatives. The primary balancing criteria include long-term effectiveness and permanence; reduction of toxicity, mobility, or volume through treatment; short-term effectiveness; implementability; and cost. The primary balancing criteria represent the main technical criteria upon which the alternatives evaluation is based.

Modifying criteria include state acceptance and community acceptance and may be used to modify aspects of the preferred alternative when preparing the ROD. Modifying criteria are generally evaluated after public comment on the FS and the proposed plan. Accordingly, only the seven threshold and primary balancing criteria are considered in the detailed analysis phase. The following sections contain descriptions of the first seven evaluation criteria, individual evaluations of the alternatives, and comparative evaluations for each subarea. Descriptions of the remedial alternatives are provided in Section 4.

## 5.1 Description of Evaluation Criteria

### 5.1.1 Overall Protection of Human Health and the Environment

This evaluation criterion assesses how each alternative provides and maintains adequate protection of human health and the environment. Alternatives are assessed to determine whether they can adequately protect human health and the environment from unacceptable risks posed by contaminants present at the Site, in both the short and long term. This criterion is also used to evaluate how risks would be eliminated, reduced, or controlled through treatment, engineering, institutional controls, or other remedial activities. The considerations evaluated during the analysis of each alternative for the overall protection of human health and the environment are presented in Table 5-1. As discussed in the RAOs (see Section 2), the remedial alternatives presented in this FS do not directly address future migration of mine-related groundwater contamination or potential groundwater discharges to surface water. If those pathways are a concern in the future as it cannot yet be determined if this is going to be a long-term pathway of concern.

**TABLE 5-1**
Overall Protection of Human Health and the Environment
*Feasibility Study Report for Operable Unit 2 Groundwater Lava Cap Mine Superfund Site, Nevada City, California*

| Analysis Factors | Considerations |
|---|---|
| Human Health Protection | Likelihood that the alternative reduces risk to human health through exposure to contaminants in drinking water by direct contact, ingestion, or inhalation. |
| Environmental Protection | Not applicable for this portion of OU-2. |

### 5.1.2 Compliance with ARARs

This evaluation criterion is used to determine if each alternative would comply with federal and state ARARs, or whether invoking waivers to specific ARARs is adequately justified. Other information, such as advisories, criteria, or guidance, is considered where appropriate during the ARARs analysis. The considerations evaluated during the analysis of the ARARs for each alternative are presented in Table 5-2. Potential action-, location-, and chemical-specific ARARs for the alternatives presented in this FS are identified in Section 2.

**TABLE 5-2**
Compliance with ARARs
*Feasibility Study Report for Operable Unit 2 Groundwater Lava Cap Mine Superfund Site, Nevada City, California*

| Analysis Factors | Considerations |
|---|---|
| Chemical-specific ARARs | Likelihood that the alternative will achieve compliance with chemical-specific ARARs within a reasonable period of time.<br>If it appears that compliance with chemical-specific ARARs will not be achieved, evaluation of whether a waiver is appropriate. |
| Location-Specific ARARs | Likelihood that the alternative will achieve compliance with the location-specific ARARs (if any apply).<br>Evaluation of whether a waiver is appropriate if location-specific ARARs cannot be met. |
| Action-specific ARARs | Likelihood that the alternative will achieve compliance with action-specific ARARs.<br>Evaluation of whether a waiver is appropriate if action-specific ARARs cannot be met. |

### 5.1.3 Long-term Effectiveness and Permanence

This evaluation criterion addresses the long-term effectiveness and permanence of maintaining the protection of human health and the environment after implementing the RA described in the remedial alternative. The primary components of this criterion are the magnitude of residual risk remaining at the Site after remedial objectives have been met and the extent and effectiveness of controls that might be required to manage the risk posed by treatment residuals and untreated wastes. The considerations evaluated during the analysis of each alternative for long-term effectiveness and permanence are presented in Table 5-3.

**TABLE 5-3**
Long-term Effectiveness and Permanence
*Feasibility Study Report for Operable Unit 2 Groundwater Lava Cap Mine Superfund Site, Nevada City, California*

| Analysis Factors | Considerations |
|---|---|
| Magnitude of Residual Risks | Identity of remaining risks (risks from treatment residuals) and risks from untreated residual contamination. |
| | Magnitude of the remaining risks. |
| Adequacy and Reliability of Controls | Likelihood that the technologies will meet required process efficiencies or performance specifications. |
| | Type and degree of long-term management required. |
| | Long-term monitoring requirements. |
| | Operation and maintenance functions that must be performed. |
| | Difficulties and uncertainties associated with long-term operation and maintenance functions. |
| | Potential need for technical components replacement. |
| | Magnitude of threats or risks should the RA need replacement. |
| | Degree of confidence that controls can adequately handle potential problems. |
| | Uncertainties associated with land disposal of residuals and untreated wastes. |

### 5.1.4 Reduction of Toxicity, Mobility, or Volume through Treatment

This evaluation criterion addresses the anticipated performance of the alternative's treatment technologies in permanently and significantly reducing the toxicity, mobility, and volume of hazardous materials at the Site. The NCP prefers RAs where treatment is used to reduce the principal threats at a site through destruction of toxic contaminants, irreversible reduction in contaminant mobility, or reduction of total volume of contaminated media. The considerations evaluated during the analysis of each alternative for the reduction of toxicity, mobility, or contaminant volume are presented in Table 5-4.

**TABLE 5-4**
Reduction of Toxicity, Mobility, or Volume through Treatment
*Feasibility Study Report for Operable Unit 2 Groundwater Lava Cap Mine Superfund Site, Nevada City, California*

| Analysis Factors | Considerations |
|---|---|
| Treatment process and remedy | Likelihood that the treatment process addresses the principal threat. |
| | Special requirements for the treatment process. |
| Amount of hazardous material destroyed or treated | Portion (mass) of contaminant that is destroyed. |
| | Portion (mass) of contaminant that is treated. |
| Reduction in toxicity, mobility, or volume | Extent that the mass of contaminants is reduced. |

**TABLE 5-4**
Reduction of Toxicity, Mobility, or Volume through Treatment
*Feasibility Study Report for Operable Unit 2 Groundwater Lava Cap Mine Superfund Site, Nevada City, California*

| Analysis Factors | Considerations |
|---|---|
| | Extent that the mobility of contaminants is reduced. |
| | Extent that the volume of contaminants is reduced. |
| Irreversibility of treatment | Extent that the effects of the treatment are irreversible. |
| Type and quantity of treatment residual | Residuals that will remain. |
| | Quantities and characteristics of the residuals. |
| | Risk posed by the treatment residuals. |
| Statutory preference for treatment as a principal element | Extent to which the scope of the action covers the principal threats. |
| | Extent to which the scope of the action reduces the inherent hazards posed by the principal threats at the Site. |

### 5.1.5 Short-term Effectiveness

This evaluation criterion considers the effect of each alternative on the protection of human health and the environment during the construction and implementation process. The short-term effectiveness evaluation only addresses protection prior to meeting the RAO. The considerations evaluated during the analysis of each alternative for short-term effectiveness are presented in Table 5-5.

**TABLE 5-5**
Short-term Effectiveness
*Feasibility Study Report for Operable Unit 2 Groundwater Lava Cap Mine Superfund Site, Nevada City, California*

| Analysis Factors | Considerations |
|---|---|
| Protection of the community during the RA | Risks to the community that must be addressed. |
| | How the risks will be addressed and mitigated. |
| | Remaining risks that cannot be readily controlled. |
| Protection of workers during RAs | Risks to the workers that must be addressed. |
| | How the risks will be addressed and mitigated. |
| | Remaining risks that cannot be readily controlled. |
| Environmental impacts | Environmental impacts that are expected with the construction and implementation of the alternative. |
| | Mitigation measures that are available and their reliability to minimize potential impacts. |
| | Impacts that cannot be avoided, should the alternative be implemented. |
| Time until RA objectives are achieved | Time to achieve protection against the threats being addressed. |
| | Time until any remaining threats are addressed. |
| | Time until RAOs are achieved. |

### 5.1.6 Implementability

This criterion evaluates the technical feasibility and administrative feasibility (i.e., the ease or difficulty) of implementing each alternative and the availability of required services and materials during its implementation. The considerations evaluated during the analysis of each alternative for implementability are presented in Table 5-6.

