



Argonaut Mine Tailings Pile Removal Assessment Report Jackson, California

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List of Abbreviations and Acronyms

ACEHD	Amador County Environmental Health Department
AOC	area of concern
bgs	below ground surface
COC	contaminant of concern
CSCC	California Slimes Concentrating Company
DQO	Data Quality Objective
DTSC	California Department of Toxic Substances Control
E & E	Ecology and Environment, Inc.
EMAD	Eastwood Multiple Arch Dam
GPS	Global Positioning System
J	concentration is estimated
MCL	Maximum Contaminant Levels
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
NIST	National Institute of Standards and Technology
µg/L	micrograms per liter
PAH	Polycyclic Aromatic Hydrocarbons
R	correlation coefficient
R ²	coefficient of determination
RPD	relative percent difference
r-RSL	Regional Screening Level for a residential scenario
R9 Laboratory	United States Environmental Protection Agency Region 9 Richmond Laboratory

List of Abbreviations and Acronyms (cont.)

SAP	Sampling and Analysis Plan
START	Superfund Technical Assessment and Response Team
STLC	Soluble Threshold Limit Concentration
SVOC	Semi-volatile organic compound
TDD	Technical Direction Document
U.S. EPA	United States Environmental Protection Agency
UJ	Detected concentration is less than the quantifiable reporting limit and is an estimate
WET	Waste extraction test
XRF	x-ray fluorescence
YSI	Yellow Springs Instruments

1 Introduction

The United States Environmental Protection Agency (U.S. EPA) Region 9 Federal On-Scene Coordinator Dan Shane tasked Ecology and Environment, Inc.'s (E & E's) Superfund Technical Assessment and Response Team (START) to support a time-critical assessment at the Argonaut Mine Tailings Pile (site) located in the City of Jackson, Amador County, California (Figure 1 in Appendix A). These assessment activities were conducted under E & E's U.S. EPA Region 9 START Contract number EP-S5-08-01, under Technical Direction Document (TDD) number TO-02-09-13-01-0004. The U.S. EPA is concerned about exposure risks posed by the site based on findings of previous assessments conducted for the U.S. EPA and California Environmental Protection Agency's Department of Toxic Substances Control (DTSC), which documented contamination from arsenic and other toxic heavy metals (U.S. EPA 1998a and b, URS 2009) and outlined a removal action plan (URS 2011).

The site is comprised of approximately 64.8 acres of largely undeveloped land located in Jackson and is currently prioritized as the number two site on the Abandoned Mine Site Prioritization List for the U.S. EPA Region 9 Superfund Division. Tailings materials at the site were generated from silver, gold, and other metal mining and ore processing operations that were conducted there from the 1850s through the early 1940s.

Samples collected in previous assessments documented that arsenic, lead, and mercury contamination are present at the site. The assessment work performed on behalf of the DTSC in 2008 and 2009 documented that surface soils in the 5-acre western portion of the site contained arsenic at hazardous concentrations. Arsenic, chromium, nickel, and zinc were documented in groundwater samples from the site at concentrations that exceeded the California Maximum Contaminant Levels (MCLs) for drinking water (URS 2011).

2 Site Background

2.1 Site Location and Description

The site is located in an alluvial valley and consists of open space characterized by soil and processed mine tailings impounded behind several berms and dams. The site is abutted by a relatively new single-family residential development (i.e. houses) to the north, northeast, west, and east. City of Jackson administrative offices, an undeveloped residential parcel, and a public high school about the west side, and open undeveloped areas are adjacent to the northwest, south, and southeast sides. The approximate geographic coordinates for the site are Longitude 120°47'23.44" West and Latitude 38°21'26.95" North (Figure 1 in Appendix A).

In the western portion of the site near the topographical high point, there is an approximately 5-acre area of concern (AOC) designated as AOC-1. The area is characterized by surface deposits of unprocessed and semi-processed ore (Figure 2 in Appendix A). During wet weather, AOC-1 contains localized areas of saturated sediments. A surface impoundment appears to have been present in AOC-1 but the dike is currently breached.

East and down grade from AOC-1 is a former cyanide processing plant (Cyanide Plant). This 6.5-acre area is designated as AOC-2 and contains abandoned vats and tanks reportedly used for cyanide leaching of processed ore. Additionally there is a former thickening basin in AOC-2 associated with the cyanide plant. Extraction processes performed in this area reportedly used coal tars (U.S. EPA 2013).

AOC-3 is located southeast and down grade from AOC-2 and is a 48-acre area designated as the Tailings Disposal Area and Impoundments. There are two earthen impoundment areas in AOC-3, the Gray Sands Tailings Area and the Historic Impound Basin. These impoundments were constructed to store processed tailings and to catch runoff from the tailings area. Based on borings advanced by URS, mine wastes are present to a maximum depth of approximately 80 feet below ground surface (bgs) in AOC-3. Although the area behind the lower tailings dam does retain water, both the upper and lower tailings dams are currently breached and surface water eventually flows down grade to the south and/or east of AOC-3 to a 5.3 acre area containing an Eastwood-style reverse-arched concrete dam referred to as Eastwood Multiple Arch Dam (EMAD).

Site soils are predominantly ore and/or waste rock in AOC-1. These soils are rocky and acidic (pH 2 to 5) and generally do not support vegetation. Soils in AOC-2 and AOC-3 are predominantly grey tailings. In most portions of AOC-3, vegetation has been re-established and a thin layer of organic material is present over the tailings. In these areas, the soils are generally stable. However, large portions of AOC-2 and portions of AOC-3 near the lower tailings dam contain exposed gray tailings that are devoid of vegetation. These soils are easily eroded during large magnitude rain events and large gullies have formed. Some of the gullies in AOC-2 and AOC-3 exceed 20 feet in depth and top-width (see cover photo). Four sinkholes are present behind the lower earthen tailings dam.

A small pond is present in the north-central portion of the site. Based on observed changes in vegetation, the pond appears to vary greatly in size based on the amount of recent rainfall. During a July 2013 site visit by START and the U.S. EPA, the pond was approximately 30 feet

in diameter and 6 to 10 feet deep. However, surface topography and observed changes in vegetation suggest that the pond was approximately 1 acre in size and up to 15 feet deep during the wettest times of the year.

Surface waters and sediment discharging from the EMAD and from other areas of the site are designated as AOC-4. The EMAD is roughly 390 feet wide and 46 feet tall. Sediment and tailings have filled the basin behind the dam to within a few feet of its top. Standing water flows over the top of the dam during wet periods. Water also flows through cracks in the base of the dam, suggesting sediments behind the dam are saturated.

