DRAFT
ENGINEERING EVALUATION/COST ANALYSIS

POND MINE
PLACER COUNTY, CALIFORNIA

Prepared For

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT
CALIFORNIA STATE OFFICE
SACRAMENTO, CALIFORNIA

November 2006

Prepared By

TETRA TECH EM INC.
10860 Gold Center Drive, Suite 200
Rancho Cordova, California, 95670

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Gregory J. Reller, Project Manager

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ACRONYMS AND ABBREVIATIONS

ºF	Degree Fahrenheit
µg/L	Microgram per liter
amsl	Above mean sea level
AQMD	Air Quality Management District
ARAR	Applicable or relevant and appropriate requirement
ATSDR	Agency for Toxic Substances and Disease Registry
AWQC	Ambient water quality criterion
BLM	U.S. Department of the Interior, Bureau of Land Management
CCR	California Code of Regulations
CDFG	California Department of Fish and Game
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
Cherokee	Cherokee Development Corporation
CNDD	California Natural Diversity Database
CSM	Conceptual site model
CTR	California Toxics Rule
CWA	Clean Water Act
E & E	Ecology and Environment, Inc.
EE/CA	Engineering evaluation/cost analysis
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
gpm	Gallon per minute
GPS	Global positioning system
HRMC	Human risk management criteria
MCL	Maximum contaminant level
MCLG	Maximum contaminant level goal
mg/kg	Milligram per kilogram
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NPDES	National Pollutant Discharge Elimination System
O&M	Operation and maintenance
OSHA	Occupational Safety and Health Administration

PRAG	Preliminary removal action goal
PRAO	Preliminary remedial action objective
PRG	Preliminary remediation goal
PRP	Potentially responsible party
RCRA	Resource Conservation and Recovery Act
RSI	Removal site inspection
SDWA	Safe Drinking Water Act
SMARA	California Surface Mining and Reclamation Act
SMCRA	Surface Mining Control and Reclamation Act
SWRCB	State Water Resources Control Board
Tetra Tech	Tetra Tech EM Inc.
U.S.C.	*United States Code*
USGS	U.S. Geological Survey
WLRMC	Wildlife and livestock risk management criteria
Water Board	California Regional Water Quality Control Board, Central Valley Region
WRCC	Western Regional Climate Center
WQO	Water quality objective
yd^3	Cubic yard

EXECUTIVE SUMMARY

The Pond Mine is an abandoned hydraulic gold mine located in the historic Foresthill mining district of Placer County, California. The site consists of a 45-acre mine pit, highwalls, an extensive sluice tunnel system, a network of ground sluices, a plunge pool, and a waste rock pile. The mine is located on mixed private and U.S. Department of the Interior, Bureau of Land Management (BLM)-administered land. The sluice tunnel outlet is on BLM-administered land, with drainage onto adjacent land managed by the U.S. Department of the Interior, Bureau of Reclamation. Drainage from the Pond Mine flows into Pond and Todd Creeks, which join the Middle Fork of the American River just over a mile downstream from the site. Tetra Tech EM Inc. (Tetra Tech) and the U.S. Geological Survey (USGS) conducted site investigations and sampling at the Pond Mine between 2003 and 2005. Ecology and Environment, Inc. (E&E) prepared a removal site investigation report that synthesized the existing data and concluded that a removal action is warranted to prevent discharge of mercury or mercury compounds from the site. Based on the findings of the investigation and the preliminary risk screening, BLM is exercising its authority as lead agency under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) to undertake a removal action to control the release of and exposure to mercury at the Pond Mine.

This engineering evaluation/cost analysis (EE/CA) presents a detailed analysis of removal action alternatives that BLM and appropriate regulatory agencies can use for decision-making at the Pond Mine. The EE/CA identifies, screens, and evaluates technologies that may be implemented to reduce releases of mercury to the environment and exposure of potential human and ecological receptors to mercury-bearing sediment and water at the site. Tetra Tech prepared this EE/CA in accordance with the U.S. Environmental Protection Agency (EPA) "Guidance on Conducting Non-Time Critical Removal Actions under CERCLA" (EPA 1993).

Environmental investigations at the Pond Mine assessed concentrations of total and methyl mercury in surface water discharging from the sluice tunnel, sediment in the sluice tunnel and plunge pool (Tetra Tech 2004a, 2004b), and in biota at the sluice tunnel outlet (BLM 2005). Mercury and methyl mercury are present in sediment, water, and biota at the Pond Mine. Sediment in the sluice tunnel and plunge pool was identified as a source of mercury contamination; under the current investigation, liquid mercury was observed in panned samples from more than a dozen locations within the tunnel. Laboratory analysis of sediment samples from the sluice tunnel detected mercury at concentrations up to 45.1 milligrams per kilogram, which exceeds human health and ecological screening criteria established by the BLM and EPA. Laboratory analysis of surface water samples from the sluice tunnel discharge detected mercury at concentrations up to 0.047 micrograms per liter (µg/L), which does not exceed applicable human health and ecological screening criteria. However, a surface water sample collected from the sluice tunnel discharge after samplers walked upstream in the tunnel and agitated the sediment (a "disturbed" sample intended to mimic conditions after recreational miners walk in the tunnel) contained 0.817 µg/L of total mercury. The concentration of mercury in the

disturbed water sample exceeds EPA risk screening criteria and demonstrates that agitation of sluice tunnel sediment causes a release of mercury from the site.

Biota samples collected at the Pond Mine sluice tunnel outlet generally contained low concentrations of mercury compared with samples collected at other mines in the area. However, concentrations of mercury in dragon fly larvae were elevated relative to the comparison samples, indicating a high rate of mercury bioaccumulation relative to the other mines in the area.

Mercury in sediment and water at the Pond Mine poses a threat to human health and the environment. Although exposure to mercury in sediment and water may lead to adverse effects on humans or wildlife, a significant concern is biomagnification of mercury in the food chain and exposure of upper trophic level fauna and humans through consumption of organisms that contain mercury. For example, humans may eat fish or frogs that have accumulated and concentrated mercury from ingestion of insects that contain mercury.

Underground reconnaissance was conducted during the EE/CA to gain a better understanding of site dynamics, constrain the volume of material that would require handling, and aid in identifying effective means for accessing the sluice tunnel and cleaning up the site. A treatability study was also completed to evaluate if physical separation methods could effectively segregate mercury from sluice tunnel sediment and whether residuals created by washing mercury from the sediment require additional stabilization or special handling.

A partial ceiling collapse prevented advancing farther than 1,600 feet upstream from the tunnel outlet during the underground reconnaissance. The Pond Mine sluice tunnel system is believed to include 2,000 to 3,000 feet of underground workings upstream from the collapse; the ability to access and the condition of sediment upstream from the collapse are not known. Removal of the collapse debris would allow advancement farther into the tunnel to inspect the upstream workings. However, additional collapses are likely to be present and removing the material at 1,600 feet might only provide access to a short segment of tunnel before the next collapse.

Based on the results of the human health and ecological risk screening, three preliminary removal action objectives were developed for the Pond Mine:

- Prevent the migration of mercury from the sluice tunnel and plunge pool to the small drainage and the Middle Fork of the American River.
- Minimize the potential for human and ecological exposure to mercury in sluice tunnel and plunge pool sediment.
- Improve public awareness of on-site physical hazards posed by previous mining activities.

Attaining these objectives is expected to result in protection of human and ecological receptors at the Pond Mine and of water quality downstream from the site.

Four removal action alternatives were developed to address these preliminary removal action objectives. The following alternatives were evaluated and compared for effectiveness, implementability, and cost: (1) no action; (2) check dam installation and institutional controls; (3) in situ sediment covering, check dam installation, and institutional controls; and (4) sediment excavation, on-site physical separation, on-site disposal, covering, check dam installation, and institutional controls.

The recommended removal action alternative to reduce the release of mercury and the threat to human health and the environment associated with sediment and surface water discharged from the Pond Mine sluice tunnel and plunge pool is Alternative 4. Alternative 4 involves:

- Excavating contaminated sediment from the sluice tunnel and plunge pool.
- Pressure washing the floors to remove mercury from bedrock foliations (cracks and bedding planes).
- Covering the cleaned floors with concrete to sequester mercury that might remain after pressure washing.
- Installing two check dams at the upstream end of the sluice tunnel work area to retain potentially mercury-bearing sediment that might be transported from upstream in the tunnel system and one check dam downstream from the plunge pool to retain sediment transported from the tunnel and plunge pool.
- Removing debris at the collapse 1,600 feet upstream from the sluice tunnel outlet and assessing the need for and viability of additional removal activities.
- Separating mercury and other heavy metals from the excavated sediment.
- Recycling or properly disposing of recovered mercury.
- Installing a bat gate inside the sluice tunnel outlet to prevent unauthorized entrance, thereby protecting the integrity of the concrete surface and minimizing physical hazards to site visitors.
- Installing warning signs to alert site visitors that the area may be hazardous and to identify the potential hazards present to deter trespass and misuse.

Based on results from the treatability study (see Appendix C), 99 percent of the excavated sediment (washed fines, sand, and gravel) could be spread on site after mercury separation was completed. Heavy mineral concentrates, which represented almost 1 percent of the excavated sediment, might also be acceptable for on-site disposal, but additional leach testing would be necessary. Heavy mineral concentrates could be solidified and buried on site if leach testing

demonstrates an unacceptable threat to water quality. Water captured in the sluice tunnel construction area and process water from the aggregate plant are expected to contain dissolved and particulate-bound mercury at concentrations that prohibit direct discharge to surface water. Therefore, the water would be captured, recycled, and treated or evaporated.

Alternative 4 was determined to provide the highest degree of protection for human health and the environment. Alternative 4 would comply with applicable or relevant and appropriate requirements, provide long-term effectiveness and permanence, and greatly reduce the volume and mobility of mercury at the Pond Mine. Alternative 4 would also provide a higher degree of permanence than Alternative 2 or 3 because the contaminant source would have been removed and less operation and maintenance (O&M) would be required to maintain the removal action measures. The removal action is anticipated to take place over three construction seasons. O&M would consist of cleaning out the sediment basin behind the check dam at the plunge pool and inspecting and replacing warning signs and the bat gate as necessary. Alternative 4 could be implemented at an estimated present worth cost of $2,324,108, of which $2,300,408 are capital costs, $23,700 are yearly operation and maintenance costs over the next 25 years.

1.0 INTRODUCTION

Tetra Tech EM Inc. (Tetra Tech) is under contract to the U.S. Department of the Interior, Bureau of Land Management (BLM), California State Office, to prepare an engineering evaluation/cost analysis (EE/CA) for the non-time critical mitigation of mercury associated with historical mining at the Pond Mine in Placer County, California. This work is being performed under General Services Administration Contract Number GS10F0076K, Requisition Number R0605122, and U.S. Department of Agriculture Forest Service Contract Number AG91SC060024, Requisition Number R068425/0001. A removal site investigation (RSI) completed for the Pond Mine concluded that a removal action is warranted to prevent discharge of mercury or mercury compounds from the site (Ecology and Environment, Inc. [E & E] 2005). The BLM is exercising its authority as lead agency under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) to undertake a removal action at the Pond Mine to control the exposure to and release of mercury at the site.

This EE/CA presents a detailed analysis of removal action alternatives that the BLM and appropriate regulatory agencies can use for decision-making. This EE/CA identifies, screens, and evaluates technologies that may be implemented to address on-site exposure to and off-site release of mercury in sediment and surface water at the Pond Mine. The technologies evaluated in this report would facilitate long-term attainment of the water quality standards that apply to surface water discharged from the Pond Mine, minimize the potential for exposure to and release of mercury in surface water and sediment, and allow ecological restoration of the disturbed site.

This EE/CA presents background information, findings from site investigations, risk screening results, an evaluation of applicable or relevant and appropriate requirements (ARAR), preliminary removal action objectives (PRAO) and preliminary removal action goals (PRAG), and the development and screening of removal action alternatives. This EE/CA is organized into nine sections. The contents of Sections 2.0 through 9.0 are briefly described below.

- Section 2.0, which briefly describes the Pond Mine location and topography, mine history and features, climate, geology and soils, hydrology and hydrogeology, vegetation and wildlife, land use and population, significant cultural and archeological features, and property ownership and mineral rights.
- Section 3.0, which summarizes findings from previous site investigations and presents a conceptual site model (CSM) for the Pond Mine.
- Section 4.0, which summarizes the human health and ecological risk screening methodology and results and recommends removal actions based on risk findings.
- Section 5.0, which presents the state and federal chemical-, location-, and action-specific ARARs that may be pertinent for a removal action at the Pond Mine.
- Section 6.0, which presents the preliminary removal action objectives and goals.

- Section 7.0, which identifies and describes general response actions, technologies, and process options; screens technologies, and develops removal action alternatives.
- Section 8.0, which presents the detailed analysis of removal action alternatives using effectiveness, implementability, and cost as criteria.
- Section 9.0, which presents a comparative analysis of removal action alternatives for consistency with the effectiveness, implementability, and cost criteria; summarizes the findings from the analysis; and presents a recommended removal action alternative.
- Section 10.0, which presents a list of sources used in preparation of this EE/CA.

This EE/CA also includes the following appendices:

- Appendix A, Site Photographs
- Appendix B, Cost Estimate Assumptions
- Appendix C, Treatability Study Technical Memorandum

Figures and tables are presented after the text of the report.

2.0 SITE LOCATION AND BACKGROUND

This section presents background information on the Pond Mine pertinent to the development of an EE/CA. The information presented includes a description of the mine location and topography, mine history and features, climate, geology and soils, hydrology and hydrogeology, vegetation and wildlife, significant historical and archeological features, and land use and population. The location of the site is presented in Figure 1. Much of the information in this section was obtained from the RSI report (E & E 2005).

2.1 LOCATION AND TOPOGRAPHY

The Pond Mine is located at an elevation of 2,700 feet above mean sea level (amsl) in Township 13 North, Range 10 East, Section 3 of the Mount Diablo Baseline and Meridian. The approximately 45-acre pit is on mixed private and BLM-administered land, and the sluice tunnel outlet is on BLM-administered lands with drainage onto adjacent lands managed by the U.S. Department of the Interior, Bureau of Recreation. The site is located 2 miles southwest of Foresthill, California, on the southeastern side of the Foresthill Divide in the watershed of the Middle Fork of the American River. The area of the hydraulic pit is relatively flat to gently sloping, with near-vertical highwalls surrounding the pit floor.

2.2 HISTORY AND FEATURES

The Pond Mine is located within the Todd Valley mining district and is part of the larger Foresthill Mining District (Clark 1998). Mining began in the area in 1850 and continued through the 1900s, with another period of activity in the 1930s (Clark 1998). Most of the work at the Pond Mine was done before 1875; production recorded from the valley after 1888 was usually $2,500 per year or less from small-scale individual mining (Logan 1936). The gold-bearing placer deposit at the Pond Mine was reportedly 1 mile long by ¼ mile wide with a maximum depth of 60 to 75 feet and an average depth of 35 feet. By 1875, the mine produced 9 million cubic yards (yd^3) of ore that yielded $4 million of gold. Gold was recovered from the Pond Mine with hydraulic mining methods, which used high-pressure water cannons ("monitors") to dislodge hillside placer deposits. An estimated 2 million to 4 million cubic yards of auriferous (gold-bearing) gravel remains on the claim, but the increasing overburden thickness became cost prohibitive for gravel removal. The loose sediment was washed into ground sluices and sluice tunnels, where liquid mercury was added to facilitate gold recovery. An estimated 10 to 30 percent of the mercury added to the sluices was lost to the environment (Alpers and others 2005a). Hydraulic mining ceased in 1884, when the practice was prohibited by the Sawyer decision.

Hydraulic mine features at the Pond Mine include the mine pit, highwalls, an extensive sluice tunnel system, a network of ground sluices, a plunge pool, and a waste rock pile. The sluice system reportedly includes more than 5,000 feet of tunnels. Tetra Tech documented 14 sluice tunnel inlets (nine open and five plugged) in the mine pit floor adjacent to Patent Road and on

private property in the northwest mine pit area; other tunnel inlets that feed the Pond Mine sluice tunnel are suspected to exist. The feeder shafts were reportedly also used for disposal of municipal waste at one time. The sluice tunnel contains a bulkhead equipped with an entry portal 121 feet from the tunnel outlet. Water flowing from the sluice tunnel falls into a plunge pool below the tunnel outlet. The plunge pool is a small slot canyon approximately 20 feet deep, 30 feet long, and less than 3 feet wide incised into the bedrock. A waste rock pile consisting of angular slate fragments was observed west of the sluice tunnel outlet. The waste rock pile presumably contains geologic material generated by construction of the tunnel. Site features at the Pond Mine are shown on Figure 2.

2.3 CLIMATE

The climate of the Pond Mine region (elevation 2,700 feet amsl) is characterized by mild spring and fall months, warm summers, and cool winters. Average temperature and annual precipitation data measured at nearby Auburn, California (elevation 1,500 feet amsl), were obtained from the Western Regional Climate Center (WRCC) (2006) based on data collected between 1914 and 2005. The average maximum and minimum temperatures are 92.5 degrees Fahrenheit (ºF) in July and 36.3 ºF in January (see Table 1). Average annual precipitation is 34.45 inches, most of which occurs as rain between November and March. Temperatures are slightly cooler and precipitation is slightly greater at the Pond Mine than at Auburn because of the difference in elevation.

2.4 GEOLOGY AND SOILS

The Pond Mine was developed on gold-bearing alluvial quartzitic gravels. These gravels overlie bedrock that is composed of slate with some phyllite, schist, and serpentinite (Oakland Museum of California 1998).

2.5 HYDROLOGY AND HYDROGEOLOGY

The Pond Mine lies within the watershed of the Middle Fork of the American River, just more than 1 mile northwest of the river (see Figure 1). Todd Creek and Pond Creek are the natural drainages for the Pond Mine area. Todd Creek lies north and west of the pit in a relatively flat to gently sloping area. Todd Creek flows from the Pond Mine pit to the southwest, passing through numerous mine areas along its course before it eventually discharges into the Middle Fork of the American River. Pond Creek, whose headwaters are just over a mile from the Middle Fork of the American River, is a major drain from the Pond Mine and receives discharge from the sluice tunnel.

The hydrology of the Pond Mine area has been substantially altered by historical hydraulic mining. Numerous sluice tunnel inlets are present in the northwest section of the mine pit; some of the inlets remain open, and others have collapsed or become plugged. The tunnel inlets are located in topographic low areas within the mine pit to drain water from the site. Ground sluices

and drainage channels are incised deeply due to the high flows that are associated with hydraulic mining.

Springs that discharge from the northwest pit highwall contribute surface water to the pit floor. The property owner captures discharge from the westernmost spring into a series of four ponds on his property. The ponds are presumably depressions that formed over plugged tunnel inlets. There is no surface drainage pathway for the ponds; instead, water within the ponds is lost to evaporation and infiltration (Tetra Tech 2006b). Infiltration from the ponds is believed to enter the Pond Mine sluice tunnel system. During Tetra Tech's site visit on August 22, 2006 (seasonal dry conditions), the discharge rate from the westernmost spring was estimated to be 50 to 60 gallons per minute (gpm). The first three ponds were filled to capacity, but the fourth pond contained very little standing water. Springs that discharge from the pit highwall east of the ponds flow to a topographically low area east of the property owner's residence. Topography and drainage patterns indicate that the low area captures most of the surface water north of Patent Road and east of the property owner's driveway. Standing water and riparian vegetation (including cattails and blackberries) were observed in the low area below the springs. Tetra Tech observed two open tunnel inlets within the low area; surface water was flowing into one of the open inlets at an estimated rate of 10 to 15 gpm.

The Pond Mine sluice tunnel system was constructed to drain surface water from the mine pit. Tunnel inlets were constructed in topographically low areas where water flowed under the force of gravity. Diversion of surface water away from the tunnel inlets would require major engineering, construction, and grading.

2.6 VEGETATION AND WILDLIFE

The Pond Mine is located in Sierra mixed conifer habitat with tree species including Ponderosa pine, Douglas fir, incense cedar, sugar pine, black oak, canyon live oak, madrone, big-leaf maple, California bay, toyon, mountain misery, and honeysuckle (BLM 2004). Other species commonly found in Sierra mixed conifer habitat understory include deerbrush, manzanita, chinquapin, tan oak, bitter cherry, squaw carpet, mountain whitethorn, gooseberry, and rose (California Department of Forestry and Fire Protection 2006). Sierra mixed conifer habitat reportedly supports approximately 355 different species of animals. No animals were observed during Tetra Tech's visits to the Pond Mine site; however, the lack of observed wildlife does not mean the site does not provide habitat for animal species.

The California Natural Diversity Database (CNDD) was queried to identify reports of special status plant and animal species in the Foresthill area (California Department of Fish and Game [CDFG] 2006). No special status plant or animal species were reported on the Pond Mine site. The CNDD records indicate that habitat range for the black swift (*Cypseloides niger*) extends to within approximately 0.85 mile to the northeast of the Pond Mine. The black swift is a California species of concern. The black swift inhabits mountain foothill canyons during the

nesting season, which begins in mid-May. They nest on cliffs behind or adjacent to waterfalls and lay a single egg per nesting season (CDFG 2006).

The BLM conducted a biological and botanical inventory of the Pond Mine that included site visits in December 2003 and September 2004 (BLM 2004). BLM wildlife biologists surveyed inside the sluice tunnel and the area around and downstream from the tunnel outlet. BLM searched specifically for Red Hills soaproot (*Chlorogalum grandiflorum*), foothill yellow-legged frog (*Rana boylii*), and bat sign. No sensitive species, weeds, or biological or wildlife resources were identified at the site. BLM observed harvestmen during the December 2003 survey and a banana slug, red-breasted nuthatch, Pacific treefrog, and Cooper's hawk during the September 2004 visit. The summary report for the BLM biological and botanical survey concluded that cleanout of mercury-contaminated sediment in the Pond Mine sluice tunnel and installation of a gate on the tunnel outlet would not have an impact on biological and botanical resources at the site, and recommended the cleanout project proceed.

2.7 SIGNIFICANT HISTORICAL AND ARCHEOLOGICAL FEATURES

Remnants of the sluice system are present in the Pond Mine sluice tunnel. Cherokee Development Corporation (Cherokee) identified pavestones within the tunnel, which are large cobbles that were manually flattened and used as riffles within the sluice. Use of pavestones was a labor-intensive process that was generally discontinued in the 1860s (Tetra Tech 2006c). Wood planks and riffles from the sluice box extend from just past the bulkhead to the partial collapse 1,600 feet into the tunnel. Use of wood riffles like the ones observed in the Pond Mine sluice tunnel was generally discontinued in the 1900s (Tetra Tech 2006c). There is a section from approximately 430 to 500 feet into the tunnel where the sluice box apparently remains intact below the sediment in the tunnel floor and running water disappears below the sediment. No information on archeological resources at the site was provided by BLM; Tetra Tech therefore assumes that a cultural resource survey has not been performed.

2.8 LAND USE AND POPULATION

A local storage business and permanent residences occupy the northwest section of the pit floor. Claimants who hold mineral rights claims engage in small-scale recreational mining at the site. BLM has taken measures to temporarily prohibit entry at the Pond Mine until remedial measures have been taken. This closure action is based on the potential for contaminant exposure to miners who enter the sluice tunnel and on concern that entry would disturb sediments and increase the potential for release of mercury and methyl mercury to surface water. However, the Pond Mine remains accessible until the temporary closure is published in the *Federal Register*. Information on property boundaries and private holdings in the Pond Mine area were not available for review when this document was prepared.

3.0 SITE INVESTIGATION SUMMARY

Tetra Tech (2004a, 2004b) and the USGS (Alpers and others 2005b; BLM 2005) conducted site investigations and sampling at the Pond Mine between 2003 and 2005. E & E (2005) prepared an RSI report that synthesized the existing data. The existing site data documented mercury contamination at the Pond Mine, but additional information on surface water drainage patterns and the sluice tunnel system (including tunnel inlets, water sources, underground conditions, and the volume of sediment in the sluice tunnel) was needed to evaluate removal action alternatives in this EE/CA. As a component of the EE/CA, Tetra Tech conducted surface and subsurface reconnaissance at the Pond Mine to better characterize the site. Tetra Tech also completed a treatability study to evaluate if physical separation methods could effectively segregate mercury from sluice tunnel sediment and whether residuals created by washing mercury from the sediment require additional stabilization or special handling. The following sections summarize the results of the previous investigations and the EE/CA reconnaissance and provide a CSM developed for the Pond Mine based on the current understanding of site conditions. The treatability study is described in detail in Appendix C.

3.1 PREVIOUS INVESTIGATIONS

Previous environmental investigations conducted at the Pond Mine assessed concentrations of total and methyl mercury in sluice tunnel sediment and discharge (Tetra Tech 2004a, 2004b) and in biota at the sluice tunnel outlet (BLM 2005). Analytical results for samples collected by Tetra Tech and the USGS are presented in Tables 2 and 3. These data were synthesized in the RSI report (E & E 2005) and are the basis for the recommendation for a removal action at the Pond Mine.

Tetra Tech collected samples of water and sediment at the Pond Mine in December 2003 during seasonal high flow conditions and in September 2004 during seasonal low flow conditions. Water samples Tetra Tech collected from the Pond Mine sluice tunnel under undisturbed conditions contained 0.0036 to 0.047 micrograms per liter (µg/L) of total mercury and 0.00003 to 0.000218 µg/L of methyl mercury. Tetra Tech collected a “disturbed” water sample at the tunnel outlet in September 2004 after samplers walked upstream in the tunnel and agitated the sediment to evaluate whether the disturbance (intended to mimic recreational miners walking in the tunnel) released mercury; the disturbed sample contained 0.817 µg/L of total mercury. Sediment samples Tetra Tech collected from the Pond Mine sluice tunnel contained 1.7 to 45.1 milligrams per kilogram (mg/kg) of total mercury and 0.000335 to 0.00566 mg/kg of methyl mercury.

USGS collected five biota samples (including predaceous diving beetles, water striders, dobsonflies, and dragonfly larvae) at the outlet to the Pond Mine sluice tunnel on August 8, 2005. The biota samples generally contained low concentrations of mercury when compared with samples collected at other mines in the area. However, concentrations of mercury in

dragonfly larvae collected at the Pond Mine ranked ninth and 21st of the 79 samples at other mines in the area (BLM 2005). Dragonfly larvae are higher-level insect predators and increased mercury in these samples indicates bioaccumulation is occurring at the Pond Mine.

The RSI concluded that mercury is present in surface water and sediments at the Pond Mine at concentrations that exceed screening benchmarks for the protection of human health and the environment, and a removal action appears warranted to prevent the discharge of mercury from the site (E & E 2005).

3.2 CURRENT INVESTIGATION

The BLM contracted Tetra Tech to complete an EE/CA for the Pond Mine, which included surface and subsurface reconnaissance to fill data gaps and gain a better understanding of site dynamics, and a treatability study to evaluate physical separation as a removal alternative technology. Environmental samples were not collected during the EE/CA, but process samples were collected during the treatability study as described in Appendix C.

Tetra Tech conducted surface reconnaissance and mapping on August 22, 2006. Field activities included surveying the locations of site features (such as tunnel inlets, ground sluices, drainages, ponds, and roads) with a global positioning system (GPS) receiver, evaluating site topography and surface water flow patterns, and taking photographs of relevant site features. Results of the GPS survey and topographic evaluation were used to create the site map in Figure 2. Selected site photographs are presented in Appendix A.

Tetra Tech contracted Cherokee to conduct subsurface reconnaissance within the Pond Mine sluice tunnel. Subsurface reconnaissance utilizing trained and certified underground workers was conducted from August 21 to 29, 2006. Workers entered the sluice tunnel from the outlet portal, removed the concrete bulkhead inside the tunnel 121 feet upstream of the portal outlet, and mapped the tunnel interior for a distance of 1,600 feet from the outlet. The orientation and gradient of the tunnel is consistent enough to allow the outlet to be visible from the collapse 1,600 feet inside. No major tunnel inlets or feeder shafts were observed in the length of tunnel that was inspected; surface feature mapping confirms that known tunnel inlets are more than 1,600 feet from the tunnel outlet (see Figure 2). A surface water flow rate of 60 gpm was measured at the Pond Mine tunnel outlet on August 22, 2006. The flow rate 1,600 feet inside the sluice tunnel was estimated to be at least 75 percent of the flow rate at the tunnel outlet; groundwater seeps appeared to contribute a small amount of water to the tunnel within the inspected area, but no major sources of water were identified.

A partial ceiling collapse prevented advancing more than 1,600 feet into the tunnel. Water and sediment are impounded behind the material that fell from the tunnel ceiling, and water was observed spilling over the top of the debris dam. The dam and retained water must be removed if workers are to advance farther into the tunnel. The collapse also presents serious safety and engineering problems that include the release of stored water, limited working space, and

potentially unstable sections of tunnel ceiling. Additionally, conditions in the tunnel past the collapse are not known. It is uncertain at this time if the collapse at 1,600 feet is the only obstruction or if others are also present.

The sluice tunnel cross section and sediment thickness was measured at 16 locations between the outlet and the collapse. The dimensions of the plunge pool were also measured and the thickness of sediment in the plunge pool was estimated based on surrounding features (see Table 4). Based on these field measurements, the estimated volume of sediment in the sluice tunnel (from the outlet to the collapse at 1,600 feet) is 1,000 loose yd^3 (assuming a 30 percent expansion factor for excavation) and the volume of sediment in the plunge pool is 31 loose yd^3.

Samples of Pond Mine sluice tunnel sediment collected at a dozen locations throughout the section of the tunnel that was inspected and panned and inspected for liquid mercury. Small beads of mercury, approximately the size of a ballpoint pen tip, were observed in every panned sample. Though the beads were small, field panning demonstrate that elemental mercury is present throughout the Pond Mine sluice tunnel. The plunge pool is also expected to contain mercury that has been released from the sluice tunnel. A similar removal action at the Boston Mine recovered elemental mercury from the plunge pool below the sluice tunnel outlet (Tetra Tech 2006a).

Based on the free liquid mercury observed in the Pond Mine sluice tunnel sediment and BLM's experience at the Boston Mine, Tetra Tech suggested gravity separation as a potential method for segregating liquid mercury and other heavy minerals from sluice tunnel sediments. However, the concentration of residual mercury in washed sediment and process water discharged from the gravity separation plant were not known. The need for a treatability study was identified in light of these uncertainties and potential impacts of these unknowns on treatment costs.

Approximately 2,000 pounds (roughly ¾ yd^3) of sediment from the Pond Mine sluice tunnel was collected for the treatability study. The sediment was processed using a portable aggregate plant and rotary concentration table to segregate mercury and other heavy minerals. Results of the treatability study indicated that 99 percent of the processed sediment was discharged as washed cobbles, gravel, sand, and fines that are suitable for on-site disposal. Approximately 1 percent of the processed sediment was separated as heavy mineral concentrates with a mercury concentration below the risk-based and hazardous waste criteria. However, additional leaching analysis may be necessary to evaluate potential impacts to groundwater if the heavy mineral concentrates are disposed of on site where meteoric water can infiltrate. Thirty-three grams (1.2 ounces; measure of mass) of elemental mercury and amalgam and 1.3 ounces (measure of volume) of granular heavy minerals that are not amalgamated ("Number 2 Product") were separated from 2,000 pounds of sluice tunnel sediment during the treatability study. The treatability study is described in detail in Appendix C.

