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**ARGONAUT MINE TAILINGS SITE
SITE INVESTIGATION REPORT**

Prepared for:

**Agreement No. 07-T337.5
California Environmental Protection Agency
Department of Toxic Substances Control
Northern California Central Cleanup Operations Branch
8800 Cal Center Drive
Sacramento, California 95826**

Prepared by:

URS
**2870 Gateway Oaks Drive, Suite 150
Sacramento, California 95833**

March 2009

IDENTIFICATION & APPROVAL FORM

Document Title: ARGONAUT MINE SITE INVESTIGATION REPORT, SACRAMENTO, CALIFORNIA

Prepared for: Department of Toxic Substances Control
Northern California Central Cleanup Operations Branch
8800 Cal Center Drive
Sacramento, California 95826

Prepared by: Don Gruber
URS Corporation
2870 Gateway Oaks Drive, Suite 150
Sacramento, California 95833

Approved by:

Signature: _____ Date: _____
Name: Don Gruber
Title: URS Project Manager

Signature: _____ Date: _____
Name: Scott Rice, R.G.
Title: URS Program Manager

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- Tami Treasre, DTSC Project Manager

URS Corporation

- Don Gruber, Project Manager
- Scott Rice, Program Manager
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ABBREVIATIONS AND ACRONYMS

bgs	below ground surface
°C	degrees Celsius
CHHSLs	California Human Health Screen Levels for Soils
COPC	contaminants of potential concern
C&T	Curtis & Tompkins, Ltd.
DTSC	Department of Toxic Substances Control
GIS	geographic information system
MCL	maximum contaminant level
mg/kg	milligrams per kilogram, equivalent to parts per million (ppm)
PPE	personal protective equipment
PVC	polyvinyl chloride
sonic	vibratory sonic
URS	URS Corporation
USCS	Unified Soils Classification System
XRF	x-ray fluorescence

1.0 INTRODUCTION

This site investigation report (SIR) presents the results of a site investigation conducted at the Argonaut Mine Tailings Site in Jackson, Amador County, California (Figure 1). The primary objectives of the investigation activities were to determine the type and extent of contamination on the entire site (approximately 65 acres) and evaluate mitigation measures for an approximately 3-acre portion of the site that has been impacted by the mine tailings. This report has been prepared by URS Corporation (URS) for the California Environmental Protection Agency, Department of Toxic Substances Control (DTSC), under Agreement No. 07-T337.5.

The investigation activities were conducted by URS in accordance with *Investigation Work Plan, Argonaut Mine Tailings* (URS, 2008).

1.1 SITE LOCATION

The Argonaut Mine Tailings Site is approximately 65 acres of undeveloped land located in the City of Jackson, California. The site is an open space surrounded by new residential development (housing), county offices, a high school, and open areas. In 1990, a portion of the property was sold and developed into residential housing. The corresponding county parcel numbers are 44-010-100-00, 44-010-074-00, 44-010-082-00, 44-010-083-00, and 44-010-084-00 (referred to as Parcel #100, 74, 82, 83 and 84, respectively, on Figures 1, 2, and 3). Located northwest area of the site (Parcel #100, approximately 11 acres) are the Amador Metal Reductions custom mill, two ponds, a tailings pile, and three former cyanide tanks. The northwest portion (approximately 3 acres) of this parcel is generally devoid of plant life and the tailings piles of concern are located on this parcel. For purpose of the investigation activities described in this work plan, the northwest portion of Parcel #100 has been designated as Area 1 and the remainder of the site has been designated as Area 2.

1.2 OBJECTIVES

The specific objectives of the 2008 investigation were as follows:

- Assess the lateral and vertical extent of impacted soil and groundwater beneath the site.
- Provide additional analytical data to assess potential source(s) of soil and groundwater contamination impacting the site and determine contaminants of potential concern (COPCs) within tailings at the site.
- Provide lithological and analytical data to be used for determining the potential volume of tailings that exists at the site.
- Collect sufficient data in Area 1 for evaluation of mitigation measures in a remedial action work plan.

The following tasks were completed during the 2008 investigation to meet the objectives:

- Drilled and collected soil and depth-discrete groundwater samples from 46 soil borings (12 from Area 1 [see Figure 2] and 34 from Area 2 [see Figure 3]) to a maximum depth of 80 feet below ground surface (bgs) using direct-push, vibratory sonic (sonic) drilling systems.

- Collected depth-discrete groundwater samples from four sonic borings within Area 2.

1.3 REPORT FORMAT

This report consists of the following sections:

- Section 1.0 – Introduction: Provides background site information, including a brief summary of the previous investigations performed at the site.
- Section 2.0 – Investigation: Describes the field work associated with the 2008 investigation.
- Section 3.0 – Results: Presents analytical results of samples collected during the 2008 investigation direct push and sonic soil logging.
- Section 4.0 – Conclusions and Recommendations: Presents conclusions and recommendations based on analytical results, historical data, and field observations.
- Section 5.0 – References: Lists references used to prepare this report.

Tables and figures are provided at the end of this report, followed by the referenced appendices.

1.4 SITE BACKGROUND

1.4.1 Operational History

The Argonaut Mine operated from the 1850s until 1942 processing ore from the Argonaut Gold Mine. The ore was processed through the Argonaut Mill (located approximately 0.5 mile north of the site). From 1923 to 1938, the tailings were hydraulically transported from the Argonaut Mill through aboveground pipes and impounded in large ponds. Circa 1923, Amador Metal Reductions built a custom mill in the tailings area. Amador Metals Reductions reprocessed the tailings from that time until October 1938. In March 1942, the mine ceased operations. Today, several thousand tons of tailings remain on the site.

From the mid-1800s until 1936, ore was crushed in a stamp mill at the site. In 1936, the Amador Metals Reduction Company began using cyanide for ore processing at the site. Cyanide residue was placed on the property (within the basin) adjacent to the processing plant. The concrete remains of the processing plant and tanks are located approximately 400 feet southeast of Area 1. Tailings from the stamp mill were apparently ponded and piled on Area 1 for further processing. A concrete dam was constructed on the eastern-most extent of the property, to prevent the tailings from entering Jackson Creek. The dam, located approximately 2,100 feet down slope of the processing plant, was positioned in a natural drainage basin at an elevation 160 feet below the plant. Tailings and sediment have migrated to the basin and have filled the natural depression since the dam was constructed.

In June 1987, Biomet II leased the property from the current owner to remove tailings (several tons) from Area 1 and transport them to Nevada for further processing. Since 1988, no further mining or business activity has taken place at the site.

1.4.2 Regulatory History

The California Regional Water Quality Control Board made DTSC aware of the site after completing surface water runoff investigations. In response, DTSC investigated the site in 1993, collected soil samples in Area 1 and found the soil and tailings to be impacted by arsenic and lead. The maximum arsenic level reported was approximately 24,500 milligrams per kilogram (mg/kg). At that time, DTSC determined that the site required fence repairs to keep people and animals off the property. In 1995, DTSC installed a fence on the site. DTSC inspected the site in October 2006 and observed that a large portion of the fencing was down and both foot and bicycle tracks were present on site. The fence posts had corroded where the metal posts touched the soil/tailings allowing the posts to come down. In June 2007, DTSC had the fence repaired.