**TABLE 5-6**
Implementability
*Feasibility Study Report for Operable Unit 2 Groundwater Lava Cap Mine Superfund Site, Nevada City, California*

| Analysis Factors | Considerations |
|---|---|
| Technical Feasibility | |
| Ability to construct and operate the technology | Difficulties associated with the construction. |
| | Uncertainties associated with the construction. |
| Reliability of the technology | Likelihood that technical problems will lead to schedule delays. |
| Ease of undertaking additional RA | Likely future RAs that may be anticipated. |
| | Difficulty implementing additional RAs. |
| Monitoring considerations | Migration or exposure pathways that cannot be monitored adequately. |
| | Risk of exposure should the monitoring be insufficient to detect failure. |
| Administrative Feasibility | |
| Coordination with other agencies | Steps required to coordinate with regulatory agencies. |
| | Steps required to establish long-term or future coordination among agencies. |
| | Ease of obtaining permits for offsite activities, if required. |
| Availability of Services and Materials | |
| Availability of treatment, storage capacity, and disposal services | Availability of adequate treatment, storage capacity, and disposal services. |
| | Additional capacity that is necessary. |
| | Whether lack of capacity prevents implementation. |
| | Additional provisions required to ensure that additional capacity is available. |
| Availability of necessary equipment and specialists | Availability of adequate equipment and specialists. |
| | Additional equipment or specialists that are required. |
| | Whether there is a lack of equipment or specialists. |
| | Additional provisions required to ensure that equipment and specialists are available. |
| Availability of prospective technologies | Whether technologies under consideration are generally available and sufficiently demonstrated. |
| | Further field applications needed to demonstrate that the technologies could be used full-scale to treat the waste at the Site. |
| | When technology should be available for full-scale use. |
| | Whether more than one vendor will be available to provide a competitive bid. |

### 5.1.7 Cost

This criterion evaluates the cost of implementing each alternative. The cost of an alternative encompasses all engineering, construction, and operation and maintenance costs incurred over the life of the project. According to CERCLA guidance, cost estimates for remedial alternatives were developed with an expected accuracy range of –30 to +50 percent.

The costs of the remedial alternatives are compared using the estimated NPV of the alternative. The NPV allows costs for remedial alternatives to be compared by discounting all costs to the year that the alternative is implemented. In the *Guide to Developing and Documenting Cost Estimates During the Feasibility Study* (EPA, 2000), EPA states that the commonly used assumption of a 30-year period of analysis for estimating present value is not recommended. Most of the remedial alternatives developed for this Site require long-term operation and maintenance activities, including treatment of groundwater and groundwater monitoring. A duration of 50 years was chosen as the period of analysis for this FS, rather than an assumption of 30 years. Operation and maintenance for the remedial alternatives will likely extend beyond 50 years. However, the NPV reaches an asymptotic level for increasing periods of analysis, and large uncertainties exist with regard to technological advances that could occur if longer durations are assumed for costing.

For all alternatives, the NPV was calculated using the real discount rate in Appendix C of *Office of Management and Budget Circular A-94*. The real discount rate based on the economic assumptions from the 2004 budget for programs with durations of 30 years or longer is 3.2 percent.

The capital costs, annual O&M costs, and 50-year NPV for each of the alternatives are summarized in Table 4-3. Detailed cost estimates and cost estimate assumptions are provided in Appendix B.

# 5.2 Individual Analysis of Remedial Alternatives

The remedial alternatives developed to address arsenic in drinking water are described in detail in Section 4. The remedial alternatives target exposure to groundwater that exceeds the cleanup goal of 10 µg/L (the MCL).

Four alternatives have been analyzed for groundwater at Lava Cap Mine:

- Alternative 1 – No Action
- Alternative 2 – Point-of-use Treatment
- Alternative 3 – Wellhead Treatment
- Alternative 4 – NID Water Supply

These alternatives are described in the following sections; a summary of the detailed analysis for the alternatives is presented in Table 5-7.

## 5.2.1 Alternative 1 - No Action

The no action alternative provides a baseline from which to analyze other alternatives.

**TABLE 5-7**
Remedial Alternatives Comparative Analysis Matrix
*Feasibility Study Report for Operable Unit 2 Groundwater Lava Cap Mine Superfund Site, Nevada City, California*

| | | Threshold Criteria | | Balancing Criteria | | | | |
|---|---|---|---|---|---|---|---|---|
| **Remedial Alternative** | **Major Components** | **Protection of Human Health and the Environment** | **Compliance with ARARs** | **Long-term Effectiveness and Permanence** | **Reduction in Toxicity, Mobility and Volume** | **Short-term Effectiveness** | **Implementability** | **Estimated Total NPV ($)** |
| Alternative 1: No Action | None | C – RAOs would not be achieved. Health risks to residents would be above acceptable range. | C – Would not comply with the SDWA. | C – Future risks to human health and the environment would not be diminished. | C – No treatment or reduction in toxicity, mobility, and volume of arsenic in drinking water. | C – No RA; therefore, no additional impacts to populations from implementation. RAOs would not be achieved. | A – Implementable. | 0 |
| Alternative 2: Point-of-use Treatment | Point-of-use treatment<br>Monitoring<br>Land-use notifications | B – Significantly reduces arsenic ingestion by residents if only treated water is consumed. | B – Would comply with SDWA if residential consumption is limited to only POU treated water. | B – Significant groundwater contamination remains, but human health risk is controlled. Some uncertainty associated with long-term reliance solely on undersink POU treatment to limit exposure. | B –Point-of-use treatment would reduce toxicity in drinking water at the unit, though other water supplies in the household would not. | A – Very limited construction activities; therefore, minimal additional impacts to community from implementation. RAO of protection of human exposure to arsenic in drinking water would be achieved rapidly. | A – Readily implementable with adequate coordination with property owners. Most existing residential wells that exceed the MCL have some form of POU treatment already installed. | 1,184,000 |
| Alternative 3 Wellhead Treatment | Wellhead treatment<br>Monitoring<br>Land-use notifications | B – Significantly reduces risks of exposure to arsenic in residential water. | A – Would comply with ARARs, including SDWA. | B – Significant groundwater contamination remains, but human health risk is controlled if the wellhead treatment units are properly maintained. | A –Wellhead treatment would reduce the toxicity of arsenic in residential water. | A – Very limited construction activities; therefore, minimal impacts to community from implementation. RAO of protection of human exposure to arsenic in drinking water would be achieved rapidly. | A – Readily implementable with adequate coordination with property owners. | 1,554,000 |
| Alternative 4: NID Water Supply | Replacement water supply from NID<br>Monitoring<br>Land-use notifications | A – Higher level of protection of human health than Alternative 3 because it does not rely on treatment of residential wells. | A – Expected to comply with all ARARs, including any location-specific ARARs associated with the pipeline route. | A – Significant groundwater contamination remains, but human health risks are controlled without the requirement of maintaining treatment units. | B – Although there is no treatment, there is significant reduction in toxicity by eliminating use of contaminated residential wells. | B – Installation of the NID pipeline would create a short-term risk to workers and have significant short-term nuisance impacts on the local community adjacent to the mine. | B – Implementable, but with administrative challenges associated with installation of the NID pipeline, including coordination with NID and a larger number of property owners. | 4,263,000 |

Qualitative assessment of the results of criteria evaluation:

A = Favorable

B = Favorable with qualifiers

C = Not favorable

#### 5.2.1.1 Overall Protection of Human Health and the Environment

The estimated excess lifetime cancer risk for the residential receptor in Exposure Unit 3 (residents in the Mine Area and Source Area) is $1.3 \times 10^{-3}$, which is greater than the acceptable range for Site-related exposures, defined by EPA as between $1 \times 10^{-6}$ and $1 \times 10^{-4}$. Arsenic was determined to be the primary risk driver via the exposure pathway of ingestion of drinking water. The no action alternative would not actively attempt to eliminate, reduce, or control the risk to residents. It should be noted that currently actions are being taken (i.e., POU treatment and wellhead treatment) at residential properties to reduce potential risks associated with exposure to arsenic-contaminated groundwater. Even if the no action alternative is selected, these actions may continue; however, that is not certain.