3.3 CONCEPTUAL SITE MODEL

A CSM was developed for the Pond Mine (Figure 3) based on the analytical data and Tetra Tech's understanding of the site dynamics. The CSM addresses the mine workings at the Pond Mine and identifies five potential primary sources of mercury:

1. Pit floor and highwalls
2. Pit ponds
3. Sluice tunnel
4. Ground sluices
5. Plunge pool

Five primary mechanisms for release of sediment and mercury to the environment are identified in the CSM. One or more of the primary release mechanisms may operate at the Pond Mine on any of the potential primary sources to mobilize mercury to the environment. Primary release mechanisms that may be operating on individual primary sources at the Pond Mine include the following:

1. Surface Water – Mercury may be released and transported away from any of the primary sources by surface water, including discharge from springs within the mine pit and storm water runoff. Mercury in surface water can also methylate and enter the food chain.
2. Dissolution – Mercury in the primary sources may dissolve into the water column or methylate and enter the food chain.
3. Erosion – Mercury may be released by erosion of sediment from the primary sources, which can lead to transport of mercury-bearing suspended sediment, dissolution into the water column, migration of airborne particles and dust (under seasonal dry conditions), and volatilization.
4. Particles and Dust – Particulate-bound mercury from the exposed ground surfaces on the pit floor and ground sluices can be released by migration of airborne particles and dust during the dry season.
5. Volatilization – Mercury entrained in either sediment or surface water from any of the primary sources can volatilize and become airborne.

In addition, two secondary sources of mercury presented in the CSM include the following:

1. Surface Water (affected by primary release through storm water runoff, dissolution, slope failure, or particles and dust).
2. Air (affected by primary release through dissolution and particles and dust).

Secondary release mechanisms operating on the secondary sources listed above include:

1. Methylation – Mercury in surface water (including ponds and wetlands) may be methylated, leading to accumulation in the food chain. Mercury on dust particles may also deposit in surface water bodies and methylate.
2. Volatilization – Ambient air also acts as a reservoir for mercury and is an exposure pathway that does not require a secondary release mechanism. Mercury in air occurs on dust and particulates and as mercury vapor. Mercury can also volatilize from the water column to the atmosphere.

Three direct exposure media for potential receptors have been identified based on an evaluation of primary and secondary sources, release mechanisms, and environmental data. Potential receptors may be exposed to mercury or methyl mercury in these media through inhalation, ingestion, and dermal contact.

1. Surface Water – Exposure routes for recreational visitors and fauna include ingestion of and dermal contact with water from the Pond Mine. Water samples collected from the Pond Mine tunnel contained up to 0.817 µg/L of total mercury (Tetra Tech 2004a, 2004b). The maximum concentration was measured in an unfiltered sample collected after sediment upstream in the tunnel had been agitated (a "disturbed" sample). This concentration exceeds the California Toxics Rule (CTR) criterion for water used for drinking and consumption of aquatic organisms (0.050 µg/L) by more than an order of magnitude. However, the mine pit is not a source for drinking water, and substantial ingestion is unlikely. This concentration also exceeds the EPA ambient water quality criterion (AWQC) for the protection of freshwater aquatic life (0.77 µg/L) (Marshack 2003), the most likely receptor in the area. The AWQC is for dissolved mercury; the disturbed sample was not filtered before it was analyzed and was cloudy with suspended sediment. Ingestion or dermal contact with surface water discharged from the Pond Mine sluice tunnel is one of three completed pathways identified at this time based on field observations and existing analytical data.
2. Sediment – Exposure routes for site visitors and fauna include ingestion of and dermal contact with sediment from the Pond Mine. Six sediment samples collected within the sluice tunnel and plunge pool contained 1.7 to 45.1 mg/kg of total mercury (Tetra Tech 2004a, 2004b). The maximum concentration was measured in a sample from the floor of the sluice tunnel upstream from the bulkhead (which was removed during the underground reconnaissance). According to risk management criteria BLM developed for mine sites (Ford 1996), this concentration represents a moderate risk to humans under a recreational exposure scenario and a moderate to high risk to ecological receptors.

3. Ambient Air – Ambient air is also a potentially completed pathway for human visitors and terrestrial and aquatic receptors because mercury has a low vapor pressure and is easily volatilized. Mercury vapor is a potential concern in areas of stagnant air where temperatures are moderate to high. Air samples were not collected at the Pond Mine to demonstrate that this path is complete. However, the potential exposure to area receptors is considered low based on the low levels of mercury and methyl mercury in sediment and surface water samples.

Although each of the media and associated exposure routes may lead to adverse effects on humans or wildlife, a significant concern is biomagnification of mercury in the food chain and exposure of upper trophic level fauna and humans through consumption of organisms that contain mercury. For example, humans may eat fish or frogs that contain mercury; or birds of prey may consume fish or frogs that have accumulated mercury from ingesting insects that contain mercury. Elevated mercury concentrations in dragonfly larvae from the Pond Mine indicate predatory insects are bioaccumulating mercury at the site.

4.0 PRELIMINARY RISK SCREENING

The completed pathways shown in the CSM (Figure 3) identify the media and routes of exposure that are evaluated in human health and ecological risk screening presented in this section and potentially addressed by future response actions. Potential risks to human health and ecological receptors were evaluated by comparison to screening criteria for soil and drinking and tap water. Concentrations of mercury in sediment were compared with risk-based screening criteria for soils because generally applicable screening criteria for sediment are not available for all receptors. Tetra Tech believes that, for risk screening, exposure of humans and fauna to mercury in sediment at the Pond Mine is similar to exposure of fauna and humans to soil. Furthermore, soil screening criteria are generally more conservative than sediment screening criteria. This risk screening was based on data collected by Tetra Tech (2004a, 2004b) and the USGS (Alpers and others 2005b; BLM 2005) and reported in the RSI (E & E 2005).

Potential risks to human health and ecological receptors of methyl mercury were evaluated by comparison to background results from the Bear River and a compilation of results for samples collected from background locations, mine sites and downstream of mine sites in the Bear River and Greenhorn Creek Watersheds, and water quality criteria compiled by Marshack (2003).

Threats to water quality by discharge from the sluice tunnel are described in Section 4.3. Justification for a removal action is presented in Section 4.4 and is based on the findings of the human health and ecological risk screening and threats to water quality.

4.1 HUMAN HEALTH RISK SCREENING

Potential risks to human health were evaluated by comparing mercury concentrations in water and sediment at the Pond Mine with screening criteria. Surface water screening criteria used for this comparison include human risk management criteria (HRMC) developed by BLM for metals at mine sites (Ford 1996), the EPA Region IX preliminary remediation goals (PRG) for tap water (Smucker 2004), the EPA maximum contaminant levels (MCL), and the CTR 30-day average criterion for inland surface waters used for consumption of drinking water and aquatic organisms (Marshack 2003). The MCL and CTR are described in Section 5.2; all are applicable to surface water discharged from the Pond Mine tunnel. Site water is not expected to be used as a source of drinking water; thus, the screening criteria developed for sources of drinking water (PRGs and MCLs) likely overstate the potential risk for the permanent resident and recreational visitors. Table 5 compares concentrations of total and methyl mercury in surface water at the Pond Mine with human health risk screening criteria. Concentrations of total mercury in surface water are shown graphically in Figure 4, including comparison to screening criteria and data from the nearby Greenhorn Creek watershed.

Concentrations of total mercury in five surface water samples from the Pond Mine sluice tunnel ranged from 0.00361 to 0.817 µg/L. The maximum concentration was measured in an unfiltered

"disturbed" sample collected after sediment upstream in the tunnel was intentionally agitated to mimic recreational miners walking in the tunnel. The maximum concentration exceeded the CTR concentration (0.050 µg/L) by more than an order of magnitude. None of the water samples collected from the Pond Mine contained methyl mercury at a concentration above the EPA PRG for tap water (3.6 µg/L), which is the most conservative screening criterion identified (Smucker 2004). BLM has not published a screening criterion for methyl mercury as of the time this report was published.

Solid matrix screening criteria used for this comparison include HRMC developed by BLM for metals at mine sites (Ford 1996) and EPA Region IX PRGs for residential exposure (Smucker 2004). HRMC and PRG benchmarks for the residential exposure scenario were selected because a permanent resident lives on private property in the northwestern area of the Pond Mine pit floor. Less frequent exposure scenarios, including the HRMC for a camper scenario and industrial PRGs, appear to be more appropriate for the sluice tunnel, where human exposure occurs during small-scale mining and recreation. The EPA industrial PRG is calculated based on an industrial use scenario (for humans working at a site), which is routinely thought to reflect exposures greater than recreational exposures. The industrial exposure calculation assumes exposure of five 8-hour days per week for 50 weeks per year for 25 years. This exposure time is likely greater than would be selected for recreational exposures. Therefore, use of the industrial PRG likely overstates the potential risk for miners and recreational visitors. Table 6 compares total and methyl mercury concentrations in sediment at the Pond Mine with human health risk screening criteria. Concentrations of total mercury in sediment are shown graphically in Figure 5, including comparison to screening criteria and data from the nearby Greenhorn Creek watershed.

Concentrations of total mercury in six solid matrix samples from the Pond Mine sluice tunnel and plunge pool ranged from 1.7 mg/kg to 45.1 mg/kg. The concentration of total mercury in both samples collected from the sluice tunnel floor upstream from the bulkhead (45.1 and 3.8 mg/kg) and the sample from the plunge pool (4.8 mg/kg) exceeded the HRMC for a resident exposure scenario (2 mg/kg) and represent a moderate to high risk to residential receptors. The maximum concentration also exceeded the EPA Region IX residential PRG (23 mg/kg). It is unlikely that the residential exposure scenario applies to sediment within the sluice tunnel. Still, the maximum reported concentration of mercury in sluice tunnel sediment exceeded the HRMC for a camper scenario (40 mg/kg), which is a more realistic exposure scenario considering the small-scale mining known to occur within the tunnel. The maximum reported concentration of mercury in Pond Mine sluice tunnel sediment represents a moderate risk to humans under a camper exposure scenario. Beads of elemental mercury were found in the sediment throughout the sluice tunnel (from the outlet to the collapse 1,600 feet inside), indicating concentrations of mercury at some locations within the tunnel may exceed the maximum reported concentration in the existing data set. The highest measured concentration of methyl mercury in Pond Mine sluice tunnel sediment was 0.00566 mg/kg; a benchmark concentration has not been promulgated for methyl mercury in the screening criteria selected.

4.2 ECOLOGICAL RISK SCREENING

Potential risks to ecological receptors were evaluated by comparing mercury concentrations at the Pond Mine with screening criteria, and by comparing the results of biota sampling at the Pond Mine with results of biota sampling in nearby watersheds. Screening criteria used for this comparison include wildlife and livestock risk management criteria (WLRMC) developed by BLM for metals at mine sites (Ford 1996) and the EPA AWQC. The WLRMC were developed for 12 species; the robin, cottontail rabbit, mule deer, and mallard were selected as representative species for the Pond Mine. The median concentration presented in the BLM reference document for the 12 species was also used for comparison. The AWQC for the protection of freshwater aquatic life for a continuous (4-day average) concentration was selected, as this scenario is believed to be most representative of site conditions and biologic receptors. Benchmark concentrations have not been promulgated for methyl mercury in the screening criteria selected. Results for background biota samples collected by USGS between 1999 and 2001 (Alpers and others 2005b) are also used for comparison. Tables 5 and 6 compare total and methyl mercury concentrations in water and sediment at the Pond Mine with the screening criteria. Concentrations of total mercury in surface water and sediment are shown graphically in Figures 4 and 5, including comparison to screening criteria and data from the nearby Greenhorn Creek watershed.

Concentrations of mercury in surface water were generally below the BLM and EPA screening benchmarks. The concentration of total mercury in the "disturbed" water sample from the sluice tunnel (0.817 µg/L) exceeded the AWQC (0.77 µg/L) (Marshack 2003). The AWQC is for dissolved mercury; the disturbed sample was not filtered before it was analyzed and was cloudy with suspended solids. Mercury in the "disturbed" water sample appears to be associated with suspended sediment, as an undisturbed sample collected at the same location (which was not cloudy) contained much less (0.00361 µg/L) total mercury.

Concentrations of mercury in all six solid matrix samples exceeded the WLRMC for a robin receptor (1 mg/kg). Additionally, the concentration of mercury in the sample from the plunge pool (4.8 mg/kg) exceeded the WLRMC for a mallard receptor (4 mg/kg). The maximum concentration of mercury in sluice tunnel sediment (45.1 mg/kg) exceeded the WLRMC for the robin, mallard, median concentration (8 mg/kg), mule deer (9 mg/kg), and cottontail rabbit (15 mg/kg) receptors. In accordance with BLM guidance (Ford 1996), concentrations of mercury in Pond Mine sluice tunnel and plunge pool sediments represent a moderate to high risk to ecological receptors.

An alternative way to evaluate potential ecological risk is to compare mercury concentrations detected in biota at the Pond Mine with biota throughout nearby watersheds. Sample results are presented in Table 7. Samples of the predaceous diving beetle from the Pond Mine contained relatively low concentrations of total mercury compared with samples from the Bear River background site. Concentrations of total mercury in samples of water strider and dragonfly from the Pond Mine were one to two orders of magnitude higher than in samples from the Bear River

background site. In addition, concentrations of total mercury in dragonfly larvae samples from the Pond Mine ranked ninth and 21st of 79 samples from other mines in the area, indicating a relatively high bioaccumulation rate at the Pond Mine (BLM 2005).

4.3 THREATS TO WATER QUALITY

Results of environmental sampling at the Pond Mine show that mercury is present in sluice tunnel sediment and water. Disturbance of the tunnel sediment, which can be caused by recreational mining or exploring within the tunnel, causes a surface water release of particulate-bound mercury at concentrations that exceed water quality criteria. The observation of beads of mercury in panned sediment collected at more than a dozen locations within the sluice tunnel confirms that mercury is present within the tunnel and is likely to be present in the plunge pool. This mercury may be released to downstream surface water bodies unless protective measures are taken. Methyl mercury was not detected in water samples at concentrations above the water quality criteria.

4.4 BASIS FOR REMOVAL ACTION

Concentrations of mercury in samples from the Pond Mine exceed human health and ecological screening benchmarks developed by BLM, EPA, and the State of California. In accordance with BLM guidance for risk screening at mine sites, concentrations of mercury in solid materials represent a moderate risk to human receptors under a resident and camper scenario and a moderate to high risk to ecological receptors. Disturbance of sediment from the sluice tunnel floor releases mercury to surface water at concentrations (0.817 µg/L in sample PM-WAT-13) that exceed the CTR criterion for human consumption of water and organisms (0.05 µg/L). Furthermore, beads of elemental mercury were observed in panned sediment samples collected at more than a dozen locations within the sluice tunnel. The surface water, sediment, and air pathways appear to be complete for human and ecological receptors based on the analytical results, field observations, and apparent uses of the site. The Pond Mine is a source for mercury (a hazardous substance) to Pond Creek and the Middle Fork of the American River (waters of the United States), which is prohibited by the Clean Water Act (CWA). Potential impacts to human and ecological receptors posed by exposure to mercury from the Pond Mine are described below, followed by a summary of removal action criteria from the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) that are met at the Pond Mine.

Potential Human Impacts of Mercury Exposure. The potential human impacts of exposure to mercury are summarized from the Toxicological Profile for Mercury (Agency for Toxic Substances and Disease Registry [ATSDR] 1999). Exposure to high levels of metallic, inorganic, or organic mercury can permanently damage the brain, kidneys, and developing fetus. Mercury's harmful effects that may be passed from the mother to the fetus include brain damage, mental retardation, lack of coordination, blindness, seizures, and inability to speak. Children poisoned by mercury may develop problems in the nervous and digestive systems and kidney damage. Effects of exposure to mercury on brain functioning may result in irritability, shyness,

tremors, changes in vision or hearing, and memory problems. Methyl mercury and metallic mercury vapors are more harmful than other forms, because mercury in these forms more readily reaches the brain. Short-term exposure to high levels of metallic mercury vapors may cause effects including lung damage, nausea, vomiting, diarrhea, increases in blood pressure or heart rate, skin rashes, and eye irritation.

Potential Ecological Impacts of Mercury Exposure. Potential ecological impacts of mercury exposure are summarized from ATSDR (1999) and Wiener and others (2003). In the environment, inorganic mercury can be methylated by microorganisms to produce methyl mercury. Methyl mercury will accumulate in the tissues of organisms. The animals at the top of the food chain tend to accumulate the most methyl mercury in their bodies. Any source of mercury release to the environment may, therefore, lead to increased levels of methyl mercury in tissues of large fish, reptiles, birds, and mammals (ATSDR 1999). Mercury affects the reproduction and foraging ability of fish and is neurotoxic to fish. Exposure to mercury can impair reproduction of birds, cause mortality of bird eggs, and is related to the impaired feeding ability of birds. Exposure effects of mammals to mercury are similar to effects in humans and include lethargy, tremors, convulsions, and mortality (Wiener and others 2003).

Potential Safety Concerns. Mine tunnels, ground sluices and high walls may cause unsafe conditions for publicly accessed land. The tunnel system at the Pond Mine includes numerous open and collapsed inlets across the site, creating fall and cave-in hazards. Similarly, highwalls and ground sluice walls could fail near the steep embankments, causing a site visitor to fall or be buried by loose material that unexpectedly sloughs off as a result of natural or human triggered erosion. There are currently no controls to minimize the physical hazards to site visitors.

NCP Removal Action Criteria. The potential risks to humans and ecological receptors described above document that the following NCP removal action factors found at *40 Code of Federal Regulations* (CFR) Section 300.415(b)(2) have been attained:

- Actual or potential exposure to nearby human populations, animals, or the food chain from hazardous substances, pollutants, or contaminants.
- Actual or potential contamination of drinking water supplies or sensitive ecosystems.
- High levels of hazardous substances, pollutants, or contaminants in soils largely at or near the surface that may migrate.
- Weather conditions that may cause hazardous substances, pollutants, or contaminants to migrate or be released.
- Other situations or factors that may pose threats to public health or welfare or the environment.

Based on these five NCP factors, a removal action is warranted at the Pond Mine to minimize human and ecological exposure to mercury, to minimize the release of mercury through

disturbance of sluice tunnel sediment and storm water runoff, and to minimize accumulation of mercury in the food chain.

5.0 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

This section summarizes the BLM's analysis of potential federal and State of California ARARs and the resultant identification of potential ARARs for each removal action alternative retained for detailed analysis in this EE/CA. Section 5.1 summarizes the definitions and concepts pertinent to ARAR determinations. The three categories of ARARs — chemical-, location- and action-specific — are described in Sections 5.2, 5.3, and 5.4. Section 5.5 follows the ARAR discussion and analyzes the exemption of mining wastes from regulation as a hazardous waste under Section 3001(a)(3)(A)(ii) of the Resource Conservation and Recovery Act (RCRA) (the Bevill Amendment exemption) and under the California Health and Safety Code, Section 25143.1(b)(1) and (2).

The BLM has primary responsibility for identifying federal ARARs at the Pond Mine. The BLM has identified the following federal and state ARARs for Pond Mine.

5.1 SUMMARY OF COMPREHENSIVE ENVIRONMENTAL RESPONSE, COMPENSATION, AND LIABILITY ACT AND NATIONAL OIL AND HAZARDOUS SUBSTANCES POLLUTION CONTINGENCY PLAN REQUIREMENTS

Section 121(d) of CERCLA (42 *United States Code* [U.S.C.] Section 9621[d]), as amended, states that remedial actions on CERCLA sites must attain (or the decision document must justify the waiver of) any federal or more stringent state environmental standards, requirements, criteria, or limitations that are determined to be legally applicable or relevant and appropriate.

Applicable requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that specifically address the situation at a CERCLA site. The requirement is applicable if the jurisdictional prerequisites of the law or regulation directly address the circumstances at the site. An applicable federal requirement is an ARAR. An applicable state requirement is an ARAR only if it is more stringent than federal ARARs.

If the requirement is not legally applicable, then the requirement is evaluated to determine whether it is relevant and appropriate. Relevant and appropriate requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that, while not applicable, address problems or situations similar to the circumstances of the proposed removal action and are well suited to the conditions of the site (EPA 1988). A requirement must be determined to be both relevant <u>and</u> appropriate to be considered an ARAR.

To qualify as a state ARAR under CERCLA and the NCP, a state requirement must be a promulgated law, substantive, consistently applied, and more stringent than a federal requirement. Provisions of generally relevant federal and state statutes and regulations that were determined to be procedural or nonenvironmental, including permit requirements, are not

considered ARARs. Nonpromulgated advisories or guidance issued by federal or state governments are not legally binding and do not have the status of ARARs. However, these requirements may be useful and are "to be considered" for guiding decisions on cleanup levels or methodologies when regulatory standards are not available.

The BLM developed ARARs in three categories to assist in their identification. The three categories are (1) chemical-specific, (2) location-specific, (3) and action-specific ARARs. EPA guidance recognizes that some requirements do not fall neatly into these three categories. The three categories developed by the BLM and two additional categories of ARARs (mining waste regulations and other issues) are described in the following sections.

5.2 CHEMICAL-SPECIFIC APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND TO BE CONSIDEREDS

Chemical-specific ARARs are generally health- or risk-based numerical values or methodologies applied to site-specific conditions that result in the establishment of a cleanup level. The media of potential concern at the Pond Mine are surface water and sediment. Potential ARARs for these media are evaluated below.

5.2.1 Applicable or Relevant and Appropriate Requirements for Surface Water

Identification of ARARs for surface water depends on the beneficial uses of the water. Beneficial uses of surface waters in California are identified in water quality control plans, known as Basin Plans. Basin Plans are adopted and amended by regional water boards with input from the public, environmental review by the state, and approval by the water boards (California Regional Water Quality Control Board, Central Valley Region [Water Board] 2004). Basin Plans are regulatory references for meeting the state and federal requirements for water quality control. The Basin Plan for the Central Valley Region does not specifically identify the existing beneficial uses for the small drainages that receive discharge from the Pond Mine. However, the Basin Plan identifies a beneficial use of municipal domestic supply for water bodies that are not specifically identified unless the criteria of Resolution 88-63 are exceeded. The small drainages meet the federal and state criteria for sources of drinking water. These water bodies are tributaries to the Middle Fork of the American River. Beneficial uses for the Middle Fork of the American River include municipal domestic supply, agriculture, industry, recreation, warm and cold freshwater habitat, spawning, and wildlife habitat. Potential federal surface water ARARs for tributaries to the Middle Fork of the American River are the regulations promulgated under the Safe Drinking Water Act (SDWA) and the CWA. Potential state ARARs for tributaries to the Middle Fork of the American River are the State of California MCLs, the Basin Plan, and Resolutions 68-16 and 92-49.

5.2.1.1 Safe Drinking Water Act

The SDWA, 42 U.S.C. Section 300(f), sets limits on the concentrations of certain hazardous materials in drinking water. MCLs are applied at the tap to water that is delivered directly to 25 or more people or to 15 or more service connections. Under the SDWA, EPA has also designated MCL goals (MCLG), which are health-based goals and generally are more stringent than MCLs. CERCLA Section 1211(d)(2)(B) provides that response actions "shall require a level of standard or control which at least attains MCLGs established under the Safe Drinking Water Act." Section 300.430(f)(5) of the NCP provides that remedial actions must generally attain MCLs or non-zero MCLGs if water is a current or potential source of drinking water. EPA has adopted a concentration of 2 µg/L as the MCL (40 CFR 141.62(b)) and MCLG (40 CFR 141.51) for mercury in tributaries to the Middle Fork of the American River:

5.2.1.2 State Safe Drinking Water Act

The State of California has adopted primary and secondary MCLs for public drinking water under the California SDWA of 1976. Some state MCLs may be more stringent than the corresponding federal MCL, in which case the state MCL would generally be the ARAR. The MCLs are set forth in Title 22 California Code of Regulation (CCR) Sections 64431 and 64449(a). The state MCL for mercury in tributaries to the Middle Fork of the American River is 2 µg/L; an MCLG for mercury has not been established.

5.2.1.3 Clean Water Act Water Quality Standards

On December 22, 1992, EPA promulgated federal water quality standards under the authority of CWA Section 303(c)(2)(B) to establish water quality standards where the State of California had failed to do so. Priority toxic pollutants for California inland surface waters are contained in 40 CFR Section 131.38(a). Criteria for mercury in tributaries to the Middle Fork of the American River are as follows:

EPA CALIFORNIA TOXICS RULE WATER QUALITY CRITERIA

	Freshwater		Human Health	
Substance	**Maximum Concentration (µg/L)**	**Continuous Concentration (µg/L)**	**Consumption of water and organisms (µg/L)**	**Consumption of organisms (µg/L)**
Mercury	Not promulgated	Not promulgated	0.050*	0.051*

Notes:

* Total recoverable concentration

µg/L Microgram per liter

5.2.1.4 Clean Water Act Ambient Water Quality Criteria

Section 121 of CERCLA states that remedial actions shall attain federal water quality criteria where they are relevant and appropriate under the circumstances of the release. AWQC are non-enforceable guidance developed by EPA and are used by the state to establish water quality standards. Generally, AWQC are considered potentially relevant and appropriate for surface water regarded as a potential source of drinking water only in the absence of promulgated MCLs or MCLGs. However, the AWQC may be more stringent than the MCL or MCLG if the surface water's designated beneficial use includes protection of aquatic life. The AWQC for mercury within tributaries to the Middle Fork of the American River are as follows:

EPA AMBIENT WATER QUALITY CRITERIA

	Freshwater		Human Health	
Substance	**Maximum Concentration (µg/L)**	**Continuous Concentration (µg/L)**	**Consumption of water and organisms (µg/L)**	**Consumption of organisms (µg/L)**
Mercury	1.4	0.77	Not promulgated	Not promulgated

Note:

µg/L Microgram per liter

5.2.1.5 Clean Water Act Effluent Limitations

No effluent limitations are specifically identified for inactive placer gold mines. There are limitations for active placer gold mines, which are found at 40 CFR Section 440.140- 440.148. These effluent limitations are potentially relevant and appropriate because the problems of mine drainage from abandoned placer gold mines are similar to the problems of active placer gold mines. The CWA established effluent limitations according to whether the discharge is from a new or existing source and whether the pollutant is conventional and toxic or is a non-conventional, non-toxic pollutant. Existing sources were initially required to achieve best practicable technology and later best available technology economically achievable. The instantaneous maximum effluent limitation for settleable solids at placer gold mines is 0.2 milliliter per liter.

5.2.1.6 Central Valley Water Quality Control Plan (Basin Plan)

The Basin Plan identifies MCLs as the standard for surface water drinking sources. The Basin Plan also includes narrative water quality objectives (WQO) for surface water within the region. The WQOs potentially pertinent to the removal action at the Pond Mine are as follows (Water Board 2004):

> *Suspended material: Waters shall not contain suspended material in concentrations that cause nuisance or adversely affect beneficial uses.*

Toxics: Water shall be maintained free of toxic substances in concentrations that produce detrimental physiological responses in human, plant, animal, or aquatic life.

5.2.1.7 State Water Resources Control Board Resolution 68-16

State Water Resources Control Board (SWRCB) Resolution 68-16, Statement of Policy with Respect to Maintaining High Quality Waters in California, establishes the policy that high-quality waters of the state "shall be maintained to the maximum extent possible" consistent with the "maximum benefit to the people of the state." It requires the maintenance of high-quality waters until it has been demonstrated that any change would be consistent with maximum benefit to the people of the state, would not unreasonably affect beneficial uses of the water, and would comply with applicable water quality control policies. It further requires that any discharge of waste to high-quality waters comply with requirements resulting in best practicable treatment or control to prevent pollution or nuisance.

5.2.1.8 State Water Resources Control Board Resolution 92-49

SWRCB Resolution 92-49 contains policies and procedures that the regional boards apply to all investigations and cleanup and abatement for all types of discharges subject to California Water Code Section 13304. Section III.G of the resolution requires attainment of background water quality, or the best water quality that is reasonable if background cannot be restored.

5.2.2 Applicable or Relevant and Appropriate Requirements for Sediment

Section 3001(b) of RCRA temporarily prohibited EPA from regulating solid waste from the "extraction, beneficiation, and processing of ores and minerals" as hazardous waste pending further study. EPA has since concluded that regulation of many of the wastes from mineral extraction do not warrant regulation as hazardous waste. Specifically, 22 CCR Section 66261.4(b)(5)(A) excludes "solid waste from the extraction, beneficiation, and processing of ores and minerals" from the definition of hazardous waste. All of the wastes generated at the Pond Mine relate in some manner to historical mining operations. Therefore, the mining wastes at the Pond Mine are not subject to RCRA Subtitle C regulation or to regulation as hazardous wastes under the California Hazardous Waste Control Law. The wastes would, however, be regulated under the provisions of California Water Code Section 13172. The level of control required under state law would depend on whether the wastes are classified as Group A, B, or C (see Section 5.4.4).

5.3 LOCATION-SPECIFIC APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND TO BE CONSIDEREDS

Location-specific ARARs are restrictions on the conduct of activities solely because they are in specific locations. Special locations include floodplains, wetlands, historic places, and sensitive ecosystems or habitats. The Endangered Species Act of 1973, the Archeological and Historic

Preservation Act, the Fish and Wildlife Coordination Act, the Migratory Bird Treaty Act, and various California natural resource laws are potential ARARs. Each is summarized below.

5.3.1 Endangered Species Act of 1973

The Endangered Species Act of 1973 (ESA), 16 U.S.C. Chapter 35, was enacted to protect the ecosystems upon which endangered and threatened species depend, and to conserve and recover endangered and threatened species. The ESA applies to actions taken or funded by federal agencies. No special status plant or animal species were reported on the Pond Mine site (CDFG 2006).

5.3.2 Archeological and Historic Preservation Act

The Archeological and Historic Preservation Act, 16 U.S.C. Section 469, establishes procedures to provide for preservation of historical and archeological data that might be destroyed through alteration of terrain as a result of a federal construction project or a federally licensed activity or program. If any removal action would cause irreparable loss or destruction of significant scientific, prehistoric, historical, or archeological data, it would be necessary to follow the procedures in the statute to provide for data recovery and preservation. No information on archeological resources at the site was provided by BLM; Tetra Tech assumes a cultural resource survey has not been performed.

5.3.3 Fish and Wildlife Coordination Act

The Fish and Wildlife Coordination Act, 16 U.S.C. Section 661, was enacted to protect fish and wildlife when federal actions result in the control or structural modification of a nature stream or body of waste. The statute requires federal agencies to consider the effect of water-related projects on fish and wildlife and then take action to prevent loss or damage to these resources.

5.3.4 Migratory Bird Treaty Act

The Migratory Bird Treaty Act, 16 U.S.C. Section 703, establishes federal responsibility for the protection of international migratory bird resources. It prohibits, at any time, using any means or manner, the pursuit, hunting, capturing, killing, or attempting to take, capture, or kill any migratory bird. No migratory birds have been identified at the site.

5.3.5 California Natural Resource Laws

Two potential location-specific ARARs were identified and are discussed below.

5.3.5.1 California Wildlife Statutes

California Fish and Game Code Section 3005 prohibits the taking of any mammal or bird with poison. California Fish and Game Code Section 5650 makes it unlawful to "deposit in, permit to pass into, or place into waters of the state … substances or materials deleterious to fish, plant life, or bird life." No special status plant or animal species were reported on the Pond Mine site (CDFG 2006).