1.4.3 Previous Investigation Results

Analysis of the soil samples collected in June 1993 indicated that the site contained elevated levels of arsenic, lead, and mercury. Arsenic concentrations at the site were identified as the greatest concern because the maximum concentration of arsenic detected was 24,500 mg/kg. Additional soil samples were collected and analyzed during the site visit on October 6, 2006, using x-ray fluorescence (XRF) techniques. The XRF indicated that the arsenic concentrations remained at the site at levels up to 7,227 mg/kg. The visit also revealed that, along with high levels of arsenic, acidic levels in soil at the site are high enough to corrode metal.

1.4.4 Site Description

The site slopes generally downward towards the east-southeast. An intermittent creek runs the length of the site, and carries surface drainage from its northern portion through multiple drainage areas. The creek flows southeastward to the concrete dam at the eastern portion of the site. Concrete vats were constructed along the creek immediately southeast of Area 1. The concrete vats previously held cyanide that was used while processing the tailings.

The site is primarily covered with gray sands which are considered processed tailings from the Argonaut Mine. It is estimated that the depth of the gray sands at the northern area of the site is 25 feet, and the sand extends deeper toward the southern portion of the site to at least 80 feet bgs. The surface material (tailings) is lighter color near the surface, becoming progressively darker with depth.

The area of greatest environmental concern is located at the northwest portion of the property, where an area of approximately 3 acres is devoid of plant and animal life (66 years after operations ceased). Based on DTSC investigations, this area (designated as Area 1) contains the least-processed tailings and the greatest concentrations of arsenic. The remainder of the site (described in the following paragraph) contains flora consisting primarily of native grasses, evergreens (mixed), and planted trees near water. There are several areas southeast of Area 1 that contain processed tailings with no vegetative cover. The south-southwestern portion of the site is an open field vegetated with native grasses.

Currently, two areas within the site serve as retention basins (see the two vegetated, grass-covered areas shown on Figure 3). There are also local areas of saturated sediments with standing water in the basins. One of the retention basins is located near the center of the site (property) and runoff from that basin is contained by a berm constructed from tailings. Runoff from the other retention basin is contained by the berm from the first basin to the west and the concrete dam to the east. Both of the basins contain trees, vegetation, and water. The

area between the upgradient basin and the processing plant is generally less vegetated than the two basins and contains the largest volume of tailings on the site.

1.4.5 Geology

The following is a general description of the geology in the Jackson-Plymouth Gold District (Clark, 1980). Gold deposits are in a north- and northwest-trending mile-wide belt of gray to black slate of the Mariposa Formation (Upper Jurassic age), with some interbedded coarse and locally sheared conglomerate and minor sandy layers. Massive greenstone of the Logtown Ridge Formation (Upper Jurassic) lies west of the belt of Mariposa Formation slate. Metasedimentary rocks, chiefly graphitic schist, metachert, and amphibolite of the Calaveras Formation (Carboniferous to Permian) are to the east. Several deposits of Tertiary auriferous (gold bearing) channel gravels are exposed south of Jackson. Alluvial soils, such as Pardee cobbly loam, are found throughout the ground surface in the Jackson area.

A brief discussion of the nature of the ore deposits in this mining district is important to understand the characteristics of the native rock at the site. The ore deposits occur in massive and sheared quartz veins commonly with abundant fault gouge. The veins are mainly in Mariposa Formation slate, sometimes tens of feet thick. Veinlets or stringers are also common. The ore deposits contain disseminated fine free gold, pyrite (arsenic sulfide), and minor amounts of other sulfides. The sulfides usually average one to two percent of the ore. Greenstone masses with disseminated auriferous pyrite known as “gray ore” are locally adjacent to the quartz veins at depth (Clark, 1980).

2.0 2008 SITE INVESTIGATION

Site activities for the 2008 investigation consisted of drilling, soil sampling, and groundwater sampling within Area 1 (parcel #100) and Area 2 (parcel #s 74, 82, 83, and 84). This section describes the strategy that was used to characterize the tailings (metals contamination), sediments, and groundwater. To assess the concentration of metals in the tailings (and possibly native material) and the volume of the tailings, direct-push and sonic drilling methods were used to collect soil and groundwater samples. A brief overview of the investigation is also presented in this section, followed by a detailed discussion of field activities. Results of these activities are presented in Section 3.0.

2.1 INVESTIGATION OVERVIEW

This section presents the activities conducted by URS staff to complete the objectives described in Subsection 1.2. Detailed procedures for the completion of each task are contained in this section. All work was performed in accordance with the approved project work plan (URS, 2008). Site investigation activities included the following:

- Samples were collected from 12 soil boreholes (SB-1 through SB-12) located on approximately 3 acres in the northeast portion of parcel #100 (Area 1). This sampling was performed to assess the lateral and vertical extent of impacted soil. An unknown amount of tailings from this area were previously removed in 1987. The sampling rationale was based on the assumption that the remaining tailings were less than 5 feet deep in Area 1. Soil samples were collected from at least two depths from each borehole within the tailings. If no tailings were observed at a sample location, only a surface sample of the native material was collected. The boreholes were drilled until native soil was encountered to determine the tailings total depth thickness. To ensure laboratory soil samples were collected from the non-impacted soil in Area 1, DTSC field-screened background soil samples using a multi-element low-energy XRF analyzer. The field screening was conducted by DTSC on December 4 and 5, 2008.
- Samples were collected from 34 soil boreholes (SB-13 through SB-46) located in the southern portion of parcel #100 and parcel #s 74, 82, 83, and 84 (Area 2) that contain discarded tailings. Soil samples were collected at varying depths from each borehole within the tailings. The boreholes were drilled to native soil to determine the tailings thickness. Depth-discrete groundwater samples were collected from four boreholes located in Area 2 to assess the impact to groundwater. Groundwater samples were collected within 2 feet of the borehole's total depth.

Borehole locations for this investigation are shown on Figures 2 (Area 1) and 3 (Area 2).

2.1.1 Direct-Push and Vibratory Sonic Drilling, and Soil Sampling

Soil boreholes were drilled using a limited access, direct-push drill rig and a limited access sonic drill rig to native soil or refusal. Locations where the direct push method was unable to reach target depths (native soil) were drilled with auger equipment attached to the direct-push rig to reach the target depth.

Area 1

Borings SB-1 through SB-12 were advanced using a direct-push drill rig at the locations shown on Figure 2 within the Area 1. The boreholes were advanced to a maximum depth of 30 feet bgs. Sediment was collected continuously in 2-inch-diameter, 4-foot-long acrylic liners. The materials encountered were logged by a URS geologist according to the Unified Soil Classification System (USCS) and the URS Technical Standard Operating Procedures (SOP) guidance. Samples were preserved for laboratory analysis by cutting the acrylic liner containing the sample from the target depth interval using a hand saw, transferring the soil to 8-ounce glass jars, labeling the glass jars with the appropriate information, sealing them in resealable plastic bags and storing in an ice-filled chest at approximately 4 degrees Celsius (°C) until delivery to the laboratory. Each soil sample was delivered to Curtis and Tompkins Ltd. (C&T), a California State-certified laboratory, within the appropriate holding times and accompanied by chain-of-custody documents. Where the use of the liner was not feasible, the samples were collected with a split-spoon sampler and then directly transferred from the sampler to 8-ounce glass jars then preserved following the above-stated procedures.

Area 2

Borings SB-13 through SB-46 were advanced using either a direct-push/auger drill rig or sonic drill rig at the locations shown on Figure 3 within Area 2. The goal of the sonic boreholes was to reach native soil beneath the tailings. The boreholes were advanced to a maximum depth of 80 feet bgs. For boreholes drilled with the direct-push/auger rig, sediments were collected and preserved following the same procedures used for drilling and sampling in Area 1.