No monitoring programs would be implemented to help refine the nature and extent of mine-related contamination or monitor for potential future contaminant migration. Therefore, potential future impacts of mine-related groundwater contamination on drinking water would remain unknown.

#### 5.2.1.2 Compliance with ARARs

Action- and location-specific ARARs are not applicable to the no action alternative. Alternative 1 would allow residential drinking water exposure to arsenic concentrations above the MCL and would not comply with the SDWA.

#### 5.2.1.3 Long-term Effectiveness and Permanence

All current and future risks remain under Alternative 1. Untreated contamination in drinking water would continue to pose a risk to human health and the environment. No controls would be implemented to manage untreated groundwater.

#### 5.2.1.4 Reduction of Toxicity, Mobility, or Volume through Treatment

There is no reduction of toxicity, mobility, or volume through treatment because no treatment technologies would be employed. No treatment residuals would be generated.

#### 5.2.1.5 Short-term Effectiveness

Because no RA would be taken under Alternative 1, no short-term risks to the community or to workers would occur as a result of implementing the alternative. Similarly, no environmental impact from construction activities would occur. RAOs would not be met. No actions would be taken to protect against human exposure to contamination in groundwater that poses a significant risk.

#### 5.2.1.6 Implementability

The no action alternative is implementable, and no permits would be required.

#### 5.2.1.7 Cost

No cost is associated with the no action alternative.

## 5.2.2 Alternative 2 – Point-of-use Treatment

A detailed description of Alternative 2 is presented in Section 4.2. Point-of-use treatment systems would be installed in all residences that fall within the potential flowpath of mine-related contamination and that use groundwater contaminated with arsenic above the MCL. Land-use notifications would be implemented to reduce the potential for future new residential exposures to contaminated groundwater. Monitoring of groundwater would be performed to assess potential impacts to residential wells.

### 5.2.2.1 Overall Protection of Human Health and the Environment

If used properly by the residents, POU treatment would greatly reduce ingestion of arsenic at residential properties. According to the HHRA, ingestion is the most important exposure pathway for risk to residential receptors. However, the human health protection offered by Alternative 2 could be compromised if the residents do not consistently ingest water supplied by a POU treatment system or if proper O&M of the treatment system is not performed in a timely manner. The land-use notification process included in Alternative 2 should reduce the likelihood that new residential wells would be installed in contaminated portions of the aquifer without the residents being aware of the potential presence of arsenic; thereby reducing the potential for future ingestion of contaminated drinking water. Alternative 2 groundwater monitoring would help track potential future migration of mine-related groundwater contamination toward residential wells.

### 5.2.2.2 Compliance with ARARs

No location- or action-specific ARARs will likely apply to Alternative 2.

Point-of-use treatment would reduce, but not eliminate, potential consumption of drinking water with arsenic concentrations exceeding the MCL. Therefore, full compliance with the SDWA ARAR is possible but cannot be certain.

### 5.2.2.3 Long-term Effectiveness and Permanence

Under Alternative 2, the arsenic contamination present in groundwater would remain essentially unchanged. However, Alternative 2 manages the risks to human health by reducing the ingestion exposure pathway. Implementation of a routine monitoring program in conjunction with the land-use notification process should increase the likelihood that residences with arsenic-contaminated groundwater that need POU treatment would have access to it. There are questions about the long-term effectiveness of POU treatment, because contaminated water would continue to be supplied to the house and effective risk reduction would require residents to only ingest water treated by a POU treatment system. In addition, the residents need to either perform operation and maintenance activities or coordinate with the entity providing these services. Residential ownership could change over time, reducing the long-term effectiveness and permanence. Also, the land-use notification process might not be fully effective over the long-term because it relies on the diligence of the agency providing notifications, landowner knowledge of the residential well permit process, and their willingness to follow recommendations.

#### 5.2.2.4 Reduction of Toxicity, Mobility, or Volume through Treatment

The Alternative 2 POU treatment units would reduce toxicity in drinking water that is used for human consumption; however, other water supplies in the household would not be treated.

#### 5.2.2.5 Short-term Effectiveness

Very limited construction activities would be implemented as part of Alternative 2, including installation of a small number of POU treatment units inside residences. The short-term risks to the community during RA construction would be insignificant. The land-use notification process can be implemented rapidly and required POU treatment units could be readily installed (POU treatment units are already in place at most of the impacted residences). After any new or existing wells within the potential footprint of groundwater flow away from the mine have been sampled and any required POU systems are in place, RAOs to limit human exposure to arsenic in drinking water would be achieved.

#### 5.2.2.6 Implementability

Implementation of Alternative 2 would be feasible from a technical and administrative perspective. Effective implementation of the land-use notification process would require coordination with Nevada County and property owners. Although several POU treatment units have already been installed at existing residences with arsenic above the MCL, installation of any additional units and routine monitoring and maintenance of both existing and new units would require access to each residence.

#### 5.2.2.7 Cost

The estimates of capital cost, annual cost, and NPV to implement Alternative 2 are summarized in Table 4-3. The capital cost includes labor to develop the land-use notification process and installation costs for additional POU treatment units. The estimated annual cost includes treatment unit operations and maintenance, monitoring program implementation, land-use notification process coordination, and costs for replacement of treatment units after 25 years. To calculate the NPV, the project duration was assumed to be 50 years.

### 5.2.3 Alternative 3 – Wellhead Treatment

A detailed description of Alternative 3 is provided in Section 4.3. Wellhead treatment systems would be installed on all residential wells that fall within the potential flowpath of mine-related contamination and yield groundwater contaminated with arsenic above the MCL. Land-use notifications would be implemented to reduce the potential for future new residential exposures to contaminated groundwater. Monitoring of groundwater would be performed to assess future impacts to residential wells.

#### 5.2.3.1 Overall Protection of Human Health and the Environment

Wellhead treatment would greatly reduce exposure to arsenic in drinking water at residential properties. Wellhead treatment is considerably more protective of human health than POU treatment because all of the water produced from contaminated residential wells is treated. However, the human health protection provided by Alternative 3 requires routine monitoring of the residential well and proper O&M of the wellhead treatment system. As described for Alternative 2, the land-use notification process should reduce the likelihood that new residential wells would be installed in contaminated portions of the aquifer without the residents being aware of the potential presence of arsenic; thereby reducing the potential for future exposure to contaminated groundwater. The proposed groundwater monitoring would help track potential future migration of mine-related groundwater contamination and potential discharges to surface water.

#### 5.2.3.2 Compliance with ARARs

No location- or action-specific ARARs will likely apply to Alternative 3. The wellhead treatment systems should eliminate potential consumption of groundwater with arsenic concentrations exceeding the MCL, in compliance with the SDWA ARAR.