5.3.5.2 California Lake and Streambed Alteration Program

California Fish and Game Code Sections 1600-1616 prohibit alteration of streambeds or impeding natural flow in streambeds absent an agreement with the CDFG.

5.4 ACTION-SPECIFIC APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND TO BE CONSIDEREDS

Action-specific ARARs are technology- or activity-based requirements of limitations on actions taken with respect to hazardous substances. These requirements are triggered by the specific remedial activities selected. This section summarizes the general action-specific ARARs for the alternatives. A more detailed discussion of the action-specific ARARs as they apply to each alternative is included in Section 8.0 as part of the detailed analysis of the alternatives.

The following regulations were evaluated as ARARs for alternatives that involve the excavation, treatment, or disposal of contaminated media.

5.4.1 Northern Sierra Air Quality Management District Regulations

Northern Sierra Air Quality Management District (AQMD) rules and regulations include standards for dust controls and nuisances. Specifically, AQMD rules set standards for discharges of particulate matter from sources other than combustion sources and prohibit the discharge of air contaminants that would cause nuisances. A dust control plan must be submitted to the AQMD for construction that disturbs more than 1 acre of land surface.

5.4.2 Clean Water Act

The CWA contains permit requirements for discharges to waters of the United States. The substantive requirements of 40 CFR Part 122 are potential ARARs for those alternatives that would involve discharge to surface water.

5.4.3 Clean Water Act Permit Requirements for Storm Water Discharges

Any on-site discharge of storm water runoff associated with construction of the proposed remedy must meet the substantive requirements of the General National Pollutant Discharge Elimination System (NPDES) Permit for Stormwater Discharges Associated with Construction Activity,

Order 99-08-DWQ, issued by SWRCB pursuant to its delegated authority under the CWA. In addition, the substantive requirements of the General Permit for Stormwater Discharges Associated with Industrial Activities, Order 97-03-DWQ, may be potential ARARs because inactive mines are considered an industrial activity under the permit.

5.4.4 Off-Site Disposal of Mine Waste

Off-site disposal of mine wastes would require compliance with California and federal transportation requirements and compliance with relevant disposal criteria. In particular, RCRA land disposal restrictions require that wastes be analyzed for the potential to create leachate using the toxicity characteristics leaching procedure before off-site disposal can occur.

5.5 MINING WASTE REGULATIONS

All of the soil wastes at the Pond Mine are the result of mineral extraction or beneficiation at the site. Under RCRA Section 3001(a)(3)(A)(ii), 42 U.S.C. 6921(a)(3)(A)(ii) (also known as the "Bevill Amendment"), EPA has exempted most mining wastes from regulation as hazardous waste. Exempted material includes waste generated from the extraction and beneficiation of minerals and some mineral processing wastes (including amalgam) (see 40 CFR Section 261.4(b)(7)). Surface water drainage from the Pond Mine is not exempt from RCRA regulation. Treatment process wastes, including precipitates and sludges, are not excluded from RCRA regulation.

5.5.1 State Exclusion of Mining Waste from Regulation as Hazardous Waste

California's Health and Safety Code recognizes the Bevill Amendment exclusion, so that wastes that would otherwise be regulated by the California Hazardous Waste Control Law, the California analogue to RCRA, are instead subject only to the requirements of Water Code Section 13172, detailed in 27 CCR Section 22470. Under Health and Safety Code Section 25143.1(b)(1 & 2), as stated below:

> "Wastes from the extraction, beneficiation, and processing of ores and minerals that are not subject to regulation under Subchapter III (commencing with Section 6921) of Chapter 82 of Title 42 of the United States Code are exempt from the requirements of this chapter, except the requirements of Article 9.5 (commencing with Section 25208) and Chapter 6.8 (commencing with Section 25300)... The wastes subject to this subdivision are subject to Article 9.5 (commencing with Section 25208) and Chapter 6.8 (commencing with Section 25300) if the wastes would otherwise be classified as hazardous wastes pursuant to Section 25117 and the regulations adopted pursuant to Section 25141."

5.5.2 Surface Mining Control and Reclamation Act

The Surface Mining Control and Reclamation Act (SMCRA), 30 U.S.C. Section 1201, establishes a nationwide program for the protection of human health and the environment from the adverse effect of surface coal mining operations. Although SMCRA addressed abandoned coal mines, it may be relevant and appropriate to cleanup of other types of mining sites. In its CERCLA Compliance with Other Laws Manual (EPA 1988), EPA explained that SMCRA may be relevant and appropriate at (1) sites with sulfide-containing geologic materials and where there is a release or threat of release of acid, and at (2) sites subject to erosion and thus where releases are contaminated by heavy metals. The following regulations, which provide guidelines for post-mining rehabilitation and reclamation of surface mines (Part 816) and underground mines (Part 817) may be potentially relevant and appropriate (EPA 1988):

- 30 CFR 816.43/817.43 – standard for diversions of flow from disturbed areas
- 30 CFR 816.56/817.56 – post mining rehabilitation of sedimentation ponds, diversions, impoundments
- 30 CFR 816.97/817.97 – protection of fish and wildlife
- 30 CFR 816.111/817.11, 816.114/817.114, and 816.116/817.116 – revegetation requirements

5.5.3 California Surface Mining and Reclamation Act of 1975

Pursuant to the State Surface Mining and Reclamation Act (SMARA), the California Department of Conservation, Office of Mine Reclamation has adopted reclamation standards for mining operations in Article 9, Title 14. These standards do not apply to operations that completed reclamation prior to January 15, 1993 or had an approved reclamation plan prior to January 15, 1993. Pertinent requirements include provisions of the follow regulations:

- 14 CCR 3703 – protection standards for wildlife habitat
- 14 CCR 3704 – performance standard for backfilling, regrading, slope stability, and recontouring
- 14 CCR 3705 – performance standards for revegetation
- 14 CCR 3706 – performance standards for drainage, diversion structures, waterways, and erosion control
- 14 CCR 3710 – performance standards for stream protection
- 14 CCR 3713 – performance standards for closure of surface openings

5.5.4 California Mining Waste Regulations

Pursuant to California Water Code Section 13172, the State of California has adopted regulations designed to address the management of mining waste. These regulations are found at 27 CCR 22470-22510. The regulations establish three groups of mining waste:

- Group A – mining waste that must be managed as hazardous waste, provided the Water Board finds that the mining wastes pose a significant threat to water quality
- Group B – mining wastes that consist of or contain hazardous wastes that qualify for a variance, provided that the Water Board finds that the mining wastes pose a low risk to water quality, or mining wastes that consist of or contain nonhazardous soluble pollutants of concentrations that exceed water quality objectives for, or could cause, degradation of waters of the state
- Group C – wastes from which any discharge would be in compliance with the applicable water quality control plan, including water quality objectives other than turbidity

Classification of the mining waste as hazardous under the Hazardous Waste Control Act is used to identify the group designation that is appropriate. Untreated mining wastes from the Pond Mine may be classified as Group A wastes. Treated mining wastes from the Pond Mine may be classified at Group B or C wastes, depending on the hazardous characteristic and the level of threat to water quality. The regulations contain specific requirements on siting, construction, monitoring, and closure and post-closure maintenance of existing and new units. These requirements are ARARs for alternatives that involve the creation of an on-site disposal unit or closure of existing units.

5.6 OTHER ISSUES

Property ownership is another issue that could affect the removal action at the Pond Mine. Any response action undertaken for the site should take into account the rights of private property owners. Although the Widen Amendment (16 U.S.C. § 1011(a) and P.L. 105-227 § 323) allows for federal money to be spent on private property for the benefit of federal lands, the property owner's rights and wishes should be carefully considered before actions that may affect private property would proceed. Information provided by BLM did not clearly define the property boundaries at the Pond Mine. The southeastern portion of the mine, including the ground sluices and the sluice tunnel outlet, is believed to be located on public lands administered by the BLM. The northwestern portion of the mine, including most of the tunnel inlets and surface water capture areas, is located on private property.

Tetra Tech is not aware of a potentially responsible party (PRP) search completed for the Pond Mine. A PRP search could be completed to identify any viable PRPs that could be pursued for cost recovery if a response action is taken at the Pond Mine.

6.0 REMOVAL ACTION OBJECTIVES AND GOALS

The goal of the EE/CA process at the Pond Mine is to develop and select remedies in accordance with CERCLA criteria. These criteria require that remedies be protective of human health and the environment and comply with ARARs (see Section 5.0). PRAOs and PRAGs have been developed for the Pond Mine in consideration of CERCLA criteria. The objectives and goals for the removal action identified in this EE/CA are typical of those used for cleanup actions at abandoned mine sites. They will be refined and updated as additional information becomes available. The final objectives and final removal action goals for the removal action will be identified in the action memorandum.

6.1 PRELIMINARY REMOVAL ACTION OBJECTIVES

PRAOs are intended to remove the site conditions that trigger NCP criteria for a removal action. These factors are as follows:

- **Actual or potential exposure to nearby human populations, animals, or the food chain from hazardous substances or pollutants or contaminants.** Concentrations of mercury in solid matrix samples from the sluice tunnel and plunge pool exceeded screening criteria and represent a moderate risk to human receptors under resident and camper scenarios and a moderate to high risk to ecological receptors (Ford 1996). Humans are exposed to mercury when they disturb sediment in the sluice tunnel and plunge pool during recreational gold prospecting or use water from the sluice tunnel or plunge pool. Ecological receptors are exposed to mercury through contact with sediment in the sluice tunnel and plunge pool. Results of macroinvertebrate sampling show elevated concentrations of mercury in dragonfly larvae at the Pond Mine when compared with samples for the Bear River background site, which indicates that fauna at the Pond Mine are bioaccumulating mercury.

- **Actual or potential contamination of drinking water supplies or sensitive ecosystems.** Water from the sluice tunnel outlet discharges to a small drainage that joins the Middle Fork of the American River 1 mile downstream from the tunnel outlet. Under certain conditions, water from the sluice tunnel contains mercury at concentrations above water quality criteria developed for the protection of human health and the environment. Humans and upper trophic level fauna may be exposed to harmful levels of mercury by consuming mercury-containing organisms and water downstream from the Pond Mine.

- **High levels of hazardous substances or pollutants or contaminants in soils largely at or near the surface that may migrate.** Laboratory analysis of sediment samples from the Pond Mine sluice tunnel showed the sediment contains elevated levels of total mercury. Field panning of sluice tunnel sediment samples showed that elemental mercury is present throughout the tunnel. Disturbance of the sluice tunnel sediment releases particulate-bound mercury into water as it flows through the sluice tunnel and discharges from the site.

- **Weather conditions that may cause hazardous substances or pollutants or contaminants to migrate or be released.** Numerous tunnel inlets are believed to feed surface water into the Pond Mine sluice tunnel. Storm water runoff during a large precipitation event could cause high flows within the sluice tunnel, thereby mobilizing mercury-bearing sediment from the tunnel floor.

- **Other situations or factors that may pose threats to public health or welfare or the environment.** Physical hazards caused by historical hydraulic mining could pose a substantial threat to site visitors. The numerous open and collapsed tunnel inlets are a serious fall hazard for inattentive site visitors. Small-scale mining is believed to occur within the sluice tunnel. Physical hazards associated with the sluice tunnel include steep tunnel portal access, limited visibility within the tunnel, and the potential for poor air quality and collapse within the tunnel. Mine tunnel entrants are exposed to mercury-bearing sediment and disturb tunnel floor sediment, releasing mercury to water discharging from the tunnel outlet.

Based on these NCP removal action factors, the following PRAOs are identified for the Pond Mine:

- *Prevent migration of mercury from the sluice tunnel and plunge pool to the small drainage and the Middle Fork of the American River.*

- *Minimize the potential for human and ecological exposure to mercury in sluice tunnel and plunge pool sediment.*

- *Improve public awareness of on-site physical hazards posed by previous mining activities.*

Attaining these objectives is expected to result in mitigation of the NCP removal action factors, protection of human and ecological receptors, and protection of water quality at the Pond Mine.

6.2 PRELIMINARY REMOVAL ACTION GOALS

No known specific cleanup levels apply to mercury in sluice tunnel and plunge pool sediment at the Pond Mine; therefore, the PRAG is to reduce the amount of mercury in sediment available for transport, dissolution, volatilization, methylation, and bioaccumulation and limit the potential exposure of human and ecological receptors to mercury-contaminated sediment. The removal action will also reduce the amount of mercury in sediment available for dissolution and transport in surface water.

In meeting these qualitative goals, long-term risk reduction for human and ecological receptors may be attained. A human health and ecological risk assessment for the Pond Mine has not been prepared; therefore, risk screening criteria presented in Section 4.0 have been used to identify long-term risk reduction goals at the Pond Mine. Table 8 presents long-term risk reduction goals for surface water and solid materials. Any process or treatment waters discharged during

implementation of the removal action will attain the water quality criteria presented in Table 8. Reduction of the volume and mobility of mercury in sediment and surface water is consistent with attaining long-term risk reduction goals.

7.0 IDENTIFICATION AND SCREENING OF RESPONSE ACTIONS, TECHNOLOGY TYPES, AND PROCESS OPTIONS

Selection of the appropriate removal action alternatives for the Pond Mine depends on the following: (1) the scope of the proposed removal action; (2) the nature and types of source materials; (3) the volume and location of the source material; (4) the mobility of sediment from source areas; (5) the concentration of mercury in the source materials; (6) the effectiveness of the potentially applicable technology and process options; and (7) property ownership.

The selection process for the removal action alternative involves five steps that include: (1) identification of general response actions, technologies, and process options; (2) initial technology screening and alternative development; (3) detailed analysis of alternatives; (4) analysis of implementability of identified alternatives; and (5) comparative analysis of alternatives. General response actions, technologies, and process options are identified in Section 7.1. The results of the initial technology screening and alternative development process for the Pond Mine are described in Section 7.2. A detailed analysis of the alternatives is presented in Section 8.0. A comparative analysis of alternatives and the recommendation for a site strategy are presented in Section 9.0.

7.1 IDENTIFICATION OF GENERAL RESPONSE ACTIONS, TECHNOLOGIES, AND PROCESS OPTIONS

The first step in the removal action alternative selection process is identifying general response actions that may satisfy the PRAOs. General response actions are then progressively refined into technology types and process options. The process options are then screened in Section 7.2, and the retained technologies and process options are combined into potential removal action alternatives. The purpose of the initial screening is to eliminate from further consideration the process options that are not feasible and retain those process options that are potentially feasible.

Sources of mercury contamination identified at the Pond Mine that will be addressed by this removal action include: (1) sediment within the sluice tunnel, (2) sediment within the plunge pool; and (3) surface water dissolving mercury from sediment and moving sediment through the tunnel and plunge pool. Residual mercury that may remain on the pit floor, pit ponds, ground sluices, and private property may be evaluated and addressed separately, as necessary. General response actions, technologies, and process options potentially capable of meeting the PRAOs for these sources of mercury contamination in surface water and sediment are identified in Tables 9 and 10.

7.2 TECHNOLOGY SCREENING SUMMARY AND DEVELOPMENT OF REMOVAL ACTION ALTERNATIVES

The purposes of technology and process option screening, the second step in the removal action alternative development process, are to (1) evaluate the identified technologies and process

options based on the NCP criteria of effectiveness, implementability, and relative costs, and (2) eliminate technologies and process options to reduce the number of alternatives developed and carried forward for detailed analysis in Section 8.0. A technology or process option can be eliminated from further consideration if it does not meet the effectiveness or implementability criteria. In addition, a technology or process option can be eliminated if its cost is substantially higher than other technologies or process options and at least one other technology or process option is retained that offers equal protectiveness. Summaries of the initial screening of technologies and process options for controlling mercury in surface water and sediment are identified in Tables 11 and 12.

The technologies and process options that were retained have been combined into the four removal action alternatives shown in Table 13. In accordance with guidance from the BLM, the four alternatives include no action plus three removal alternatives that appear to be most feasible for the site. All of these alternatives will be carried through to the detailed analysis in Section 8.0 because the number of alternatives is not unreasonably high and none of these alternatives could obviously be eliminated through an additional screening step.

8.0 DETAILED ANALYSIS OF REMOVAL ACTION ALTERNATIVES

The third step in the alternative selection process for the Pond Mine is the detailed analysis. The detailed analysis evaluates the removal action alternatives for their effectiveness, implementability, and cost to minimize off-site migration of mercury from, and the potential for human and ecological exposure to, mercury at the Pond Mine. Alternatives evaluated in this EE/CA include measures to address documented mercury contamination in sediment within the plunge pool and accessible portion of the sluice tunnel (from the outlet to the collapse 1,600 feet upstream) and potential mercury contamination in portions of the tunnel that are not currently accessible (upstream from the collapse). The removal action alternatives that were retained after the technology and process option identification and screening processes in Section 7.0 are included in the detailed analysis.

As suggested in "Guidance on Conducting Non-Time Critical Removal Actions under CERCLA" (EPA 1993), removal action alternatives that were retained after the technology and process option identification and screening processes will be evaluated individually against the following three broad criteria: effectiveness, implementability, and cost. The qualitative evaluation criteria are described in the following paragraphs.

Effectiveness Evaluation. The ability of the process to protect human health and the environment is reviewed during an evaluation of the effectiveness of a removal action alternative (EPA 1993). Protection is achieved by reducing the toxicity, mobility, or volume of metals in surface water over a short-term and long-term period while complying with ARARs.

Effectiveness relates to the potential of an alternative to achieve the PRAOs, considering the chemical and physical characteristics of the source and the site conditions. Potential impacts to human health and the environment during the construction and implementation phase as well as the reliability of the process with respect to the site conditions are also considered. The evaluation considered effectiveness as low, moderate, high, or uncertain.

Implementability Evaluation. The technical and administrative feasibility of constructing, operating, and maintaining the alternative is measured during an evaluation of the implementability of a removal action alternative (EPA 1993). Technical feasibility takes into account whether the removal action alternative applies to and can be properly constructed and operated at the site. The evaluation considers long-term operation, maintenance, and monitoring of the alternative implemented. Administrative feasibility considers regulatory approval and scheduling constraints, as well as the availability of disposal services, disposal locations, and the necessary construction expertise and equipment. This evaluation considered implementability as easy, moderately difficult, or difficult.

Cost Evaluation. The types of costs that will be assessed include the following:

- Capital costs, including both direct and indirect costs
- Annual operation and maintenance (O&M) costs, including long-term effectiveness monitoring cost
- Net present worth of capital, O&M costs, and periodic costs

In accordance with EPA guidance (EPA 1993, 2000), these engineering costs are estimates that are expected to be within plus 50 to minus 30 percent of the actual project cost (based on year 2006 dollars). Cost estimates were prepared in substantial accordance with EPA guidelines (EPA 2000) using engineer's estimates, historical costs for similar projects, and vendor quotes. Changes in the cost elements are likely as a result of new information and data collected during the removal action design. The present worth of each removal action alternative provides the basis for the cost comparison. The present worth cost represents the amount of money that, if invested in the initial year of the removal action at a given interest rate, would provide the funds required to make future payments to cover all costs associated with the removal action over its planned life.

The present worth analysis will be performed on all removal action alternatives using a 7 percent discount rate (the historical average) over a period of 30 years. Inflation and depreciation were not considered in preparing the present worth costs.

The final step of this analysis is to conduct a comparative analysis of the removal action alternatives. The comparative analysis, presented in Section 9.0, will discuss each alternative's relative strengths and weaknesses with respect to each of the criteria. Once completed, the findings of the comparative analysis will be used to identify the preferred removal action alternatives.

8.1 ALTERNATIVE 1: NO ACTION

Under the No Action alternative, no treatment or removal action would occur at Pond Mine. Consequently, potential human health, ecological, and water quality impacts associated with sediment mobility and exposure to mercury are assumed to remain unchanged. The No Action alternative is used as a baseline against used to compare the removal action alternatives. The No Action alternative is applicable to all media at Pond Mine. The No Action alternative will be retained through the detailed analysis of alternatives.

8.1.1 Effectiveness

The effectiveness of the No Action alternative is considered low for achieving PRAOs. This alternative would not minimize the potential exposure to or transport of mercury from the Pond Mine. This alternative would provide no control of mercury concentrations or mobility and no reduction in risk to human health or the environment. Therefore, increased protection of human health and the environment would not be achieved under the No Action alternative.

A comprehensive list of federal and state ARARs for Pond Mine is presented in Section 5.0. ARARs are divided into contaminant-specific, location-specific, and action-specific requirements. Under the No Action alternative, mercury would not be treated, removed, or actively managed. Consequently, no location- or action-specific ARARs apply to the No Action alternative. Surface water discharged from the sluice tunnel would continue to release mercury to the watershed, and site visitors could still be exposed to mercury in sluice tunnel and plunge pool sediment. Storm water runoff from Pond Mine would continue to release sediment to receiving surface water bodies; therefore, the No Action alternative would not comply with chemical-specific ARARs.

No controls or long-term measures would be implemented to control mercury at the site under the No Action alternative; consequently, this alternative provides no long-term effectiveness. Therefore, the No Action alternative would not be effective at improving water quality or reducing potential risks to human and ecological receptors. The No Action alternative would provide no reduction in toxicity, mobility, or volume of mercury-contaminated soil at the site. In the short term, the No Action alternative would not reduce the threat to the community or the environment than exists under the current site conditions.

8.1.2 Implementability

The No Action alternative would be readily implementable and administratively feasible. No permits would be required to implement this alternative. No services or materials would be needed to implement this alternative.

8.1.3 Cost

No foreseen costs are associated with the No Action alternative.

8.2 ALTERNATIVE 2: CHECK DAM INSTALLATION AND INSTITUTIONAL CONTROLS

Under Alternative 2, direct contact with and mobility of mercury-contaminated sediment would be reduced through engineering and institutional controls. Engineering controls are used primarily to reduce the mobility of, and exposure to, contaminants. These goals are achieved by creating a barrier that prevents direct exposure to and transport of waste from the contaminated source to the surrounding media. Engineering controls under Alternative 2 (check dams) would reduce human and ecological risk associated with mercury downstream of the site by decreasing the mobility and transport of mercury-contaminated sediment in surface water discharged from Pond Mine. Private property ownership and hydraulic characteristics (surface water drainage is routed into drain tunnel inlets in topographic low areas) limit the feasibility of surface water control in the northwest mine pit. Under Alternative 2, check dams would be constructed downstream of the tunnel outlet to capture mercury-bearing sediment in water discharged from the tunnel.

Institutional controls can be used to protect human health and the environment by precluding future access to, or development of, affected areas. In addition, these restrictions may be used to protect an implemented remedy. Institutional controls do not change the volume and toxicity of mercury in the environment. Institutional controls under Alternative 2 would include posting warning signs around the site to alert visitors that the area may be hazardous and to identify the potential hazards present to deter trespass and misuse. A bat gate would be installed inside the sluice tunnel outlet to prevent unauthorized entrance, thereby limiting exposure to and release of mercury. (Results of water sampling at the Pond Mine documented that agitation of sluice tunnel sediment releases mercury from the tunnel.) The gate would be designed to allow passage of small animals, birds, and bats for shelter and nesting.

Engineering and institutional controls in Alternative 2 could be implemented as a stand-alone remedy or in combination with other alternatives. Implementation of this alternative would involve the activities described below. The item number assigned to each activity corresponds to the cost summary presented in Table 14. Assumptions used to develop Alternative 2 are presented in Appendix B. Figure 2 shows locations for the site features described in the list of activities.

1. Procure necessary insurance and bonding.
2. Mobilize and demobilize necessary equipment to and from the site one time.
3. Prepare and secure a staging area for equipment storage and use during construction.
4. Realign, grade, and gravel an access road to the sluice tunnel outlet.
5. Construct an access ramp to the plunge pool.
6. Construct a water collection system to divert sluice tunnel discharge around the working areas. The diversion system is necessary to maintain a dry construction area and minimize mobilization and release of particulate-bound mercury in surface water during the disturbance.
7. Construct three check dams below the plunge pool.
8. Rehabilitate the staging area after construction is complete. Install and maintain a lockable truck gate at the top of the sluice tunnel outlet access road.
9. Install a bat gate within the sluice tunnel to prevent unauthorized access but permit bats to pass through. The gate would be welded to rebar driven or sealed into the bedrock inside the tunnel.
10. Install 20 signs near probable entry points and near known site hazards to warn visitors of the potential for both marked and unmarked hazards in the vicinity. Post a sign at the tunnel outlet to warn visitors of physical and chemical hazards at the tunnel.

11. Provide site security during non-working hours for the duration of the construction project.
12. Remove sediment behind each check dam every 5 years. Treat the excavated sediment using an aggregate processing plant to physically separate mercury and other heavy minerals from the sediment (see summary of processing plant treatability study in Appendix C). Dispose of washed sediment on site and provide mercury and other heavy minerals to BLM for disposal.
13. Perform annual site visits to monitor the integrity of removal action measures.

8.2.1 Effectiveness

The implementation of this alternative would reduce the mobility of mercury and subsequent human and ecological exposure to surface water, reduce mercury loading to the Middle Fork of the American River, and reduce direct contact with contaminated sediment. The volume of mercury in the environment would remain unchanged, but mercury in sediment retained behind the check dams would be removed from the site during periodic sediment excavation. The toxicity of mercury in the environment would remain unchanged. Entrainment of contaminated sediment, dissolution and migration of mercury, and mercury methylation would be reduced. The threat to human and ecological receptors associated with on-site ingestion of contaminated sediment and surface water, dermal contact with contaminated sediment and surface water, and inhalation of mercury vapors would remain, however. Installation of a bat gate on the tunnel outlet would provide protection for human and ecological receptors by restricting access to contaminated sediment and physical hazards within the tunnel, and by reducing agitation and release of mercury in sluice tunnel sediment.

The sluice tunnel system at the Pond Mine is believed to include 2,000 to 3,000 feet of underground workings upstream from the collapse 1,600 feet in from the tunnel outlet; the ability to access the tunnel and the condition of sediment upstream from the collapse are not known. Sluice tunnel sediment upstream from the collapse might represent a source for mercury that could be released through surface water or to which human and ecological receptors could be exposed. The collapse debris currently acts as a sediment retention dam to limit the downstream transport of potentially contaminated sediment and a physical barrier to prevent humans and wildlife from accessing upstream sediment. Under Alternative 2, the collapse debris dam would be left in place to limit the mobility of and potential exposure to upstream sediment.

Engineering and institutional controls are considered feasible alternatives for capturing mobile sediment that contains mercury. The permanence of the check dams and institutional controls in Alternative 2 for reducing migration of mercury through surface water and the risk to human and ecological receptors depends on maintenance. Periodic inspections would be necessary to monitor retention of sediment behind check dams and the condition of any warning signs posted. Alternative 2 would provide a low degree of reduction in the mercury load and protection of human health and the environment.

Construction of engineering and institutional controls in Alternative 2 would reduce contaminant loads. They would not, however, meet federal and state contaminant-specific ARARs for degradation of water quality caused by continued, though reduced, dissolution of mercury from sediment into surface water with subsequent methylation, and mobilization of contaminated sediment in surface water. Surface water discharge from the site would continue to degrade downstream water quality, would likely exceed the MCL and AWQC for mercury, and could continue to affect the food chain.

Location-specific ARARs are expected to be met without any conflicts. Design and placement of the bat gate would allow wildlife to use the tunnel. Contacts with appropriate agencies regarding historical and cultural resources would be required. A biological and botanical resource inventory report prepared by BLM concluded that the project would not have an impact on sensitive species (BLM 2004).

The contaminated sediments addressed by this alternative were derived from the beneficiation and extraction of ores and are assumed to be exempt from federal and California regulations as a hazardous waste. Standards for drainage, diversion structures, waterways, erosion control, and closure of surface openings contained in SMARA would be met. Storm water generated during construction, though not anticipated, would be managed in accordance with the CWA. Northern Sierra AQMD nuisance dust suppression and control requirements apply for construction and earth moving associated with this alternative for control of fugitive dust emissions; these requirements would be met by applying water to roads that receive heavy vehicular traffic and to construction or excavation areas, if necessary. Occupational Safety and Health Administration (OSHA) requirements would be met by requiring appropriate safety training for all on-site workers during the construction phase.

The construction phase for Alternative 2 would be accomplished within one field season; therefore, impacts associated with construction would likely be short term and minimal. On-site workers would be adequately protected by using appropriate personal protective equipment and by following safe work practices. Short-term impacts to air quality in the surrounding environment may also occur during grading and excavation. Fugitive dust emissions would be controlled by applying water to surfaces that receive heavy vehicular traffic or in excavation areas, as needed. Short-term risks of physical injury during construction would also exist, as well as community risk off site from increased truck traffic required to transport construction material to the site.

8.2.2 Implementability

Alternative 2 is both technically and administratively feasible and could be implemented within one field season. Excavation, grading, posting of warning signs, and constructing dams and bat gates require conventional construction practices; materials are readily available. Design methods, construction practices, and engineering requirements for installation of dams,

roadways, and bat gates are well documented and understood. Equipment, materials, and labor would be available through the local market.

Excavation and grading would require the use of heavy equipment, including scrapers, loaders, dozers, and haul trucks. Controlling fugitive dust emissions and storm water discharge (if generated) during excavation and grading would be required. Alternative 2 could be supplemented in the future with additional alternatives to control or remove contaminated sediments.

Long-term monitoring and maintenance would be required, including cleanout of sediment detention basins behind the check dams and replacement of warning signs. Sediment removed from detention basins would be placed in the two ponds northwest of the tunnel outlet near the access road. The sediment would be sampled and treated as needed using on- or off-site physical separation. Heavy metals concentrates, if generated, would then be stabilized and disposed of on site, and the remaining washed sediment would be spread on site.

8.2.3 Costs

The total present worth cost for Alternative 2 — check dam installation and institutional controls — is estimated to be $402,543. Table 14 presents a summary of the costs associated with implementing Alternative 2. The total present worth cost includes the present value of 30 years of annual maintenance and monitoring, in addition to the capital costs. Changes in the cost elements are likely as a result of new information and data collected during the removal action design.

8.3 ALTERNATIVE 3: IN SITU SEDIMENT COVERING, CHECK DAM INSTALLATION, AND INSTITUTIONAL CONTROLS

Under Alternative 3, direct contact with and mobility of mercury-contaminated sediment would be reduced through engineering and institutional controls. Engineering controls are used primarily to reduce the mobility of, and exposure to, contaminants. These goals are achieved by creating a barrier that prevents direct exposure to and transport of waste from the contaminated source to the surrounding media. Engineering controls under Alternative 3 (in situ sediment covering and check dams) would reduce human and ecological risk associated with mercury on and downstream of the site by isolating the contaminated sediment and decreasing its mobility and transport in surface water discharged from the Pond Mine. Sediment within the sluice tunnel and plunge pool would be covered in place with concrete to hold the sediment and minimize contact with surface water. The concrete surface on the plunge pool would then be covered with coarse rock to dissipate surface water energy and protect the integrity of the concrete. In addition to the sediment covering, check dams would be constructed within the sluice tunnel and downstream of the tunnel outlet to capture mercury-bearing sediment in water discharged from the tunnel.