Roughly 300 feet north of AOC-1 is a residential lot of roughly 0.39 acre that appears to have been used for storage or disposal of ore or mine tailings. This residential lot, designated as AOC-5, has yellow and orange-colored stained ground and is largely devoid of plant life.

The locations of AOC-1 through AOC-5, the approximate parcel boundaries, and other site features are shown on Figure 2 (Appendix A).

2.2 Site Geology and Hydrogeology

Gold deposits in the Jackson area 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 (URS 2009). The ore deposits contain disseminated fine free gold, arsenopyrite (arsenic sulfide), and minor amounts of other sulfide minerals.

The depth to groundwater at the site is unknown, but is estimated to range from 45 to 100 feet bgs, (U.S. EPA 1998a).

2.3 Site History

The Argonaut Mine operated in various forms from the 1850s until 1942. The raw ore was processed at one of two stamp mills located approximately 0.5 mile north of the site and topographically up gradient from the Argonaut Mine and the Argonaut Tailings Pile.

The Pioneer Mine (later known as the Argonaut Mine) was founded in 1850. It ran as a small-scale operation until 1893. From 1893 until 1942, it was operated by the Argonaut Mining Company.

In 1915 an agreement was reached between mining companies, Central Valley farmers, and other interested parties in California to impound mine tailings. In 1916 the EMAD was constructed in an alluvial canyon approximately ½-mile southeast of the Argonaut mine. The purpose of the dam was to impound tailings generated from the Argonaut mining and milling operations. This impounded area became what is now known as the Argonaut Mine Tailings Pile Site, the current subject of this current assessment.

2. Site Background

In 1918 the California Slimes Concentrating Company (CSCC) built a cyanide plant (AOC-2) to process the tailings, which included cyanide vat leaching. The Amador Metal Reductions Company took over the cyanide plant from the CSCC in 1922 and enlarged the plant by adding additional equipment units for processing slime and concentrate. In the cyanide plant, the mill concentrates were coated with coal tar and placed in cyanide leaching vats while slimes were treated with cyanide in an agitator. The gold-bearing solution was precipitated and then roasted.

The mechanical concentrating process at the mine resulted in three product streams: mineral concentrate, middlings (a recalcitrant ore material of low gold value, but consisting of a high concentration of sulfide minerals), and the waste sand and slime tailings. Middlings were captured as a middle product, heavier than tailings sands but lighter than the gold. The middlings contained sulfide minerals consisting primarily of pyrite and arsenopyrite with trace amounts of gold locked up within the sulfide crystal structure. Both amalgamation and cyanidization captured only the free gold, therefore the middlings were set aside until an alternative process was developed to release the gold at an economic cost. It was not until the 1980s that the potential for extraction of gold from recalcitrant ores was economically viable, when techniques such as the use of roasting and pressure leaching and bioleaching were developed to reprocess recalcitrant ores.

From 1923 to 1938, after initial processing by mercury amalgamation methods at the mills located near the mine, the residual tailings were hydraulically transported (slurried) down gravity piping for further processing and metal extraction at the AOC-2 cyanide extraction plant. Prior to processing, middlings from the stamp mill were apparently held on site in surface impoundments (thickening basins) and/or stockpiled at AOC-1 for further processing. The processed middlings, consisting of grey sands and fine clay-sized particles, were impounded in large ponds behind two tailings berms and the EMAD. The dam, located approximately 2,100 feet down slope of the processing plant, was positioned in a natural drainage basin at an elevation approximately 160 feet below the cyanide plant. The concrete dam has since silted in with sediments.

In 1942 the U.S. Government directed the halt of all domestic gold mining operations in favor of other metals and the Argonaut Mine and associated mills ceased operations in March of that year.

In 1986 Biomet II acquired mineral rights to 60,000 tons of the middlings ore stockpile in AOC-1. In 1989 Biomet II relinquished rights to the ore pile. In May, 1991 North American Reclamation, Inc. contracted with the owner of the stockpile to ship and process the ore at a plant in Carlin, Nevada. This work reportedly occurred in 1991 or 1992. Since then, no further mining or business activity has taken place at the site. Presently, approximately 1 million cubic yards of tailings remain on the site (URS 2011).

2.4 Previous Investigations

The California Central Valley Regional Water Quality Control Board informed DTSC of the site after conducting surface water runoff investigations. In response, DTSC conducted three investigations at the site:

- 1) In June 1993 DTSC collected soil and water/runoff samples from AOC-1, AOC-2, and AOC-3 and found the soil and tailings contained arsenic and lead.

2) On October 6, 2006 DTSC collected an unknown number of additional soil samples from AOC-1. These samples were analyzed using x-ray fluorescence (XRF) techniques.

3) In 2008-2009 URS Corporation (URS) performed an investigation on behalf of DTSC that consisted of drilling, soil sampling, and groundwater sampling in AOC-1 through AOC-3.

Brief summaries of the results of the DTSC/URS investigations in each AOC are provided in sections below. In addition to the DTSC investigations, Geotechnical Research Development and the Amador County Environmental Health Department (ACEHD) conducted sampling in AOC-5 in 2002 and 2003. The results of these investigations are discussed below in the AOC-5 section.

AOC-1: Unprocessed/Semi-Processed Ore Pile

On June 16, 1993, DTSC collected four surface soil samples from locations in AOC-1 and had them analyzed for arsenic. Arsenic concentrations in surface soil ranged from 306 mg/kg at the northeastern edge of the AOC to a maximum of 24,500 mg/kg at the north end of the AOC, near the gated entry to the site. One sample collected from the adjacent property north of Argonaut Lane contained arsenic at 8 mg/kg. Lead was detected at concentrations up to 2,090 mg/kg and mercury up to 38 mg/kg. Water samples collected from runoff from AOC-1 contained arsenic at a concentration of 2,070 milligrams per liter (mg/l), selenium at 4.3 mg/l, copper at 40 mg/l, and nickel at 31 mg/l. Arsenic concentrations at the site were identified as the greatest concern. The text of the report was not available for review, therefore it is unclear what conclusions, if any, were made. However, DTSC requested that the property owner conduct a Preliminary Endangerment Assessment and subsequently issued an order in 1995 requiring that AOC-1 be fenced and warning signs be posted.

DTSC collected additional samples in 2006. Arsenic was detected at concentrations up to 7,227 mg/kg in samples from AOC-1. No information on where or how many samples were collected was available (URS 2008). The characterization work also indicated there were acidic soils present that could cause or contribute to acid mine drainage.