#### 5.2.3.3 Long-term Effectiveness and Permanence

Arsenic contamination in groundwater would not be significantly reduced under Alternative 3. However, Alternative 3 manages the risks to human health by eliminating potential exposure to arsenic concentrations exceeding the MCL at residential wells. Implementation of a routine monitoring program in conjunction with the land-use notification process should increase the likelihood that residential wells producing arsenic-contaminated groundwater would have access to wellhead treatment. The long-term effectiveness of wellhead treatment requires routine monitoring of the system effluent and timely implementation of required system maintenance. Residential ownership changes over time might reduce long-term effectiveness if future residents are less diligent in maintaining the treatment system. Also, the land-use notification process might not be fully effective over the long-term because it relies on continuing diligence of the agency providing notifications, landowner knowledge of the residential well permit process, and their willingness to follow the recommendations.

#### 5.2.3.4 Reduction of Toxicity, Mobility, or Volume through Treatment

The Alternative 3 wellhead treatment systems would reduce the toxicity all water pumped from arsenic-contaminated residential wells.

#### 5.2.3.5 Short-term Effectiveness

Limited construction activities would be implemented as part of Alternative 3, including installation of a limited number of wellhead treatment units. Accordingly, the short-term risks to the community during RA construction would be small. The land-use notification process could be implemented rapidly and the required wellhead treatment units could be readily installed. After existing and new (if any) wells within the potential footprint of groundwater flow away from the mine have been sampled and any required wellhead treatment units installed, the RAO of limiting human exposure to arsenic in drinking water would be achieved

#### 5.2.3.6 Implementability

Implementation of Alternative 3 would be feasible from a technical and administrative perspective. Effective implementation of the land-use notification process requires coordination with Nevada County and property owners. Wellhead treatment units would need to be installed at existing residential wells with arsenic concentrations exceeding the MCL. This requires approval of the property owners and access agreements. Routine monitoring and O&M of wellhead treatment units would also require access to the residential wells.

#### 5.2.3.7 Cost

The estimates of capital cost, annual cost, and NPV to implement Alternative 3 are summarized in Table 4-3. The capital cost includes labor to develop the land-use notification process and installation costs for wellhead treatment units. The estimated annual costs include treatment unit maintenance, monitoring program implementation, land-use notification process coordination, and costs for replacement of wellhead units after 25 years. To calculate the NPV, the project duration was assumed to be 50 years.

### 5.2.4 Alternative 4 – NID Water Supply

A detailed description of Alternative 4 is provided in Section 4.4. A new municipal water supply pipeline would be installed from NID's existing supply system, north of the mine, and extending south through the mine property to Greenhorn Road (and beyond if necessary). Connections to the water supply line would be provided to all properties within the potential flowpath of mine-related contamination that have residential wells producing groundwater contaminated with arsenic exceeding the MCL. The land-use notification process would be implemented to reduce the potential for future new residential exposures to contaminated groundwater. Monitoring of groundwater would be performed to assess future impacts to residential wells.

#### 5.2.4.1 Overall Protection of Human Health and the Environment

Alternative 4 would greatly reduce human health risks by eliminating potential residential exposure to drinking water containing arsenic above the MCL. An alternative water supply provides greater protection than wellhead treatment because it is a more reliable supply of clean water that does not depend on timely well monitoring and proper O&M of the wellhead treatment systems. As a regulated water utility, NID can be expected to consistently provide a high-quality water supply. The land-use notification process should increase the likelihood that property owners in potentially contaminated areas are aware of the option to connect to the NID water supply rather than installing new residential wells that might cause exposure to arsenic. The groundwater monitoring program for Alternative 4 would be used to identify potential migration of mine-related groundwater contamination toward residential wells.

#### 5.2.4.2 Compliance with ARARs

Alternative 4 would comply with ARARs identified for this alternative. Depending on the pipeline route ultimately selected, there may be some action-specific and location-specific ARARs to be addressed. However, it is expected that the NID pipeline would be routed along existing roadways.

#### 5.2.4.3 Long-term Effectiveness and Permanence

Arsenic contamination in groundwater would not be reduced under Alternative 4. However, Alternative 4 manages the risks to human health by eliminating potential exposure to arsenic in excess of the MCL at residential wells. Implementation of a routine monitoring program in conjunction with the land-use notification process should effectively reduce the potential for drinking water exposures to arsenic exceeding the MCL in residential wells within the potential pathways of mine-impacted groundwater. An alternative water supply should provide reliable long-term effectiveness and permanence, particularly if the impacted residential wells are properly abandoned.

#### 5.2.4.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative 4 does not contain a treatment component. Alternative 4 would not reduce toxicity, mobility, or volume of arsenic in groundwater. However, drinking water toxicity is greatly reduced by eliminating the use of contaminated residential wells.

#### 5.2.4.5 Short-term Effectiveness

There would be short-term impacts to the local community and risks to workers during installation of the NID pipeline. Community impacts include increased traffic from construction workers and equipment, increased truck traffic for delivery of pipe and construction materials, and nuisance noise from the truck traffic and construction work. The construction would likely extend along Lava Cap Mine Road and Tensy Lane (see Figure 4-1). These two roads are small, privately-owned roads with limited numbers of users, but they run close to homes in two small neighborhoods. Although the overall impacts to the community are small (similar to any small, public works project), they will represent a significant, short-term inconvenience for the few residents directly along the pipeline route. Also, the pipeline will be routed through the mine property; care will be necessary to reduce potential worker contact with contaminated materials during pipeline installation.

The RAO of limiting potential human exposures to arsenic in drinking water would be achieved after connection of the impacted properties to the NID pipeline.

#### 5.2.4.6 Implementability

Implementation of Alternative 4 would be feasible from a technical and administrative perspective. However, there would be additional challenges compared with the other alternatives. Pipeline installation would require cooperation and close coordination with NID, property owners, and other stakeholders. Access agreements or easements for pipeline installation will need to be obtained from numerous private property owners. Effective implementation of the land-use notification process would require coordination with Nevada County and property owners.

Individual residences would need to be connected to the NID water supply line. This would require approval of the property owners and, potentially, an access agreement.

#### 5.2.4.7 Cost

The estimates of capital cost, annual cost, and NPV to implement Alternative 4 are summarized in Table 4-3. The most significant component of the capital cost is construction of the NID pipeline. The primary component of the estimated annual cost is implementation of the groundwater monitoring program. To estimate the NPV of the alternative, the total project duration was assumed to be 50 years.

# 5.3 Comparative Analysis of Remedial Alternatives

## 5.3.1 Overall Protection of Human Health and the Environment

Alternative 1 is not adequately protective of human health or the environment because it allows uncontrolled human exposure and does not provide any monitoring of potential additional migration toward residential wells. Alternatives 2 through 4 provide protection of human health by limiting or preventing exposure to arsenic in drinking water. Alternative 2 provides the lowest overall protection because contaminated water would continue to be used in residences and under-sink POU treatment is unlikely to completely eliminate exposure. Alternative 3 provides a greater level of protection by treating all water from impacted wells, further reducing potential exposure. Alternative 4 provides the highest level of human health protection by providing an alternative water supply that does not rely on the effectiveness of wellhead treatment or the associated long-term O&M. Alternative 2 through 4 monitor potential future impacts related to continued migration of mine-impacted groundwater contamination toward residential wells.

## 5.3.2 Compliance with ARARs

Alternative 1 would not comply with SDWA requirements that drinking water supplies meet MCLs. All other alternatives are expected to meet the MCL for arsenic in drinking water, although there is some potential under Alternative 2 for residential consumption of drinking water that exceeds the arsenic MCL. Alternatives 2 through 4 are expected to comply with all action- and location-specific ARARs during construction.