The working area within the sluice tunnel and plunge pool would be kept as dry as possible to ease construction and minimize off-site transport of disturbed sediment. Surface water flowing through the sluice tunnel would be captured upstream from the work area and diverted around the construction. Water that does not bypass the construction area would be collected in a downstream sump and treated or used as an on-site source of water as needed.

Institutional controls can be used to protect human health and the environment by precluding future access to, or development of, affected areas. In addition, these restrictions may be used to protect an implemented remedy. Institutional controls do not change the volume and toxicity of mercury in the environment, however. Institutional controls under Alternative 3 would include warning signs and a bat gate. Warning signs would be posted around the site to alert visitors that the area may be hazardous and to identify the potential hazards present to deter trespass and misuse. A bat gate would be installed inside the sluice tunnel outlet to prevent unauthorized entrance, thereby protecting the integrity of the sediment cover and limiting exposure to and release of mercury. (Results of water sampling at the Pond Mine documented that agitation of sluice tunnel sediment releases mercury from the tunnel.) The gate would be designed to allow passage of small animals, birds, and bats for shelter and nesting.

Sediment cover, check dams, and institutional controls in Alternative 3 could be implemented as a stand-alone remedy or in combination with certain other alternatives. Covering the sluice tunnel and plunge pool sediments would complicate sediment removal in the future.

Implementation of this alternative would involve the activities described below. The item number assigned to each activity corresponds to the cost summary presented in Table 15. Assumptions used to develop Alternative 2 are presented in Appendix B. Figure 2 shows locations for the site features described in the list of activities.

1. Procure necessary insurance and bonding.
2. Mobilize and demobilize necessary equipment to and from the site two times (two construction seasons).
3. Prepare and secure a staging area for equipment storage and use during construction.
4. Realign, grade, and gravel an access road to the sluice tunnel outlet.
5. Prepare a staging area at the sluice tunnel outlet.
6. Construct an access ramp to the plunge pool.
7. Reinforce unstable sections of the sluice tunnel wall and ceiling for safe access and underground work.
8. Construct a water collection system to divert water flowing through the sluice tunnel around the working areas. The diversion system is necessary to maintain a dry

construction area and minimize the mobilization and release of particulate-bound mercury in surface water during the disturbance.

9. Smooth the tunnel floor and plunge pool sediments in preparation for the concrete cover. Rocks larger than 8 inches in diameter would be removed.
10. Cover the floor and lower sidewalls of the sluice tunnel and plunge pool floor with fiber-reinforced concrete. Place coarse rock on the covered plunge pool floor to dissipate surface water energy and protect the integrity of the concrete.
11. Winterize the site one time to minimize erosion between the two construction seasons.
12. Rehabilitate the staging area after construction is complete. Install and maintain a lockable truck gate at the top of the access road to the sluice tunnel outlet.
13. Install a bat gate within the sluice tunnel to prevent unauthorized access but permit bats to pass through. The gate would be welded to rebar driven or sealed into the bedrock inside the tunnel.
14. Construct three check dams. Two would be constructed 1,600 feet upstream of the sluice tunnel outlet (near the collapse) and one would be constructed below the plunge pool.
15. Install 20 signs near probable entry points and near known site hazards to warn site visitors of the potential for both marked and unmarked hazards in the vicinity. Post a sign at the tunnel outlet to warn visitors of physical and chemical hazards at the tunnel.
16. Provide site security during non-working hours for the duration of the construction project.
17. Remove sediment behind the plunge pool check dam every 10 years. Sediment behind the two check dams inside the sluice tunnel would not be removed. Treat the excavated sediment from the check dam at the plunge pool using an aggregate processing plant to physically separate mercury and other heavy minerals from the sediment. (See summary of processing plant treatability study in Appendix C.) Dispose of washed sediment on site and provide mercury and other heavy minerals to BLM for disposal.
18. Perform annual site visits to monitor the integrity of removal action measures.

8.3.1 Effectiveness

Implementation of this alternative would reduce the mobility of mercury and subsequent human and ecological exposure to surface water, reduce mercury loading to the Middle Fork of the American River, and reduce direct contact with contaminated sediment. The volume of mercury in the environment would remain unchanged, but mercury in sediment retained behind the check dams would be removed from the site during periodic sediment excavation. The toxicity of

mercury in the environment would remain unchanged. The concrete cover over sediment in the sluice tunnel and plunge pool would minimize human and ecological exposure to mercury-contaminated sediment. The concrete cover would also reduce surface water transport of contaminated sediment, dissolution of mercury, and mercury methylation. However, the uneven sediment surface and the potential for sediment to settle under the weight of the concrete might cause cracks to develop in the concrete cover. These cracks might allow surface water to seep below the concrete cover and contact the mercury-bearing sediment below. Water potentially flowing through the covered sediment may transport sediment and dissolved mercury, though the potential for mercury transport is less than if the sediments remained exposed. The collapse debris 1,600 feet from the tunnel inlet and the new check dams would further reduce migration of mercury-bearing sediments within the sluice tunnel (including potentially contaminated sediments that might remain upstream from the collapse) and from the site. Installation of a bat gate on the tunnel outlet would provide protection for human and ecological receptors by restricting access to contaminated sediment (upstream from the covered area) and physical hazards within the tunnel and by reducing agitation and release of mercury in sluice tunnel sediment. The collapse debris would continue to function as a physical barrier to prevent humans and wildlife from accessing sediment upstream from the area covered with concrete.

Sediment covering, check dam installation, and institutional controls are considered feasible technologies for reducing the exposure to and release of mercury in sediment from the sluice tunnel and plunge pool and surface water discharged from the tunnel. The permanence and effectiveness of these physical measures at reducing migration of mercury to surface water and the risk to human and ecological receptors depend on maintenance. Periodic inspections would be necessary to monitor the integrity of the concrete cover surfaces, sediment retention behind check dams, and the condition of posted warning signs. The sediment cover in Alternative 3 would reduce the required frequency of sediment removal from behind the check dams compared with the frequency required under Alternative 2. Alternative 3 would provide a moderate degree of reduction in mercury load and protection of human health and the environment.

In situ covering of sediments and construction of check dams would reduce contaminant loading to the Middle Fork of the American River but may not meet federal and state contaminant-specific ARARs for degradation of water quality during storm water runoff. Sluice tunnel sediment would still remain exposed upstream of the collapse (1,600 feet from the sluice tunnel outlet). Potential surface water contact with covered sediment caused by cracks that may develop in the concrete surface may dissolve mercury or mobilize particulate-bound mercury into surface water. Mercury released into surface water could become methylated. Therefore, surface water discharge from the site could degrade water quality at concentrations likely exceeding the MCL and AWQC for mercury and could continue to affect the food chain.

Location-specific ARARs are expected to be met without any conflicts. Design and placement of the bat gate would allow wildlife to use the tunnel. Contacts with appropriate agencies regarding historical and cultural resources would be required. A biological and botanical

resource inventory report prepared by BLM concluded that the project would not have an impact on sensitive species (BLM 2004).

The contaminated sediments addressed by this alternative were derived from the beneficiation and extraction of ores and are assumed to be exempt from federal and California regulations as a hazardous waste. Construction of surface controls would meet the standards for diversion of flow from disturbed areas and the revegetation requirements contained in SMCRA and SMARA. Storm water generated during construction, though not anticipated, would be managed in accordance with the CWA. In situ covering of sediments would require temporary containment of surface water to limit discharge of water that exceeds a pH of 10 (cement, an ingredient in concrete, has caustic properties) while the concrete is setting and curing. Northern Sierra AQMD requirements for nuisance dust suppression and control apply for construction and earth moving associated with this alternative to control fugitive dust emissions; these requirements would be met by applying water to roads that receive heavy vehicular traffic and to construction or excavation areas, if necessary. OSHA requirements would be met by requiring appropriate safety training for all on-site workers during the construction phase. Appropriate levels of dermal and respiratory protection would be evaluated and implemented as necessary when concrete is mixed and poured. Work within the tunnel and ground sluices would require monitoring the atmosphere for oxygen, carbon dioxide, methane, and mercury vapor and may require ventilation.

The construction phase for Alternative 3 might be accomplished in one season, but could be split into two seasons to accommodate funding availability and seasonal weather conditions. If construction was implemented in two seasons, precautions would be taken to winterize the site and minimize erosion and other impacts between construction seasons. Winterization would include installation of temporary check dams within the sluice tunnel to reduce sediment migration into cleaned areas, temporary bypass of storm water flow over partially covered areas, and installation of a permanent gate at the top of the access road to the sluice tunnel to deter off-highway vehicle traffic. Exposure of on-site workers to contaminated material would be a potential short-term risk while they work with sluice tunnel and plunge pool sediment. On-site workers would be adequately protected by using appropriate atmospheric monitoring and personal protective equipment and by following safe work practices. Short-term impacts to air quality in the surrounding environment may also occur as a result of cement mixing, grading, and excavating. Fugitive dust emissions would be controlled by applying water to hoppers and surfaces that receive heavy vehicular traffic or in excavation areas, as needed. Short-term risks of physical injury during construction would also exist, as well as off site from the increased truck traffic required to transport construction material to the site.

8.3.2 Implementability

Alternative 3 is both technically and administratively feasible and could be implemented within one field season. However, work may be split into two seasons because of the availability of funding and a desire to avoid work during the wet season. Tetra Tech anticipates that

Alternative 3 would be implemented over two construction seasons and that proper winterization precautions would be taken between work periods. Concrete work, excavation, trenching, grading, and bat gate construction require conventional construction practices; materials are readily available. Design methods, construction practices, and engineering requirements for covering sediment in place and for construction of check dams and bat gates are well documented and understood. Work inside the sluice tunnel would require ventilation and lighting equipment and a project team trained and certified for underground work. Equipment, materials, and labor would be available through the local market.

Excavation and grading would require the use of heavy equipment, including scrapers, loaders, dozers, and haul trucks. In situ covering of sediments would require a large quantity of concrete. A small batch plant may be temporarily mobilized to the site to reduce truck traffic. Controlling fugitive dust emissions and storm water discharge (if generated) during concrete mixing and placement, excavation, and grading would be required. Water collected from the construction area within the tunnel is anticipated to contain suspended sediment and mercury and would therefore require treatment. In addition, future removal of contaminated sediment would be more costly after the concrete has been placed. Check dams installed at the collapse inside the sluice tunnel would impede access upstream for future inspection or removal.

Long-term monitoring and maintenance would be required, including cleanout of the sediment detention basins behind the plunge pool check dam; inspection of the integrity of concrete surfaces in the sluice tunnel and plunge pool, the bat gate, and warning signs; and revegetation of disturbed areas. Sediment removed from the detention basin behind the check dam at the plunge pool would be placed in the two ponds northwest of the tunnel outlet near the access road, and then characterized and treated as needed using on- or off-site physical separation. Washed sediment and heavy metals concentrates would then be stabilized (if necessary) and disposed of on site. If long-term monitoring indicates that the sediments in the sluice tunnel or plunge pool that have been covered with concrete are still releasing mercury from the site, removal of the sediment may be necessary.

8.3.3 Costs

The total present worth cost for Alternative 3 — in situ covering, check dam installation, and institutional controls — is estimated to be $1,127,609. Table 15 presents a summary of the costs associated with implementing Alternative 3. The total present worth cost includes the present value of 30 years of annual maintenance and monitoring, in addition to the capital costs. Changes in the cost elements are likely as a result of new information and data collected during the removal action design.

8.4 ALTERNATIVE 4: SEDIMENT EXCAVATION, ON-SITE PHYSICAL SEPARATION, ON-SITE DISPOSAL, COVERING, CHECK DAM INSTALLATION, AND INSTITUTIONAL CONTROLS

Under Alternative 4, direct contact with and mobility of mercury-contaminated sediment would be reduced through engineering and institutional controls. Engineering controls are used primarily to reduce the mobility of, and exposure to, contaminants. These goals are achieved by creating a barrier that prevents direct exposure to and transport of waste from the contaminated source to the surrounding media. Engineering controls under Alternative 4 (excavation of sluice tunnel and plunge pool sediment, pressure washing the tunnel and plunge pool floors, covering the tunnel and plunge pool floors with concrete, and installing check dam dams) would reduce human and ecological risk associated with mercury on and downstream of the site by removing elemental mercury and contaminated sediment from the sluice tunnel and plunge pool. After sediment has been removed, the sluice tunnel and plunge pool floors would be pressure washed to recover mercury potentially remaining in bedrock foliations (cracks and bedding planes). The floor and lower sidewalls of the sluice tunnel and plunge pool would be covered with concrete to encapsulate residual mercury that may remain after pressure washing. The concrete surface on the plunge pool would then be covered with coarse rock to dissipate surface water energy and protect the integrity of the concrete. In addition to the sediment covering, check dams would be constructed within the sluice tunnel and downstream of the tunnel outlet to capture mercury-bearing sediment in water discharged from the tunnel.

A portable aggregate plant mobilized to the Pond Mine would be used to separate particles of high specific gravity (including mercury, gold, and lead) from the excavated sediment. Off-site physical separation of mercury and other heavy minerals from the excavated sediment is not feasible because of the high transportation cost and low ratio of recoverable gold to mercury. Various techniques (grizzlies, vibrating screens, trommels, concentration tables, and sluices) are used to segregate oversize, coarse, medium, and fine materials at aggregate plants. Tetra Tech estimates that 1,031 yd^3 of sediment would be excavated from the Pond Mine sluice tunnel (from the outlet to the collapse at 1,600 feet) and the plunge pool. Results of the Pond Mine treatability study for sluice tunnel sediment (see Appendix C) indicate processing this volume of sediment would generate approximately 10 yd^3 of heavy mineral concentrates, 109 pounds of elemental mercury and amalgam, and 1.39 cubic feet of granular heavy minerals that are not amalgamated ("Number 2 Product"). Results of the treatability study indicate that washed sediment can be disposed of on site. Heavy mineral concentrates did not contain mercury at a concentration that would prohibit on-site disposal, but additional leaching analysis may be necessary to evaluate potential impacts to groundwater if the heavy mineral concentrates are placed where meteoric water can infiltrate. If concentrations of metals in leachate are problematic, the heavy mineral concentrates could be stabilized and buried on site. Mercury, amalgam, and Number 2 Product would be provided to BLM for disposal.

The working area within the sluice tunnel and plunge pool would be kept as dry as possible to ease construction and minimize off-site transport of disturbed sediment. Surface water flowing

through the sluice tunnel would be captured upstream from the work area and diverted around the construction. Water that does not bypass the construction area would collected in a downstream sump and treated or used as an on-site source of water as needed.

Institutional controls can be used to protect human health and the environment by precluding future access to, or development of, affected areas. In addition, these restrictions may be used to protect an implemented remedy. Institutional controls do not change the volume and toxicity of mercury in the environment, however. Institutional controls under Alternative 4 would include warning signs and a bat gate. Warning signs would be posted around the site to alert visitors that the area may be hazardous and to identify the potential hazards present to deter trespass and misuse. A bat gate would be installed inside the sluice tunnel outlet to prevent unauthorized entrance, thereby protecting the integrity of the concrete surface and minimizing physical hazards to site visitors. The gate would be designed to allow passage of small animals, birds, and bats for shelter and nesting.

Implementation of Alternative 4 would involve the activities described below. The item number assigned to each activity corresponds to the cost summary presented in Table 16. Assumptions used to develop Alternative 2 are presented in Appendix B. Figure 2 shows locations for the site features described in the list of activities.

1. Procure necessary insurance and bonding.
2. Mobilize and demobilize necessary equipment to and from the site three times (three construction seasons).
3. Prepare and secure a staging area for equipment storage and use during construction.
4. Realign, grade, and gravel an access road to the sluice tunnel outlet.
5. Prepare a staging area at the sluice tunnel outlet.
6. Construct an access ramp to the plunge pool.
7. Reinforce unstable sections of the sluice tunnel wall and ceiling for safe access and underground work.
8. Construct a water collection system to divert water flowing through the sluice tunnel around the working areas. The diversion system is necessary to maintain a dry construction area and to minimize mobilization and release of particulate-bound mercury in surface water during the disturbance.
9. Excavate an estimated 1,000 yd^3 of sediment from the sluice tunnel between the outlet and the collapse 1,600 feet into the tunnel. Remove remnants of the wooden sluice box from the sluice tunnel.
10. Excavate 31 yd^3 of sediment from the plunge pool.

11. Pressure-wash the floors of the sluice tunnel and plunge pool to remove residual mercury from foliations. Cover the floor and lower sidewalls of the sluice tunnel and plunge pool floor with fiber-reinforced concrete. Place coarse rock on the covered plunge pool floor to dissipate surface water energy and protect the integrity of the concrete.

12. Mobilize an aggregate processing plant to the site for physical separation of mercury and other heavy minerals from the excavated sediment (approximately 1,031 yd^3). Process the excavated sediment to segregate coarse materials and heavy mineral concentrates (passing 100 mesh) using physical separation techniques. Dispose of washed sediment on site. (Stabilization of heavy mineral concentrates might be necessary, depending on chemical characteristics.) Provide mercury and other heavy minerals to BLM for disposal.

13. Dispose of the remnants of the wooden sluice box at an off-site landfill.

14. Rehabilitate the staging area after construction is complete. Install and maintain a lockable truck gate at the top of the access road to the sluice tunnel outlet.

15. Winterize the site two times to minimize erosion between the three construction seasons.

16. Install a bat gate within the sluice tunnel to prevent unauthorized access but permit bats to pass through. The gate would be welded to rebar driven or sealed into the bedrock inside the tunnel.

17. Removed the caved material at the collapse 1,600 feet into the sluice tunnel and assess the need for and viability of additional removal activities.

18. Construct three check dams. Two would be constructed 1,600 feet upstream of the sluice tunnel outlet (near the collapse) and one would be constructed below the plunge pool. The decision to construct dams inside the tunnel near the collapse might change after assessment of tunnel conditions upstream from the collapse; dams might not be constructed if additional work past the collapse is undertaken.

19. Install 20 signs near probable entry points and near known site hazards to warn visitors of the potential for both marked and unmarked hazards in the vicinity. Post a sign at the tunnel outlet to warn visitors of physical and chemical hazards at the tunnel.

20. Provide site security during non-working hours for the duration of the construction project.

21. Remove sediment behind the plunge pool check dam every 15 years. Sediment behind the two check dams inside the sluice tunnel would not be removed. Treat the excavated sediment from the check dam at the plunge pool using an aggregate processing plant to physically separate mercury and other heavy minerals from the sediment. (See summary of the processing plant treatability study in Appendix C.)

Dispose of washed sediment on site and provide mercury and other heavy minerals to BLM for disposal.

22. Perform annual site visits to monitor the integrity of the removal action measures.

8.4.1 Effectiveness

Implementation of this alternative would reduce the mobility of mercury, exposure of human and ecological receptors to mercury in surface water and sediment, and mercury loading to the Middle Fork of the American River. The volume of mercury in the environment would remain unchanged, but mercury would be separated from the excavated sediment and transported off site for recycling or disposal. The toxicity of mercury would remain unchanged. The primary source for mercury in surface water (contaminated sediment in the sluice tunnel and plunge pool) within the currently accessible portion of the tunnel would be eliminated. The concrete cover in the sluice tunnel and plunge pool would sequester residual mercury that might remain in bedrock foliations. Results of the treatability study indicated that sediment and heavy mineral concentrates processed through a specific aggregate plant and rotary concentrating table are suitable for on-site disposal (see Appendix C). More than 99 percent of the processed sediment could be placed and graded on site. Check dams inside the tunnel at the collapse area and downstream from the plunge pool would further reduce migration of potentially mercury-bearing sediments within the sluice tunnel and from the site. Installation of a bat gate on the tunnel outlet would provide protection for human and ecological receptors by restricting access to contaminated sediment (upstream from the excavated and covered area) and physical hazards within the tunnel and by reducing agitation and release of mercury in sluice tunnel sediment.

The sluice tunnel system at the Pond Mine is believed to include 2,000 to 3,000 feet of underground workings upstream from the collapse; the ability to access the tunnel and the condition of sediment upstream from the collapse are not known. Sluice tunnel sediment upstream from the collapse might represent a source for mercury that could be released through surface water or to which human and ecological receptors could be exposed. The collapse debris currently acts as a sediment retention dam to limit the downstream transport of potentially contaminated sediment and as a physical barrier to prevent humans and wildlife from accessing upstream sediment. Under Alternative 4, the collapse debris dam would be removed to assess the currently unknown conditions upstream from the collapse, including tunnel stability and potential sediment contamination. Resolution of these uncertainties would allow evaluation of measures to address upstream conditions, if necessary. However, removal of the collapse debris for upstream reconnaissance would forfeit its sediment retention and access restriction capacity. Alternative 4 includes construction of two check dams at the collapse dam area to retain sediment and installation of a bat gate at the tunnel outlet to limit tunnel access. These measures could be changed based on upstream reconnaissance past the collapse. For example, check dams might not be constructed inside the tunnel if sediment upstream from the collapse is not contaminated or if upstream sediment excavation is necessary and feasible.

The engineering and institutional controls included in Alternative 4 are considered feasible technologies for reducing exposure to and release of mercury in sediment from the sluice tunnel and plunge pool and surface water discharged from the tunnel. Excavation of contaminated sediments and physical separation of mercury and mercury-containing fines is considered a feasible technology for removing mercury from the environment. A treatability study conducted for sluice tunnel sediment at Pond Mine demonstrated that heavy minerals could be separated from a bulk sediment sample. Separation yielded washed sediment and heavy mineral concentrates that appear chemically suitable for on-site disposal (see Appendix C). The heavy mineral concentrates, which represented approximately 1 percent of the volume of processed sediment, could be stabilized and buried on site if leach test analysis demonstrates an unacceptable threat to water quality. The permanence and effectiveness of these physical measures at reducing migration of mercury to surface water and the risk to human and ecological receptors depend on maintenance. Periodic inspections would be necessary to monitor the integrity of the concrete covers, sediment retention behind check dams, and the condition of warning signs posted. Sediment removal and floor covering in Alternative 4 would reduce the required frequency of sediment removal from behind the check dams compared with the frequency required under Alternatives 2 and 3. Alternative 4 would provide a high degree of reduction in mercury load and protection of human health and the environment.

Permanence would be achieved by covering the floors of the sluice tunnel and plunge pool with concrete to ensure that any residual mercury is immobilized, by properly disposing of mercury separated from the excavated sediment, and by stabilizing heavy mineral concentrates (if necessary). Alternative 4 would provide a moderate to high degree of reduction in the mercury load and protection of human health and the environment, although additional contaminated sediment may remain in the sluice tunnel system upstream from the collapse.

Alternative 4 would provide a large reduction in contaminant loading (an estimated 109 pounds of uncontrolled mercury would be collected) from Pond Mine to the Pond Creek and ultimately to the Middle Fork of the American River. Discharge from Pond Mine is expected to meet federal and state contaminant-specific ARARs for degradation of water quality during both low and storm flows. Sediment upstream of the collapse might contain mercury, but the check dams constructed at the upstream end of the work area would retain upstream sediment that is mobilized by flowing water.

Location-specific ARARs are expected to be met without any conflicts. Design and placement of the bat gate would allow wildlife to use the tunnel. Contacts with appropriate agencies regarding historical and cultural resources would be required. A biological and botanical resource inventory report prepared by BLM concluded that the project would not have an impact on sensitive species (BLM 2004).

The contaminated sediments addressed by this alternative were derived from the beneficiation and extraction of ores and are assumed to be exempt from federal and California regulations as a hazardous waste. Construction of surface controls would meet the standards for diversion of

flow from disturbed areas and revegetation requirements contained in SMCRA and SMARA. In addition, standards for backfilling, grading, drainage, diversion structures, waterways, and erosion control contained in SMARA would also be met. Storm water generated during construction, though not anticipated, would be managed in accordance with the CWA. Process water generated during on-site physical separation would be reused or evaporated rather than discharged to surface water; the treatability study indicated that concentrations of mercury, lead, and suspended solids in process water exceed surface water quality criteria. The associated residue would then be tested and stabilized if necessary. Covering bedrock surfaces and foliations within the plunge pool floor would require temporary diversion of surface water around the pool to limit discharge of water that exceeds a pH of 10 (cement, an ingredient in concrete, has caustic properties) while the cement is setting and curing. Northern Sierra AQMD requirements for nuisance dust suppression and control apply for construction, physical separation, and earth moving associated with this alternative to control fugitive dust emissions; these requirements would be met by applying water to roads that receive heavy vehicular traffic, to bar screens, and to construction or excavation areas, if necessary. OSHA requirements would be met by requiring appropriate safety training for all on-site workers during the construction phase. Appropriate levels of dermal and respiratory protection would be evaluated and implemented as necessary during removal of sediments (mercury and mercury vapors), during sediment processing, and during mixing cement and covering bedrock surfaces and foliations. Work within the tunnel and ground sluices would require monitoring the atmosphere for oxygen, carbon dioxide, methane, and mercury vapor and may require ventilation.

The construction phase for Alternative 4 would be accomplished over three seasons. However, precautions would be taken to winterize the site and minimize erosion and other impacts between construction seasons. Winterization would include installation of temporary check dams within the sluice tunnel to reduce sediment migration into cleaned areas, temporary bypass of storm water flow over partially cleaned areas, and installation of a permanent gate at the top of the access road to the sluice tunnel to deter off-highway vehicle traffic. Short-term risks of exposure to contaminated material would be a potential for the site worker during excavation, physical separation, covering, and entry in the tunnel and sluice. On-site workers would be adequately protected by using appropriate atmospheric monitoring and personal protective equipment and by following safe work practices. Short-term impacts to air quality in the surrounding environment may also occur during excavation, suction dredging, physical separation, cement mixing, backfilling, and grading. Fugitive dust emissions would be controlled by applying water to hoppers and mixers, bar screens, surfaces that receive heavy vehicular traffic, and excavation and grading areas, as needed. Short-term risks of physical injury during construction would also exist, as well as off site from the increased truck traffic required to transport construction material to the site.

8.4.2 Implementability

Alternative 4 is both technically and administratively feasible. Tetra Tech anticipates that Alternative 4 would be implemented over three construction seasons. Concrete work,

excavation, trenching, grading, and bat gate construction require conventional construction practices; materials are readily available. Design methods, construction practices, and engineering requirements for covering sediment in place and construction of check dams and bat gates are well documented and understood. Work inside the sluice tunnel would require ventilation and lighting equipment and a project team trained and certified for underground work. Physical separation of heavy minerals and liquid mercury from excavated sediment and solidification of concentrates would require a specialized aggregate processing plant (see the description in Appendix C) and a contractor experienced with mercury recovery and management. Equipment, materials, and labor would be available through the local market.

Excavation, backfilling, and grading would require the use of heavy equipment, including scrapers, loaders, dozers, and haul trucks. A portable aggregate processing plant would be mobilized to the site to physically separate mercury and other heavy minerals from the excavated sediment. In situ covering of the floors in the sluice tunnel and plunge pool would require a large quantity of concrete. A small batch plant might be temporarily mobilized to the site to reduce truck traffic. Controlling fugitive dust emissions generated during excavation, cement mixing, and grading would be required. Water collected from the construction area within the tunnel is anticipated to contain suspended sediment and mercury and would therefore require treatment. Results of the treatability study also indicated that process water from the aggregate plant cannot be discharged directly to surface water. In addition, check dams installed at the collapse inside the sluice tunnel would impede access upstream for future inspection or removal.

Long-term monitoring and maintenance would be required, including cleanout of sediment detention basins behind the plunge pool check dam; inspection of the integrity of concrete surfaces in the sluice tunnel and plunge pool, the bat gate, and warning signs; and revegetation of disturbed areas. Sediment removed from the detention basin behind the check dam at the plunge pool would be placed in the two ponds northwest of the tunnel outlet near the access road, and then characterized and treated as needed using on- or off-site physical separation. Washed sediment and heavy metals concentrates would then be stabilized (if necessary) and disposed of on site. It is assumed that sediment removed from behind the tunnel check dams would require on-site separation that would be completed in conjunction with ongoing tunnel cleanout for the first 3 years. After separation equipment is demobilized from the site, the accumulated sediment would be stockpiled in the treatment ponds and physically separated on or off site every fifteenth year. Additional upstream tunnel cleanout could reduce the costs of sediment treatment.

8.4.3 Costs

The total present worth cost for Alternative 4 — excavation, physical separation, on-site disposal, covering, and institutional controls — is estimated to be $2,324,108. Table 16 presents a summary of the costs associated with implementing Alternative 4. The total present worth cost includes the present value of 30 years of annual maintenance and monitoring, in addition to the capital costs. Changes in the cost elements are likely as a result of new information and data collected during the removal action design.

9.0 COMPARATIVE ANALYSIS OF REMOVAL ACTION ALTERNATIVES

This section compares the removal action alternatives retained for detailed analysis at Pond Mine to address mercury-contaminated sediment in the sluice tunnel and plunge pool. The comparison focuses on the effectiveness, implementability, and cost of each alternative. The following sections present the comparative analysis, a summary of the findings from the analysis, and the recommended removal action alternative based on the analysis.

9.1 COMPARATIVE ANALYSIS

The final step of an EE/CA is to conduct a comparative analysis of the removal action alternatives. The analysis will discuss each alternative's relative strengths and weaknesses in terms of each of the comparison criteria. Once completed, the analysis will be used to select the recommended removal action alternatives. A public meeting to present the recommended removal action alternative will be conducted and oral and written comments will be addressed in writing. The preferred removal action alternative will be documented in an action memorandum.

The analysis compares the relative effectiveness, implementability, and cost of the removal action alternatives in controlling and reducing the release of sediment and mercury from Pond Mine. The effectiveness comparison includes consideration of the following criteria: (1) protectiveness of human health and the environment; (2) compliance with ARARs; (3) long-term effectiveness and permanence; (4) reduction of toxicity, mobility, and volume; (5) short-term effectiveness of each alternative; and (6) cost. The cost comparison will consider the estimated total present worth cost of each alternative.

Each criterion is presented and compared for each removal action alternative in Table 17. Acceptance by supporting agencies and the community are additional criteria that will be addressed in the action memorandum after the state agency and the public review the evaluation process and the recommended removal action alternative.

9.2 SUMMARY OF FINDINGS

Baseline conditions at Pond Mine as represented by Alternative 1, the no action alternative, allow the continued release of mercury and are not protective of human health and the environment. Alternative 2 would reduce but not eliminate the release of particulate-bound mercury in discharge from the sluice tunnel by settling the sediment behind check dams. The collapse debris 1,600 feet upstream from the tunnel outlet would be left in place to retain sediment and limit upstream access by humans and wildlife. Installation of a bat gate in the tunnel would reduce the potential for exposure of site visitors and large animals to contaminated sediment inside the sluice tunnel, but would not control the release of or exposure to water discharging from the tunnel. Therefore, Alternative 2 is considered to provide a low degree of protection to human health and the environment.

Alternative 3 would reduce dissolution of mercury and transport of particulate-bound mercury into discharge from the sluice tunnel by minimizing direct contact between flowing water and the contaminated sediment within the accessible length of the tunnel. The collapse debris 1,600 feet upstream from the tunnel outlet would be left in place to retain sediment and limit upstream access by humans and wildlife. Two check dams would be installed downstream from the collapse debris to further limit the transport of upstream sediment onto the covered area. Installation of a bat gate in the tunnel would reduce the potential for exposure of site visitors and large animals to contaminated sediment inside the sluice tunnel and protect the integrity of the concrete surface, but would not control the release of or exposure to water discharging from the tunnel. Therefore, Alternative 3 is considered to provide a moderate degree of protection to human health and the environment.