Site activities for a 2008 and 2009 investigation by URS Corporation performed on behalf of DTSC consisted of drilling, soil sampling, and groundwater sampling. Samples were collected from 12 soil boreholes in AOC-1 to assess the lateral and vertical extent of exposed ore. Additional samples were collected from 34 soil boreholes located in other portions of the site. Depth-discrete groundwater samples were collected from four of the boreholes to assess impacts to groundwater. Arsenic concentrations exceeding 1,000 mg/kg were detected at two locations (soil borings SB-2 and SB-8) and low pH (approximately 3 to 5) surface soils were detected in samples collected from these borings. The lowest documented pH readings for surface soils in AOC-1 were from samples collected from borings SB-8 (pH = 2.6), SB-2 (pH=2.9), and SB-4 (pH = 3.3).

Except for boring SB-1, the report concluded that the lateral and vertical distribution of metal contamination (in both native soil and tailings) at concentrations exceeding the U.S. EPA Region 9's Regional Screening Levels for a residential scenario (r-RSLs) were not defined. However, the metal concentrations generally decreased with depth when native material/shale was encountered (roughly 20 feet bgs at AOC-1). Arsenic was determined to be the primary contaminant of concern (COC) in soil. Lead and mercury were also detected above their r-RSLs in soil boring SB-2 (URS 2011) and were also COCs at AOC-1. Samples from this boring also contained the highest concentrations for arsenic of any samples collected at the site during the URS investigation (39,000 mg/kg in a sample collected from 0 to 6 inches bgs). URS estimated there are approximately 159,000 tons (e.g. 106,000 cubic yards) of soil and ore in AOC-1 containing arsenic concentrations greater than 20 mg/kg.

AOC-2: Cyanide Plant

During the June 1993 DTSC investigation 4 soil samples and an unknown number of water samples were collected from AOC-2. Arsenic concentrations in soil ranged from 1,950 mg/kg in to 4,180 mg/kg in a sample collected near the border of AOC-1. Arsenic was detected at 623 mg/l in a water sample collected downstream from the cyanide plant. Other water samples collected from the vats in the cyanide plant did not contain arsenic at concentrations greater than 1 mg/l (URS 2008).

During the URS investigation, two borings were advanced in the area currently designated as AOC-2. Detected arsenic and other metal concentrations in samples collected from these borings were lower in AOC-2 than in AOC-1 (URS 2011). The vertical extent of tailings appeared to have been reasonably defined in AOC-2 (up to 35 feet bgs at the location of the thickening basin shown on Figure 2). The lateral extent of tailings remained undefined. Similar to AOC-1, all metal concentrations generally decreased with depth and/or where native material/shale was encountered at depth. However, at surface sample locations, elevated levels of arsenic were detected. Arsenic was considered the primary COC in soil in AOC-2. Lead was also considered to be a COC based on its occurrence in one sample above the r-RSL. Additionally, cyanides and coal tars used in the extraction process were identified as potential COCs in AOC-2.

AOC-3: Tailings Disposal Area and Impoundments

On June 16, 1993, DTSC collected surface soil and water samples from locations in AOC-3 and had them analyzed for arsenic. Arsenic concentrations in surface soil ranged from 381 mg/kg at the east edge of the AOC to a maximum of 11,800 mg/kg at the west end of the AOC, near the cyanide plant. The water samples did not contain arsenic at concentrations greater than 1 milligram per liter (mg/l).

During the 2008-2009 URS investigation, arsenic was detected at concentrations up to 670 mg/kg and lead at concentrations up to 160 mg/kg. The highest arsenic concentrations were detected in samples collected from between 10 and 20 feet bgs in soil borings SB-41 and SB-42, which were located just west of the EMAD. Except for these two borings, detected arsenic concentrations were less than 500 mg/kg for all samples collected from AOC-2 and AOC-3 and were generally about one order of magnitude less than concentrations detected in AOC-1.

Groundwater samples collected in AOC-3 yielded arsenic at concentrations up to 400 micrograms per liter ($\mu\text{g/l}$), chromium up to 130 $\mu\text{g/l}$, lead up to 24 $\mu\text{g/l}$, nickel up to 400 $\mu\text{g/l}$, and zinc up to 1,200 $\mu\text{g/l}$. For comparison, the National primary MCL for arsenic is 10 $\mu\text{g/l}$, for chromium is 100 $\mu\text{g/l}$, and for lead is 15 $\mu\text{g/l}$. There are no National MCLs for nickel or zinc. These metals were determined to be COCs for surface waters.

AOC-4: Surface Water Drainage

The DTSC collected surface water samples on June 16, 1993, in the drainage areas on site. Arsenic was detected at a concentration of 2,070 mg/l in a sample collected from AOC-1, and at 612 mg/l in a sample collected from just downstream of the Cyanide Plant in AOC-2. Surface water samples from AOC-3 did not show elevated levels of arsenic or other heavy metals.

AOC-5: Residential Lot-Tailings Disposal Area

On April 30, 2002, Geotechnical Research Development collected two soil samples from AOC-5 and had them analyzed for arsenic (ACEHD 2003). The arsenic values for these two samples were 120 mg/kg and 1,300 mg/kg. On February 24, 2003, the ACEHD sampled runoff from the two adjacent residential lots. The ACEHD measured the pH of the stormwater runoff with pH indicator strips; all results were in the pH 1 to 2 range (ACEHD 2003).

3 START Activities

3.1 Project Objectives

At the direction of the U.S. EPA, the START conducted an assessment to evaluate the nature and extent of elevated arsenic, cyanides, lead, mercury, and polycyclic aromatic hydrocarbons (PAHs) in surface and shallow subsurface soils at the site, and in sediment and surface water potentially discharging from the site. The data generated by this assessment will be used to assess whether removal actions and/or additional assessments are warranted in the respective AOCs.

3.2 Project Planning Activities

Prior to mobilizing to the site and in order to support the U.S. EPA's environmental data collection activities, the START identified project data quality objectives (DQOs) and developed the *Sampling and Analysis Plan, Argonaut Mine Tailings Pile Assessment, Jackson California* (SAP), July 2013 (E&E 2013). The scope of work and objectives outlined in the SAP were derived based on direction from the U.S. EPA. The SAP described the project and data use objectives, data collection rationale, data quality assurance goals, and requirements for sampling and analysis activities. It also defined the sampling and data collection methods used during the removal assessment work. A copy of the SAP is included as Appendix C.

The specific field sampling and chemical analysis information in the SAP were prepared in accordance with the following U.S. EPA documents: *EPA Requirements for Quality Assurance Project Plans* (EPA QA/R 5, March 2001, EPA/240/B 01/003); *Guidance on Systematic Planning Using the Data Quality Objectives Process* (EPA QA/G 4, February 2006, EPA/240/B-06/001); *Guidance on Choosing a Sampling Design for Environmental Data Collection* (EPA QA/G 5S, December 2002, EPA/240/R 02/005); *Superfund Lead-Contaminated Residential Sites Handbook* (OSWER 9285.7-90, August 2003); and *Uniform Federal Policy for Implementing Environmental Quality System* (EPA/505/F-03/001, March 2005).