## 5.3.3 Long-term Effectiveness and Permanence

All current and future risks to human health and the environment would remain under Alternative 1. Significant groundwater contamination would remain in Alternatives 2 through 4; however, human health risks from this contamination would be controlled by minimizing or eliminating exposure to contaminated drinking water. Alternative 2 is ranked lower than Alternatives 3 and 4 because it relies on long-term, consistent use and proper maintenance of the POU treatment units. Similarly, Alternative 4 is ranked higher than Alternative 3 because of the increased reliability and adequacy of the NID supply compared with long-term, proper monitoring and O&M of wellhead treatment units at individual residences.

## 5.3.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Alternatives 1 and 4 would not result in a significant reduction of toxicity, mobility, or volume of arsenic in the groundwater system. However, Alternatives 2 and 3, through treatment, reduce the toxicity of arsenic in groundwater that is extracted for drinking water purposes. Although Alternative 4 does not include treatment, it does reduce toxicity by eliminating groundwater extraction from contaminated wells.

## 5.3.5 Short-term Effectiveness

There would be no short-term impacts for Alternative 1, but RAOs would not be achieved. Alternatives 2 and 3 involve very limited construction activities. Accordingly, the short-term impacts are minimal. Installation of the NID pipeline in Alternative 4 would create a short term risk to workers and have significant short-term nuisance impacts on the local community adjacent to the mine. Accordingly, this alternative is ranked lower than Alternatives 2 and 3.

For Alternatives 2 and 3, RAOs for the protection of human health should be achieved relatively quickly (less than 1 year) given the limited properties expected to require treatment. Alternative 4 would take longer because of the additional administrative requirements, including NID coordination and numerous agreements with private property owners, associated with installation of the NID pipeline and connection of individual residences to the supply.

Overall, Alternative 4 is ranked lowest for this criterion because the NID pipeline increases the short-term impacts to the community and extends the time until RAOs are achieved.

### 5.3.6 Implementability

The no-action alternative, Alternative 1, would be readily implementable. Alternatives 2 and 3 are also expected to be readily implementable because of the small number of residences involved

As previously noted, Alternative 4 requires coordination with NID, property owners, and other stakeholders. Installation of an NID water supply pipeline will provide additional administrative challenges but is feasible. This alternative is ranked lowest for this criterion.

### 5.3.7 Cost

The estimated NPV of each alternative is shown in Table 5-7. Alternatives 2 and 3 are the lowest cost alternatives, with estimated NPVs of approximately $1.5 and $1.9 million, respectively. Alternative 4 is the highest cost alternative, with an estimated NPV of $4.4 million.

SECTION 6

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# Appendix A
# Extension of Nevada Irrigation District Water Pipeline

# Alternative 4: Extension of Nevada Irrigation District Water Pipeline

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This technical memorandum discusses the requirements and associated costs for constructing a new pipeline to create an extension to Nevada Irrigation District (NID) potable water main near Lava Cap Mine (see Figure A-1). The purpose of this pipeline would be to provide a suitable water supply to existing wells that are potentially contaminated as a result of historical Lava Cap Mine operations. Two options are considered for the pipeline. Option A would deliver water to 10 existing wells (Wells 10I, 10J, 10N, 10H, 10G, 11AV, 11AS, 11AL, 11AZ, and 11AY) located north of Greenhorn Road. Option B would deliver water to the 10 existing wells in Option A plus 5 additional existing wells (Wells 11AK, 11AF, 11AX, 11AX2, and 11AM) south of Greenhorn Road (see Figure A-1). General requirements, pipeline alignment, and associated costs are discussed in the following sections. These should be considered preliminary details for use in developing and costing remedial alternatives only. If this alternative is selected, specific details regarding the new pipeline will be developed during remedial design.

## General Requirements for the Extension Pipeline

The water main extension would be constructed using ductile iron pipe (DIP), wrapped in 6-mil polyethylene film for corrosion protection, with an 8-gauge locating wire located above it, as required by NID development standards. While the new pipeline would be installed to replace 10 or 15 residential wells that pump up to 10 gallons per minute (gpm) each (100 or 150 gpm total), it is required to be designed to provide adequate flow for fire protection (approximately 1,000 gpm). To comply with required NID fire hydrant flows, the pipeline should be 8 inches in diameter and operate at more than 150-pounds per square inch (psi) static pressure where a hydrant is present. NID requires hydrants to be spaced at 500-foot intervals.

The topography of the region is characterized by rolling terrain and extensive tree cover. To ease construction, reduce environmental impacts, and eliminate the need for easements, the pipeline would be installed in the existing road right-of-way. A minimum of 3 feet of cover would be placed above the pipeline, primarily to protect it from vehicle loads.

Air vents and blowoffs would be required at high and low points, respectively; surge protection may be required. Upon installation and before connecting to the existing system, the entire pipeline would need to undergo disinfection and pressure-leak testing.

## Alignment

Alignments for both options would connect at the intersection of Banner Lava Cap Road and Lava Cap Mine Road. The pipeline would extend south along the Lava Cap Mine Road right-of-way to the Lava Cap Mine property. It would then extend southward under unpaved roads near Clipper Creek.

### Option A

Option A serves four wells on the northern portion of the Lava Cap Mine property and then extends south along the primary mine access road and Tensy Lane, north of Greenhorn Road, to reach the six remaining wells (see Figure A-1). Approximately 14,200 feet (2.7 miles) of 8-inch-diameter DIP would be needed for Option A.

### Option B

Option B follows the alignment of Option A, but it extends the new water main farther south along Greenhorn Road, southwest on Christmas Tree Lane, and west on Raccoon Mountain Road to supply the five southernmost wells of interest. An additional 8,200 feet of pipeline are needed for Option B, bringing the total length of new pipeline to approximately 22,400 feet (4.2 miles).

## Cost Estimate Classification

This cost estimate is considered a preliminary, budget-level (Class 4) estimate as defined by the Association for the Advancement of Cost Engineering International. Cost estimates of this type are expected to be accurate within –20 to –50 percent on the low side and +30 to +100 percent on the high side.

The cost estimate has been prepared to provide guidance for project evaluation and implementation. The final cost of the project will depend on the final design, the actual labor and material costs, competitive market conditions, implementation schedule, and other variables. As a result, the final project costs will vary from this cost estimate. To help ensure proper project evaluation and adequate funding, the project feasibility and funding needs must be carefully reviewed before making specific financial decisions. This estimate is based on material, equipment, and labor pricing as of April, 2008.

## Assumptions

This estimate should be evaluated for market changes after 90 days of the issue date. This estimate includes the following major assumptions and conditions:

- The work will be done on a competitive bid basis, and the contractor will have a reasonable amount of time to complete the work.
- The pipe and equipment are readily available.
- Existing wells produce 10 gpm. This flow is used as the design flowrate for delivery to each parcel.