Alternative 4 would reduce dissolution of mercury and transport of particulate-bound mercury into discharge from the sluice tunnel by removing the contaminated sediment within the accessible length of the tunnel and minimizing direct contact between flowing water and residual mercury on the floors of the tunnel and plunge pool. The collapse debris 1,600 feet upstream from the tunnel outlet would be removed to allow reconnaissance in the currently inaccessible length of tunnel. Two check dams would be installed at the collapse site to limit the transport of upstream sediment onto the covered area, unless results of upstream reconnaissance determine another measure is more appropriate. Installation of a bat gate in the tunnel would reduce the potential for exposure of site visitors and large animals to contaminated sediment inside the sluice tunnel and protect the integrity of the concrete surface, but would not control the release of or exposure to water discharging from the tunnel. Alternative 4 is considered the most protective of human health and the environment because the source of contamination (mercury in the sluice tunnel and plunge pool sediment) would be removed from the site.

No ARARs apply to Alternative 1, No Action. Alternative 2 would only reduce the potential for off-site transport of particulate-bound sediment in sluice tunnel discharge; surface water discharged from the site may not meet chemical-specific ARARs, however. Alternatives 3 and 4 are expected to comply with chemical-specific ARARs by reducing the amount of sediment and particulate-bound mercury released from the site. Alternative 2, 3, and 4 would comply with location-specific ARARs. Issues such as private property boundaries and areas of archeological protection must be taken into account for Alternatives 2, 3, and 4. Alternatives 2, 3, and 4 would comply with action-specific ARARs through proper implementation.

Alternative 1, No Action, is not considered to have long-term effectiveness for addressing the release of and exposure to mercury at the Pond Mine. Alternatives 2 and 3 would reduce off-site transport of mercury in surface water indefinitely as long as the engineering controls are adequately maintained. The check dams would require periodic inspection and sediment removal. The concrete cover in Alternative 3 could crack over time and allow surface water to contact the underlying contaminated sediment. Alternative 4 would be most effective in the long term and is expected to require the least O&M of the three construction alternatives.

Alternative 1, No Action, is not considered to have short-term effectiveness. Alternative 2 is considered to have short-term effectiveness because it would be implemented in one field season. Alternatives 3 and 4 are anticipated to take more than one construction season, but winterization measures between the construction seasons (see Sections 8.3 and 8.4) would provide short-term effectiveness during the off seasons. Qualified contractors are capable of accomplishing the construction tasks described in Section 8.0, and equipment and materials are commercially available. Short-term effects of construction would be minimized by applying water to construction surfaces (dust suppression) and employing adequate storm water control measures. There would be increased heavy traffic in the local area; however, appropriate traffic control measures would be used to minimize these effects.

Alternative 1 is the least expensive because no cost is incurred. Costs are $402,543 for Alternative 2, $1,127,609 for Alternative 3, and $2,324,108 for Alternative 4. These construction costs are estimates that are expected to be within plus 50 percent to minus 30 percent of the actual project cost (based on year 2006 dollars). Changes in the cost elements are likely as a result of new information and data collected during engineering design and construction pre-bid and walk-through meetings.

9.3 RECOMMENDED REMOVAL ALTERNATIVE

The recommended removal action alternative to reduce the release of mercury and the threat to human health and the environment associated with sediment and surface water discharge from the Pond Mine sluice tunnel and plunge pool is Alternative 4. Alternative 4 involves:

- Excavating contaminated sediment from the sluice tunnel and plunge pool.
- Pressure washing the floors to remove mercury from bedrock foliations.
- Covering the cleaned floors with concrete to sequester mercury that might remain after pressure washing.
- Installing two check dams at the upstream end of the sluice tunnel work area to retain potentially mercury-bearing sediment that might be transported from upstream in the tunnel system and one check dam downstream from the plunge pool to retain sediment transported from the tunnel and plunge pool.
- Removing debris at the collapse 1,600 feet upstream from the sluice tunnel outlet and assessing the need for and viability of additional removal activities.
- Separating mercury and other heavy metals from the excavated sediment.
- Recycling or properly disposing of recovered mercury.
- Installing a bat gate inside the sluice tunnel outlet to prevent unauthorized entrance, thereby protecting the integrity of the concrete surface and minimizing physical hazards to site visitors.

- Installing warning signs to alert site visitors that the area may be hazardous and to identify the potential hazards present to deter trespass and misuse.

Based on results from the treatability study (see Appendix C), 99 percent of the excavated sediment (washed fines, sand, and gravel) could be spread on site after mercury separation was completed. Heavy mineral concentrates, which represented almost 1 percent of the excavated sediment, might also be acceptable for on-site disposal, but additional leach testing would be necessary. Heavy mineral concentrates could be solidified and buried on site if leach testing demonstrates an unacceptable threat to water quality. Water captured in the construction area for the sluice tunnel and process water from the aggregate plant is expected to contain dissolved and particulate-bound mercury at concentrations that prohibit direct discharge to surface water. The water would therefore be captured, recycled, and treated or evaporated.

Alternative 4 was determined to provide the highest degree of protection for human health and the environment. Alternative 4 would comply with ARARs, provide long-term effectiveness and permanence, and greatly reduce the volume and mobility of mercury at the Pond Mine. Alternative 4 would also provide a higher degree of permanence than Alternatives 2 or 3 because the contaminant source would have been removed and less O&M would be required to maintain the removal action measures. The removal action is anticipated to take place over three construction seasons. O&M would consist of cleaning out the sediment basin behind the check dam at the plunge pool and inspecting and replacing warning signs and the bat gate as necessary. Alternative 4 could be implemented at an estimated present worth cost of $2,324,108, of which $2,300,408 are capital costs and $23,700 are yearly operation and maintenance costs over the next 25 years.

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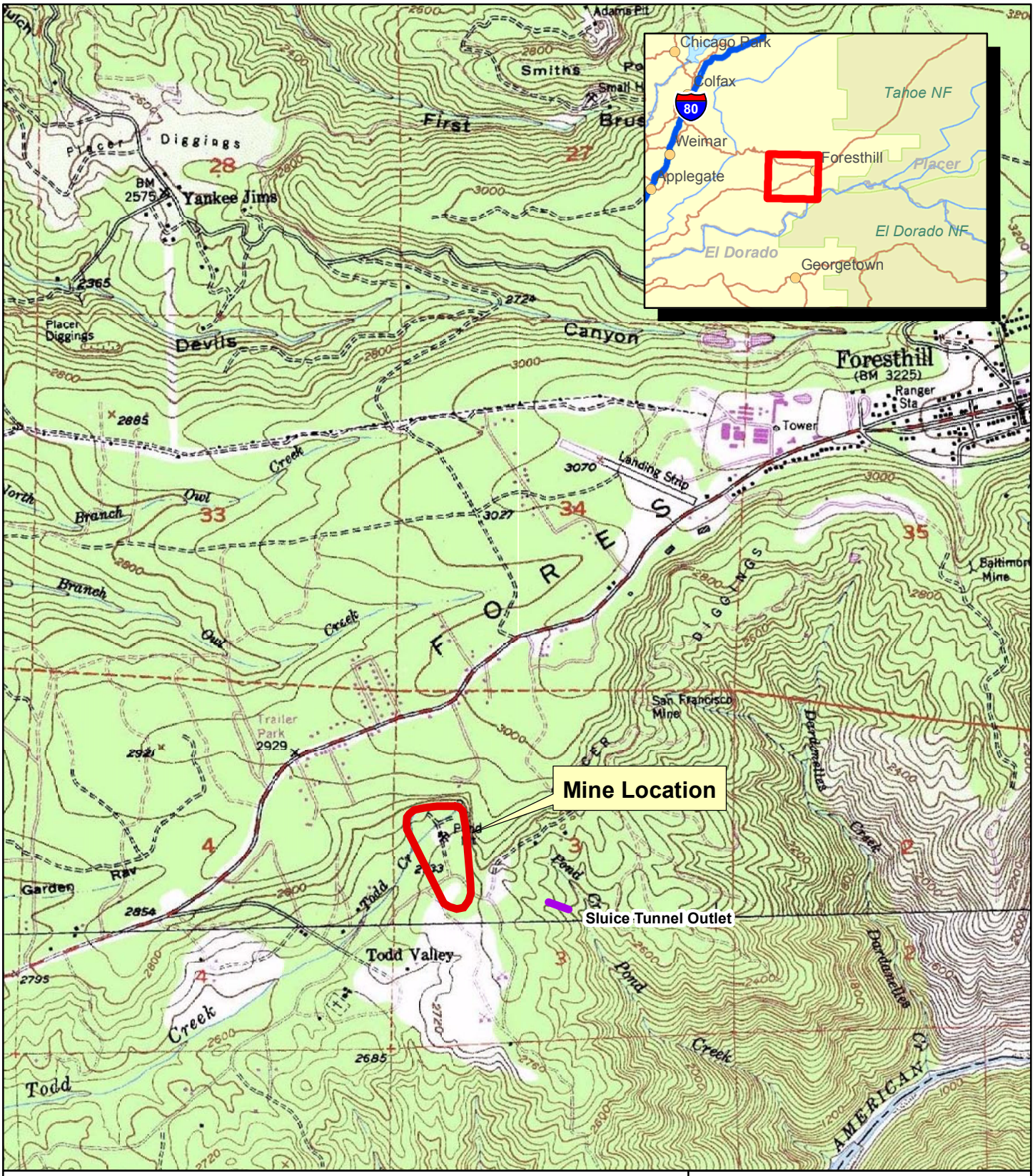
FIGURES



Mine Location

N

0 1,000 2,000

Feet

FIGURE 1

Site Location Map

Pond Mine
Placer County, California

TETRA TECH EM INC.

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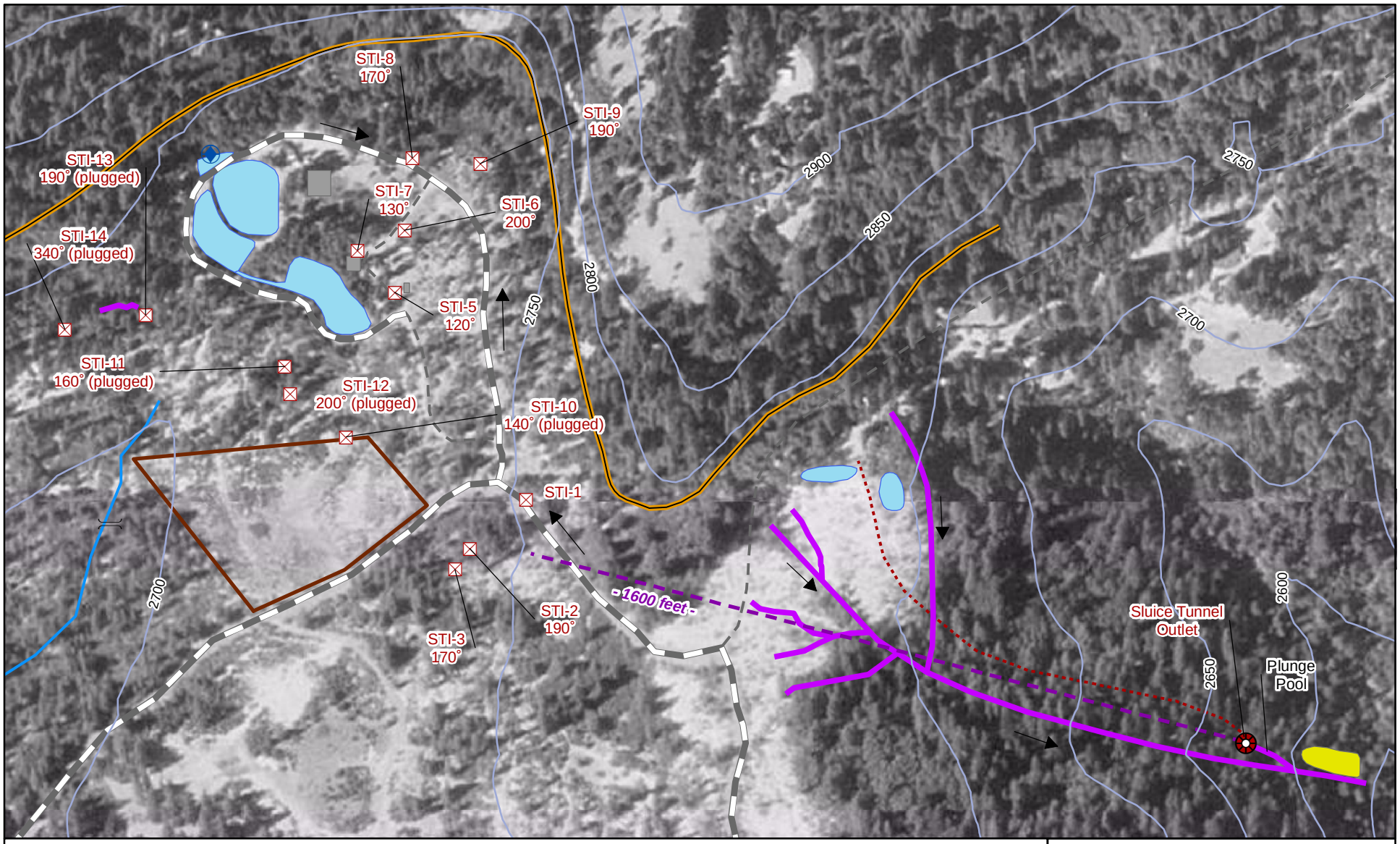

Sluice Tunnel Inlet
Bridge
Sluice Tunnel Outlet
Spring
Ground Elevation (50-foot interval)
Access Road
Creek
Dirt Road
Direction of Surface Water Flow
Highwall
Ground Sluice
Trail
Sluice Tunnel
Self Storage Business (Fenced)
Building
Pond
Waste Rock Pile

N

0 100 200 300
Feet

FIGURE 2

Site Features
Pond Mine
Placer County, California

TETRA TECH EM INC.

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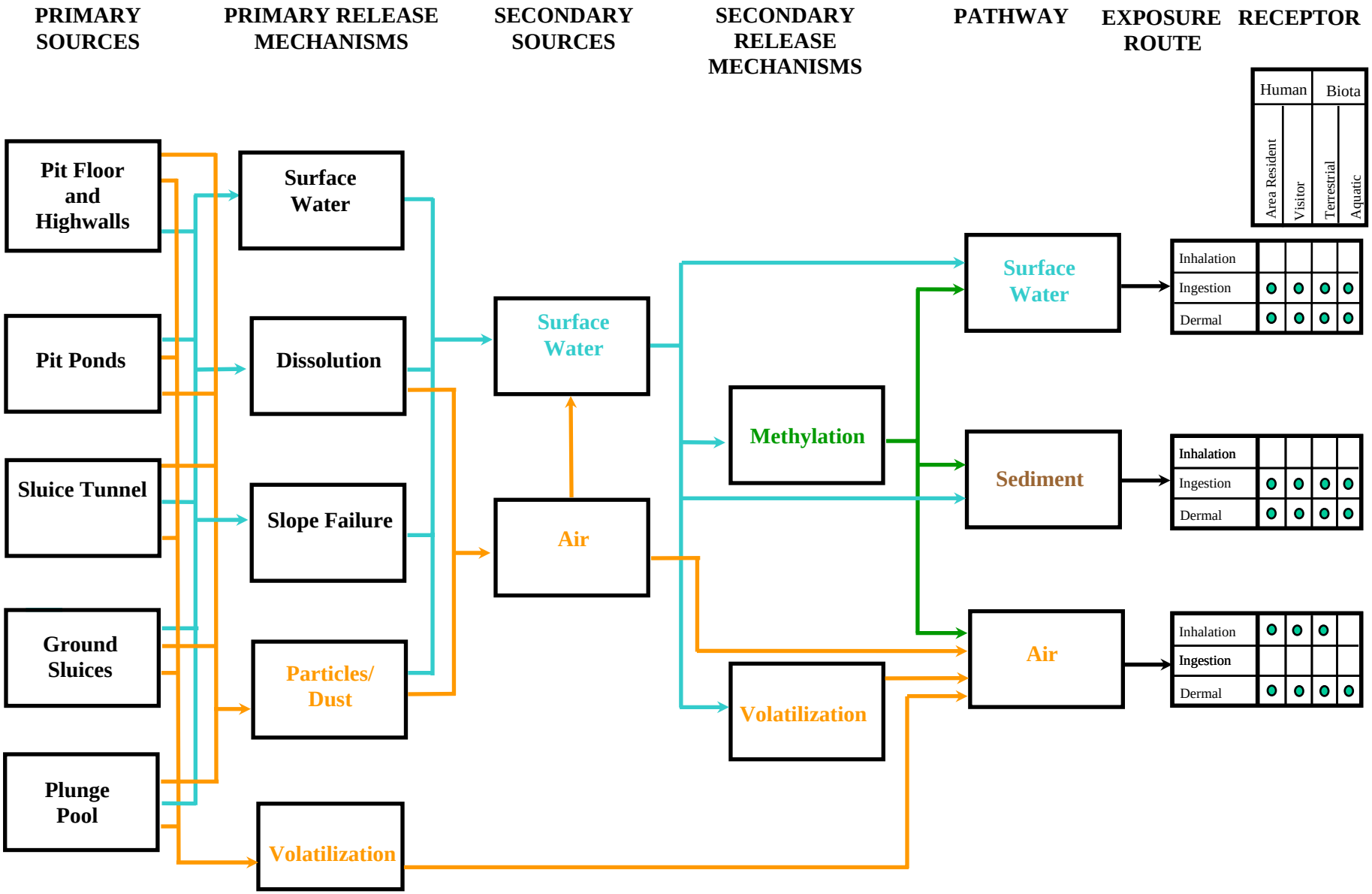


Sources and mechanisms occurring in surface water
Sources and mechanisms occurring in air
Mechanisms occurring by methylation

FIGURE 3

Conceptual Site Model

Pond Mine
Placer County, California

Tetra Tech EM Inc.

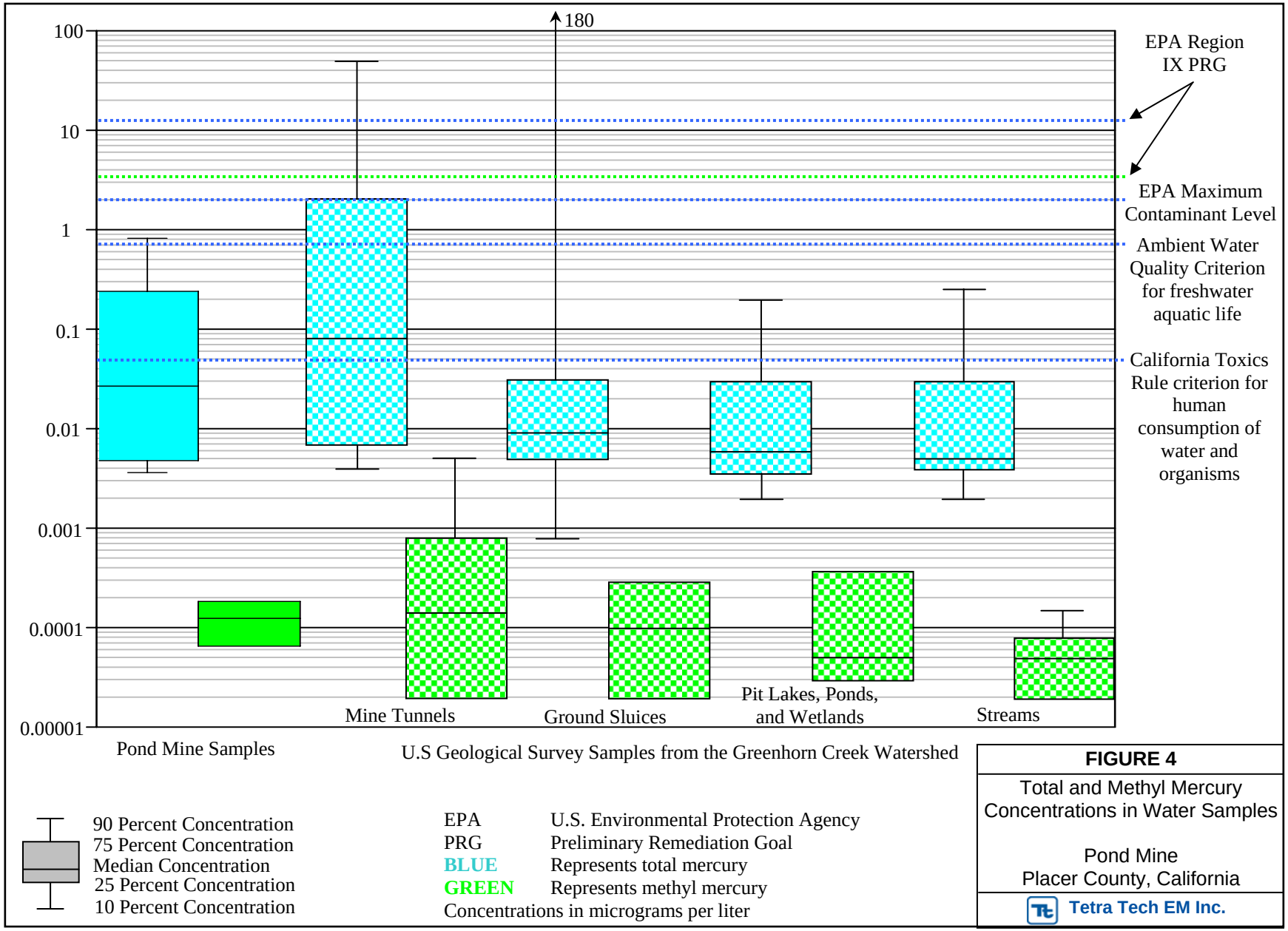
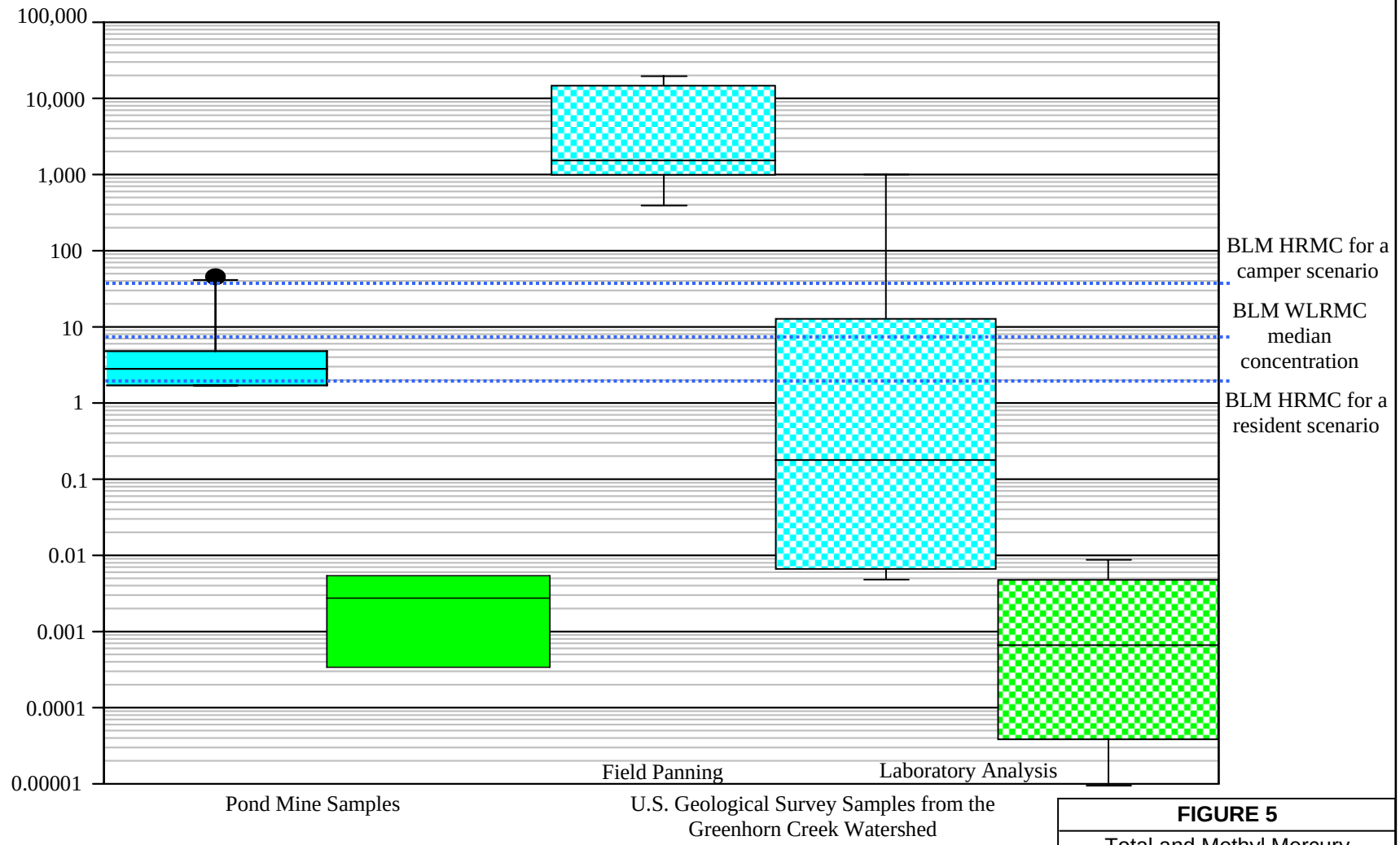


FIGURE 4

Total and Methyl Mercury Concentrations in Water Samples

Pond Mine
Placer County, California

Tetra Tech EM Inc.



Outlier
90 Percent Concentration
75 Percent Concentration
Median Concentration
25 Percent Concentration
10 Percent Concentration

BLM	Bureau of Land Management
HRMC	Human risk management criteria
WLRMC	Wildlife and livestock risk management criteria
BLUE	Represents total mercury
GREEN	Represents methyl mercury

Concentrations in milligrams per kilogram

FIGURE 5

Total and Methyl Mercury Concentrations in Sediment

Pond Mine
Placer County, California

Tetra Tech EM Inc.

TABLES

Table 1. Climate Data

Month	Auburn Weather Station[a]		
	Average Temperature		Average Precipitation
	High	Low	
January	53.9	36.3	6.40
February	58.4	39.2	6.03
March	62.0	41.2	5.20
April	68.0	44.7	2.79
May	76.2	50.1	1.21
June	85.2	56.5	0.37
July	92.5	61.9	0.05
August	91.4	60.9	0.08
September	86.2	57.3	0.46
October	76.5	50.8	1.83
November	62.8	42.6	4.16
December	54.7	37.0	5.86
Annual	72.3	48.2	34.45

Notes:

Source: Western Regional Climate Center 2006

[a] Auburn weather station is 13 miles west-southwest of the Pond Mine and 1,200 feet lower in elevation.