Based on the DTAC and URS investigations, the U.S. EPA determined that arsenic, lead, and mercury were the COCs for soil and arsenic, lead, chromium, nickel, and zinc were COCs for surface water. The site-specific investigation level for soils during this assessment was 61 mg/kg for arsenic, 400 mg/kg for lead, and 10 mg/kg for mercury. These investigation levels were based in part on the U.S. EPA's r-RSLs (U.S EPA 2013b). Based on direction from the U.S. EPA, the screening levels for arsenic corresponds to an estimated excess cancer risk of 10^{-4} for a residential scenario and the screening levels for PAHs are either the concentration corresponding to an excess cancer risk of 10^{-4} , or a Hazard Index of 1 for non-cancer health affects. For the purpose of this investigation, surface soils were assumed to include soils from 0-inches to 2-inches bgs and shallow subsurface soils were considered to be from 12-inches to 18-inches bgs.

In addition to the DQOs and the SAP, the START prepared a site-specific health and safety plan for the removal assessment field work.

3.2.1 Deviations from the SAP

There were several deviations from the proposed methods and procedures described in the SAP. The SAP specified the collection of surface and shallow subsurface samples at AOC-5.

However, AOC-5 was not sampled or otherwise disturbed during the investigation because the property owner denied access to the parcels at the time of fieldwork. An access order was subsequently issued to the property owner of AOC-5 and soil samples were collected on September 26, 2013. A separate removal assessment report will be prepared for AOC-5.

Two sediment samples and one water sample were collected from within the boundaries of AOC-3. Based on the SAP, these samples would normally have been identified first by the AOC they were collected from (i.e. AOC-3). However, since these samples represented residual contamination from runoff within the surface drainages (designated AOC-4) of the site, they were designated AOC4-SD-02-00, AOC4-SD-03-00, and AOC4-W-02, respectively.

Based on the SAP, samples with total metals concentrations between approximately 10 times their respective soluble threshold limit concentration (STLC) values and the total threshold limit concentrations values were to be analyzed for soluble metals. However, not all samples that met the criteria were analyzed for soluble metals. Instead, based on professional judgment and verbal direction from the U.S. EPA, four samples with concentrations within the desired range (using XRF technology) were selected for analysis for STLC analysis using the California Waste Extraction Test (WET).

In accordance with U.S. EPA Method 6200, sample preparation for XRF analysis includes passing samples through a No. 60 mesh sieve. However, not all samples were sieved prior to analysis for metals. Normally U.S. EPA Method specifies that samples with a high moisture content be dried to allow sieving. However, drying samples would have resulted in the volatilization of mercury, a contaminant of concern. In general, samples with a high relative moisture content were homogenized, then analyzed directly through the plastic bag they were collected into using XRF technology. Selected samples that could not be screened were then transferred to a 4-ounce or 8-ounce sample jar and submitted to the analytical laboratory for total metals analysis by U.S. EPA Method 6010B.

The SAP specified sequential number of samples within an AOC; however, not all samples collected from AOC-1 were sequentially numbered. At the time of sample collection, the total number and exact location of samples to be collected was varying based on direction from the U.S. EPA. Because of the uncertainty in the total number of samples to be collected, START reserved some sample location designations for possible future use. Due to time and budget constraints, some of these reserved location designations were never used. Thus, samples were not numbered using the locations designations AOC1-D-31 through AOC1-D-33 and AOC1-D-35; thus, there are no samples with these location numbers. The surface sample from AOC1-D-23-00 was inadvertently not analyzed by either method. Due to the presence of hard rock, no sample was collected from the 12-inches to 18-inch depth at locations AOC1-D-04 and AOC1-D-28. Although not technically a deviation from the SAP, it should be noted that three sample locations designated as being in AOC-1, (AOC1-D-18, AOC1-D-19, and AOC1-D-36) were in AOC-2.

At the direction of the U.S. EPA, additional samples (AOC1-D-37-00 and AOC1-D-37-12) were collected near the top of a low hill located approximately 550 feet west of AOC-1. The purpose of these samples was to evaluate the potential for this area to represent background COC concentrations. These samples were not specifically included in the original SAP.

In accordance with the SAP, the START attempted to record the position of all soil, water, and sediment samples collected during the assessment using global positioning system (GPS) technology (a Trimble, GeoXT® GPS unit). However, local terrain features (i.e. a dense and broad tree canopy or locations between tanks) prevented the collection of the latitude and longitude information at some sample locations in AOC-2 and at locations near the EMAD. Photographs and hand drawn maps were used to approximate some sample locations in these areas.

3.3 Removal Assessment Field Activities

During the period from July 9 through July 12, 2013, START, the U.S. EPA, and three members of the U. S. Coast Guard's Pacific Strike Team mobilized to Jackson, California and traveled to the site daily to perform removal assessment (i.e., soil, water, and sediment sampling) activities. Photographs of selected removal assessment activities are included as Appendix D.

Except as noted in Section 3.2 samples were collected in accordance with the SAP. Soil samples were collected from 0 to 2 inches bgs at each sampling location using a plastic or stainless steel scoop. Soil samples were collected from 12 to 18 inches bgs into clean plastic bags or a laboratory-prepared sample jar using a hand auger or shovel. Samples deemed dry enough for XRF analysis was passed through a No. 60 mesh sieve to remove large particles. Sieved sample material was transferred to a pre-labeled polyethylene cup and covered with mylar film to be analyzed for COCs using XRF technology in accordance with U.S. EPA Method 6200 (U.S. EPA 2007).

Samples submitted for definitive analysis were analyzed for arsenic, lead, and other toxic heavy metals using U.S. EPA SW-846 Method 6010B and for mercury using U.S. EPA Method 7470A. Sample locations for AOC-1 are shown on Figures 3 and Figure 4 (Appendix A). Sample locations in AOC-2 are shown on Figures 5 through Figure 8, and locations for AOC-4 are shown on Figures 9 through Figure 11.

Of the 95 soil and sediment samples (including field duplicate and preparation duplicate samples) collected and analyzed using XRF technology, thirty-one samples were submitted to Test America Laboratories Inc., in West Sacramento, California (Test America) for confirmatory laboratory analysis for selected metals by definitive methods. Twenty-one soil samples (including three field duplicates) collected from AOC-1, five samples from AOC-2, and five samples from AOC-4 (including one field duplicate sample) were submitted to Test America. Two soil samples from AOC-1 and two sediment samples from AOC-2 were analyzed for soluble metals by Test America using the California WET test.