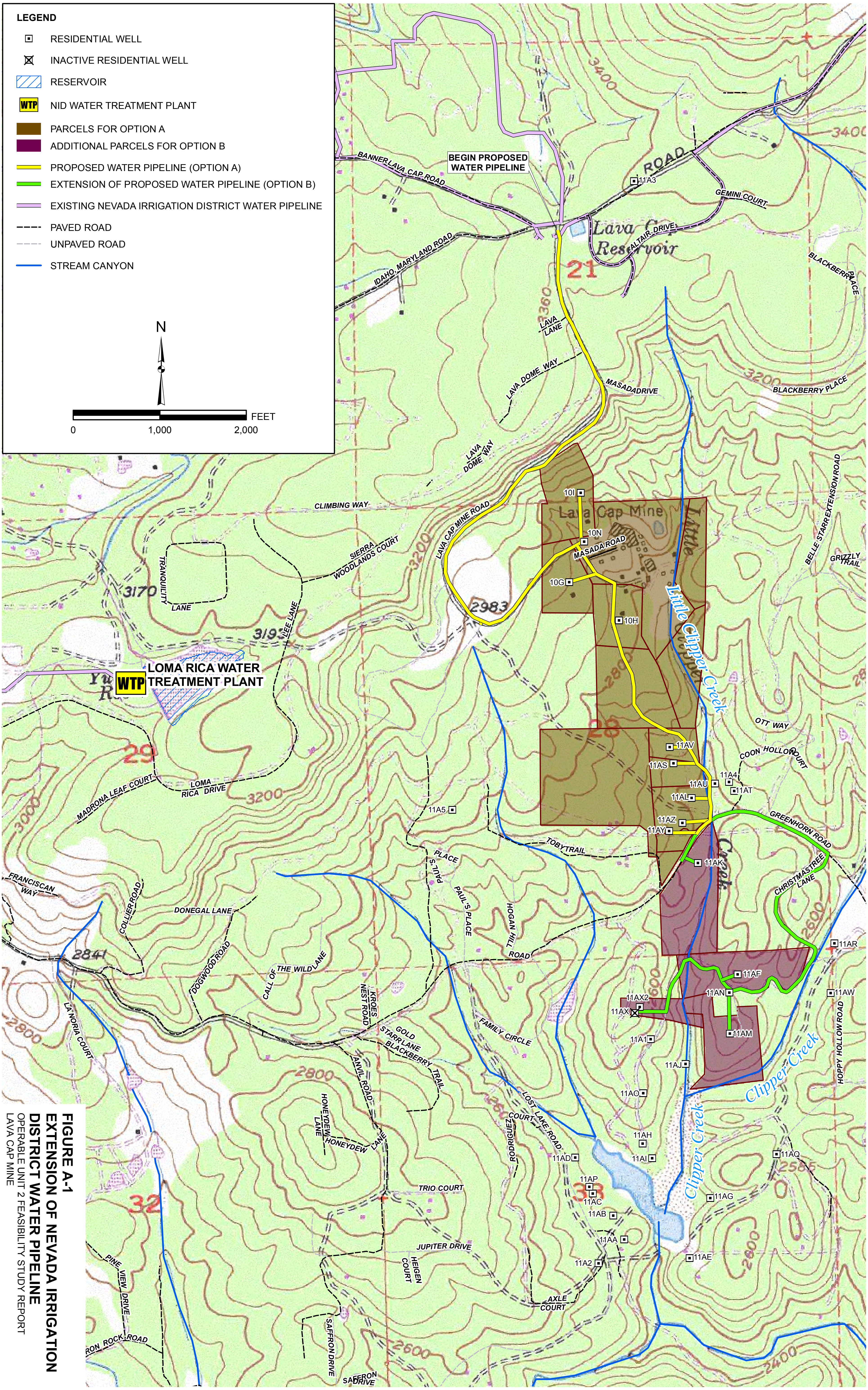


FIGURE A-1
EXTENSION OF NEVADA IRRIGATION DISTRICT WATER PIPELINE
OPERABLE UNIT 2 FEASIBILITY STUDY REPORT
LAVA CAP MINE

- The road right-of-way is wide enough to accommodate the pipeline.
- Potential fees and equipment required by NID to connect to the existing water system are not included in the cost estimate.
- Existing well demolition costs are not included in the cost estimate.
- Connections to the new 8-inch-diameter DIP include a saddle and 100 feet of 3-inch-diameter polyvinylchloride (PVC) pressure pipe.
- The pipeline will be installed in existing right-of-way.
- Costs of easements that could reduce the length of pipe are not considered.
- Although NID allows the use of DIP and polyvinyl chloride (PVC) pressure pipe to construct water mains, DIP is used for its ability to withstand higher internal pressures.
- Costs associated with pressure reducing stations or pump stations are not included.
- Installation of pipeline will not interfere with existing utilities.
- Minimum pipe cover is 3 feet.
- Appurtenances are included in the cost estimate at 15 percent of construction cost.
- Class A or Class B fire hydrants for flows of 1,000 gpm will be installed every 500 feet along the water main extension.
- The fire hydrant connects to the existing main at 125 psi or greater.
- Pressure increases caused by elevation changes do not require surge tanks or pressure reducing valves.
- There are no dewatering costs during trench excavation.

## Total Project Costs

An itemized construction cost estimate is provided in Table A-1. Table A-2 provides the total project costs for both options, including remedial design investigation, engineering with services during construction, construction management, license, and legal costs.

TABLE A-1
Alternative 4 Construction Costs
*Extension of Nevada Irrigation District Water Pipeline*

| | Option A | | | Option B | | |
|---|---|---|---|---|---|---|
| **Item** | **Quantity** | **Unit Cost ($)** | **Item Cost ($)** | **Quantity** | **Unit Cost ($)** | **Item Cost ($)** |
| 8-inch-diameter DIP (under paved road) | 2,500 feet | 106/foot | 265,000 | 4,500 feet | 106/foot | 477,000 |
| 8-inch-diameter DIP (under unpaved road) | 11,700 feet | 76/foot | 889,000 | 17,900 feet | 76/foot | 1,360,000 |
| Appurtenances (15% construction cost) | | | 224,000 | | | 357,000 |
| Fire Hydrants | 28 units | 3,500 | 98,000 | 44 units | 3,500 | 154,000 |
| Parcel Connections | 10 units | 2,000 | 20,000 | 15 units | 2,000 | 30,000 |
| **Total** | | | **1,496,000** | | | **2,378,000** |

TABLE A-2
Alternative 4 Total Costs
*Extension of Nevada Irrigation District Water Pipeline*

| **Item** | **Estimated Cost Option A ($)** | **Estimated Cost Option B ($)** |
|---|---|---|
| Construction Costs | | |
| Contractor Costs | 1,496,000 | 2,378,000 |
| Contractor Markup[a] | 541,000 | 860,000 |
| Contingency (25%) | 509,000 | 809,000 |
| **Total Construction Costs** | **2,546,000** | **4,047,000** |
| Non-Construction Costs | | |
| Engineering Services (20%) | 509,000 | 809,000 |
| Construction Management Services (6%) | 153,000 | 243,000 |
| **Total Non-Construction Costs** | **662,000** | **1,052,000** |
| **Total Project Cost** | **3,208,000** | **5,099,000** |

[a]Field detail allowance = 2.5%; mobilization/bonds/insurance = 5%; contractor overhead = 15%; profit = 10%.

# Appendix B
# Cost Estimates and Assumptions

APPENDIX B

# Cost Estimate and Assumptions

## B.1 Introduction

This appendix presents the cost estimates for the *Operable Unit 2 Feasibility Study Report for Lava Cap Mine Superfund Site* (FS Report). Cost estimates for remedial alternatives were developed with an expected accuracy range of –30 to +50 percent. Table B-1 provides a summary of the costs for each Alternative (tables are located at the end of this Appendix). More detailed cost estimates are provided in subsequent tables. The remedial alternatives developed for drinking water are made up of several components. The costs for these components are the same for each alternative. This appendix describes the assumptions for each component.

The assumptions made in the FS Report are not intended to be used for design or to provide specific recommendations for remedial technologies. In the remedial design phase, changes may be made to the components of the alternatives. The cost estimates have been prepared for guidance in alternative evaluation using information available at the time of the estimate. The actual cost of each alternative and resulting feasibility would depend on actual labor and material costs, competitive market conditions, actual site conditions, final design and project scope, implementation schedule, continuity of personnel and engineering, and other variable factors. As a result, actual project costs will vary from the estimates presented in this appendix.

## B.2 Component Descriptions and Assumptions

Brief descriptions of the treatment technologies and process options selected for each remedial alternative in the FS Report, as well as assumptions made for costing, are included in this section.