The sonic boreholes were advanced by drilling a 3-inch-diameter borehole. Sediment samples were collected continuously using an Aqualock sampling system for lithologic description. Soil samples were collected from the retrieved soil cores at 5-foot intervals. Samples collected for laboratory analysis were placed in 8-ounce glass jars, labeled with the appropriate information, sealed in re-sealable plastic bags, and stored in an ice-filled chest at approximately 4°C until delivery to the laboratory. For tailings present beyond 60 feet bgs (the sample depth proposed in the work plan), additional soil samples were collected every 5 feet bgs, until native material was encountered. The material encountered was logged by a URS geologist according to the USCS and the URS Technical SOP guidance.

To collect soil samples using the Aqualock sampling system, the soil core barrel is loaded with water. A floating piston with a spring-loaded plunger is pushed to the head of the core barrel creating a water-tight seal within the core barrel. The water serves as a non-compressible inner rod, holding the piston in position just behind the cutting shoe on the barrel. A valve attached at the top of the barrel is then closed, and the water and piston are fixed in place on the drill rod. The sampler is advanced through the open borehole to the current depth, and the valve opened by using an inner rod to release the valve spring at the end of the head of the sampler. The tool is then advanced through the sample interval, the trapped water is released into the drive rods while the core barrel extends over the piston and the core moves up into the barrel. After sampling, the valve is closed and the core barrel is retrieved. The closed valve above the piston creates a vacuum, retaining the core during retrieval to the surface. At the surface, the valve head was opened and the core and piston extruded with a high-pressure water pump. Cores were extruded onto a sample gutter where each core run was inspected, lithologically logged and soil samples transferred into 8-ounce jars for laboratory analysis.

Borehole Abandonment

At the completion of daily field activities, open boreholes were decommissioned by backfilling with cement grout pumped through a tremie pipe. The grout consisted of a cement mix ratio of approximately 6 gallons of clean water blended to 94-pounds of type I Portland cement. As grout was pumped into the tremie pipe, the pipe was removed from the borehole. Upon completion, the surface of each location was restored to match the existing surface. The borehole locations were also marked with a stake and flag. Borehole positions were located with a geological positions system (GPS) receiver prior to drilling to assure access was feasible based on the site conditions. After completion of the sampling activities, each borehole was relocated with the GPS receiver.

2.1.2 DEPTH-DISCRETE GROUNDWATER SAMPLING

Area 2

In addition to advancing soil borings for lithologic logging and collecting soil samples, a second boring was advanced adjacent to selected soil boreholes for the purpose of collecting depth-discrete groundwater samples. A sonic drill rig was used to advance the boreholes at the locations shown on Figure 3 (SB-27, SB-30, SB-37 and SB-40). A HydroPunch sampler was used to collect depth-discrete groundwater samples from each borehole. The sample depth in HydroPunch borings were within 2 feet of the borehole total depth. Sample depths were approximately 29 feet bgs (SB-27), 48 feet bgs (SB-30), 26 feet bgs (SB-37), and 27 feet bgs (SB-40).

The HydroPunch sampler operates by pushing 1.75-inch-diameter hollow rods with a retrievable tip to the desired sample depth. A polyvinyl chloride (PVC) filter screen is attached to the tip. At the targeted sampling depth, the rods are retracted approximately 1.5 feet exposing the filter screen to allow groundwater infiltration. After the body of the tool is pulled back and the groundwater flows into the sampler, a groundwater sample is collected by lowering a stainless steel bailer into the HydroPunch. The bailer is then retrieved to the surface and the groundwater sample is transferred from the bailer into precleaned, laboratory provided, sample containers for delivery to the laboratory. The groundwater samples that were collected at the site by the HydroPunch method contained a visible amount of solids and were filtered in the laboratory prior to analysis. All groundwater samples were analyzed for metals by United States Environmental Protection Agency Method SW6020. In addition, a portion of each groundwater sample was placed in a container and measured for pH using a calibrated field meter. The HydroPunch rods and bailer were decontaminated after collecting each sample as described in Section 2.5. The boreholes were decommissioned by backfilling with cement grout as described in Section 2.1.1.

2.2 DECONTAMINATION

2.2.1 Drilling Equipment

All drilling equipment was decontaminated before leaving the contractor's yard, before each borehole, and before leaving the site. The drilling contractor used a high-pressure steam-cleaning sprayer system on all augers and drill rods used during the investigation. Light equipment (i.e., hand tools) was scrubbed with clean water

and mild soap in a bucket, rinsed with clean water, and allowed to dry. Decontamination water generated during on-site decontamination of the drilling equipment rods remained on site.

2.2.2 Sampling Equipment

Soil and groundwater sampling equipment, including the stainless steel bailers used with the HydroPunch sampler, was decontaminated before each use by scrubbing with water and a mild soap, rinsing with distilled water, and being allowed to dry.

2.3 MANAGEMENT OF INVESTIGATION-DERIVED WASTE

Drill cuttings generated during the 2008 investigation were comprised primarily of tailings and, as such, remain on site within the interior tailings area. Decontamination water was containerized and transported by the drilling subcontractor to their facility for treatment and appropriate disposal. Level 4 personal protective equipment (PPE) was used by URS site personnel during this investigation. No disposable PPE was generated.

2.4 DEVIATIONS FROM WORK PLAN

The work performed was consistent with the investigation work plan with the exception of the following:

- Limited access drill rigs and support vehicles were required based on site conditions. The sonic drilling method was also used in addition to direct push and hollow-stem auger methods.
- The depth of the tailings in Area 1 were deeper than expected; therefore, more than two samples were collected from the tailings at each sampling location.
- Shale was also encountered in Area 1 and was similar in color (grey to dark gray) with the tailings; therefore, borings depths at locations SB-3 and SB-4 were more than 5 feet below native material (shale) and more than one sample was collected from the native material/shale.
- Boring total depths at SB-15 and SB-16 were terminated at 20 feet bgs within the tailings based on the extensive thickness of tailings in this area.
- Four additional borings were completed in Area 2 (SB-43 through SB-46) to evaluate the lateral extent of the tailings.
- Groundwater samples were filtered by the laboratory prior to analysis in place of the planned field filtering.
- Split samples were collected at all locations and preserved for at least 60 days.

3.0 INVESTIGATION RESULTS

This section presents the results of soil and groundwater sampling. The focus of the following data presentation is to: (1) summarize the extent of soil contamination for Areas 1 and 2; (2) identify COPCs by comparing soil metal concentrations with DTSC residential California Human Health Screening Levels for Soil (CHHSLS) and groundwater metal concentrations to state maximum cleanup levels (MCLs); (3) estimate the approximate volume of tailings on the site; and (4) evaluate the need for further soil and/or groundwater investigation. Soil analytical results for Areas 1 and 2 are presented in Table 1 and 2, respectively. Table 3 presents the groundwater analytical results for Area 2. As discussed below, analytical results are also presented on soil isopleths maps and generalized geologic cross-sections prepared for Areas 1 and 2. A data quality summary is included in Subsection 3.3. Boring logs, describing site lithology, are presented in Appendix A. The laboratory analytical data sheets for the 2008 investigation are included in Appendix B. The GPS coordinates and elevations for the borings area included as Appendix C.

3.1 SOIL ANALYTICAL RESULTS

3.1.1 Area 1

Table 1 includes results for soil samples collected from 12 borings (SB-1 through SB-12) located in Area 1. The sample depth intervals include: 12 samples at surface; 8 samples at 5 feet bgs; 3 samples at 15 feet bgs; 2 samples at 20 feet bgs; 2 samples at 25 feet bgs; and 1 sample at 30 feet bgs.