Table 2. Results for Mercury Analysis in Pond Mine Water and Solid Matrix Samples

Sample Location	Date	Sample Identification	Estimated Flow (gpm)	pH	Eh (mV)	SC (µS/cm)	Temperature (°C)	Total Mercury Concentration[a]	Methyl Mercury Concentration[a]
Water Samples									
Tunnel Outlet	12/11/2003	PM-WAT-1	60-80	6.30	121	140	10.6	0.0268	0.000148
	9/8/2004	PM-WAT-11	50-60	6.69	300	264	14.7	0.00361	0.00003
	9/8/2004	PM-WAT-13[b]	50-60	6.79	303	258	13.1	0.817	Not Analyzed
Inside Tunnel, Past Bulkhead	12/11/2003	PM-WAT-2	60-80	6.62	92	140	9.5	0.047	0.000218
	9/8/2004	PM-WAT-12	50-60	6.56	288	117	13.1	0.00514	0.0001
Sediment Samples									
Tunnel Outlet	12/11/2003	PM-SED-1	Not Analyzed					1.8	0.00566
	9/8/2004	PM-SED-11	Not Analyzed					1.7	0.000345
Inside Tunnel, Past Bulkhead	12/11/2003	PM-SED-2	Not Analyzed					45.1	0.00513
	9/8/2004	PM-SED-12	Not Analyzed					3.8	0.000335
Tunnel Wall, Past Bulkhead	12/11/2003	PM-SED-3	Not Analyzed					1.7	Not Analyzed
Plunge Pool Below Outlet	9/8/2004	PM-SED-13	Not Analyzed					4.8	Not Analyzed

Notes:

Sources: Tetra Tech 2003, 2004

°C Degree Celsius
Eh Oxidation-reduction potential
gpm Gallon per minute
mV Millivolt
SC Specific conductance
µS/cm MicroSiemen per centimeter
[a] Concentrations for water samples in micrograms per liter; concentrations for sediment samples in milligrams per kilogram
[b] Disturbed sample collected after sampling personnel agitated sluice tunnel sediment by walking into the tunnel

Table 3. Results of Mercury Analysis in Pond Mine Biota Samples Collected at the Sluice Tunnel Outlet on August 8, 2005

Sample Identification	Common Name	Order	Family	Arsenic (dry weight in ppm)	Mercury (dry weight in ppm)	Mercury (wet weight in ppm)	Percent Moisture
BY-PND1-8080805-006	Predaceous diving beetle	*Coleoptera*	*Dytiscidae*	0.199	0.117	0.052	55.8
BY-PND1-8080805-005	Water strider	*Hemiptera*	*Gerridae*	1.120	0.301	0.106	64.8
BY-PND1-8080805-001	Dobsonfly	*Megaloptera*	*Corydalidae*	2.730	0.511	0.107	79.1
BY-PND1-8080805-003	Dragonfly	*Odonata*	*Cordulegastridae*	1.310	0.652	0.106	83.7
BY-PND1-8080805-002	Dragonfly	*Odonata*	*Gomphidae*	1.990	1.09	0.256	76.5

Notes:

Source: Ecology and Environment 2005

ppm Parts per million; equivalent to milligrams per kilogram

Table 4. Estimated Dimensions and Sediment Volumes in the Pond Mine Sluice Tunnel and Plunge Pool

Cross Section Location	Tunnel Width (ft)	Tunnel Height (ft)	Average Sediment Depth (ft)	Sediment Cross Section (ft^2)
50 feet in from the portal	5	7	1	5
Bulkhead (121 feet in from the portal)	5	7	1.5	7.5
Station 1 (100 feet past the portal)	4.83	7	3	14.49
Station 2 (200 feet past the portal)	4.5	7	3.5	15.75
Station 3 (300 feet past the portal)	4.5	7	3.5	15.75
Station 4 (400 feet past the portal)	4.5	7	3.5	15.75
Station 5 (500 feet past the portal)	4.5	7	3.5	15.75
Station 6 (600 feet past the portal)	4.5	7	3.5	15.75
Station 7 (700 feet past the portal)	4.5	7	3.5	15.75
Station 8 (800 feet past the portal)	4.5	7	3.5	15.75
Station 9 (900 feet past the portal)	4.5	7	3.5	15.75
Station 10 (1,000 feet past the portal)	4.5	7	3.5	15.75
Station 11 (1,100 feet past the portal)	4.5	7	3.5	15.75
Station 12 (1,200 feet past the portal)	4.5	7	3.5	15.75
Station 13 (1,300 feet past the portal)	4.5	7	3.5	15.75
Station 14 (1,400 feet past the portal)	4.5	7	3.5	15.75
Estimated volume of sediment in the sluice tunnel (to 1,600 feet)[a]				**1,000 yd^3**
Plunge Pool	4	20[b]	8	32
Estimated volume of sediment in the plunge pool[a]				**31 yd^3**

Notes:

[a] Volume is in loose cubic yards and assumes 30 percent expansion factor for excavation

[b] Length of the plunge pool within a slot canyon below the tunnel outlet

ft Foot

ft^2 Square foot

yd^3 Cubic yard

Table 5. Comparison of Total and Methyl Mercury Concentrations in Water Samples to Screening Criteria

Sample ID	Sample Description	Total Mercury Concentration (µg/L)	Methyl Mercury Concentration (µg/L)
Pond Mine Samples			
PM-WAT-1	Tunnel Outlet	0.0268	0.000148
PM-WAT-11		0.00361	0.00003
PM-WAT-13[b]		**0.817**	NR
PM-WAT-2	Inside the Tunnel, Past the Bulkhead	0.047	0.000218
PM-WAT-12		0.00514	0.0001
U.S. Geological Survey Data			
Mine tunnels in the Greenhorn Creek Watershed (16 total mercury samples; 14 methyl mercury samples)	90 percent concentration	50	0.005
	75 percent concentration	2	0.0008
	50 percent concentration	0.08	0.00013
	25 percent concentration	0.007	0.00002
	10 percent concentration	0.004	NR
Ground sluices in the Greenhorn Creek Watershed (7 samples)	90 percent concentration	180	NR
	75 percent concentration	0.03	0.0003
	50 percent concentration	0.009	0.0001
	25 percent concentration	0.005	0.00002
	10 percent concentration	0.0008	NR
Pit lakes, ponds, or wetlands in the Greenhorn Creek Watershed (6 total mercury samples; 5 methyl mercury samples)	90 percent concentration	0.2	NR
	75 percent concentration	0.03	0.00037
	50 percent concentration	0.006	0.00005
	25 percent concentration	0.0035	0.00003
	10 percent concentration	0.002	NR
Streams in the Greenhorn Creek Watershed (16 total mercury samples; 14 methyl mercury samples)	90 percent concentration	0.25	0.00014
	75 percent concentration	0.03	0.00008
	50 percent concentration	0.005	0.00005
	25 percent concentration	0.004	0.00002
	10 percent concentration	0.002	NR
Median concentration in Greenhorn Creek Watershed (44 total mercury samples; 40 methyl mercury samples)		0.0096	0.00007
Screening Levels			
BLM Human Risk Management Criteria, Camper Exposure Scenario[a]		93	NP
EPA Maximum Contaminant Level[b]		2	NP
EPA National Recommended Ambient Water Quality Criteria for Freshwater Aquatic Life Protection, Continuous Concentration (4-day average)[b]		**0.77[c]**	NP
California Toxics Rule Criteria for Inland Surface Waters, Human Health Criteria (30-day Average) for Drinking Water Sources[b]		**0.05**	NP
EPA Preliminary Remediation Goal for tap water[b]		11	3.6

Notes:

Sources: Tetra Tech EM Inc. 2004a, 2004b; U.S. Geological Survey unpublished data; Alpers and others 2005b

Bold font indicates analyte in real sample exceeds one or more criteria (criteria exceeded also noted in bold)

Gray shading indicates highest concentration of this constituent measured at the Pond Mine

[a] Source: Ford 1996

[b] Source: Smucker 2004

[c] Expressed as dissolved mercury

Table 5. Comparison of Total and Methyl Mercury Concentrations in Water Samples to Screening Criteria

µg/L	Microgram per liter
BLM	U.S. Department of the Interior, Bureau of Land Management
EPA	U.S. Environmental Protection Agency
ID	Identification
NP	Not promulgated
NR	Not reported

Table 6. Comparison of Total and Methyl Mercury Concentrations in Solid Matrix Samples to Screening Criteria

Sample ID	Location	Total Mercury Concentration (mg/kg)	Methyl Mercury Concentration (mg/kg)
Pond Mine Samples			
PM-SED-1	Tunnel Outlet	**1.8**	0.00566
PM-SED-11		**1.7**	0.000345
PM-SED-2	Inside Tunnel, Past Bulkhead	**45.1**	0.00513
PM-SED-12		**3.8**	0.000335
PM-SED-3	Tunnel Wall, Past Bulkhead	**1.7**	NA
PM-SED-13	Plunge Pool Below Outlet	**4.8**	NA
U.S. Geological Survey Data			
Sediment from the Greenhorn Creek Watershed by field panning method (14 samples)	90 percent concentration	20,000	NA
	75 percent concentration	15,000	NA
	50 percent concentration	1,500	NA
	25 percent concentration	1,000	NA
	10 percent concentration	400	NA
Sediment from the Greenhorn Creek Watershed by lab methods (10 total mercury samples; 9 methyl mercury samples)	90 percent concentration	10,000	0.009
	75 percent concentration	11	0.005
	50 percent concentration	0.18	0.0007
	25 percent concentration	0.007	0.00004
	10 percent concentration	0.005	0.00001
Screening Levels			
Average concentration in California background soils[a]		0.26	NR
Human Health Screening Benchmarks	EPA Preliminary Remediation Goal (Residential)[b]	23	NP
	EPA Preliminary Remediation Goal (Industrial)[b]	310	NP
	BLM Risk Management Criteria[c]	**Resident**	**2**	NP
		Camper	**40**	NP
		Human Worker	60	NP
		Surveyor	480	NP
		ATV Driver	550	NP
Ecological Screening Benchmarks	**BLM Risk Management Criteria[c]**	**Robin**	**1**	NP
		Cottontail Rabbit	**15**	NP
		Mule Deer	**9**	NP
		Mallard	**4**	NP
		Median Concentration (12 species)	**8**	NP

Notes:

Sources: Tetra Tech EM Inc. 2004a, 2004b; U.S. Geological Survey unpublished data; Alpers and others 2005b

Bold font indicates analyte in real sample exceeds one or more criteria (criteria exceeded also noted in bold)

Gray shading indicates highest concentration of this constituent measured at the Pond Mine

[a] Source: Bradford and others 1996

[b] Source: Smucker 2004

[c] Source: Ford 1996

ATV All terrain vehicle

BLM U.S. Department of the Interior, Bureau of Land Management

EPA U.S. Environmental Protection Agency

ID Identification

mg/kg Milligram per kilogram

NA Not analyzed

NP Not promulgated

NR Not reported

Table 7. Comparison of Total Mercury Concentrations in Pond Mine Invertebrate Samples to Regional Background Data

Common Name	Sample Location	Date	Moisture (Percent)	Total Mercury (mg/kg)
Predaceous Diving Beetle	**Sluice Tunnel Outlet**	**8/8/2005**	**55.8**	**0.117**
	Background Bear River[a]	9/15/2001	57.6	0.14
	Background Bear River[a]	9/15/2001	54.8	0.061
	Background Bear River[a]	8/23/2002	56.7	0.14
Water Strider	**Sluice Tunnel Outlet**	**8/8/2005**	**64.8**	**0.301**
	Background Bear River[a]	9/21/2000	76.1	0.028
	Background Bear River[a]	9/15/2001	64.7	0.070
	Background Bear River[a]	8/23/2002	63.0	0.045
Dobsonfly	**Sluice Tunnel Outlet**	**8/8/2005**	**79.1**	**0.511**
Dragonfly	**Sluice Tunnel Outlet**	**8/8/2005**	**83.7**	**0.652**
	Sluice Tunnel Outlet	**8/8/2005**	**76.5**	**1.09**
	Background Bear River[a]	9/15/2001	81.9	0.022
	Background Bear River[a]	8/23/2002	79.9	0.024

Notes:

Data sources: U.S. Geological Survey unpublished data; Alpers and others 2005b

Bold font indicates sample was collected at the Pond Mine

[a] Sample was collected from Bear River at Highway 20 near Emigrant Gap.

mg/kg Milligram per kilogram

Table 8. Long-Term Risk Reduction Goals for Mercury in Surface Water and Solid Materials

Matrix	Human Health Protection	Unit	Source	Ecological Protection	Unit	Source
Surface Water (Direct Discharge to Waters of the State)	0.050	µg/L	[a]	0.77	µg/L	[b]
Surface Water (On-site Infiltration	1.0	µg/L	[c]	15.4	µg/L	[c]
Solid Materials	40	mg/kg	[d]	8	mg/kg	[e]

Notes:

a U.S. Environmental Protection Agency California Toxics Rule water quality criteria based on total recoverable mercury
b U.S. Environmental Protection Agency ambient water quality criteria based on dissolved mercury
c Goal for surface water direct discharge State multiplied by a factor or 20 to all for attenuation of infiltrating water
d U.S. Department of the Interior, Bureau of Land Management, human risk management criteria for metals at mining sites, camper exposure scenario
e U.S. Department of the Interior, Bureau of Land Management, wildlife and livestock risk management criteria for metals at mining sites, median concentration
µg/L Microgram per liter
mg/kg Milligram per kilogram

Table 9. General Response Actions, Technology Types, and Process Options for Surface Water

General Response Action	Technology Type	Process Options
No Action	None	None
Institutional Controls	Access Restrictions	Fencing/Barrier
		Land Use Control
		Water Use Control
Engineering Controls	Surface and Subsurface Controls	Sediment Detention Structure
		Surface Diversion
Treatment	Physical/Chemical Treatment	Coagulation, Clarification, and Filtration
		Neutralization and Precipitation
		Oxidation and Precipitation
		Zero Valent Iron Reactor
		Reverse Osmosis/Nano-Filtration
		Carbon Adsorption
		Ion Exchange
		Evaporation

Table 10. General Response Actions, Technology Types, and Process Options for Sediment

General Response Action	Technology Type	Process Options
No Action	None	None
Institutional Controls	Access Restrictions	Fencing/Barrier
		Land Use Control
Engineering Controls	Surface Controls	Consolidation
		Grading
		Revegetation
		Erosion and Flood Control
	Containment	Earthen Cover
		Earthen Cover with Cement Cover or Geomembrane Liner
		Tunnel Grouting
	Excavation and On-Site Disposal	Earthen Cover
		Earthen Cover with Geomembrane Liner
		Group A Mine Waste Repository
	Excavation and Off-Site Disposal	Solid Waste Landfill
		Class 1 Repository
Excavation and Treatment	Reprocessing	On- or Off-Site Physical Separation
	Physical/Chemical Treatment	Soil Washing
		Acid Extraction
		Alkaline Leaching
		Solidification/ Stabilization
	Thermal Treatment	Rotary Kiln
		Retorting
		Vitrification
In-Place Treatment	Physical/Chemical Treatment	Soil Flushing
		Solidification/ Stabilization
	Thermal Treatment	Vitrification

Table 11. Technology Screening Comments Summary for Surface Water

General Response Actions	Technology	Process Options	Description	Screening Comment
No Action	None	Not applicable	No action.	Not applicable.
Institutional Controls	Access Restrictions	Fencing/Barrier	Install fence around tunnel inlets, ground sluices, and the plunge pool. Install a bat gate on the sluice tunnel outlet.	Partially effective. Public exposure to features on BLM-administered land (plunge pool and ground sluices) can be controlled, but it is impractical to limit access to sluice tunnel discharge. Readily implementable on BLM-administered land, but not implementable for features on private property.
		Land Use Control	Implement restrictions to control current and future land use.	Not effective. Public exposure to tunnel inlets and ground sluices is contingent on cooperating landowners, and sluice tunnel discharge cannot be controlled by use restrictions alone. Not readily implementable.
		Water Use Control	Implement restrictions to control current and future water use.	Partially effective for on-site waters; however, beneficial uses of off-site water cannot be readily changed. Not readily implementable.
Engineering Controls	Surface and Subsurface Controls	Sediment Detention Structure	Install sediment detention basins to capture mobile sediment and mercury above ponds, ground sluices, and below the sluice tunnel outlet.	Effective for capturing mobile sediment and reducing downstream entrainment of sediment (reduces velocity). Very effective in conjunction with other technologies. Readily implementable.
		Surface Diversions	Install surface drains or ditches to capture and divert run-off around sluice tunnel inlets. Water could also be diverted to a treatment system, if such an option is implemented.	Effective for capturing surface runoff for bypass around mine workings. Also allows sediment settling and diversion of water for water treatment. Implementable on private land under the Widen Amendment (16 U.S.C. § 1011(a) and P.L. 105-227 § 323). However, this alternative would substantially alter a private landowner's property without substantial benefit to the landowner. Inconvenience during construction and the addition of a substantial amount of standing water may create resistance by the landowner. This alternative would also leave BLM with a long-standing operation and maintenance responsibility to keep culverts and drainage ditches clear. Furthermore, tunnel inlets are in topographic low areas, and major engineering, construction, and long-term maintenance would be required to redirect surface water.
Treatment	Physical/ Chemical Treatment	Coagulation, Clarification, and Filtration	Concentrate metals in floc after coagulant addition, then settle metal floc or separate using a fine sand filter.	Process moderately effective at fine sediment removal, but not effective a dissolved mercury removal. Effectiveness is also questionable given variability in dosage required to address changing influent chemistry and flow. In addition, process is not readily implementable because of the lack of electrical infrastructure.
		Neutralization and Precipitation	Dissolved metals are neutralized causing formation of metal precipitates that settle out or are separated using a fine sand filter.	Process slightly to moderately effective at mercury removal, given pH and redox dependency of precipitation. Effectiveness is also questionable given variability in dosage required to address changing influent chemistry and flow. In addition, process is not readily implementable because of the lack of electrical infrastructure.

Table 11. Technology Screening Comments Summary for Surface Water

General Response Actions	Technology	Process Options	Description	Screening Comment
Treatment (Continued)	Physical/ Chemical Treatment (Continued)	Oxidation and Precipitation	Dissolved metals are oxidized by passive aeration, causing formation of metal precipitates that settle out or are separated using a fine sand filter.	Process not effective at mercury removal. Effectiveness is also questionable given variability in dosage required to address changing influent chemistry and flow. In addition, process is not readily implementable because of the lack of electrical infrastructure.
		Zero Valent Iron Reactor	Concentrates metals on reduced iron surfaces and creates reducing conditions for extended metal sulfide precipitation.	Process very effective at mercury removal and maintaining reduced conditions for sulfide removal. Process is passive, gravity fed, does not rely on a constant flow, and is able to operate for extended periods without maintenance. Long-term treatment of surface water is not within the scope of this removal action. Not conducive to short-term batch treatment of excavation or process waters.
		Reverse Osmosis/ Nano-Filtration	Uses hydraulic pressure to force water from a concentrated solution through a semipermeable membrane into a dilute solution. Dissolved metals are retained in the concentrated solution.	Process very effective at mercury removal. Effectiveness is questionable given operational variability required to address changing influent chemistry and flow. In addition, process is not readily implementable because of the lack of electrical infrastructure.
		Adsorption	Concentrates metals on carbon surfaces. Preferable for short-term metals removal from process water.	Process very effective at removing mercury. Sulfur-coated carbon is required to obtain high removal efficiencies. Carbon may be regenerated or retorted to recover mercury. Readily implementable.
		Ion Exchange	Concentrates metals on exchange resins. Preferable for short-term metals removal from process water.	Process very effective at removing mercury. Pre-filtration is required to prevent blinding of exchange resin. Resin is regenerated to recover mercury. Readily implementable.
		Evaporation	Water is evaporated and not discharged directly to the watershed. Evaporation can rely on natural processes or can be enhanced through physical measures. Preferable for disposal of process water.	Excess water is eliminated without discharge to the watershed. Dissolved and particulate-bound mercury is deposited where evaporation occurs (typically an evaporation pond. Readily implementable for batches of water (process water ponds) or low-flow water sources (surface water collected in the sluice tunnel construction area), but less implementable for constant high-flow water sources (sluice tunnel discharge).

Notes:

Eliminated alternatives are shaded

BLM U.S. Department of the Interior, Bureau of Land Management

U.S.C. United States Code

Table 12. Technology Screening Comments Summary for Sediment

General Response Action	Technology	Process Options	Description	Screening Comment
No Action	None	Not applicable	No action.	Not applicable.
Institutional Controls	Access Restrictions	Fencing/ Barrier	Install grate on sluice tunnel outlet.	Public exposure to sluice tunnel is controlled; does not address dissolution of and exposure to mercury; readily implementable on BLM land.
		Land Use Control	Implement restrictions to control current and future land use.	Not effective for tunnel inlets and ground sluices located on public property. Sluice tunnel and plunge pool sediment and discharge on BLM property cannot be controlled by use restrictions.
Engineering Controls	Surface Controls	Grading, Revegetation, and Erosion Control	Grade pit floor away from tunnel inlets to reduce water inflow to the tunnel and manage surface water runoff and erosion; add amendments to disturbed areas, and seed with appropriate vegetative species to establish an erosion-resistant ground surface.	Reduces surface water flow through the sluice tunnel system, thereby reducing mobilization of contaminated sediment within the tunnel. Does not address direct exposure to sediments or dissolution of and exposure to mercury in surface water discharged from the tunnel. Implementable on private land under the Widen Amendment (16 U.S.C. § 1011(a) and P.L. 105-227 § 323). However, this alternative would substantially alter a private landowner's property without substantial benefit to the landowner. Inconvenience during construction and the addition of a substantial amount of standing water may create resistance by the landowner. This alternative would also leave BLM with a long-standing operation and maintenance responsibility to keep culverts and drainage ditches clear. Furthermore, tunnel inlets are in topographic low areas, and major engineering, construction, and long-term maintenance would be required to redirect surface water.
		Check dam construction	Construct a series of check dams within the sluice tunnel or downstream from the plunge pool to trap sediment before it leaves the site.	Reduces off-site migration of mercury bound to suspended sediment. Does not address direct exposure to sediments or dissolution of and exposure to mercury. Readily implementable.
		Tunnel Covering	Cover sluice tunnel and plunge pool sediments in place with concrete. Covering may also be used after sediment excavation from the sluice tunnel and plunge pool to sequester residual mercury that may remain in bedrock foliations.	Sediment erosion and mercury volatilization would be reduced; dissolution of mercury into water would be reduced as long as the concrete surface remains intact (underlying sediment, if not excavated, could cause settling and cracking in the concrete surface); limits direct exposure. Readily implementable after sediment is removed, but more difficult to implement on top of the sediment. (The uneven surface would require rough grading and removal of cobbles before concrete is poured.)
	Excavation and On-Site Disposal	Earthen Cover	Excavate sediment from the sluice tunnel and plunge pool, deposit sediment on site, apply inert soil cover to excavated sediment, and backfill the plunge pool.	Eliminates direct contact (surface water and human and ecological receptors) with mercury-bearing sediment as well as erosion, dissolution, dust generation, and mercury volatilization by removing the contaminant source; readily implementable. Meteoric water could infiltrate through the earthen cover and leach mercury from excavated sediment into surface or groundwater. Does not meet on-site disposal requirements for the likely classification (Group A or B) of Pond Mine sediment.

Table 12. Technology Screening Comments Summary for Sediment

General Response Action	Technology	Process Options	Description	Screening Comment
Engineering Controls (Continued)	Excavation and On-Site Disposal (Continued)	Earthen Cover with Geomembrane Liner	Excavate sediment from the sluice tunnel and plunge pool, deposit sediment on site, install geomembrane liner on top of excavated sediment, apply inert soil cover on top of liner, and backfill the plunge pool.	Eliminates direct contact (surface water and human and ecological receptors) with mercury-bearing sediment as well as erosion, dissolution, dust generation, and mercury volatilization by removing the contaminant source; readily implementable. Elemental mercury could drain from excavated sediment into surface or groundwater. Does not meet on-site disposal requirements for the likely classification (Group A or B) of Pond Mine sediment.
		Group A Mine Waste Repository	Excavate sediment from the sluice tunnel and plunge pool, deposit sediment on site, deposit sediment on site in a constructed Group A mine waste repository and backfill the plunge pool.	Eliminates direct contact (surface water and human and ecological receptors) with mercury-bearing sediment as well as erosion, dissolution, dust generation, and mercury volatilization by removing the contaminant source. Infiltration of precipitation and cover erosion would be greatly reduced; any leachate generated would be captured by a leachate collection system; readily implementable. However, the Group A mine waste repository would require operation and maintenance in perpetuity. Mercury separation would provide a similar level of protection with much less operation and maintenance.
	Excavation and Off-Site Disposal	Solid Waste Landfill	Excavate sediment from the sluice tunnel and plunge pool and backfill the plunge pool. Haul waste to and place in a state-regulated solid waste landfill.	Eliminates direct contact (surface water and human and ecological receptors) with mercury-bearing sediment as well as erosion, dissolution, dust generation, and mercury volatilization by removing the contaminant source. Not implementable because sediment concentrations contain hazardous levels of mercury (greater than 20 mg/kg).
		Class 1 Repository	Excavate sediment from the sluice tunnel and plunge pool, backfill the plunge pool, and establish vegetation to stabilize surfaces. Haul waste to and place in a Class 1 Repository for hazardous materials.	Eliminates direct contact (surface water and human and ecological receptors) with mercury-bearing sediment as well as erosion, dissolution, dust generation, and mercury volatilization by removing the contaminant source. Not implementable if material contains concentrations of mercury above 260 mg/kg because of federal and state regulations.
Excavation and Treatment	Reprocessing	On-site Physical Separation	Excavate sediment from the sluice tunnel and plunge pool and backfill the plunge pool. Mobilize an aggregate plant designed for gold and mercury recovery and process excavated sediment to physically separate heavy minerals (including mercury, gold, and lead). Dispose of or recycle heavy minerals and dispose of washed sediment on site.	Eliminates direct contact (surface water and human and ecological receptors) with mercury-bearing sediment as well as erosion, dissolution, dust generation, and mercury volatilization by removing the contaminant source. Treatability study demonstrated this technology can effectively remove mercury from Pond Mine sluice tunnel sediment; more than 99.9 percent of washed sediment could be disposed of on site. Would require a reliable source of water to operate the processing plant. Used process water would likely contain mercury, lead, and suspended solids concentrations that prohibit direct discharge to surface water; process water would require treatment or evaporation. Readily implementable.

Table 12. Technology Screening Comments Summary for Sediment

General Response Action	Technology	Process Options	Description	Screening Comment
Excavation and Treatment (Continued)	Reprocessing (Continued)	Off-site Physical Separation	Excavate sediment from the sluice tunnel and plunge pool and backfill the plunge pool. Ship excavated sediment, as a commodity, to an off-site sand and gravel plant setup for economic recovery of gold; sell washed coarse and fine materials.	Eliminates direct contact (surface water and human and ecological receptors) with mercury-bearing sediment as well as erosion, dissolution, dust generation, and mercury volatilization by removing the contaminant source. Physical separation of sediment into coarse, medium, and fine material would allow segregation and consolidation of the fine size fraction containing mercury. The mass of fine sediment and mercury would be progressively refined until elemental mercury is recovered for reuse. Coarse and medium size material would be sold as a commodity. Experience demonstrates that transportation cost of contaminated sediment makes this option less cost effective than on-site physical separation while maintaining comparable levels of human and ecological protectiveness.
	Physical/ Chemical Treatment	Soil Washing	Excavate sediment from the sluice tunnel and plunge pool and backfill the plunge pool. Separate metals from sediment via dissolution in a heap, vat, or agitated vessel, followed by precipitation in a separate vessel.	Eliminates direct contact (surface water and human and ecological receptors) with mercury-bearing sediment as well as erosion, dissolution, dust generation, and mercury volatilization by removing the contaminant source; however, treatment process is not effective for mercury recovery. Requires that metals be readily soluble in water and sized sufficiently small so that dissolution can be achieved in a practical retention time. Mercury is not readily soluble in water, especially at the high concentrations documented in sediment.
		Acid Extraction	Excavate sediment from the sluice tunnel and plunge pool and backfill the plunge pool. Mobilize metals using acid solution applied to sediment contained in a heap, vat, or agitated vessel. Dissolved metals are subsequently plated or precipitated for disposal or reuse.	Eliminates direct contact (surface water and human and ecological receptors) with mercury-bearing sediment as well as erosion, dissolution, dust generation, and mercury volatilization by removing the contaminant source. Mercury treatment process is most effective for solubilizing and extracting low to moderate concentrations of bound metals. The concentrations of mercury in sediment are high and are more amenable to physical separation. Acid extraction may be effective as a final recovery step for bound or beaded mercury in a specific particle size fraction after physical separation. Acid extraction would also generate a large quantity of water that would require recovery of soluble mercury.
		Alkaline Leaching	Excavate sediment from the sluice tunnel and plunge pool and backfill the plunge pool. Uses alkaline solution to leach metals from solid media in a heap, vat, or agitated vessel.	Eliminates direct contact (surface water and human and ecological receptors) with mercury-bearing sediment as well as erosion, dissolution, dust generation, and mercury volatilization by removing the contaminant source. However, treatment process not effective for mercury leaching and recovery.

Table 12. Technology Screening Comments Summary for Sediment

General Response Action	Technology	Process Options	Description	Screening Comment
Excavation and Treatment (Continued)	Physical/ Chemical Treatment (Continued)	Solidification/ Stabilization	Excavate sediment from the sluice tunnel and plunge pool and backfill the plunge pool. Uses solidifying/stabilizing agents in conjunction with mixing techniques to facilitate a physical or chemical change in mobility of the contaminants. Solidification/stabilization may be appropriate for heavy mineral concentrates generated by on-site physical separation if concentrations in leachate exceed regulatory criteria.	Eliminates direct contact (surface water and human and ecological receptors) with mercury-bearing sediment as well as erosion, dissolution, dust generation, and mercury volatilization by removing the contaminant source. If stabilized product is placed on-site, then the leachable concentration of mercury cannot exceed the STLC of 0.2 mg/L. Treatability testing required to identify optimal type and quantity of solidifying agent. If stabilized product is disposed of off-site, then the initial concentration of mercury in sediment cannot exceed 260 mg/kg and the leachable concentration of mercury cannot exceed 0.025 mg/L using TCLP.
	Thermal Treatment	Fluidized Bed Reactor/ Rotary Kiln/ Multihearth Kiln	Excavate sediment from the sluice tunnel and plunge pool and backfill the plunge pool. Concentrate metals in sediment into a small volume by volatilization of metals and formation of metallic oxides as particulates.	Eliminates direct contact (surface water and human and ecological receptors) with mercury-bearing sediment as well as erosion, dissolution, dust generation, and mercury volatilization by removing the contaminant source. Process is very effective for mercury recovery; however, physical separation of fines and mercury followed by retorting is much more cost effective. Not implementable as electrical infrastructure is not available to support required load; cost prohibitive. Process is not an accepted technology for off-site treatment of mercury.
		Retorting	Excavate sediment from the sluice tunnel and plunge pool and backfill the plunge pool. Volatilizes mercury by heating of sediment, mercury vapor is collected and recondensed as an economic commodity.	Eliminates direct contact (surface water and human and ecological receptors) with mercury-bearing sediment as well as erosion, dissolution, dust generation, and mercury volatilization by removing the contaminant source. Retorting is required for off-site disposal of mercury at concentrations exceeding 260 mg/kg. Retorting would require shipping of whole sediment or smaller-size fraction to a permitted facility. Process is very effective for mercury recovery; however, physical separation of fines and mercury followed by on-site solidification and disposal is more cost effective. Readily implementable.
		Vitrification	Excavate sediment from the sluice tunnel and plunge pool and backfill the plunge pool. Uses extremely high temperature to melt and/or volatilize all components of the solid media; the molten material is cooled and, in the process, vitrified into a nonleachable form.	Eliminates direct contact (surface water and human and ecological receptors) with mercury-bearing sediment as well as erosion, dissolution, dust generation, and mercury volatilization by removing the contaminant source. Process would volatilize mercury from sediment, requiring recovery and condensation of mercury vapor. Vapor recovery process would be very difficult to control. Not implementable as electrical infrastructure is not available to support required load; cost prohibitive. Process is not an accepted technology for off-site treatment of mercury.

Table 12. Technology Screening Comments Summary for Sediment

General Response Action	Technology	Process Options	Description	Screening Comment
In-Place Treatment	Physical/ Chemical Treatment	Solidification/ Stabilization	Uses solidifying/stabilizing agents in conjunction with deep soil mixing techniques to facilitate a physical or chemical change in mobility of the contaminants.	Potentially implementable for plunge pool sediment. Sediment in the sluice tunnel would require excavation, solidification, and on-site disposal. Not as effective as ex situ solidification as adequate contact between solidifying agent and contaminated sediment cannot be assured. Treatability testing required to identify the optimal type and quantity of solidifying agent.
		Soil Flushing	Acid/base reagent or chelating agent injected into sediment to solubilize metals; solubilized metals and reagents are subsequently extracted using dewatering techniques.	Process is most effective for solubilizing and extracting low to moderate concentrations of bound metals. The concentrations of mercury in sediment are high and are more amenable to ex situ physical separation. Potential exists to increase mobility in situ by providing partial dissolution of contaminants. Acid extraction or chelation would also generate a large quantity of water requiring soluble mercury recovery. Acid extraction or chelation may be effective as a final recovery step for bound or beaded mercury in a specific particle size fraction after ex situ physical separation.
	Thermal Treatment	Vitrification	Uses extremely high temperature to melt or volatilize all components of the solid media; the molten material is cooled and, in the process, vitrified into a nonleachable form.	Process would volatilize mercury from sediment, requiring recovery and condensation of mercury vapor. Vapor recovery process would be very difficult to control. Not implementable as electrical infrastructure is not available to support required load; cost prohibitive. Process is not an accepted technology for off-site treatment of mercury.