### B.2.1 Land Use Notifications

Table B-2 provides a detailed estimate of the cost of land use notifications. Land use notifications are designed to discourage use of groundwater from properties that may be affected by arsenic in groundwater.

There would be no capital costs associated with the notifications. The annual costs would include coordinating with Nevada County Environmental Health Department (NCEHD), contacting property owners directly, and other expenses, such as postage and staff labor to prepare the notifications. Specific details regarding the land use notification process would be developed during remedial design. CH2M HILL recommends that groundwater conditions be evaluated and updated notifications be prepared annually.

### B.2.2 Point-of-Use and Wellhead Treatment

Because these two treatment technologies have common features, they are discussed together in this section. Table B-3 provides the cost estimate for point-of-use (POU) treatment, and Table B-4 provides the cost estimate for wellhead treatment. POU treatment refers to a sink-type water treatment unit. Wellhead treatment refers to the residence water supply. A POU treatment unit will treat a fraction of a gallon of water per minute, but it can be equipped with a small storage tank to provide higher flow rates as needed. For the POU component of Alternative 2 in the FS Report, five additional units are assumed to be installed (in addition to the five existing treatment units). It is assumed that all 10 POU treatment systems would require maintenance for 50 years.

For the wellhead treatment units proposed in Alternative 3 in the FS Report, it is assumed that each will produce treated water at an instantaneous rate of 10 gallons per minute and a total volume of 800 gallons per day. It is also assumed that seven existing contaminated residential and irrigation wells at Lava Cap would be equipped with wellhead treatment units, and five new wells requiring arsenic treatment would be constructed in the future. The 12 wellhead treatment systems (new and existing) are assumed to require maintenance for 50 years.

Arsenic treatment equipment designed for POU and wellhead treatment is manufactured and sold either directly or through dealers. These products have been manufactured for many years and have evolved with improvements in manufacturing and treatment technologies.

In California, the Department of Public Health (DPH) (formerly the Department of Health Services) certifies water treatment equipment for sale in the state. This applies to water treatment equipment that manufacturers claim to have health benefits, such as arsenic removal. For arsenic treatment, DPH has certified only reverse osmosis (RO) systems.

There are other POU and wellhead treatment technologies available for treating arsenic besides RO, notably granular ferric hydroxide and ion exchange. The National Sanitation Foundation (NSF) tests and certifies treatment equipment. NSF Standards 53 and 58 apply for arsenic treatment. Many manufacturers and dealers cite these standards or other standards organizations in their sales literature. For the newer arsenic-treatment technologies, limited performance data are available. However, there are case studies of successful performance. Consumers select technologies based on availability and cost. For this cost estimate, RO was assumed to be the process option selected for both the POU and wellhead treatment systems. Other assumptions include the following:

- For wellhead treatment, a 2,500-gallon polyethylene storage tank and transfer pump would be installed at each residence, and 100 feet of underground piping, electrical wire, and conduit would be required between each well and treatment system.
- For both wellhead and POU treatment, the labor required for annual replacement of filters and membranes would be performed by the property owners, and effluent from the systems would be sampled annually.

### B.2.3 Groundwater Monitoring

Table B-5 provides a summary of the costs for groundwater monitoring.

In the FS Report, it is assumed that the sampling regimen for new monitoring wells would be consistent with that of the current OU-2 sitewide program. It is also assumed that as many as 31 existing residential and monitoring wells will continue to be monitored during implementation of the interim OU-2 remedy, and up to six quality assurance/quality control samples would be required for each sampling event.

Each sampling event will consist of four parts: pre-sampling preparation, field sampling activities, post-sampling activities, and laboratory analysis. Pre-sampling activities will include preparing a database, creating sample labels and chain-of-custody documents, ordering equipment, and conducting field staff orientations. Field sampling includes travel to the site and sampling wells. A two-person team will complete the field sampling. Post-sampling activities will include documenting all field activities, shipping groundwater samples, and stowing all equipment. Laboratory costs are assumed to include analyzing groundwater samples for arsenic:

The wells are assumed to be sampled annually for 50 years, which is the assumed duration of the OU-2 remedy.

### B.2.4 Nevada Irrigation District Water Supply

The cost estimate for the Nevada Irrigation District water supply component is provided in Appendix A.

## B.3 Present Value Analysis

EPA suggests that the period for present value analysis should be equivalent to the project duration to provide a complete life-cycle cost estimate of the remedial alternative (EPA, 2000). EPA states that the commonly used assumption of a 30-year period of analysis for estimating present value is not recommended. Because arsenic is expected to persist in the subsurface for a very long time, extended long-term operations and maintenance activities will be required A duration of 50 years was chosen as the period of analysis rather than 30 years. Some maintenance of the remedial alternatives would extend beyond 50 years. However, the net present value reaches an asymptotic level for increasing periods of analysis, and large uncertainties exist regarding technological advances that might occur after 50 years.

Additionally, EPA suggests that present value analysis for federal sites should use the real discount rates in Appendix C of the Office of Management and Budget Circular A-94 (EPA, 2000). The real discount rate based on the economic assumptions from the 2004 budget for programs with durations of 30 years or longer is 3.2 percent.

## B.4 Works Cited

U.S. Environmental Protection Agency (EPA). 2000. *Guide to Developing and Documenting Cost Estimates During the Feasibility Study*.

TABLE B-1

Summary of Costs for Each Alternative

*Operable Unit 2 Feasibility Study Report for Lava Cap Mine Superfund Site*

| Alternative | Components | Direct Capital Cost | Indirect Capital Cost | Total Capital Cost | Annual Costs (O&M or Monitoring) | 50-Year NPV of Annual Cost | Total NPV |
|---|---|---|---|---|---|---|---|
| 1 | No Action | **$0** | **$0** | **$0** | **$0** | **$0** | **$0** |
| 2 | Point-of-use Treatment | | | | | | |
| | Point-of-use Treatment | $7,690 | $4,114 | $11,805 | $4,735 | $117,347 | $129,000 |
| | Land Use Notifications | $0 | $0 | $0 | $3,086 | $76,473 | $76,000 |
| | Groundwater Monitoring | $0 | $0 | $0 | $39,468 | $978,040 | $978,000 |
| | **Total** | **$7,690** | **$4,114** | **$11,805** | **$47,289** | **$1,171,860** | **$1,184,000** |
| 3 | Wellhead Treatment | | | | | | |
| | Wellhead Treatment | $114,636 | $61,330 | $175,966 | $13,044 | $323,235 | $499,000 |
| | Land Use Notifications | $0 | $0 | $0 | $3,086 | $76,473 | $76,000 |
| | Groundwater Monitoring | $0 | $0 | $0 | $39,468 | $978,040 | $978,000 |
| | **Total** | **$114,636** | **$61,330** | **$175,966** | **$55,598** | **$1,377,747** | **$1,554,000** |
| 4 | NID Water Supply | | | | | | |
| | NID Water Supply (Option A, north of Greenhorn Road only) | $2,546,000 | $662,000 | $3,208,000 | $0 | $0 | $3,208,000 |
| | Land Use Notifications | $0 | $0 | $0 | $3,086 | $76,473 | $76,000 |
| | Groundwater Monitoring | $0 | $0 | $0 | $39,468 | $978,040 | $978,000 |
| | **Total** | **$2,546,000** | **$662,000** | **$3,208,000** | **$42,554** | **$1,054,513** | **$4,263,000** |
| | Option B Additional Cost to Extend NID Water Supply south of Greenhorn Road | $1,501,000 | $390,000 | $1,891,000 | $0 | $0 | $1,891,000 |