Review of these data indicates that soil contains the following metals exceeding residential CHHSLS.

- Arsenic from all locations with the exception of the surface sample (0 to 0.5 feet, bgs) at SB-1 which was below the detection limit of 0.29 mg/kg. As discussed below, arsenic concentrations are above the CHHSLS from samples collected in both the tailings and native material.
- Lead at the surface sample from SB-2.
- Mercury at the surface sample from SB-2.

Other metal concentrations considered to be significant at the site are copper, nickel and zinc. However, analytical results were not above the CHHSLS; hence, they were not evaluated further.

Arsenic and pH Results

Arsenic-impacted soil above CHHSLS represents the most metal-impacted soil at the site. As such, depth-specific isoconcentration maps of arsenic concentrations at surface and 5 feet were prepared and shown on Figures 4 and 5, respectively. The isopleths were generated using a combination of geographic information system (GIS)-based contouring and manual extrapolation of the data (data from SB-18, which is evaluated as part of Area 2, is also included on the map for reference). Results of soil pH are also included in Table 1 and shown on Figure 6.

Significant features shown on Figures 4, 5, and 6 include:

- Two arsenic hot spots (greater than 1,000 mg/kg) at the locations of SB-2 and SB-8 area evident at the site. SB-2 is also the location where the only other metals (lead and mercury) exceeding CHHSLS occurred.
- The lateral extent of arsenic exceeding CHHSLS is undefined, except at the southwest portion of Area 1 near SB-1.
- Assuming an arsenic residential risk-based concentration of approximately 20 mg/kg, the lateral extent of arsenic is also undefined.
- Soil pH is very acidic in the surface (0 to 0.5 feet bgs) and near surface sample depths (4 to 5 feet bgs) at all locations with the exception SB-7 and SB-9. These results are consistent with the lack of vegetative growth in the area of these borings.

Section lines for generalized geologic cross-sections (A-A' through G-G') are shown on Figure 2. The generalized geologic cross-sections (A-A' through G-G') for Area 1 are presented on Figures 7 and 8. The cross-sections show the depth of native material, tailings, shale encountered beneath tailing in Area 1, and the concentrations of arsenic with depth. Significant features shown on the cross-sections include:

- The highest arsenic concentrations with depth were also found at the surface hotspot locations (SB-2 and SB-8).
- Elevated arsenic concentrations (62 to 290 mg/kg) are also found in near-surface soils that were logged as native material (SB-5, SB-9, and SB-10).
- Where shale was encountered, arsenic concentrations significantly decrease with depth (less than approximately 17 mg/kg).
- Total depth (or thickness of tailings) ranged from 15 to 20 feet at 5 of the 12 boring locations (SB-3, SB-4, SB-6, SB-8, and SB-11). Four of the borings (SB-1, SB-5, SB-9, and SB-10) only encountered native material. The remaining three borings showed less than 5 feet of tailings or an undetermined depth.

The estimated total volume of tailing in Area 1 is approximately 120,000 cubic yards. The lowest arsenic concentration found in the tailings is 20 mg/kg (see SB-4). Calculations for estimating total tailing volumes are included in Appendix D.

3.1.2 Area 2

Table 2 includes results for soil samples collected from 34 borings (SB-13 through SB-46) in Area 2. The sample depth intervals include: 34 surface samples; 27 samples at 5 feet bgs; 24 samples at 10 feet bgs; 20 samples at 15 feet bgs; 18 samples at 20 feet bgs; 2 samples at 25 feet bgs; 9 samples at 30 feet bgs; and a total of 17 deeper samples (from 40 to 80 feet bgs).

Review of these data indicates that soil contains the following metals exceeding residential CHHSLS.

- Arsenic from 0 to 20 feet bgs covering most of the site and at depths greater than 20 feet bgs at eight boring locations (SB-18 from 28 to 38 feet bgs, SB-21 from 30 to 80 feet bgs, SB-22 from 30 to 40 feet bgs, SB-26 and SB-30 from 30 to 40 feet bgs, SB-33 from 30 to 60 feet bgs, SB-40 at 27 feet bgs, and at SB-41 at 30 feet bgs).

- Lead at 15 feet bgs in one small area in the vicinity of SB-40. Lead concentrations (160 mg/kg) slightly exceeding residential CHHSLs (150 mg/kg) were not found above or below 15 feet bgs.

Other metal concentrations considered to be significant are nickel and zinc; however, analytical reports for these two metals were not above the CHHSLs; hence, they were not evaluated further.

Arsenic and pH Results

Similar to Area 1, arsenic-impacted soil above CHHSLs represents the most metal-impacted material for Area 2. Based on these results, isoconcentration maps of arsenic with depth (0 to 0.5-foot, 5-foot, and 20-foot depths) were prepared and shown on Figures 9, 10, and 11, respectively. The isopleths were generated using a combination of GIS-based contouring program and manual extrapolation. Soil pH was also measured in all soil samples and included in Table 2.

Significant features shown on Figures 9, 10, and 11 include:

- Arsenic concentrations are elevated across the entire site; however, hotspots (greater than 1,000 mg/kg) were not observed (as compared to those in Area 1). This may be related to further cyanide processing of the tailings in Area 2 in the leaching vats. Arsenic may have been further leached into the recovered material reducing the concentration in the processed tailings.
- Assuming an arsenic residential risk-based concentration of approximately 20 mg/kg, the lateral extent of arsenic at the surface locations is undefined. However, at four borings (SB-25, SB-26, SB-36, and SB-44) arsenic concentrations are below 20 mg/kg from the surface to boring total depth. Three of the borings were completed in native material and the fourth (SB-26) was completed in tailings intermixed with native material.
- The lateral extent of arsenic concentrations exceeding CHHSLs is undefined, except in the vicinity of SB-25.
- Surface samples from borings (SB-28, SB-31, SB-35, SB-38, SB-42, and SB-46) located in native material and along the boundaries of the property show elevated levels of arsenic (56 to 160 mg/kg), indicating that tailings have also impacted these areas.
- The soil pH is in the 6 to 8 range for the majority of samples. Seven out of the 147 samples showed slightly lower pH (4.5 to 5.9).

The section lines for cross-sections H-H' through K-K' are presented on Figure 3. Cross-sections H-H' (see Figure 12) traverses west to east across Area 2 and cross-sections I-I' through K-K' (see Figure 13) traverse north to south across Area 2. Arsenic concentrations with depth, the extent of tailings and native material are incorporated on these cross-sections. Review of the cross-sections indicated the following:

- The highest concentrations of arsenic (greater than 500 mg/kg) are found at depth in the most downgradient borings (SB-40 and SB-41) adjacent to the concrete dam.
- Generally, all samples from the tailings show elevated levels (greater than 20 mg/kg) of arsenic.
- The vertical extent of arsenic is undefined. However, at 13 of the 33 boring locations the deepest sample showed less than 20 mg/kg.

- The greatest thickness of tailings in Area 2 is 80 feet at SB-21, which is located in the area upgradient of the two basins adjacent to Area 1.

The estimated volume of tailings in Area 2 is approximately 1,075,000 cubic yards. Calculations for estimating total tailing volumes are included in Appendix D.