Notes:

Eliminated alternatives are shaded

BLM U.S. Department of the Interior, Bureau of Land Management
mg/L Milligram per liter
mg/kg Milligram per kilogram
STLC Soluble threshold limit concentration
TCLP Toxicity characteristic leaching procedure
USC United States Code

Table 13. Removal Action Alternatives Summary

Alternative Number	Alternative Description
Alternative 1	No Action
Alternative 2	Check Dam Installation and Institutional Controls. *Install check dams below the plunge pool to capture contaminated sediment in sluice tunnel discharge. Install a bat gate to prevent unauthorized entrance into the sluice tunnel. Post warning signs to alert visitors that the area may be hazardous and to identify the potential hazards present to deter trespass and misuse.*
Alternative 3	In Situ Sediment Covering, Check Dam Installation, and Institutional Controls. *Cover sediment in the sluice tunnel and plunge pool with concrete to minimize direct contact with and migration of contaminated sediment. Install a bat gate to prevent unauthorized entrance into the sluice tunnel. Post warning signs to alert visitors that the area may be hazardous and to identify the potential hazards present to deter trespass and misuse.*
Alternative 4	Sediment Excavation, On-Site Physical Separation, On-Site Disposal, Covering, Check Dam Installation, and Institutional Controls. *Excavate sediment from the sluice tunnel and plunge pool. Process excavated sediment on site to separate mercury and other heavy metals. Pressure-wash the floors of the sluice tunnel and plunge pool to remove mercury from bedrock foliations. Dispose of washed sediment on site and recycle segregated mercury. Cover the sluice tunnel and plunge pool floors to sequester residual mercury that might remain in bedrock foliations. Install a bat gate to prevent unauthorized entrance into the sluice tunnel. Post warning signs to alert visitors that the area may be hazardous and to identify the potential hazards present to deter trespass and misuse.*

Table 14. Cost Estimate for Alternative 2: Check Dam Installation and Institutional Controls

Cost Item	Item Description	Quantity	Unit		Cost
Capital Costs					
Item 1	Insurance and Bonding	1	LS	$	7,623
Item 2	Equipment Mobilization/Demobilization	1	LS	$	34,220
Item 3	Site Preparation and Security	1	LS	$	24,343
Item 4	Realign, Grade, and Gravel Access Road	1	LS	$	70,800
Item 5	Construct Access Ramp to Plunge Pool	1	LS	$	25,637
Item 6	Construct Water Treatment Collection System	1	LS	$	2,360
Item 7	Install Check Dams	1	LS	$	28,738
Item 8	Reclaim Site and Install Gate at Top of Access Road	1	LS	$	34,191
Item 9	Install Bat Gate	1	LS	$	9,558
Item 10	Construct Warning Signs on Site	2	LS	$	3,458
Item 11	Site Security	1	LS	$	20,789
Subtotal Construction Costs				***$***	***261,716***
Construction Oversight[a]		1	LS	$	25,084
Construction Contingencies		Percent of Construction Costs =	20%	$	52,343
Engineering Design		1	LS	$	18,500
TOTAL CAPITAL COSTS				**$**	**357,642**
O&M Costs					
Item 12	Check Dam and Sign Maintenance (every 5 Years)			$	9,710
O&M Contingencies		Percent of O&M Costs =	25%	$	2,428
Item 13	Annual Site Inspections	1	EA	$	1,000
Present Worth of O&M Cost Based on 25 Year Life @ 7%		***PF FACTOR =***	***13.1***	***$***	***44,900***
TOTAL PRESENT WORTH				**$**	**402,543**

Notes:

a	Construction oversight costs include project management, engineering, health and safety, per diem, and vehicle for oversight personnel only.
%	Percent
EA	Each
LS	Lump sum
O&M	Operation and maintenance
PF	Present worth factor

Table 15. Cost Estimate for Alternative 3: In-Situ Sediment Covering, Check Dam Installation, and Institutional Controls

Cost Item	Item Description	Quantity	Unit		Cost
Capital Costs					
Item 1	Insurance and Bonding	1	LS	$	24,305
Item 2	Equipment Mobilization/Demobilization (2 seasons)	1	LS	$	71,036
Item 3	Site Preparation and Security	1	LS	$	24,343
Item 4	Realign, Grade, and Gravel Access Road	1	LS	$	70,800
Item 5	Sluice Tunnel Outlet Staging Area	1	LS	$	7,009
Item 6	Construct Access Ramp to Plunge Pool	1	LS	$	25,637
Item 7	Provide Roof Support for Tunnel	1	LS	$	26,688
Item 8	Construct Water Treatment Collection System	1	LS	$	22,414
Item 9	Smooth Sluice Tunnel and Plunge Pool Floors	1	LS	$	90,624
Item 10	Cover Sluice Tunnel and Plunge Pool Floors with Concrete	1	LS	$	322,377
Item 11	Winterize Site (1 time)	1	LS	$	24,131
Item 12	Reclaim Site and Install Gate at Top of Access Road	1	LS	$	34,191
Item 13	Install Bat Gate	1	LS	$	9,558
Item 14	Install Check Dams	1	LS	$	28,738
Item 15	Construct Warning Signs on Site	2	LS	$	3,458
Item 16	Site Security	1	LS	$	49,155
Subtotal Construction Costs				***$***	***834,464***
Construction Oversight[a]		1	LS	$	75,752
Construction Contingencies		Percent of Construction Costs =	20%	$	166,893
Engineering Design		1	LS	$	21,500
TOTAL CAPITAL COSTS (Over 2 years)				**$**	**1,098,609**
O&M Costs					
Item 17	Check Dam and Sign Maintenance			$	9,710
O&M Contingencies		Percent of O&M Costs =	25%	$	2,428
Item 18	Annual Site Inspections	1	EA	$	1,000
Present Worth of O&M Cost Based on 25 Year Life @ 7%		***PF FACTOR =***	***13.1***	***$***	***29,000***
TOTAL PRESENT WORTH				**$**	**1,127,609**

Notes:

a	Construction oversight costs include project management, engineering, health and safety, per diem, and vehicle for oversight personnel only.
%	Percent
EA	Each
LS	Lump sum
O&M	Operation and maintenance
PF	Present worth factor

Table 16. Cost Estimate for Alternative 4: Sediment Excavation, On-Site Physical Separation, On Site Disposal, Covering, Check Dam Installation, and Institutional Controls

Cost Item	Item Description	Quantity	Unit		Cost
Capital Costs					
Item 1	Insurance and Bonding	1	LS	$	50,243
Item 2	Equipment Mobilization/Demobilization (3 seasons)	1	LS	$	127,794
Item 3	Site Preparation and Security	1	LS	$	24,343
Item 4	Realign, Grade, and Gravel Access Road	1	LS	$	70,800
Item 5	Construct Sluice Tunnel Outlet Staging Area	1	LS	$	7,009
Item 6	Construct Access Ramp to Plunge Pool	1	LS	$	25,637
Item 7	Provide Roof Support for Tunnel	1	LS	$	26,688
Item 8	Construct Water Treatment Collection System	1	LS	$	22,414
Item 9	Remove Sediment and Wooden Sluice Boxes from Tunnel	1	LS	$	394,714
Item 10	Clean Sediment from Plunge Pool	1	LS	$	32,084
Item 11	Pressure Wash Sluice Tunnel and Plunge Pool Floors and Cover with Concrete	1	LS	$	322,377
Item 12	Process Sluice Tunnel and Plunge Pool Sediments	1	LS	$	260,668
Item 13	Dispose of Sluice Box Remnants	1	LS	$	2,658
Item 14	Reclaim Site and Install Gate at Top of Access Road	1	LS	$	34,191
Item 15	Winterize Site (2 times)	1	LS	$	48,262
Item 16	Install Bat Gate	1	LS	$	9,558
Item 17	Conduct Additional Exploratory Reconnaissance	1	LS	$	61,331
Item 18	Install Check Dams	1	LS	$	28,738
Item 19	Construct Warning Signs on Site	1	LS	$	3,458
Item 20	Site Security	1	LS	$	172,044
Subtotal Construction Costs				***$***	***1,725,010***
Construction Oversight[a]		1	LS	$	208,896
Construction Contingencies		Percent of Construction Costs =	20%	$	345,002
Engineering Design		1	LS	$	21,500
TOTAL CAPITAL COSTS (Over 3 Years)				**$**	**2,300,408**
O&M Costs					
Item 21	Check Dam and Sign Maintenance	1	EA	$	9,710
O&M Contingencies		Percent of O&M Costs =	25%	$	2,428
Item 22	Annual Site Inspections	1	EA	$	1,000
Present Worth of O&M Cost Based on 25 Year Life @ 7%		***PF FACTOR =***	***13.1***	***$***	***23,701***
TOTAL PRESENT WORTH				**$**	**2,324,108**

Notes:

a	Construction oversight costs include project management, engineering, health and safety, per diem, and vehicle for oversight personnel only.
%	Percent
EA	Each
LS	Lump sum
O&M	Operation and maintenance
PF	Present worth factor

Table 17. Comparative Analysis of Alternatives

Assessment Criteria	Alternative 1 No Action	Alternative 2 Check Dam Installation and Institutional Controls	Alternative 3 In Situ Sediment Covering, Check Dam Installation, and Institutional Controls	Alternative 4 Sediment Excavation, On-Site Physical Separation, On-Site Disposal, Covering, Check Dam Installation, and Institutional Controls
Overall Protectiveness				
Public Health, Safety, and Welfare	No reduction in risk.	Reduces the discharge of particulate-bound mercury in surface water by capturing mobilized sediments behind check dams. Installation of a bat gate at the sluice tunnel outlet would reduce exposure of human receptors to mercury-contaminated sediment inside the tunnel and would reduce agitation and release of mercury-bearing sediment. Alternative 2 provides a lower level of protection than Alternatives 3 and 4 because this alternative does not address the source of mercury (sediment in the sluice tunnel and plunge pool).	Reduces the discharge of dissolved and particulate-bound mercury in surface water by limiting surface water contact with the source of contamination (sediment in the sluice tunnel and plunge pool) and capturing mobilized sediments behind check dams. Installation of a bat gate at the sluice tunnel outlet would protect the integrity of the concrete surface. Provides overall protection greater than Alternative 2. Overall protection is lower than Alternative 4 because Alternative 4 removes rather than covers the contaminated material.	Reduces the discharge of dissolved and particulate-bound mercury in surface water by removing the source of contamination (sediment in the sluice tunnel and plunge pool), encapsulating mercury that might remain in bedrock foliations under a concrete cover, and capturing mobilized sediments behind check dams. Installation of a bat gate at the sluice tunnel outlet would protect the integrity of the concrete surface. Provides overall protection greater than Alternatives 2 and 3 because the source of contamination would be removed. Inspection of the tunnel past the collapse will allow evaluation of the need for and cost of additional removal activities within the tunnel system.
Environmental Protectiveness	No protection offered.	Reduces the discharge of particulate-bound mercury in surface water by capturing mobilized sediments behind check dams. Alternative 2 provides a lower level of protection than Alternatives 3 and 4 because this alternative does not address the source of mercury (sediment in the sluice tunnel and plunge pool).	Reduces the discharge of dissolved and particulate-bound mercury in surface water by limiting surface water contact with the source of contamination (sediment in the sluice tunnel and plunge pool) and capturing mobilized sediments behind check dams. Provides overall protection greater than Alternative 2. Overall protection is lower than Alternative 4 because Alternative 4 removes rather than covers the contaminated material..	Reduces the discharge of dissolved and particulate-bound mercury in surface water by removing the source of contamination (sediment in the sluice tunnel and plunge pool), encapsulating mercury that might remain in bedrock foliations under a concrete cover, and capturing mobilized sediments behind check dams. Provides overall protection greater than Alternatives 2 and 3 because the contamination source would be removed. Inspection of the tunnel past the collapse will allow evaluation of the need for and cost of additional removal activities within the tunnel system.
Compliance with ARARs				
Chemical-Specific	Chemical-specific ARARs would not be met because of continued contact between surface water and contaminated sediment and unrestricted exposure for human and ecological receptors to contaminated material.	Chemical-specific ARARs might not be met because surface water flowing through the tunnel would continue to dissolve and mobilize particulate-bound mercury from the sluice tunnel sediment. Meeting chemical-specific ARARs is less certain than with Alternatives 3 and 4 because this alternative does not address the source of contamination.	Chemical-specific ARARs would likely met as long as the concrete cover remains intact. (Settling of the covered sediment could cause cracks to develop in the concrete surface.) Meeting chemical-specific ARARs is more certain than with Alternative 2 but less certain than with Alternative 4. Contaminated sediment upstream from the collapse (if present), might be a continued source of contamination to water flowing through the sluice tunnel, though check dams and the existing collapse debris would retain upstream sediment.	Chemical-specific ARARs would likely met because the source of contaminants would be removed. Meeting chemical-specific ARARs is more certain than with Alternatives 2 and 3. Contaminated sediment upstream from the collapse (if present), might be a continued source of contamination to water flowing through the sluice tunnel, though check dams would retain upstream sediment.
Location-Specific	None apply.	Location-specific ARARs may not be met because stream banks and beds may continue to be eroded by topographic and drainage features created by historical hydraulic mining.	Location-specific ARARs may not be met because Alternative 3 does not provide for protection of sensitive environments within the riparian conservation area.	Location-specific ARARs would be met.
Action-Specific	None apply.	Action-specific ARARs would be met.	Action-specific ARARs would be met.	Action-specific ARARs would be met.
Long-Term Effectiveness and Permanence				
Magnitude of Residual Risk	No reduction in concentrations or mobility of mercury in any media.	Limited reduction in concentrations of mercury in surface water (particulate-bound mercury only) discharged from the site. Human and ecological receptors could be exposed to dissolved mercury in sluice tunnel discharge through ingestion and dermal contact. Exposure to contaminated sediment within the sluice tunnel would be mitigated by the existing collapse debris and installation of a bat gate.	Moderate to high reduction in concentrations of mercury in surface water (dissolved and particulate-bound) discharged from the site. Exposure to contaminated sediment within the sluice tunnel would be mitigated by the concrete cover, existing collapse debris, and installation of a bat gate.	Moderate to high reduction in concentrations of mercury in surface water (dissolved and particulate-bound) discharged from the site. Mercury separated from excavated sediment would be disposed of off site. Chemical characteristics of washed sediment are anticipated to allow on-site disposal of more than 99.9 percent of the washed sediment (see Appendix C). Heavy mineral concentrates could be stabilization and buried on site if chemical conditions dictate. Human and ecological receptors would no longer be exposed to mercury in the cleaned and covered sections of the sluice tunnel and plunge pool.
Adequacy and Reliability of Controls	No controls implemented; no reliability.	Reliability depends on long-term maintenance of check dams and regular removal and potential treatment of sediment from sedimentation basins.	Reliability depends on long-term maintenance of the concrete surface on the covered sediment and the check dams. Maintenance of check dams and regular removal and potential treatment of sediment from sediment detention basins would also be required.	Reliability depends on long-term maintenance, but is less dependent than Alternatives 2 and 3 because the source of contaminants would be removed. Maintenance of check dams and regular removal and potential treatment of sediment from sediment detention basins would also be required.

Table 17. Comparative Analysis of Alternatives

Assessment Criteria	Alternative 1 No Action	Alternative 2 Check Dam Installation and Institutional Controls	Alternative 3 In Situ Sediment Covering, Check Dam Installation, and Institutional Controls	Alternative 4 Sediment Excavation, On-Site Physical Separation, On-Site Disposal, Covering, Check Dam Installation, and Institutional Controls
Reduction of Toxicity, Mobility, and Volume through Treatment				
Treatment Process Used and Materials Treated	None.	None.	In situ cover of contaminated sediments with fiber-reinforced concrete.	Physical separation of mercury and other heavy minerals from bulk excavated sediment. Water will be used to pressure wash the sluice tunnel and plunge pool floors and to operate the aggregate processing plant. Used water might contain mercury, lead, and suspended solids at concentrations that prohibit direct discharge to surface water.
Volume of Contaminated Materials Treated	None.	None.	None.	Approximately 1,000 loose cubic yards of sediment from the sluice tunnel (from the outlet to the collapse 1,600 feet upstream) and 31 loose cubic yards of sediment from the plunger pool.
Expected Degree of Reduction	None.	Limited reduction in the off-site transport of particulate-bound mercury in surface water. Lower degree of reduction than Alternatives 3 and 4. Limited reduction in on-site volume of mercury through periodic removal of sediment behind the check dams. No change in the toxicity of contaminants.	Moderate to high reduction in off-site transport of dissolved and particulate-bound mercury in surface water. Higher degree of reduction than Alternative 2 because the source of contaminants would be covered, but lower degree of reduction than Alternative 4 because the source would remain on site. Limited reduction in on-site volume of mercury through periodic removal of sediment behind the check dams. No change in the toxicity of contaminants.	Moderate to high reduction in the off-site transport of dissolved and particulate-bound mercury in surface water. Higher degree of reduction than Alternatives 2 and 3 because the source of contaminants would be removed. No change in the toxicity of contaminants, but the volume on site would be reduced through physical separation and disposal of heavy minerals.
Short-Term Effectiveness				
Protection of Community During Remediation	Not applicable.	Control of fugitive dust emissions may be required during construction. Increased truck traffic may be a concern during transport of construction material to the site.	Control of fugitive dust emissions may be required during construction. Increased truck traffic may be a concern during transport of construction material to the site.	Control of fugitive dust emissions may be required during construction. Increased truck traffic may be a concern during transport of construction material to the site.
Protection of On-Site Workers During Remediation	Not applicable.	Expected to be sufficient. On-site workers must be adequately protected by using appropriate personal protective equipment, using dust suppression measures, and by following proper operating and safety procedures.	Expected to be sufficient. On-site workers must be adequately protected by using appropriate personal protective equipment, using dust suppression measures, and by following proper operating and safety procedures. Underground work would require air quality monitoring, ventilation, and lighting measures.	Expected to be sufficient. On-site workers must be adequately protected by using appropriate personal protective equipment, using dust suppression measures, and by following proper operating and safety procedures. Underground work would require air quality monitoring, ventilation, and lighting measures.
Time Until Preliminary Remediation Measure Objectives are Achieved	Not applicable.	Meets PRAOs after implementation of physical measures; expected to take one construction season.	Meets PRAOs after implementation of physical measures; expected to take two construction seasons.	Meets PRAOs after implementation of physical measures; expected to take three construction seasons.
Implementability				
Ability to Construct and Operate	No construction or operation involved	Construction of roads, check dams, and the bat gate would require the services of a contractor experienced in the proper construction procedures.	Construction of roads, check dams, and the bat gate and application of concrete would require the services of a contractor experienced in the proper construction procedures.	Construction of roads, check dams, and the bat gate, inspection of sluice tunnel conditions past the collapse at 1,600 feet, excavation and processing of contaminated sediment, and application of concrete would require the services of a contractor experienced in the proper construction procedures.
Ease of Implementing More Action if Necessary	This measure does not inhibit implementation of other actions.	This measure does not inhibit implementation of other actions. The bat gate would be removable to allow future work within the sluice tunnel.	This measure does not inhibit implementation of other actions. The bat gate would be removable to allow future work within the sluice tunnel. Future removal of covered sediment (if necessary) would be more costly after the concrete has been placed. Check dams installed at the collapse inside the sluice tunnel would impede access upstream for future inspection or removal activities.	This measure does not inhibit implementation of other actions. The bat gate would be removable to allow future work within the sluice tunnel. Check dams installed at the collapse inside the sluice tunnel would impede access upstream for future inspection or removal activities.
Availability of Services and Capacities	Not applicable.	Construction services are available locally and within the state.	Construction services are available locally and within the state. Work within the sluice tunnel would require ventilation and lighting equipment and a project team trained and certified for underground work.	Construction services are available locally and within the state. Work within the sluice tunnel would require ventilation and lighting equipment and a project team trained and certified for underground work.
Availability of Equipment and Materials	Not applicable.	Available locally and within the state.	Available locally and within the state.	Available locally and within the state.
Estimated Present Worth Cost with 30 Years of Operation and Maintenance	**$0**	**$402,543**	**$1,127,609**	**$2,324,108**

Notes:

ARAR Applicable or relevant and appropriate requirement
BLM U.S. Department of the Interior, Bureau of Land Management
PRAO Preliminary removal action objective

APPENDIX A
SITE PHOTOGRAPHS

Photograph A-1

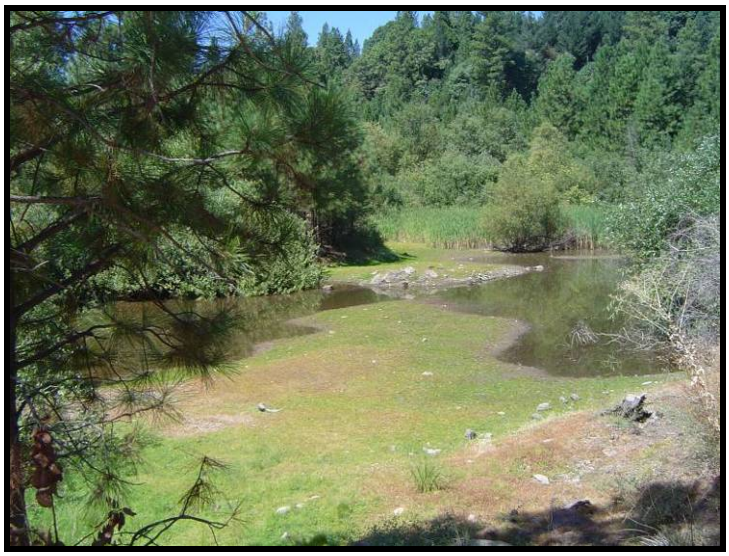
Northwest portion of the Pond Mine pit (private property). Highwall is visible in the background. Note that the ground surface slopes north toward the highwall; surface water drains into sluice tunnel inlets at the base of the highwall. Facing northeast.

August 22, 2006

Photograph A-2

View of the largest pond on private property. The pond is fed by a spring emanating from the highwall. Facing southwest.

August 22, 2006



Photograph A-3

View of the fourth (farthest downstream) pond on private property. Pond is mostly empty at this time, but fills with water in the winter. Facing north.

August 22, 2006

Photograph A-4

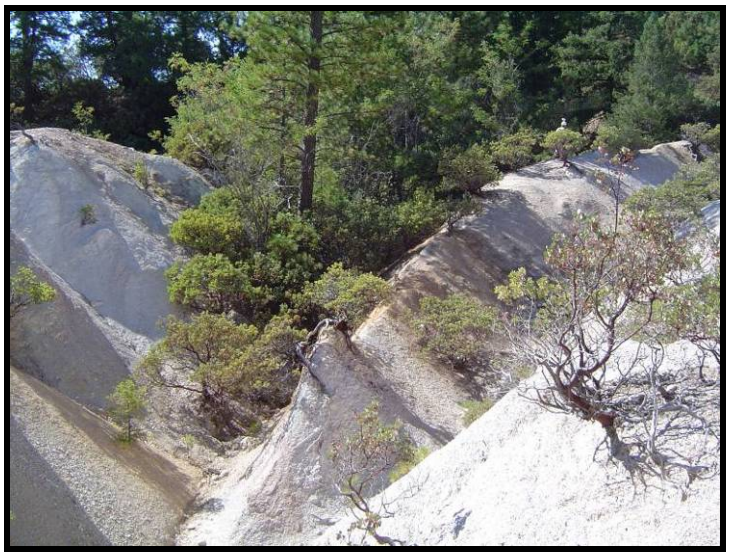
View of an open sluice tunnel inlet (STI-3 on Figure 2). Facing southwest.

August 22, 2006

Photograph A-5

View of an open sluice tunnel inlet (STI-5 on Figure 2). Facing south.

August 22, 2006



Photograph A-6

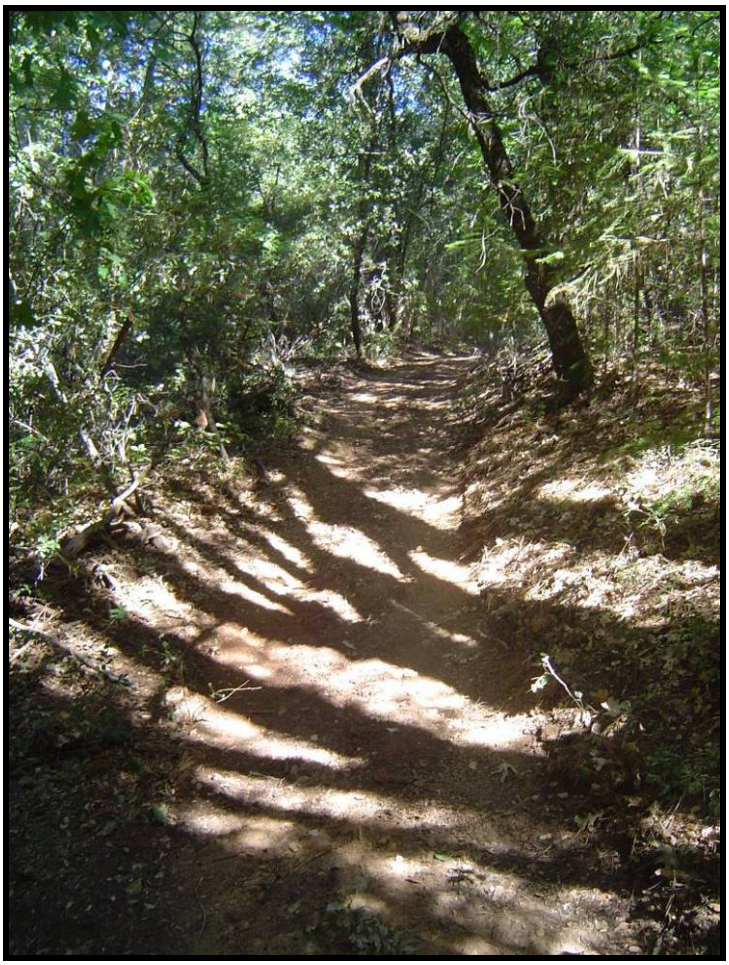
View of a ground sluice in the southeast pit floor. Facing north.

August 22, 2006

Photograph A-7

View of the disturbed ground surface in the southwest pit floor. Facing southeast.

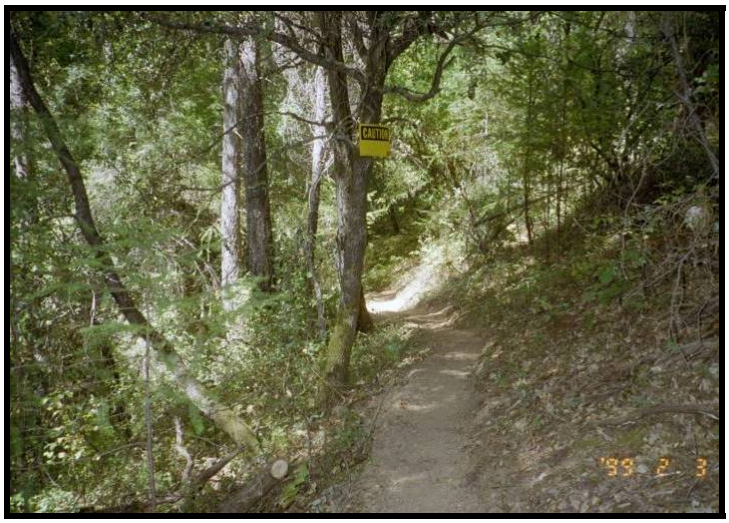
August 22, 2006



Photograph A-8

View of the access trail to the sluice tunnel outlet. The trail is wide enough for a 4-wheeler but not for a pickup truck. Photo was taken where a smaller trail branches off to the tunnel outlet. Facing northwest.

August 22, 2006



Photograph A-9

View of the smaller trail that branches off to the sluice tunnel outlet. The tunnel outlet is out of view to the lower left. Facing west.

August 22, 2006

Photograph provided by Cherokee Development Corporation (Cherokee).

Photograph A-10

Pond Mine sluice tunnel outlet. The guardrails were temporary safety measures installed by Cherokee for use during the underground reconnaissance. Facing south.

August 22, 2006

Photograph A-11

Pond Mine sluice tunnel outlet from a downstream vantage point. Note that water is falling into the plunge pool, which is out of view below the photo. Facing west.

August 22, 2006

Photograph A-12

Floor of the Pond Mine sluice tunnel. Facing west.

August 29, 2006

Photograph A-13

Floor of the Pond Mine sluice tunnel. Note the wood remnants of the old sluice box. Facing west.

August 29, 2006

Photograph A-14

View of the partial ceiling collapse 1,600 feet upstream from the tunnel outlet. Underground reconnaissance did not advance past this obstacle. Facing west.

August 29, 2006

Photograph A-15

Bulkhead 121 upstream from the sluice tunnel outlet before it was removed during the underground reconnaissance. Facing west.

December 11, 2003

Photograph taken during reconnaissance sampling (Tetra Tech EM Inc [Tetra Tech] 2004a) by the U.S. Department of the Interior, Bureau of Land Management (BLM).

Photograph A-16

Removal of the bulkhead within the Pond Mine sluice tunnel. Note the mine rail reinforcements set within the concrete. Facing west.

August 24, 2006

Photograph provided by Cherokee.

Photograph A-17

Cross-section view of the bulkhead after it was removed. Concrete was 18 inches thick. Facing southwest.

August 29, 2006

Photograph A-18

View of the upstream side of the bulkhead after it was removed. Facing east.

August 29, 2006

Photograph A-19

Overview of the plunge pool from above the sluice tunnel outlet. The plunge pool is within the small slot canyon in the center of the photograph. Facing east.

December 11, 2003

Photograph taken during reconnaissance sampling (Tetra Tech 2004a).

Photograph A-20

View of the plunge pool. The shadowy area immediately above the waterfall is the sluice tunnel outlet. Note how deeply and narrowly the plunge pool is incised into the surrounding rock. Facing west.

July 27, 2006

Photograph A-21

Top of the waste rock pile near the sluice tunnel outlet. Facing east.

August 22, 2006

APPENDIX B
COST ESTIMATE ASSUMPTIONS

APPENDIX B: ASSUMPTIONS FOR COST ESTIMATES

B-1 COST ESTIMATE ASSUMPTIONS FOR ALTERNATIVES 2 THROUGH 4

General

- Construction oversight costs include project management, engineering oversight, health and safety, per diem for oversight personnel, and vehicle for oversight personnel
- Construction to be performed during the dry season (June through November)

Insurance and Bonding

- Insurance and bonding will be supplied at as assumed cost of 3 percent of the total construction cost

Mobilization

- Includes mobilization and demobilization of all necessary equipment at the beginning and end of each construction season

Site Preparation and Security

- Includes minimal grading and cleanup of staging area.