Fourteen soil or sediment samples from AOC-2 (including two field duplicates), and five sediment samples from AOC-4 (including one field duplicate) were analyzed by Test America for total cyanides and cyanides amenable to chlorination (amenable cyanides) by U.S. EPA Method 9010C.

Ten soil or sediment samples from AOC-2 and five sediment samples from AOC-4 were analyzed by Test America for PAHs using U.S. EPA Method 8270C. This included the collection of sample AOC2-P-01, which was removed from the interior of a 55-gallon capacity processing barrel in the cyanide plant. This sample appeared to be hardened coal tar.

Two surface water samples and one field duplicate sample were collected from the site. One surface water sample (AOC4-W-01) and a duplicate sample (AOC4-W-01-7) were collected downstream from the EMAD at the inlet to the culvert beneath Sutter Street and one surface water sample (AOC4-W-02) was collected from the small pond located west of the Lower Tailings Dam (Figure 9). These samples were analyzed for total and amenable cyanides by Test America and for metals by the U.S. EPA Region 9 Laboratory. The U.S. EPA Region 9 Laboratory also analyzed samples AOC4-W-01 and AOC4-W-02 for PAHs.

A portable Yellow Springs Instruments (YSI) Model 556 meter was used to measure the pH, dissolved oxygen concentrations, temperature, and specific conductivity of water discharging to the culvert inlet at Sutter Street. The unit was calibrated for pH and conductivity in the field immediately prior to use. The measurements were made at the same location and immediately prior to the collection of surface water sample AOC4-W-01.

3.3.1 XRF Analysis Procedures

During this field assessment, a total of 83 soil samples were analyzed using a field portable XRF unit operated in accordance with the manufacturer's guidance and generally according to U.S. EPA SW-846 Method 6200, including Quality Assurance/Quality Control procedures. The energy calibration and resolution check analysis, standard reference material sample analysis, control standard sample analysis, and sand blank sample analysis used for XRF calibration, performance, and quality control are discussed in the SAP (Appendix C). As previously discussed, not all samples could be sieved prior to analysis. These samples were homogenized in the plastic bag they were collected into, smoothed to a roughly uniform thickness of approximately ½-inch, and laid flat on the XRF stand for analysis. Eleven of the unprocessed samples were then placed into glass sample jars and submitted to Test America for confirmation analysis by U.S. EPA Method 6010B. Twenty-one samples were also submitted to Test America in the XRF cups used during the Method 6200 analysis.

Before operation of the XRF unit each day, the unit was allowed the manufacturer-recommended warm up time of 25 to 30 minutes. The XRF unit was then subjected to an initial calibration that included an energy calibration and resolution check and standard reference material analysis. Standard reference materials used for XRF calibration were obtained from the National Institute of Standards and Technology (NIST) and referenced as NIST 2702 or NIST 2710a when analyzed. Once calibrated, two source control standards and a sand blank sample were analyzed to evaluate instrument performance. In addition to periodic instrument performance checks, sand blank samples were periodically prepared and analyzed to monitor for cross-contamination. Sand blank samples were ground using a mortar and pestle, and then prepared by following the same preparation method and using the same sample preparation equipment as for site soil samples. Approximately one out of every 10 samples was selected for preparation duplicate analysis. Preparation duplicates were collected by splitting a single site sample after homogenization and sieving and then preparing two separate sample aliquots for XRF analysis. Preparation duplicates were labeled with a "PD" following the corresponding sample identifier.

All XRF sample analyses were performed in the intrusive mode with a 120-second count time for measurement at the U.S. EPA Region 9 Laboratory (U.S. EPA 2007). Except for analysis, preparation, and field duplicate samples, each sample was analyzed one time and the corresponding arsenic, lead, and mercury concentrations were recorded in the field notebook.

4 Results

4.1 Data Quality

Laboratory data generated during the removal assessment were validated by START using the *Region 9 Draft Superfund Data Evaluation/Validation Guidance* (U.S. EPA 2001b). Copies of the data validation and laboratory analytical reports are included in Appendix E. All laboratory analytical data were considered valid, definitive, and suitable for the intended project uses with qualifications.

Data validation reports document the following data issues:

- Several samples used for matrix spike and matrix spike duplicate analyses had recovery percentages outside of the normal range. Qualification of the data was not necessary where the amount present in the parent sample was greater than four times the amount spiked; otherwise results of the batch were marked with a J qualifier indicating the respective concentrations are estimated. The following samples exhibited this issue: AOC1-D-29-00 for lead, AOC1-D-34-12 for arsenic and mercury, and AOC2-SD-01-00 and AOC4-SD-02-00 for cyanide.
- The relative percent difference (RPD) for several samples and their field duplicates was greater than the allowable maximum RPD of 35 percent for soil or 20 percent for water; these results are marked with a J qualifier. The following samples exhibited this issue: AOC2-SD-10-7 and AOC2-SD-10-00 for cyanide, AOC4-SD-03-07 and AOC4-SD-03-00 for benzo(a)anthracene and pyrene.
- Surrogate recovery was outside control limits generated by the laboratory for several samples in the analysis for PAHs: AOC2-SD-02-00, AOC2-SD-03-00, AOC2-SD-05-00, AOC2-SD-06-12, AOC2-SD-08-00, AOC2-SD-09-12, and AOC2-SD-10-00. The detected results were qualified as estimated (J-flagged). The surrogate recoveries were above the upper limit in most of samples except AOC2-SD-02-00 and AOC2-SD-05-00. The surrogate recoveries were between 10 percent and the lower limit in these samples and the non-detected results were qualified as estimated (UJ).

4.1.1 Equipment Rinse Blank Results

Two equipment rinse blanks (AOC1-D-30-EB and AOC4-SD-03-EB) were collected and submitted for analysis by Test America to evaluate equipment decontamination procedures. The samples were obtained by pouring clean distilled water over decontaminated equipment and collecting it directly into the appropriate sample containers. Sample AOC1-D-30-EB contained calcium at 0.057 mg/l and nickel at 0.0078 mg/l. Calcium was detected at the same concentration in sample AOC4-SD-03-EB. Both detections for calcium were estimates (J-flagged) as they were only slightly above the method detection limit of 0.050 mg/l and much less than the quantifiable reporting limit of 0.50 mg/l. No other metals were detected in either sample. Sample AOC4-SD-03-EB was also analyzed for PAHs and total and amenable cyanide. No analytes in either class of compounds were detected. These sample results indicate decontamination methods used at the site were unlikely to result in cross-contamination between samples.