3.2 GROUNDWATER ANALYTICAL RESULTS

The 2008 investigation included the collection of HydroPunch groundwater samples from sonic borings SB-27, SB-30, SB-37, and SB-40 in Area 2 to determine the presence of possible metal contamination in groundwater. Results of the HydroPunch sampling are summarized in Table 3 and also include pH levels measured in groundwater. This table compares the metal results to California MCLs. Review of the HydroPunch results indicate that groundwater contains the following metals exceeding MCLs.

- Arsenic was reported in borings SB-27, SB-30, and SB-40 and ranged from 120 micrograms per liter ($\mu\text{g/L}$) to 220 $\mu\text{g/L}$. The MCL for arsenic is 10 $\mu\text{g/L}$.
- Chromium was reported in only one boring (SB-40) at 130 $\mu\text{g/L}$. The MCL for chromium is 50 $\mu\text{g/L}$.
- Nickel was reported in borings SB-27, SB-30, and SB-40 and ranged from 150 to 400 $\mu\text{g/L}$. The MCL for nickel is 100 $\mu\text{g/L}$.
- Zinc was reported in all four borings and ranged from 74 to 1,200 $\mu\text{g/L}$. The MCL for zinc is 67 $\mu\text{g/L}$.

Other metals detected in the groundwater that do not have an MCL include:

- Cobalt was reported in all four borings and ranged from 46 to 330 $\mu\text{g/L}$.
- Vanadium was reported in borings SB-30, SB-37, and SB-40 and ranged from 1.5 to 580 $\mu\text{g/L}$.

The pH level in three out the four samples tested ranged from 6.3 to 6.7. The fourth sample (SB-40) was inadvertently not tested for pH.

Groundwater samples were analyzed for total metals to ascertain worst-case conditions for use in health risk evaluation. The HydroPunch samples were collected within the tailings and contained approximately 50% solids in the groundwater sample.

3.3 DATA MANAGEMENT AND QUALITY ASSESSMENT

Data generated in support of the characterization of the chemical impact at the site were reviewed, compiled, and input into a GIS supported by a relational database management system. This GIS also was used to generate the figures included in this SIR. Other data sources compiled and reviewed in support of the development of this SIR include direct push and sonic boring logs (Appendix A) and analytical data reports from C&T Laboratories (Appendix B).

Approximately 197 sample records from 46 locations on the site resulted in the generation of the 4,314 chemical analyte records included in the data management system version used to support the development of this SIR.

Site characterization data generated by URS at this site have been reviewed to check that they meet the quality requirements listed in the quality assurance project plan section of the investigation work plan.

No significant quality deficiencies were found in the data collected for the site characterization summarized in this report that would preclude their use for their designed intentions. Sample and data collection quality control activities and protocols were carried out in the field as detailed in the investigation work plan (URS, 2008).

4.0 CONCLUSIONS AND RECOMMENDATIONS

This section presents our conclusions and recommendations based on the data collected during the 2008 field investigation. These conclusions and recommendations address the lateral and vertical extent of soil/tailings and groundwater contamination at the site and the need for site remediation.

4.1 CONCLUSIONS

4.1.1 Soil Contamination

Area 1

- The extremely high concentrations (1,000 mg/kg) of arsenic detected at two locations in Area 1 and the low pH in this area confirm past sampling efforts.
- The lateral extent of tailings appear to have been determined in the area of borings SB-1, SB-5, SB-9, and SB-10. The lateral extent of tailings have not been determined in the area of borings SB-2, SB-4, SB-11, and SB-12 suggesting tailings may extend beyond the western and northern property boundaries at these locations. East to southeast of Area 1 (locations SB-7 and SB-8) tailings continue into Area 2.
- The lateral and vertical distribution of metal contamination (in both the native soil and tailings) at concentrations exceeding residential California CHHSLs have not been defined beneath the site. Further sampling will be required to better define the two hot spots in Area 1 and also the lateral and vertical extent of contamination and tailings in Areas 1.
- The vertical extent of all metal concentrations generally decreases at depth when native material/shale was encountered. However, at surface locations where native material was sampled, elevated levels of arsenic were detected, suggesting tailings may have been mixed and/or have impacted areas which appear to be native soil.
- Arsenic is the primary COPC in soil. Lead and mercury were also detected above CHHSLs in the 0.5-foot sample at SB-2, which also contained the highest concentrations for arsenic. Although this may be an isolated occurrence, the COPCs in Area 1 should include lead and mercury. Other metal concentrations considered to be significant for remediation were copper, nickel, and zinc. However, analytical reports were not above the CHHSLs; hence, they were not evaluated further.

Area 2

- Overall arsenic concentrations in Area 2 are lower than those detected in Area 1. This difference may be attributed to the cyanide processing which further leached the tailing creating lower metal concentrations.
- The vertical extent of tailings appears to have been reasonably defined in Area 2. The lateral extent of tailing is undefined particularly along the northern site boundary.
- Similar to Area 1, the vertical extent of all metal concentrations generally decreases at depth (less than 20 mg/kg) when native material/shale was encountered and sampled. However, at surface

locations where native material was sampled (SB-28, SB-31, SB-35, and SB-42) elevated levels of arsenic were detected, suggesting tailings may have been mixed and/or impacted areas which appear to be native soil. (Note: The elevated arsenic levels [greater than 20 mg/kg] in native soil could also be related to background arsenic concentrations.)

- Arsenic is also considered the main COPCs in soil in Area 2. Lead is also considered to be a COPC based on the occurrence of one sample above CHHLS. Mercury was not tested for in Area 2; however, the further processing performed on the tailings in this area and the absence of mercury in the groundwater indicate mercury may not be a concern in Area 2.

4.1.2 Groundwater Contamination

- Metals in soil have impacted the shallow groundwater beneath the site at concentrations exceeding MCLs. These metals include arsenic, chromium, nickel, and zinc. Results from recommended monitor wells on site will be necessary to determine if these metals are COPCs in groundwater.

4.2 RECOMMENDATIONS

Based on the presence of impacted soil and groundwater at the site, recommendations are provided below.

4.2.1 Soil Contamination – Area 1

The remedial action work plan for Area 1 should include a sampling plan for addressing data gaps in Area 1. The sampling plan should include soil sampling to adequately characterize the two hot spots in Area 1 and others areas (described above) that do not include sufficient data to determine the lateral and vertical extent of tailings and arsenic contamination. The sampling plan should address the extent of tailings/soil contamination along the site boundaries and off site, if necessary.

4.2.2 Soil Contamination – Area 2

Similar to Area 1, additional soil sampling is necessary to define the lateral and vertical extent of tailings and soil contamination. This sampling should be performed in the area between the observed presence of tailings and the site perimeter to fill data gaps. The new and existing soil data should be used to determine background arsenic concentrations and support a risk-based cleanup level to evaluate alternatives for the site.

4.2.3 Groundwater Contamination

Groundwater monitor wells should be installed and sampled to confirm the groundwater contamination identified from the HydroPunch sampling results. It is recommended that two monitor wells be installed within the tailings at the locations of SB-30 and SB-40 at a total depth of approximately 50 and 30 feet bgs, respectively. If metal contamination is confirmed in these wells, additional well installations may be required to determine the vertical extent (within the native material below the tailings) and any offsite impacts to groundwater.

5.0 REFERENCES

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United States Geological Survey, 1966. *Geology of Northern California*. Bulletin 190. California Division of Mines and Geology. San Francisco. California.