Realign, Grade, and Gravel Access Road

- Road will be no more than 2,100 linear feet and will generally follow the existing trail
- Includes no more than four 20-inch culverts
- Road will be rocked with 6 inches of crushed base
- Brush and logs up to 6 inches will be shredded and left on site
- Larger logs and stumps will be left on site
- Access road will be accessible by four-wheel-drive vehicle only

Construct Water Treatment Collection System

- Collection system will consist of sump downstream of construction work
- Collection system will be used only during working hours
- Water will be treated by evaporation
- Remaining fines will be processed with plunge pool sediment

Install Check Dams

- Check dams will be 3 feet high, 12 inches thick, and 5 feet wide
- Check dams will be constructed of fiber-reinforced concrete

Reclaim Site and Install Gate at Top of Access Road

- Lockable truck gate will be installed at the top of access road to prevent off-highway vehicle use
- Site reclamation will consist of returning the staging area to similar condition as it was pre-removal action
- Revegetation will not be necessary

Install Bate Gate

- Tunnel portal is 6 feet by 8 feet
- Bat gate will be constructed of painted, welded steel
- Bat gate design will be comparable to the Boston Mine sluice tunnel bat gate (Tetra Tech 2006a)
- Requires drilling to set anchors in rock

Construct Warning Signs on Site

- Twenty signs will be installed to warn site visitors of potential marked and unmarked hazards
- Signs will be aluminum with 4-inch by 4-inch redwood posts

Site Security

- Temporary gates will be installed at the tunnel outlet and access road
- A night watchman will be present during non-working hours (nights and weekends) for the duration of construction

Site Maintenance

- Site maintenance will be performed during the dry season
- Sediment removed from behind the check dams will require off-site separation using the technology employed during the Pond Mine sluice tunnel sediment treatability study (see Appendix C)

- Washed sediment and heavy mineral concentrates (rotary table reject) from check dam sediment processing will be disposed of on site and will not require stabilization measures
- Elemental mercury and Number 2 Product separated during check dam sediment processing will be weighed and turned over to BLM for disposal
- The access road will require minimal re-grading, to occur in conjunction with sediment removal
- Four of the warning signs will require replacement every 5 years
- BLM will procure and manage necessary maintenance and perform annual inspections
- Annual inspection will include collecting two grab sediment samples for analysis of total mercury

B-2 ADDITIONAL COST ESTIMATE ASSUMPTIONS FOR ALTERNATIVE 2: CHECK DAM INSTALLATION AND INSTITUTIONAL CONTROLS

Item 5 – Construct Access Ramp to Plunge Pool

- Access ramp will be sufficient for access by backhoe, loader, or similar vehicle

Item 13 – Check Dam and Sign Maintenance

- Up to 10 cubic yards of sediment will be excavated from behind the check dams every 5 years
- A treatability study will not be necessary

B-3 ADDITIONAL COST ESTIMATE ASSUMPTIONS FOR ALTERNATIVE 3: IN SITU SEDIMENT COVERING, CHECK DAM INSTALLATION, AND INSTITUTIONAL CONTROLS

Item 2 – Equipment Mobilization/Demobilization

- Equipment will be mobilized and demobilized from the site two times to accommodate two construction seasons

Item 5 – Construct Access Ramp to Plunge Pool

- Access ramp will be sufficient for access by backhoe, loader, or similar vehicle

Item 7 – Provide Roof Support for Tunnel

- 161 linear feet of tunnel will be reinforced for safe entry
- Work inside the tunnel will require atmospheric testing, ventilation, and lighting

Item 9 – Smooth Sluice Tunnel and Plunge Pool Floors

- 1,600 feet of tunnel floor will be smoothed by hand at the average rate of 50 linear feet per day by a crew of four.
- Rocks larger than 8 inches will be removed
- No rocks heavier than 50 pounds will require removal

Item 10 – Cover Sluice Tunnel and Plunge Pool Floors with Concrete

- Sluice tunnel and plunge pool floors will be covered to an average depth of 4 inches with fiber-reinforced concrete
- Concrete cover will extend 12 inches up the sluice tunnel and plunge pool sidewalls and taper to a thickness of 1 inch
- Coarse rock used to cover the concrete surface on the plunge pool will be obtained from an on-site source

Item 11 – Winterize Site

- The site will be winterized one time between construction seasons
- Winterization measures include sand bags for sediment traps within the sluice tunnel where work ends after the first year, erosion control and water bars on the access roads, and general housekeeping
- Removal of new collapses is not included in site winterization
- Major reconstruction of the access road is not included in site winterization

Item 14 – Install Check Dams

- Two check dams will be constructed near the collapse 1,600 feet from the tunnel outlet. A third check dam will be constructed below the plunge pool.
- Check dams will be 3 feet high, 12 inches thick, and 5 feet wide
- Check dams will be constructed of reinforced concrete

Item 17 – Check Dam and Sign Maintenance

- Up to 10 cubic yards of sediment will be excavated from behind the check dam below the plunge pool every 10 years
- A treatability study will not be necessary

B-4 ADDITIONAL COST ESTIMATE ASSUMPTIONS FOR ALTERNATIVE 4: SEDIMENT EXCAVATION, ON-SITE PHYSICAL SEPARATION, ON-SITE DISPOSAL, COVERING, CHECK DAM INSTALLATION, AND INSTITUTIONAL CONTROLS

Item 2 – Equipment Mobilization/Demobilization

- All work will be completed over three seasons and will require three mobilizations and three demobilizations. Work during each season will be completed continuously.

Item 3 – Site Preparation and Security

- Includes minimal excavation work to improve existing ponds for site use

Item 5 – Construct Sluice Tunnel Outlet Staging Area

- Staging area will allow safe access to tunnel outlet for equipment necessary for sediment removal

Item 6 – Construct Access Ramp to Plunge Pool

- Access ramp will be sufficient for access by backhoe, loader, or similar vehicle

Item 7 – Provide Roof Support for Tunnel

- 161 linear feet of tunnel will be reinforced for safe entry
- Work inside the tunnel will require atmospheric testing, ventilation, and lighting

Item 9 – Remove Sediment and Wooden Sluice Boxes from Tunnel

- Remove no more than 1,000 loose cubic yards of sediment from 1,600 feet of tunnel floor
- Haul sediment and wood to process area
- Assume 30 percent expansion factor for excavated sediment

Item 10 – Clean Sediment from Plunge Pool

- Remove no more than 31 loose cubic yards of sediment from the plunge pool.
- Haul sediment to process area
- Assume 30 percent expansion factor for excavated sediment

Item 11 – Pressure Wash Sluice Tunnel and Plunge Pool Floors and Cover with Concrete

- Floor will be pressure washed with 60 gallons per minute at 60 pound per square inch
- Sluice tunnel and plunge pool floors will be covered to an average depth of 4 inches with fiber-reinforced concrete
- Concrete cover will extend 12 inches up the sluice tunnel and plunge pool sidewalls and taper to a thickness of 1 inch
- Coarse rock used to cover the concrete surface on the plunge pool will be obtained from an on-site source

Item 12 – Process Sluice Tunnel and Plunge Pool Sediment

- Sediment removed from behind the check dams will require off-site separation using the technology employed during the Pond Mine sluice tunnel sediment treatability study (see Appendix C)
- Washed sediment from the processing plant will be disposed of on site and will not require stabilization measures
- Up to 5 cubic yards of heavy mineral concentrates (rotary table reject) from the processing plant will be stabilized and buried on site
- Elemental mercury and Number 2 Product separated during check dam sediment processing will be weighed and turned over to BLM for disposal
- Existing site ponds will be used to retain and recycle process water
- Used process water will contain mercury, lead, and suspended solids at concentrations that prohibit direct discharge to surface water
- A treatability study will not be necessary

Item 13 – Dispose of Sluice Box Remnants

- Wooden sluice box boards will be hauled to the Kettleman landfill and disposed of as nonhazardous waste
- Characterization sampling will be required
- Total board weight will not exceed 7.5 tons
- Boards will be placed in 20-yard roll-away bin for transport to Kettleman
- Boards will remain on site to dry out

Item 15 – Winterize Site

- The site will be winterized two times between construction seasons

- Winterization measures include sand bag sediment traps within the sluice tunnel where work ends after the first year, erosion control and water bars on the access roads, and general housekeeping
- Removal of new collapses is not included in site winterization
- Major reconstruction of the access road is not included in site winterization

Item 17 – Conduct Additional Exploratory Reconnaissance

- Remove caved material 1,600 feet back from sluice tunnel outlet
- Support additional 50 linear feet of tunnel

Item 18 – Install Check Dams

- Two check dams will be constructed near the collapse 1,600 feet from tunnel outlet. A third check dam will be constructed below the plunge pool.
- Check dams will be 3 feet high, 12 inches thick, and 5 feet wide
- Check dams will be constructed of reinforced concrete

Item 21 – Check Dam and Sign Maintenance

- Up to 10 cubic yards of sediment will be excavated from behind the check dam below the plunge pool every 15 years
- A treatability study will not be necessary

APPENDIX C
TREATABILITY STUDY TECHNICAL MEMORANDUM

APPENDIX C: TREATABILITY STUDY TECHNICAL MEMORANDUM

Tetra Tech EM Inc. (Tetra Tech) is under contract to the U.S. Department of the Interior, Bureau of Land Management (BLM), California State Office, to conduct a pilot-scale treatability study to evaluate the effectiveness of traditional gravity separation techniques to separate heavy mineral concentrates and free liquid mercury from sluice tunnel sediment at the Pond Mine in Placer County, California. Tetra Tech teamed with Cherokee Development Corporation (Cherokee) to complete the treatability study; Tetra Tech provided project management and sampling for the treatability study, and Cherokee provided equipment and construction services. This work was performed under U.S. Department of Agriculture Forest Service Contract Number AG91SC060024, Requisition Number R068425/0001.

This memorandum provides project background information, describes field activities, summarizes laboratory analytical results, and provides Tetra Tech's conclusions and recommendations based on observations and analytical data from the Pond Mine pilot-scale treatability study.

C1.0 PROJECT BACKGROUND

Sediment in the sluice tunnel at the Pond Mine was identified as containing elevated concentrations of mercury (up to 45 milligrams per kilogram [mg/kg]) (Tetra Tech 2004a, 2004b). During the underground reconnaissance included in this project, Cherokee panned free liquid mercury from more than a dozen different locations within the sluice tunnel. This mercury is available to be physically transported off site and is being accumulated in biota at the site (BLM 2005).

Based on the free liquid mercury observed in the Pond Mine sluice tunnel sediment and BLM's experience at similar abandoned hydraulic mine sites, Tetra Tech suggested gravity separation as a potential method for segregating liquid mercury and other heavy minerals from sluice tunnel sediments. However, the concentration of residual mercury in washed sediment and process water discharged from the gravity separation plant were not known. The need for a treatability study was identified in light of these uncertainties and potential impacts of these unknowns on treatment costs. This memorandum documents the pilot-scale treatability study performed to evaluate these uncertainties.

C2.0 FIELD ACTIVITIES

Field activities completed during the treatability study consisted of sluice tunnel sediment collection, sediment processing, sample collection and analysis, and disposal of process materials. These activities are described below.

C2.1 Sluice Tunnel Sediment Collection

Approximately 2,000 pounds (net dry weight) of sediment was collected from the Pond Mine sluice tunnel on August 29, 2006. Equal volumes of sediment (40 5-gallon buckets filled ¾ full; roughly ¾ cubic yard [yd^3]) were collected from two locations within the sluice tunnel where hand panning indicated liquid mercury was present. Hand tools were used to load sediment into the 5-gallon buckets, which were carried out of the mine tunnel. The sluice tunnel sediment consisted primarily of silt- to gravel-sized particles with some cobbles and a minor amount of clay (see Photograph C-1). Sluice tunnel sediment was excavated to the tunnel floor to capture mercury that was anticipated to accumulate at the bedrock surface. The sediment was collected at locations where liquid mercury was observed to be present and therefore may overestimate the concentration of mercury in sediment throughout the tunnel.

C2.2 Sediment Processing

A trailer-mounted, electric-powered aggregate processing plant was mobilized to process the Pond Mine sluice tunnel sediment. The plant consisted of a hopper, a trommel, and a Knudsen bowl. A gasoline-powered pump was used to feed source water from a tank to the processing plant. The 40 buckets of sluice tunnel sediment were emptied by hand into the hopper. Internal jets sprayed water on the material to wash gravel, sand, and fines through the trommel screen. Cobbles were washed clean by the jets and tumbling action and discharged from the end of the trommel. Gravel that passed through the trommel screen was discharged from a chute. Sand and fines were further processed in a Knudsen bowl, which used centrifugal force and a constant flow of water to capture heavy minerals in riffles on the interior of the bowl. Lighter particles (sand, silt, and clay) were washed out of the bowl and discharged from the processing plant. Washed cobbles, gravel, and sand discharged from the processing plant accumulated in a small excavation that was lined with plastic sheeting. Used process water discharged to the lined excavation was pumped into a tank for storage until an appropriate disposal method was selected based on analysis of the samples. Photographs of aggregate plant operation are presented as Photographs C-2 through C-4.

Less than ¼ cubic foot (2 gallons) of heavy mineral concentrates captured in the Knudsen bowl were taken to a rotary concentration table that was used to separate elemental mercury, amalgam, and black sands. Liquid mercury and amalgam separated at the rotary table were placed into a vial, weighed, and secured inside a secondary container. Material other than mercury and amalgam that was separated at the rotary table (primarily black sands with minor pyrite, called the “Number 2 Product”) was placed in a glass jar. Reject from the rotary table was contained in a plastic tub. Photographs of rotary concentration table operation are presented as Photographs C-5 and C-6.

Processing 2,000 pounds of sediment from the Pond Mine sluice tunnel required 18 minutes of plant time and consumed approximately 600 gallons of process water. Sediment processing generated 33 grams (1.2 ounces; measure of mass) of elemental mercury and amalgam and

approximately 1.3 ounces (1/3 of a 4-oz jar; measure of volume) of Number 2 Product. Photographs of elemental mercury and Number 2 Product segregated during the treatability study are presented as Photographs C-7 and C-8.

C2.3 Sample Collection and Analysis

Field samples were collected during the treatability study to characterize the process water and washed solids. Sampling and analytical procedures were conducted in accordance with the field sampling plan and quality assurance project plan in the project work plan (Tetra Tech 2006). Water samples were analyzed for total and dissolved (field filtered to 0.45 microns) lead and mercury and total suspended solids (TSS). Solid matrix samples were analyzed for total lead and mercury and for leachable lead and mercury by the waste extraction test using a de-ionized water leaching solution (DI WET). Analytical results for water and solid matrix samples are presented in Tables C-1 and C-2 and are discussed below by sample type. Laboratory data packages are presented in Attachment C-1.

Analytical results for treatability study samples were compared with established screening benchmarks to provide a context for managing the process water and washed solids. Screening benchmarks used for this comparison are summarized below and are discussed in greater detail in Sections 4.1, 4.2, and 5.2 of the engineering evaluation and cost analysis (EE/CA).

- **Risk management criteria for BLM mining sites.** BLM risk management criteria are established for a number of metals at mining sites under multiple human exposure and ecological receptor scenarios (Ford 1996). The BLM risk management criteria are to be used by land managers as a cautionary sign that potential health hazards are present and that natural resource management or remedial actions are warranted.
- **U.S. Environmental Protection Agency (EPA) Region 9 preliminary remediation goals (PRG).** EPA Region IX PRGs are risk-based concentrations that are intended to assist risk assessors and others in initial screening-level evaluations of environmental measurements (Smucker 2004). PRGs are not legally enforceable standards. The California-modified residential PRG was used for lead.
- **Total threshold limit concentration (TTLC).** Concentrations of metals in solid matrix samples were compared with the TTLC. The material is considered a non-Resource Conservation and Recovery Act hazardous waste if concentrations of metals exceed the TTLC.
- **EPA maximum contaminant level (MCL).** Concentrations of metals in water samples (including DI WET leachates) were compared with the MCLs. MCLs are legally enforceable standards applied at the tap to water that is delivered directly to 25 or more people or to 15 or more service connections.

- **California Toxics Rule (CTR).** Concentrations of metals in water samples (including DI WET leachates) were compared with the CTR criteria for the protection of inland surface waters (fresh water) subject to human consumption of water and aquatic organisms. EPA established CTR criteria under the authority of the Clean Water Act.

- **EPA ambient water quality criteria (AWQC).** Concentrations of metals in water samples (including DI WET leachates) were compared with the AWQC for the protection of freshwater aquatic organisms for continuous (4-day average) and maximum (1-hour average) concentrations. AWQC are non-enforceable guidance developed by EPA and used by the state to establish water quality standards.

C2.3.1 Process Water Samples

Tetra Tech collected a composite sample of process water discharged from the aggregate plant and a grab sample of process water discharged from the rotary table. The composite sample from the aggregate plant consisted of four 250-milliliter (mL) grab samples collected at approximately equal intervals while Pond Mine sediment was processed. The grab samples were collected by holding the open container below the discharge chute from the aggregate plant. The four 250-mL grab samples were combined into single 1,000-mL bottles for analysis of total metals and TSS (separate bottles for the different analyses) to form the composite sample. For analysis of dissolved metals, water was pumped from the four 250-mL bottles through a 0.45-micron disposable filter and into a 1,000-mL bottle using a peristaltic pump. The grab sample from the rotary table was collected by filling appropriate sample containers with water from the plastic tub below the table, where reject was collected. The rotary table used a fraction of the volume of water used by the aggregate plant, but concentrations of metals were anticipated to be higher based on the concentrated nature of material processed at the rotary table. Once the sample containers were filled, the bottles were labeled and placed in a cooler on ice for transport under chain-of-custody (COC) procedures to the project laboratory for analysis.

Laboratory analysis of the Pond Mine process water sample from the aggregate plant showed that the concentration of total lead (575 micrograms per liter [µg/L]) exceeded all of the surface water screening criteria (from 0.54 to 480 µg/L). The concentration of total mercury in the process water sample (0.24 µg/L) exceeded the CTR criterion (0.05 µg/L). Analysis of filtered samples showed that dissolved concentrations of both metals were below the method detection limit (MDL) (41 µg/L for lead and 0.1 µg/L for mercury). These results indicate that lead and mercury detected in the unfiltered sample are associated with suspended sediment particles. The process water sample from the aggregate plant contained a high concentration of TSS (23,900 milligrams per liter [mg/L]).

Laboratory analysis of the rotary table process water sample showed concentrations of total and dissolved lead were below the MDL (41 µg/L), but concentrations of total mercury (0.392 µg/L) and dissolved mercury (0.776 µg/L) exceeded the lowest screening criteria (0.05 µg/L for total mercury and 0.77 µg/L for dissolved mercury). It is unclear why the reported concentration for

dissolved mercury is higher than the reported concentration for total mercury. It is possible that the sample containers or identification numbers were reversed.

C2.3.2 Washed Solids Samples

Tetra Tech collected three solid samples to characterize the material washed and separated during the treatability study. The three samples included coarse material (sand and gravel) and fine material (silt and sand) discharged from the processing plant and reject from the rotary table. The Number 2 Product was not sampled because it is assumed to contain elevated concentrations of lead and mercury, and therefore to require special handling. The sample of washed coarse material was collected after processing was completed from four points within a mound of sand and gravel that formed below the discharge chute from the aggregate plant. The sample of washed fine material was collected after processing was completed from four points in the washed sediment collection pit, where fine material settled. The sample of fine material contained less clay than was desired because much of the clay was suspended in the discharged process water and pumped into the water tank to prevent overflow from the collection pit during processing. The rotary table reject sample was collected from the inside lip of the table before it overflowed into the collection tub below the table. The rotary table reject sample is believed to provide an upper estimate of the concentrations of mercury and lead because traces of the heavy metals may have remained in the inside lip of the table. (The lighter material overflowed into the collection tub.) Solid matrix samples were scooped with a previously unused plastic spoon into glass sample containers, labeled, and placed in a cooler on ice for transport under COC procedures to the project laboratory for analysis.

Laboratory analysis of the Pond Mine washed sediment samples showed that concentrations of lead and mercury were below the screening criteria. Concentrations of lead and mercury in a DI WET leachate from the washed coarse and fine material were below the MDL (50 µg/L for lead and an estimated 0.3 µg/L for mercury), though both MDLs are above the lowest water quality screening criteria.

C2.3.3 Quality Control Samples

Tetra Tech collected field samples for quality control (QC) during the treatability study. QC samples included a sample of source water used at the aggregate plant and rotary table and an aggregate plant process water sample during check sample processing. The check sample consisted of 550 pounds of aggregate for use in concrete obtained from a site not believed to contain mercury. The source water blank was a grab sample collected from the source water tank to assess chemical concentrations in the water used for processing. The process water grab sample collected at the aggregate plant during check sample processing was analyzed to evaluate the cleansing process after the treatability study. Both samples were collected and prepared by the same procedures described above for real samples. The source water blank was analyzed for total and dissolved lead and mercury and TSS. The check sample process water sample was analyzed for total lead and mercury.

Laboratory analysis of the source water blank showed that lead, mercury, and TSS concentrations were all below the MDL. Laboratory analysis of the check sample process water detected an elevated concentration of total lead (135 µg/L), but mercury was below the MDL (41 µg/L). Lead and mercury were detected at higher concentrations in the Pond Mine aggregate plant process water sample than in the check sample process water sample.

C2.4 Disposal of Process Materials

The Pond Mine treatability study generated six different materials or fluids that required disposal, each of which is described below.

Washed sediment. Washed cobbles, gravel, sand, and fines discharged from the aggregate plant made up the majority of the 2,000 pounds of sluice tunnel sediment processed during the treatability study. Laboratory analytical data for treatability study samples showed the material is not hazardous and does not pose a significant risk to likely receptors (based on comparison to screening criteria). The washed sediment was disposed of on site.

Rotary table reject. Rotary table reject consisted of heavy mineral concentrates separated by the aggregate plant, from which the heavy minerals were separated. Rotary table reject from the Pond Mine treatability study was collected in a plastic tub below the rotary table. Laboratory analytical data for the rotary table reject samples showed the material is not hazardous and does not pose a significant risk to likely receptors (based on comparison to screening criteria). The rotary table reject was disposed of on site.

Elemental mercury and amalgam. Thirty-three grams of elemental mercury and amalgam were separated from the heavy mineral concentrates using the rotary table. The mercury was placed in double containment and provided to BLM for disposal.

Number 2 Product. Number 2 Product consisted of heavy minerals other than mercury that were separated from the heavy mineral concentrates using the rotary table. Number 2 Product consisted mainly of fine-grained black sands with minor pyrite. Fine droplets of mercury or amalgam may also be present. The Number 2 Product filled a 4-ounce glass jar approximately 1/3 full. Number 2 Product was provided to BLM for disposal.

Aggregate plant process water. Approximately 600 gallons of process water was generated during the Pond Mine treatability study. The process water was temporarily stored in a portable water tank. Results for analysis of process water showed concentrations of lead and mercury were above surface water criteria. After analytical results were available, process water was released to a large metal plate with a rim and allowed to evaporate. Sediment that remained on the plate after the water evaporated was disposed of on site.

Rotary table process water. Less than 100 gallons of water was used at the rotary table. Rotary table process water was contained in the reject tub below the table. The water was combined with the aggregate plant process water for evaporation and disposal.

C3.0 CONCLUSIONS AND RECOMMENDATIONS

The trailer-mounted aggregate plant and rotary concentrating table used during the treatability study proved highly effective at separating mercury from Pond Mine sluice tunnel sediment. Processing 2,000 pounds (roughly ¾ yd^3) of sediment required approximately 600 gallons of water and 18 minutes of aggregate plant operation. Based on observations and analytical data from the treatability study, the following considerations are provided for implementing this treatment technology at the Pond Mine:

- There are many different designs for aggregate washing and separating plants. Results presented in this memorandum are specific to the aggregate plant and rotary concentrating table used during the Pond Mine treatability study.
- Approximately 99 percent of the sluice tunnel sediment processed at the aggregate plant was discharged as washed cobbles, gravel, sand, and fines that may be suitable for on-site disposal. Assuming 1,031 loose yd^3 of material will require treatment (see the EE/CA report), sediment processing will generate 1,021 yd^3 of washed material. Additional leaching analysis may be necessary to evaluate potential impacts to groundwater if the washed sediment is placed where meteoric water can infiltrate.
- Approximately 1 percent of the sluice tunnel sediment washed at the aggregate plant was separated as heavy mineral concentrates. Approximately 99 percent of the heavy mineral concentrates (rotary table reject) may be suitable for on-site disposal. Assuming 1,031 yd^3 of material will require treatment (see the EE/CA report), sediment processing will generate 10 yd^3 of heavy mineral concentrates. Additional leaching analysis may be necessary to evaluate potential impacts to groundwater if the washed sediment is placed where meteoric water can infiltrate. If concentrations of metals in leachate are problematic, the heavy mineral concentrates could be stabilized/solidified and buried on site.
- Thirty-three grams (1.2 ounces; measure of mass) of elemental mercury and amalgam were separated from 2,000 pounds of sluice tunnel sediment. This amount equates to approximately 0.004 percent mercury separated from sluice tunnel sediment. Assuming 1,031 yd^3 of material will require treatment (see the EE/CA report), sediment processing will generate more than 103 pounds of mercury and amalgam. Elemental mercury and amalgam will require handling as a hazardous substance. Fine gold may be present and recoverable in the amalgam.

- Approximately 1.3 ounces (measure of volume) of Number 2 Product was separated from 2,000 pounds (¾ yd^3) of sluice tunnel sediment. This amount equates to approximately 0.005 percent Number 2 Product from sluice tunnel sediment. Assuming 1,031 yd^3 of material will require treatment (see the EE/CA report), sediment processing will generate 1.39 cubic feet of Number 2 Product. Number 2 Product will likely require special handling because of the total and leachable concentrations of lead and mercury.

- Process water from the aggregate plant and rotary table will likely contain lead and mercury at concentrations that prohibit direct discharge to surface water bodies. Treatability study sampling showed that most metals are associated with suspended particles. Furthermore, discharged process water was very turbid. Water quality criteria for suspended solids in receiving surface waters are based on nuisance and the measured turbidity of the receiving water. Process water may be disposed of by evaporation or treated to meet criteria for discharge.

- The aggregate plant and rotary table will require a reliable source of process water.

- Tetra Tech recommends against processing remnants of the wooden sluice box from the Pond Mine sluice tunnel using the aggregate plant because of challenges in profiling the wood for disposal and in segregating washed wood from washed sediment.

C4.0 REFERENCES

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PHOTOGRAPHS

Photograph C-1

Buckets of Pond Mine sluice tunnel sediment before being processed during the treatability study.

September 19, 2006

Photograph C-2

Aggregate processing plant used during the Pond Mine sluice tunnel sediment treatability study. Jets are spraying water inside the rotating trommel to wash large gravel and cobbles.

September 19, 2006

Photograph C-3

Chute where fines, sand, and gravel are discharged from the aggregate processing plant during the Pond Mine sluice tunnel sediment treatability study.

September 19, 2006

Photograph C-4

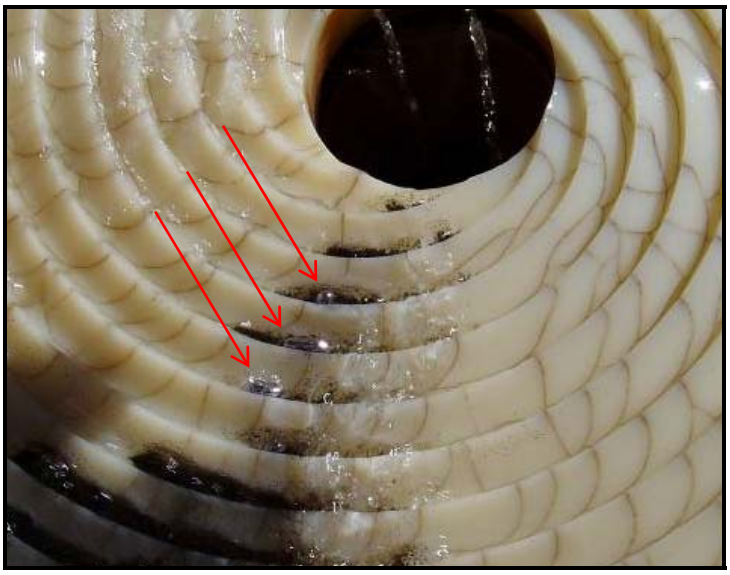
Knudsen bowl on the aggregate processing plant during the Pond Mine sluice tunnel sediment treatability study.

September 19, 2006

Photograph C-5

Rotary concentration table used to separate mercury from the heavy mineral concentrates (sediment in the Knudsen bowl). Mercury and other heavy minerals climb the spirals into the hole in the center. Rotary table reject spills over the lower lip.

September 19, 2006



Photograph C-6

Close-up of the rotary concentration table. Arrows mark beads of elemental mercury.

September 19, 2006

Photograph C-7

Elemental mercury and Number 2 Product segregated during the Pond Mine sluice tunnel sediment treatability study.

September 19, 2006

Photograph C-8

Elemental mercury and Number 2 Product segregated during the Pond Mine sluice tunnel sediment treatability study.

November 8, 2006

TABLES

Table C-1. Analytical Results for Water Samples Collected During the Pond Mine Treatability Study

Sample Number	Description	Sample Time	Total (µg/L) Lead	Total (µg/L) Mercury	Dissolved (µg/L) Lead	Dissolved (µg/L) Mercury	TSS (mg/L)
POORE-TRT-ER-091906	Process plant discharge water collected during check sample processing, before Pond Mine sediment processing. Discrete grab sample.	11:45	**135**	<0.1	--	--	--
POND-TRT-SW-091906	Source water. Discrete grab sample.	11:20	<41	<0.1	<41	<0.1	<5
POND-TRT-PW-091906	Process plant discharge water collected during Pond Mine sediment processing. Four-point composite.	13:50	**575**	**0.24**	<41	<0.1	23,900
POND-TRT-CW-091906	Process water from the spiral concentration table after mercury separation. Discrete grab sample.	15:10	<41	**0.392**	<41	**0.776**	--
Screening Criteria							
Human Risk Management Criteria for BLM Mining Sites, Camper Scenario[a]			**50**	93	--	--	--
U.S. Environmental Protection Agency Maximum Contaminant Level[b]			**15**	2	--	--	--
California Toxics Rule Criteria for Inland Surface Water, Human Consumption of Water and Aquatic Organisms[b]			**--**	**0.05**	--	--	--
U.S. Environmental Protection Agency AWQC, Continuous Concentration (4-day average)[b]			**0.54 to 19[c]**	--	0.54 to 11[c]	**0.77**	--
U.S. Environmental Protection Agency AWQC, Maximum Concentration (1-hour average)[b]			**14 to 480[c]**	--	14 to 280[c]	1.4	--

Notes:

Bold text indicates detected concentration exceeds screening criteria; criteria also in bold.

[a] Source: Ford 1996

[b] Source: Marshack 2003

[c] Value depends on the hardness of the receiving water body. Range is for receiving water hardness of 25 to 400 milligrams per liter as calcium carbonate.

< Less than

-- Not analyzed

µg/L Microgram per liter

AWQC Ambient water quality criteria

BLM U.S. Department of the Interior, Bureau of Land Management

mg/L Milligram per liter

TSS Total suspended solids

Table C-2. Analytical Results for Washed Sediment Samples Collected During the Pond Mine Treatability Study

Sample Number	Description	Sample Time	Total Concentration (mg/kg)		DI WET Leachate Concentration (µg/L)	
			Lead	Mercury	Lead	Mercury
POND-TRT-CRS-091906	Washed coarse material (sand and gravel) discharged from the processing plant.	14:00	12	2.9	<50	<0.3 N
POND-TRT-FIN-091906	Washed fine material (sand and silt) discharged from the processing plant.	14:05	12 B	1.8	<50	<0.3 N
POND-TRT-HMC-091906	Heavy mineral concentrates from the processing plant after mercury separation. Reject from the spiral concentration table.	14:20	15	2.0	<50	<0.3 N
Screening Criteria						
Human Risk Management Criteria for BLM Mining Sites, Camper Scenario[a]			1,000	40	50	93
Wildlife and Livestock Risk Management Criteria for BLM Mining Sites, Median Concentration[a]			125	8	--	--
U.S. Environmental Protection Agency Region 9 Residential Preliminary Remediation Goal[b]			150[c]	23	--	--
U.S. Environmental Protection Agency Region 9 Industrial Preliminary Remediation Goal[b]			800	310	--	--
Total Threshold Limit Concentration			1,000	20	--	--
U.S. Environmental Protection Agency Maximum Contaminant Level[d]			--	--	15	2
California Toxics Rule Criteria for Inland Surface Water, Human Consumption of Water and Aquatic Organisms[d]			--	--	--	0.5
U.S. Environmental Protection Agency AWQC, Continuous Concentration (4-day average)[d]			--	--	0.54 to 19[e]	0.77[f]
U.S. Environmental Protection Agency AWQC, Maximum Concentration (1-hour average)[d]			--	--	14 to 480[e]	1.4[f]

Notes:

[a]	Source: Ford 1996
[b]	Source: Smucker 2004
[c]	California modified preliminary remediation goal
[d]	Source: Marshack 2003
[e]	Value depends on the hardness of the receiving water body. Range is for receiving water hardness of 25 to 400 milligrams per liter as calcium carbonate.
[f]	Dissolved concentration
<	Less than
--	Not promulgated
µg/L	Microgram per liter
B	Estimated
AWQC	Ambient water quality criteria
BLM	U.S. Department of the Interior, Bureau of Land Management
DI WET	Waste extraction test using a deionized water extraction solution
mg/kg	Milligram per kilogram
N	Spiked sample recovery not within control limits

ATTACHMENT C-1
LABORATORY ANALYTICAL DATA
(Presented on Compact Disc)