4.2 Correlation between XRF and Laboratory Analytical Results for Lead, Arsenic, and Mercury

The samples submitted to the laboratory for definitive analysis were used to establish and/or document the comparability and correlation between the definitive and non-definitive data sets. A correlation study was performed for samples analyzed for arsenic, lead, and mercury by both XRF and laboratory methods. The correlation study included samples that were analyzed directly through the plastic sample bag using XRF technology (i.e. without sieving) and then submitted for analysis by U.S. EPA Method 6010B. The methods used to analyze each sample are indicated on Table 1.

The correlation coefficient (R) between the XRF and laboratory detected concentrations for arsenic was 0.996 and the coefficient of determination (R^2) was 0.991. Of the 30 pairs of results compared in the study, 16 of the results using the laboratory method were less than the concentrations measured using the XRF method and 13 were greater (one pair was identical). The RPD between the average concentrations using the respective methods was 6.2 percent and the RPD between the median values was 25.6 percent. These data suggest there is little or no skew or bias in the results.

The correlation coefficient (R) between the XRF and laboratory detected concentrations for lead was 0.992 and the coefficient of determination (R^2) was 0.983. Of the 30 pairs of results compared in the study 19 of the results using the laboratory method were less than the concentrations measured using the XRF method. The RPD between the average concentrations using the respective methods was 5.3 percent and the RPD between the median values was 10.8 percent. These data suggest there is little or no bias or skew in the results.

Mercury was not detected in several of the samples analyzed by XRF technology. Because a numeric value was not available for comparison, these data were not used in the correlation study. The correlation coefficient (R) between the XRF and laboratory detected concentrations for mercury in the 24 pairs compared was 0.919 and the coefficient of determination (R^2) was 0.844. Of the 24 pairs of results compared in the study, 23 of the results using the laboratory method were less than the concentrations measured using the XRF method. Of the samples compared, the average concentration for mercury using the XRF was 23.8 mg/kg and the average was 15.9 mg/kg using laboratory concentrations (RPD of 49.7 percent). Median values were 6.2 mg/kg using the XRF analysis and 1.6 mg/kg using the laboratory method (RPD of 284 percent). These discrepancies suggest that XRF results for mercury are biased high in comparison to the laboratory method.

4.3 AOC-1 Analysis Results

Results of sampling in AOC-1 (Figures 3 and 4 in Appendix A) are discussed in the following sections by analyte.

4.3.1 Arsenic, Lead, and Mercury

A summary of the results for arsenic, lead, and mercury in AOC-1 is shown in Table 1 (Appendix B). The results for arsenic, lead, and mercury in surface soils are shown on Figure 3 (Appendix A). The results for samples collected from 12 inches to 18 inches bgs are shown on Figure 4.

Detected arsenic concentrations in soil samples using both the XRF screening and definitive analytical methods ranged from 4.4 mg/kg in subsurface soil sample AOC1-D-07-12 to 48,000 mg/kg in subsurface soil sample AOC1-D-30-12. The latter sample was collected near the location of URS soil boring SB-2.

Samples collected from the western and northern portions of the site generally yielded the highest concentrations of arsenic and detected surface soil concentrations in those areas were generally above 3,200 mg/kg. Concentrations in samples collected near the northern boundary of AOC-1 at locations AOC1-D-01 (collected from the property on the west side of Argonaut Lane), AOC1-D-02, and AOC1-D-20 all exceeded the screening level. Detected concentrations in surface and shallow subsurface samples along the northeastern boundary of AOC-1 (i.e. sample locations AOC1-D-07 and AOC1-D-21 through AOC1-D-25) were all below the 61 mg/kg screening level, suggesting the lateral extent of arsenic contamination is defined in that direction. Although surface sample AOC1-D-24-00 yielded an arsenic concentration of 66 mg/kg using the XRF method, the definitive result using the laboratory method was 55 mg/kg, which was below the screening level. Similarly, detected concentrations in samples collected from locations AOC1-D-03, AOC1-D-15, and AOC1-D-16 were below the screening level, suggesting the lateral extent of arsenic contamination is defined to the west and southwest. Arsenic concentrations were generally lower in samples collected from the southeastern portions of AOC-1. It should be noted that three of these sample locations (AOC1-D-18, AOC1-D-19, and AOC1-D-36) were in AOC-2.

Lead concentrations as determined by definitive analysis ranged from 12 mg/kg (AOC1-D-21-00) to 4,000 mg/kg in sample AOC1-D-13-00. Lead concentrations were above the 400 mg/kg in at least one depth (i.e. 0 to 2 inches or 12 to 18 inches) in 13 of the 33 locations at AOC-1. All samples that were above the screening level for lead were also above the action level for arsenic.

Detected mercury concentrations were above the 10 mg/kg screening level in one or more samples collected from 8 locations sampled in AOC-1. Concentrations using the laboratory method ranged from 0.10 mg/kg (AOC1-D-21-00) to 360 mg/kg (AOC1-D-29-00). In all samples where mercury concentrations exceeded the screening level, arsenic concentrations also exceeded the screening level.

4.3.2 Soluble Metals

Samples AOC1-D-27-12 and AOC1-D-34-12 were analyzed for soluble metals by Test America using WET. Arsenic was detected in samples AOC1-D-34-12 at 8.9 mg/l, which is above the STLC hazardous waste criteria value of 5.0 mg/l. The total arsenic concentration in this soil sample was 290 mg/kg. Arsenic was detected at 0.42 mg/l in AOC1-D-27-12. This compares to a total arsenic concentration of 470 mg/kg using XRF technology and analyzing the unprocessed sample through the bag, and 130 mg/kg using the laboratory method. Detected concentrations of other metals in these samples were below the STLC hazardous waste criteria limits. A summary of the results for soluble metals in AOC-1 is shown on Table 2.

4.3.3 Soil pH

A summary of the results for soil pH in AOC-1 is included in Table 3. Nine soil samples from AOC-1 (including two field duplicates) were analyzed for pH. Detected soil and sediment pH concentrations ranged from a minimum pH of 3.09 in sample AOC1-D-30-12 to 7.76 in sample AOC1-D-28-00. It should be noted that the pH of field duplicate sample AOC1-D-28-00-7 was 3.07. The reason for the discrepancy is not known.

4.4 AOC-2 Analysis Results

Results of sampling in AOC-2 are discussed in the following sections by analyte.