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TABLES

TABLE 1

**Laboratory Analytical Data for Metals
Argonaut Mine Tailings Site Area 1
Jackson, California**

Sample Name	Depth (feet bgs)	Arsenic (mg/kg)	Chromium ^a (mg/kg)	Copper (mg/kg)	Lead (mg/kg)	Mercury (mg/kg)	Nickel (mg/kg)	Zinc (mg/kg)	pH
CHHSLS		0.07	17	3,000	150	18	1,600	23,000	NA
SB-1	0.5	0	6.2	80	4.7	0	9.2	79	5.2
SB-2	0.5	39,000	47	1,400	1,300	18	390	1,000	2.9
	4	7,300	100	200	120	1.7	83	180	3.5
SB-3	1.5	16	27	45	8.3	0.33	58	120	—
	1.5	24	28	47	9.8	0.37	64	94	4.7
	4.5	200	33	48	48	0.94	50	68	—
	4.5	330	28	38	80	0.57	41	59	5.9
	14.5	22	16	50	15	0.28	36	100	6.4
	19.5	12	45	40	9.6	0.24	32	64	6.8
	24	9.6	34	55	6.9	0.14	45	66	7.8
	29	17	23	72	9	0.098	54	100	8
SB-4	0.5	400	48	100	6.5	0.095	28	66	3.3
	4	210	36	51	12	0.51	110	140	4.8
	13	20	34	14	6.9	0.21	51	64	6.7
	18.5	47	29	54	7.8	0.22	75	79	6.8
	23.5	6.4	55	26	5.4	0.17	63	61	6.9
	28.5	8.5	26	63	10	0.24	59	75	7.4
SB-5	0.5	92	33	45	3.3	0.026	10	50	4.5
SB-6	0.5	23	27	53	9.5	0.15	99	150	—
	0.5	24	27	46	9.1	0.17	100	140	5.5
	4	190	28	37	20	0.31	52	84	3.1
SB-7	0.5	330	62	68	21	0.36	36	100	6.2
	2.5	130	87	74	4.8	0	40	68	4.2
SB-8	0.5	3,500	4.8	63	280	9.8	22	81	2.6
	5	2,300	11	350	250	3.7	28	60	4.1
	12	1,500	6.9	37	300	5	130	460	6.4
SB-9	0.5	62	53	42	11	0.2	22	45	6.9
SB-10	0.5	290	55	48	12	0.73	20	82	4.2
SB-11	0.5	35	22	25	6.2	0.96	35	47	5.6
	4	36	50	51	9.6	0.35	64	68	5
SB-12	0.75	220	29	47	13	0.31	37	86	3
	4	54	20	51	7.2	0.17	140	110	4.4

^a hexavalent chromium

Bold = soil concentrations exceed CHHSLS
bgs = below ground surface
CHHSLS = California Human Health Screening Levels for Soil
kg = kilogram
MCL = maximum contaminant level
mg = milligram
NA = not available
— = not analyzed

TABLE 2

**Laboratory Analytical Data for Metals
Argonaut Mine Tailings Site Area 2
Jackson, California**

Sample Name	Depth (feet bgs)	Arsenic (mg/kg)	Lead (mg/kg)	Nickel (mg/kg)	Zinc (mg/kg)	pH
CHHSLS		0.07	150	1,600	23,000	NA
SB-13	0.5	41	10	8	31	8.1
	5	51	17	8.6	32	8.1
	10	59	22	11	37	8
	15	0	1.7	27	46	6.4
SB-14	0.5	100	28	16	64	7.7
	5	96	37	19	69	7.8
	10	130	62	25	86	7.8
	15	160	61	26	76	8
	20	130	52	18	59	7.7
	27	0	4.1	2.5	73	7.5
SB-15	0.5	130	12	21	65	—
	0.5	140	15	23	69	8.2
	5	130	41	30	120	8
	10	120	55	22	88	8.4
	15	95	45	13	66	8.3
	19	97	29	24	75	8.2
SB-16	0.5	110	33	19	74	8.2
	5	70	34	17	57	8.3
	10	110	46	21	65	7.6
	15	100	40	23	61	7.8
	19	37	23	17	61	7.6
SB-17	1	130	47	40	60	8.2
	5	35	8.2	11	33	8.5
	10	26	11	8.2	40	8
	15	46	22	23	47	8.2
	20	18	9.3	9.4	34	8
SB-18	0.5	240	19	28	72	7.8
	4	460	130	40	190	6.5
	9	96	26	18	200	7.1
	15	2.5	3.4	30	46	6.8
	19	4.7	5.5	32	50	7.5
	28.5	6.6	16	60	89	7
	37.5	5.5	11	120	85	6.9
SB-19	0.5	170	44	32	82	7.5
	4.5	160	59	33	170	—
	4.5	150	50	32	150	7.5
	10	130	56	11	75	7.6
	15	0	4	22	60	6.6
	20	8.9	5.7	21	70	7.1
	22.5	0	0	21	76	6.7

TABLE 2

(Continued)

Sample Name	Depth (feet bgs)	Arsenic (mg/kg)	Lead (mg/kg)	Nickel (mg/kg)	Zinc (mg/kg)	pH
SB-20	1	43	9.5	8.3	36	8
	5	130	57	27	110	7.9
	10	180	67	35	120	7.8
	15	0.92	8.5	68	61	6.8
SB-21	1	110	16	32	75	—
	1	100	21	25	71	7.6
	5	110	29	32	110	8
	10	62	21	14	43	8
	15	57	20	28	60	7.8
	20	43	13	26	44	7.8
	30	55	9	15	41	8
	40	98	48	25	97	7.9
	50	130	31	16	68	7.5
	60	110	41	21	62	7.7
	70	26	14	8.4	35	7.5
	80	4.4	12	13	39	6.6
SB-22	1	37	6.8	7.1	30	8.8
	5	40	12	9.3	39	8.4
	10	41	6.9	9.9	35	8.3
	15	41	6.5	14	30	8.4
	20	40	9.2	11	36	9.5
	30	32	9.1	20	34	8.3
	40	36	9.7	16	35	8.4
SB-23	1	59	36	21	60	8.1
	5	44	9.8	7.7	30	8.3
	10	27	5.1	8.2	20	8.3
	15	32	8.3	16	36	8.3
	20	120	26	24	90	7.9
SB-24	0.5	420	41	64	210	6.7
	4.5	94	28	34	1,200	—
	4.5	110	31	40	1,100	7.5
	7	9.6	1.7	30	55	7.3
SB-25	0.5	0	4	47	48	6.1
SB-26	0.5	6.4	8.3	34	60	—
	0.5	13	10	31	64	7.1
	5	3.2	9.1	45	74	7.1
	10	6.6	9.7	31	91	5
	15.5	4.6	9.2	47	59	7.7
	20.5	7.2	10	38	58	7.1
	30.5	5.6	9.3	46	81	7.6
	40	5.6	8.6	42	74	7.4

TABLE 2

(Continued)