NID = Nevada Irrigation District

NPV = net present value

O&M = operations and maintenance

POU = point of use

TABLE B-2

Annual Costs for Land Use Notifications

*Operable Unit 2 Feasibility Study Report for Lava Cap Mine Superfund Site*

| Task | Functional Category | Unit Rate ($) | Quantity | Units | Total Cost |
|---|---|---|---|---|---|
| Evaluate property transactions from County records, review available GW data/maps and revise letter | Junior-level professional | 123 | 16 | Hours | $1,968 |
| Senior review | Mid-level professional | 143 | 2 | Hours | $286 |
| Format letter, assemble mailings | Office staff | 80 | 3 | Hours | $240 |
| Prepare map | Junior-level professional | 123 | 4 | Hours | $492 |
| Postage and reprographics | | 100 | 1 | Lump sum | $100 |
| **Total Annual Cost** | | | | | **$3,086** |
| **50-Year NPV of Annual Cost** | | | | | **$76,473** |

TABLE B-3
Costs for Residential Point of Use Treatment
*Operable Unit 2 Feasibility Study Report for Lava Cap Mine Superfund Site*

| Cost Item | Unit Cost | Unit | Quantity | Total Cost | Notes |
|---|---|---|---|---|---|
| Point-of-Use System | | | | | |
| Equipment | $582 | Each | 6 | $3,490 | Includes housings, valves, and controls for ERO 375 RO system |
| Installation | $700 | Each | 6 | $4,200 | |
| Total Equipment Capital Cost | | | | $7,690 | |
| Indirect Capital Costs | | | | | |
| Field Detail Allowance | 2.5% | | | $192 | |
| Mobilization/Bond/Insurance | 0% | | | $0 | Assume included in installation cost (standardized system) |
| Contractor Overhead | 0% | | | $0 | Assume included in installation cost |
| Contractor Profit | 0% | | | $0 | Assume included in installation cost |
| Contingency | 25% | | | $1,923 | |
| Engineering Services | 20% | | | $1,538 | |
| Construction Management Services | 6% | | | $461 | |
| Subtotal Indirect Capital Costs | | | | $4,114 | |
| Annual O&M Costs | | | | | |
| Pre- and Post- Filters | $79 | Each | 10 | $791 | Annual replacement performed by homeowner |
| RO Membrane | $44 | Each | 10 | $444 | Triennial replacement performed by homeowner (1/3 cost) |
| Maintenance Contractor | $2,500 | Lump sum | 1 | $2,500 | Assume contractor maintains all units annually in one trip |
| Analytical | $100 | Each | 10 | $1,000 | Annual testing (assume performed during annual groundwater sampling event) |
| Total Annual Cost | | | | $4,735 | |
| **50-Year NPV of Annual Cost** | | | | **$117,347** | |

Notes:
Operating costs are based on typical situations in Sierra Nevada Mountain foothills according to discussions with dealer.
Assumes waste water (brine) is discharged to existing drain/wastewater connection. Ratio of 3 to 1 of wastewater to treated water.
RO = reverse osmosis

TABLE B-4

Costs for Residential Wellhead Treatment

*Operable Unit 2 Feasibility Study Report for Lava Cap Mine Superfund Site*

| Cost Item | Unit Cost | Unit | Quantity | Total Cost | Notes |
|---|---|---|---|---|---|
| Equipment Capital Costs | | | | | |
| Treatment Unit | $3,000 | Each | 12 | $36,000 | Wellhead RO system[a] |
| Installation | $2,100 | Each | 12 | $25,200 | Assume 3 days for plumber to install |
| Storage Tank and Transfer Pump | $3,803 | Each | 12 | $45,636 | Taken from contractor bid for 2,500 gal poly tank installation |
| Utility Trench, Pipe, Conduit, Wire | $650 | Each | 12 | $7,800 | Taken from contractor bid for 2,500 gal poly tank installation |
| Total equipment capital cost | | | | $114,636 | |
| Indirect Capital Costs | | | | | |
| Field Detail Allowance | 2.5% | | | $2,866 | |
| Mobilization/Bond/Insurance | 0% | | | $0 | Assume included in installation cost (standardized system) |
| Contractor Overhead | 0% | | | $0 | Assume included in installation cost |
| Contractor Profit | 0% | | | $0 | Assume included in installation cost |
| Contingency | 25% | | | $28,659 | |
| Engineering Services | 20% | | | $22,927 | |
| Construction Management Services | 6% | | | $6,878 | |
| Subtotal Indirect Capital Costs | | | | $61,330 | |
| Annual Costs | | | | | |
| Feed Pump | $0.13 | kWh | 16,337 | $2,124 | 1/2 horsepower, 5% operation |
| Filter Replacement | $60 | Each | 12 | $720 | Assume twice annual replacement |
| Membrane Replacement | $500 | Each | 12 | $6,000 | Assume annual replacement of two membranes per residence |
| Maintenance Contractor | $3,000 | Annual | 1 | $3,000 | |
| Analytical | $100 | Each | 12 | $1,200 | Annual testing (assume performed during annual groundwater sampling |
| Total Annual Cost | | | | $13,044 | |
| **50-Year NPV Annual Cost** | | | | **$323,235** | |

[a]Assumes wellhead RO system with prefilters and tanks. Assumes brine is discharged to existing drain/wastewater connection.

TABLE B-5
Costs for Groundwater Sampling
*Operable Unit 2 Feasibility Study Report for Lava Cap Mine Superfund Site*

| Item | Description | Unit of Measure | Estimated Quantity | Unit Price | Wells | Times per Year | Total |
|---|---|---|---|---|---|---|---|
| Preparation | Field Database, Labels, COCs | Hour | 6 | $123.00 | -- | 1 | $738 |
| | Order Equipment and Sample Bottles | Hour | 2 | $80.00 | -- | 1 | $160 |
| | Ship Equipment | Hour | 1 | $80.00 | -- | 1 | $80 |
| | Lab requests, kick-off meetings with field staff | Hour | 6 | $80.00 | -- | 1 | $480 |
| | Field staff review documents, equipment | Hour | 12 | $80.00 | -- | 1 | $960 |
| Field | Travel Allotment | Days | 9 | $395.00 | -- | 1 | $3,555 |
| | Water levels and stream flow measurements | Hour | 12 | $80.00 | -- | 1 | $960 |
| | Well sampling - 31 wells | Hour | 155 | $80.00 | -- | 1 | $12,400 |
| | Equipment Rental - Horiba meter | Days | 9 | $28.00 | -- | 1 | $252 |
| | Equipment Rental - water level meter | Days | 9 | $15.00 | -- | 1 | $135 |
| | Equipment Rental - Geopump | Days | 9 | $15.00 | -- | 1 | $135 |
| | Field supplies (e.g. ice, plastic bags, etc.) | Event | 1 | $400.00 | -- | 1 | $400 |
| | Shipping costs | Event | 1 | $300.00 | -- | 1 | $300 |
| Post | Update database | Hour | 3 | $80.00 | -- | 1 | $240 |
| | Review and upload data | Hour | 4 | $80.00 | -- | 1 | $320 |
| | Ship equipment back, organize notes | Hour | 8 | $80.00 | -- | 1 | $640 |
| | File/data entry | Hour | 4 | $80.00 | -- | 1 | $320 |
| | Water level tables, stream gauge files | Hour | 6 | $80.00 | -- | 1 | $480 |
| | Coordination/oversight | Hour | 6 | $123.00 | -- | 1 | $738 |
| Analytical | Arsenic (Method SW6020) | Sample | 1 | $100.00 | 37 | 1 | $3,700 |
| Reporting | Prepare Annual Monitoring Report | Hour | 100 | $123.00 | | 1 | $12,300 |
| | Report shipping costs | Each | 5 | $35.00 | | 1 | $175 |
| | **Total Annual Cost** | | | | | | **$39,468** |
| | **50-Year NPV of Annual Cost** | | | | | | **$978,040** |