4.4.1 Arsenic, Lead, and Mercury

Table 4 summarizes the results for arsenic, lead, and mercury in AOC-2. The results for arsenic, lead, and mercury in surface soil samples are shown in Figure 5 and the results for subsurface samples are shown on Figure 6. Detected arsenic concentrations in AOC-2 (including samples AOC1-D-18, AOC1-D-19, and AOC1-D-36) were all above the screening level and ranged from 63 mg/kg in sample AOC2-SD-08-00 to 6,300 mg/kg in sample AOC2-SD-10-00. The latter sample was collected from what appeared to be process sludge remaining in vat V-2 in the former cyanide plant. Arsenic was detected at 4,900 mg/kg in the associated field duplicate (sample AOC2-SD-10-00-7).

Except for sample AOC2-SD-10-00, in which lead was detected at 750 mg/kg, and its duplicate AOC2-SD-10-00-7, detected lead concentrations in AOC-2 samples were all below 180 mg/kg (i.e. less than half of the 400 mg/kg screening level).

Detected mercury concentrations ranged from 0.2 mg/kg (AOC2-SD-01-00) to 41 mg/kg in sample AOC2-SD-03-00. In addition to AOC2-SD-03-00, mercury was detected at concentrations above the screening level in samples AOC2-SD-02-00, AOC2-SD-07-12 (using XRF method), and AOC2-SD-10-00. Note that the XRF result for AOC2-SD-07-12 may be biased high.

4.4.2 Soluble Metals

Samples AOC2-SD-03-00 and AOC2-SD-06-00 were analyzed for soluble metals by Test America using WET. Arsenic was detected at 0.53 mg/l in sample AOC2-SD-03-00, below the STLC hazardous waste criteria value of 5.0 mg/kg. The total arsenic concentration in this sample was 280 mg/kg and 300 mg/kg by XRF and definitive methods respectively. The maximum concentration of soluble lead (1.7 mg/l) was also detected in this sample. Soluble arsenic was detected at 4.5 mg/l in AOC2-SD-06-00; the total arsenic concentration in this sample was 350 mg/kg using XRF technology. Concentrations were below the respective STLC hazardous waste criteria values for every analyte.

4.4.3 Soil pH

Sample AOC2-SD-03-00 was collected from process piping on what appeared to be a decanting tank at the former cyanide plant. The measured pH of the sample was 2.14, the lowest of any sample collected during the assessment.

4.4.4 Cyanide

Table 5 presents a summary of the results for cyanide in AOC-2. Cyanide results are shown in Figure 7. All fifteen samples (including two field duplicate samples) collected from AOC-2 were analyzed for total and amenable cyanides. In all cases, the concentrations for total cyanides and cyanides amenable to chlorination were identical. Cyanides were not detected in samples AOC2-SD-01-00, AOC2-SD-01-12 (or its duplicate AOC2-SD-01-12-7), AOC2-SD-05-00, and AOC2-SD-06-12. Concentrations in samples AOC2-SD-02-00, AOC2-SD-07-00, AOC2-SD-07-12, and AOC2-SD-08-00 were all at or above the 22 mg/kg screening level. The maximum concentration of 75 mg/kg was detected in sample AOC2-SD-08-00, which was collected from a process drum on the northeast side of Tank No. 6.

4.4.5 PAHs

Ten sediment and soil samples collected from AOC-2 were analyzed by Test America for PAHs using U.S. EPA Method 8270. Table 6 and Figure 8 present results for PAHs in AOC-2. PAHs were detected in only three samples. One sample (AOC2-P-01) collected from the interior lining of a process drum in the cyanide plant appeared to be solidified coal tar. This sample was the only one in which numerous PAHs were detected above their respective screening levels. Benzo[a]pyrene was detected at 4.2 mg/kg in sample AOC2-SD-04-00, above the screening level of 1.5 mg/kg. All other PAHs detected in this sample were at concentrations below the associated screening level. PAHs were detected at concentrations near the method detection limit in sample AOC2-SD-07-12. PAHs were not detected in any other samples.

4.5 AOC-4 Analysis Results

The results of sampling in AOC-4 (Figure 9 through Figure 11) are discussed in the following sections by analyte and media.

4.5.1 Arsenic, Lead, and Mercury in Sediment

Table 7 and Figure 9 present results for arsenic, lead, and mercury in AOC-4. Detected concentrations for arsenic ranged from 44 mg/kg in sample AOC4-SD-03-00-7 to 7,300 mg/kg in sample AOC4-SD-02-00. Except for sample AOC4-SD-03-00 and its field duplicate, arsenic concentrations were above the screening level. This includes the surface sediment sample AOC4-SD-01-00 (4,700 mg/kg), which was collected at the base of the EMAD.

Only sample AOC4-SD-02-00 yielded lead at a concentration above the 400 mg/kg screening level. The detected concentration in this sample was 750 mg/kg. Concentrations in the other samples were all less than 19 mg/kg.

Similar to the results for lead, only sample AOC4-SD-02-00 yielded mercury at a concentration above the 10 mg/kg screening level. The detected concentration in this sample was 14 mg/kg; all other concentrations were less than 0.72 mg/kg.

4.5.1.1 Metals in Surface Water Samples

Surface water sample AOC4-W-01 and a field duplicate were collected from the inlet to the culvert that crosses Sutter Street near the down gradient site boundary. Sample AOC4-W-02 was collected from the small pond behind the lower tailings dam.

The two water samples (AOC4-W-01 and AOC4-W-02) and the duplicate sample (AOC4-W-01-7) were analyzed by the U.S. EPA Region 9 Laboratory for metals using U.S. EPA Method

6010. Lead, chromium, and mercury were not detected at their respective method detection limits in any water sample. Arsenic was detected at 59 µg/l in sample AOC4-W-01, and at 61 µg/l in the associated field duplicate. Arsenic was detected at 50 µg/l in AOC4-W-02. These concentrations were below the screening level of 150 µg/l. Detected nickel concentrations ranged from 2.1 µg/l to 2.4 µg/l and were below the screening level of 44 µg/l. Zinc concentrations range from 5.8 µg/l to 11 µg/l and were below the 100 µg/l screening level. Laboratory results and data validation reports for these samples are included in Appendix E.

A YSI Model 556 meter was used to measure the pH, conductivity, temperature, and the dissolved oxygen concentration immediately prior to the collection of, and at the same location as, sample AOC4-W-01. The measured pH was 7.43. The conductivity was 1,877 micro-Siemens per centimeter. The dissolved oxygen concentration was 8.13 mg/l and the measured temperature was 16.9 degrees Celsius (approximately 62 degrees Fahrenheit).

4.5.2 Cyanide

As part of the AOC-4 assessment, five surface sediment samples (including one field duplicate sample) were collected and analyzed by Test America for total and amenable cyanides. Similar to the results for AOC-2, the concentrations for total cyanides and cyanides amenable to chlorination were identical in all cases. Cyanide was detected in sample AOC4-SD-02-00 at an estimated concentration of 23 mg/kg. Detected concentrations in the remaining four sediment samples were all less than 1.4 mg/kg. A summary of the sediment sample results for cyanide AOC-4 is included in Table 8 and shown on Figure 10.