Sample Name	Depth (feet bgs)	Arsenic (mg/kg)	Lead (mg/kg)	Nickel (mg/kg)	Zinc (mg/kg)	pH
SB-27	1	200	12	8.9	35	6.8
	5	380	38	26	97	7.1
	10	240	32	23	63	7.3
	15	150	32	26	59	7.7
	20	150	32	31	56	7.2
	30	75	17	14	36	7.3
SB-28	0.5	160	38	29	140	7.6
	5	7.2	11	36	59	4.5
	10	9.5	9.5	35	64	—
	10	8.2	9.4	36	67	5.2
	15	4.8	7.5	59	74	5.8
	20	4.2	4.6	36	41	6.2
	31	11	7.8	30	56	7.2
SB-29	1	220	20	20	60	7.5
SB-30	1	270	20	30	67	7.4
	5	230	19	21	69	7.7
	10	79	23	19	44	7.3
	15	120	26	26	60	7.3
	20	120	22	24	49	7.3
	30	140	31	29	51	7.5
	40	95	21	26	50	7.5
SB-31	0.5	160	9.2	8.1	100	7.7
	5	220	5.9	5.7	97	7.7
SB-32	1	290	11	18	65	8.1
	5	180	7.9	16	64	8.2
	10	84	7.7	17	53	—
	10	90	7.5	17	53	7.8
	15	160	9.1	22	65	7.9
	20	38	4	6	75	4.6
SB-33	1	300	9	15	64	8.1
	5	70	9.3	13	48	8.2
	10	130	7.2	22	60	8
	15	120	9.9	35	70	7.8
	20	170	12	52	72	7.8
	30	280	11	33	78	7.9
	40	200	11	28	68	8
	50	160	12	33	69	7.8
	60	140	25	22	63	7.4
SB-34	1	100	6.4	12	37	8.3
	5	160	7.3	18	55	8.2
	10	110	7.1	20	59	7.9
SB-35	0.5	66	15	22	110	—
	0.5	81	18	17	110	6.9
SB-36	0.5	15	7.7	11	53	6.8
	5	6.4	6.4	9.1	40	7.1
	10	6.2	1.8	16	51	6.6

TABLE 2

(Continued)

Sample Name	Depth (feet bgs)	Arsenic (mg/kg)	Lead (mg/kg)	Nickel (mg/kg)	Zinc (mg/kg)	pH
SB-37	1	190	15	20	60	7.5
	5	140	16	8.5	60	7.3
	10	92	24	13	68	7.5
	15	110	43	17	81	7.3
	20	39	16	12	47	7.4
SB-38	0.5	190	15	14	120	7
SB-39	1	120	24	24	74	7.2
	5	34	5.9	16	56	6.6
SB-40	1	170	19	33	44	7.6
	5	78	15	20	29	7.6
	10	220	45	32	140	7.3
	15	370	160	31	1,000	7.6
	20	670	97	31	260	7.6
SB-41	1	190	23	24	48	7.7
	5	120	13	19	66	7.4
	10	210	60	32	300	7.4
	15	650	140	54	450	7.5
	20	580	110	33	270	7.6
	30	100	36	15	73	7.4
SB-42	0.5	56	13	11	84	6.3
SB-43	0.5	100	42	23	98	—
	0.5	93	37	22	94	7.3
	5	0	4.9	4.3	51	6.3
	10	0	5.5	2.7	59	6.2
	12	36	17	11	65	6.9
SB-44	0.5	3.3	9.4	6.7	67	5.8
	5	0	4.1	1.6	67	5.9
SB-45	1	130	19	13	130	7.4
SB-46	1	68	16	32	76	—
	1	66	15	31	82	6.9

Bold = soil concentrations exceed CHHSLs
 bgs = below ground surface
 CHHSLs = California Human Health Screening Levels for Soil
 kg = kilogram
 mg = milligram
 NA = not available
 — = not analyzed

TABLE 3

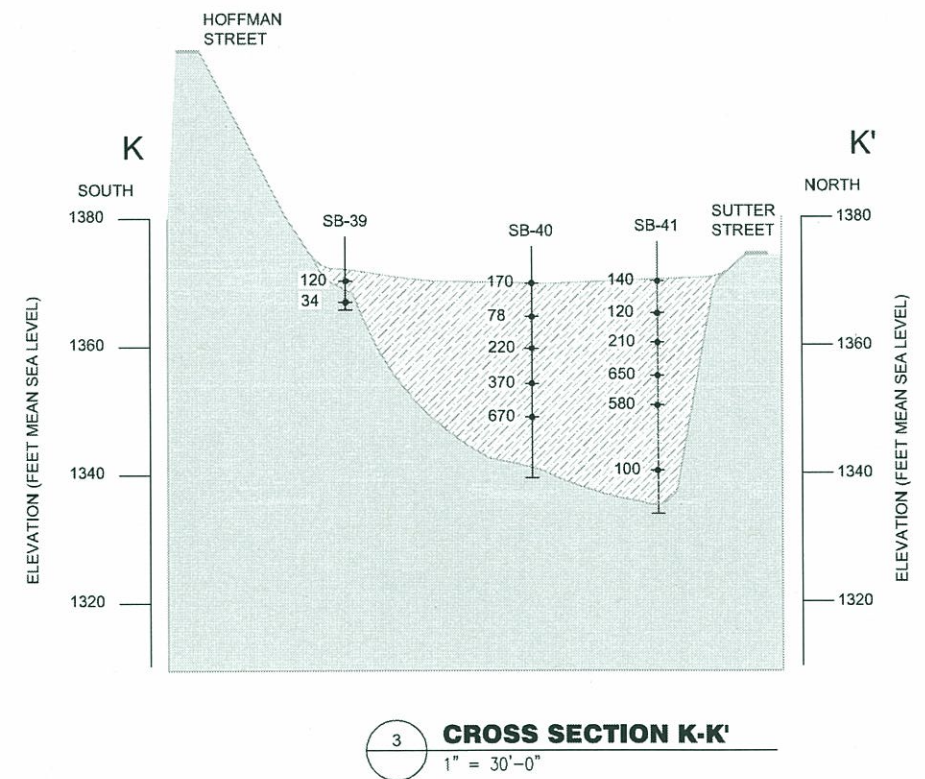
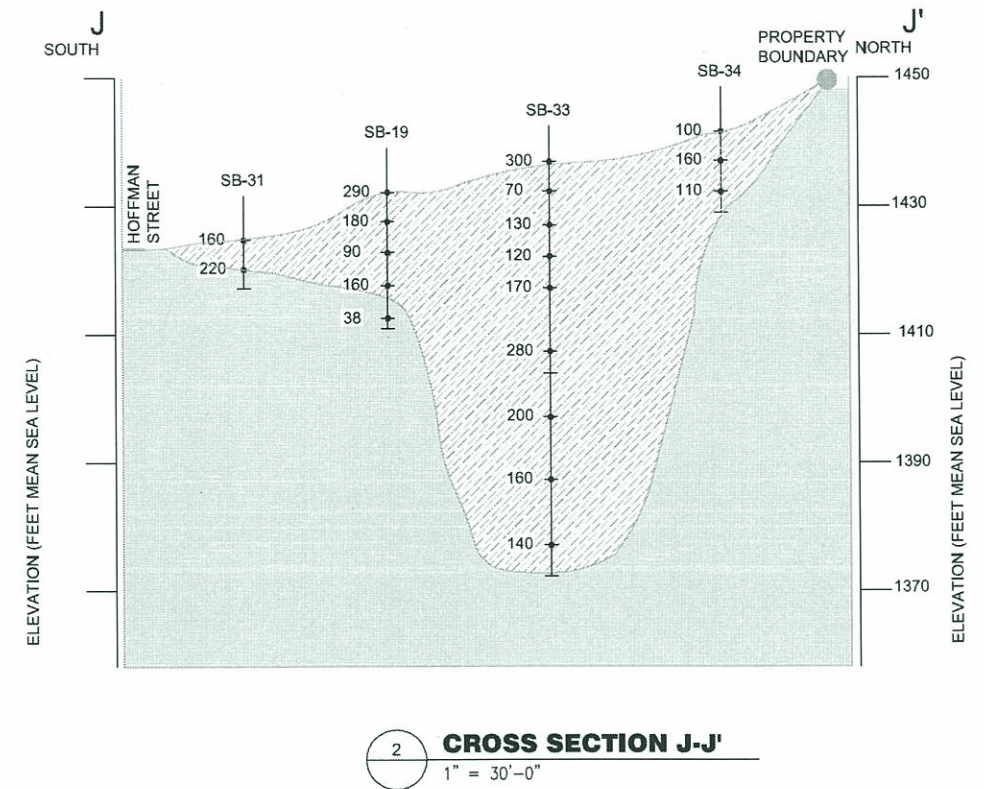
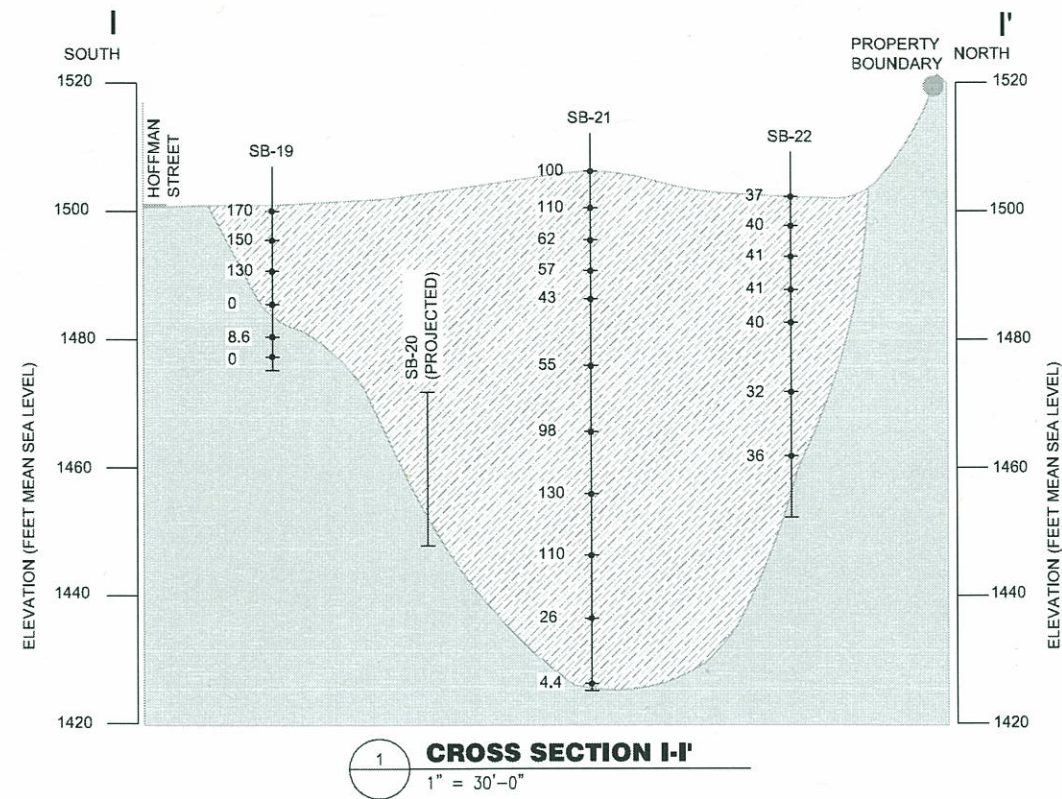
**Laboratory Analytical Data for Metals in Groundwater
Argonaut Mine Tailings Site
Jackson, California**

Sample Name	Analytical Name	Result (µg/L)	Reporting Limit (µg/L)	MCL (µg/L)
SB-27 (sampled at 29 feet bgs)	Antimony	0	1	6
	Arsenic	120	10	50
	Barium	51	10	1,000
	Beryllium	0	1	4
	Cadmium	0	1	5
	Chromium	0	1	50
	Cobalt	320	1	—
	Copper	1.2	1	1,300
	Lead	0	10	15
	Mercury	0	0.2	2
	Molybdenum	1.1	1	—
	Nickel	400	1	100
	Selenium	0	1	50
	Silver	0	1	100
	Thallium	0	1	20
	Vanadium	0	1	—
	Zinc	280	53	67
	pH		6.3	
SB-30 (sampled at 48 feet bgs)	Antimony	2.2	1	6
	Arsenic	220	1	50
	Barium	93	1	1,000
	Beryllium	0	1	4
	Cadmium	0	1	5
	Chromium	6.5	1	50
	Cobalt	46	1	—
	Copper	2.8	1	1,300
	Lead	4.0	1	15
	Mercury	0	1	2
	Molybdenum	0	1	—
	Nickel	150	1	100
	Selenium	0	1	50
	Silver	0	1	100
	Thallium	0	1	20
	Vanadium	4.6	1	—
	Zinc	1,200	5	67
	pH		6.4	

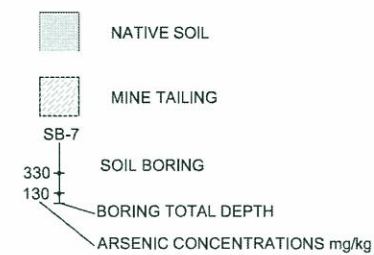
TABLE 3
(Continued)

Sample Name	Analytical Name	Result (µg/L)	Reporting Limit (µg/L)	MCL (µg/L)
SB-37 (sampled at 26 feet bgs)	Antimony	0	1	6
	Arsenic	29	5	50
	Barium	89	5.6	1,000
	Beryllium	0	5	4
	Cadmium	0	1	5
	Chromium	0	1	50
	Cobalt	150	5	—
	Copper	6.2	1	1,300
	Lead	0	1	15
	Mercury	0	20	2
	Molybdenum	0	1	—
	Nickel	71	5	100
	Selenium	0	5	50
	Silver	0	1	100
	Thallium	0	1	20
	Vanadium	1.4	5	—
	Zinc	74	27	67
	pH		6.7	
SB-40 (sampled at 27 feet bgs)	Antimony	0	1	6
	Arsenic	140	5	50
	Barium	97	5.6	1,000
	Beryllium	7.0	5	4
	Cadmium	1.3	1	5
	Chromium	130	5	50
	Cobalt	330	5	—
	Copper	7.3	5.5	1,300
	Lead	24	1	15
	Mercury	0	20	2
	Molybdenum	0	1	—
	Nickel	230	1	100
	Selenium	0	5	50
	Silver	0	1	100
	Thallium	0	1	20
	Vanadium	580	5	—
	Zinc	770	27	67
	pH		NM	

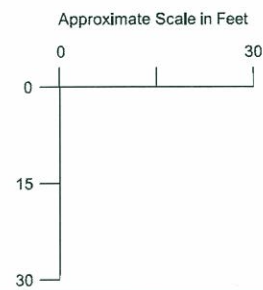
Bold = concentration exceeds MCL
 MCL = maximum concentration limit for drinking water
 NM = not measured
 µg/L = micrograms per liter
 — = no MCL for this compound



LEGEND



NOTE:
DEPTH OF NATIVE SOIL BELOW BORING TOTAL
DEPTH UNKNOWN.



URS 2870 Gateway Oaks Drive, Ste. 150 Sacramento, CA 95833-3200 TEL: (916) 679-2000 FAX: (916) 679-2900	GENERALIZED GEOLOGIC CROSS-SECTIONS I-I', J-J', K-K'		FIGURE 13
	Argonaut Mine Jackson, California		