4.5.2.1 Cyanide in Surface Water Samples

Two water samples (AOC4-W-01 and AOC4-W-02) were collected and analyzed by Test America for total and amenable cyanides. Surface water sample locations are depicted on Figure 10. Cyanides were not detected in either of the water samples above the method detection limit of 0.06 µg/l.

4.5.3 PAHs

A summary of PAH results for sediment samples collected from AOC-4 is included as Table 9 and depicted in Figure 11. Except in sample AOC4-SD-03-00, PAHs were not detected at concentrations above the method detection limits in sediment samples collected from AOC-4. Detected concentrations in AOC4-SD-03-00 were all less than the associated screening levels. However, the method detection limits for benzo[a]pyrene and dibenz(a,h)anthracene in sample AOC4-SD-01-00 were above the associated screening level. It should be noted that some of the calibration checks performed as part of the quality control procedures were outside the limits specified for the method. These data were qualified as necessary.

4.5.3.1 PAHs in Surface Water Samples

The U.S. EPA Region 9 Laboratory analyzed water samples AOC4-W-01 and AOC4-W-02 for PAHs using U.S. EPA Method 8270. PAHs were not detected at the method quantitation limits in either water sample.

5 Summary and Discussion

5.1 Use of XRF data for Site Decisions

The strong correlation between sample results for arsenic and lead using the XRF and laboratory analytical methods suggests that XRF analysis, when supported by periodic laboratory confirmation, is an acceptable method for obtaining definitive data on arsenic and lead during future assessment or removal work at the site.

The observed bias and the relatively high detection limit and variability for mercury using the definitive and XRF screening methods suggests that XRF analysis may not be appropriate for establishing background soil concentrations for mercury, or for evaluating whether mercury concentrations in soil exceed the screening level. If the removal action level for mercury remains the same as the screening level for the assessment (10 mg/kg), then XRF technology may not be a suitable tool for determining mercury concentrations in site soils and the laboratory method should be used in cases where decisions must be made based on detected mercury concentrations. However, it should be noted that mercury concentrations above the 10 mg/kg screening level were co-located with elevated concentrations of arsenic in all cases, so determinations based only on detected mercury concentrations are not likely to be necessary.

5.2 Discussion of Soil Sampling Data

5.2.1 AOC-1

Arsenic concentrations in the central, northern, and western portions of AOC-1 are above the 61 mg/kg screening level. Large sections of the surface and shallow subsurface in these portions of AOC-1 are contaminated with arsenic at hazardous concentrations (i.e. greater than 1,000 mg/kg), especially along the western boundary of AOC-1 near Argonaut Lane. Lead and mercury were also detected at concentrations above their screening levels; in all cases, elevated levels of lead and mercury were associated with samples that also yielded arsenic concentrations above the screening level. This suggests that arsenic can be used as the primary COC and that reducing the exposure risks to arsenic by removal or capping will also reduce exposure risks from other contaminants.

Mercury concentrations were generally higher in the surface samples than in the samples collected from 12 inches to 18 inches bgs at the same location. This result, combined with the relatively low concentrations for total mercury, suggests that mercury is present as an inorganic salt and not as the more volatile elemental mercury.

Detected arsenic concentrations in surface and shallow subsurface samples along the northeastern boundary of AOC-1 were generally below the screening level, suggesting the lateral extent of arsenic contamination is defined in that direction. Similarly, detected concentrations in samples collected from locations AOC1-D-03, AOC1-D-15, and AOC1-D-16 were below the screening level, suggesting the lateral extent of arsenic contamination is defined to the west and southwest. Concentrations in samples collected at and near the northern boundary of AOC-1 exceeded the screening level, indicating additional characterization is warranted in that area. During September 2103, START and the U.S. EPA collected additional surface and shallow subsurface samples from these areas. The results will be presented in a subsequent report.

Arsenic concentrations were generally lower in samples collected from the southern and southeastern portions of AOC-1, although additional sampling is likely warranted south and/or southwest of sample location AOC1-D-17. However, changes in arsenic and lead concentrations generally appeared to be correlated with observed changes in vegetation and soil type. It was visually observed that areas with higher concentrations were generally devoid of vegetation, or the vegetation that was present showed signs of stress.

To aid decision makers, START suggests dividing AOC-1 into smaller decision units roughly based on detected arsenic concentrations. The proposed decision unit areas in AOC-1 are shown in Figure 12. A table inserted into the figure shows the approximate area and volume (by 1-foot thick lifts) of soil with elevated arsenic concentrations including the area of extremely elevated arsenic concentrations near URS soil boring SB-2.

5.2.2 AOC-2

Except for the sample collected from the process vat V-2, detected concentrations of lead in AOC-2 were all below the screening level. Mercury concentrations exceeded the screening level at four sample locations, but these were all co-located with samples that also exceeded the screening level for arsenic. Arsenic was detected at concentrations above the screening level in every sample and was greatest in the sample collected from process vat V-2 (sample AOC2-SD-10-00 at 6,300 mg/kg using the laboratory method). These results suggest that the lateral and vertical extents of contaminants are not defined. Depending on the goal of future potential removal actions at the site, additional characterization may be warranted. However, since the equipment is stationary and relatively stable, if the goal is only to clean the process tanks, vats, drums, and associated appurtenances in that area, additional sampling may not be necessary unless and until removal operations are underway.

PAHs were detected at relatively low concentrations in only two soil or sediment samples collected from AOC-2. Only one constituent, benzo[a]pyrene was detected above its screening level in either sample, suggesting that contamination from the use of coal tar is not wide spread in AOC-2. This conclusion is supported by the fact that these samples were taken from relatively close proximity to sample AOC2-P-01, which appeared to be solidified tar and yielded numerous PAHs above their respective screening levels. START recommends that the drum this sample was collected from be removed and disposed of at an appropriately licensed facility.

Cyanides were detected at concentrations that exceeded the screening level in four samples collected from three locations in AOC-2. However, as was the case with lead and mercury, all detections of cyanide above the 22 mg/kg screening level were co-located with arsenic samples that exceeded the screening level.

5.2.3 AOC-4

Arsenic was detected at concentrations above the screening level in three of four samples collected from AOC-4. This includes sample AOC4-SD-01-00, which was collected from the base of the downstream side of the EMAD. Arsenic, lead, mercury, and cyanide were detected above their screening levels in sample AOC4-SD-02-00, which was collected from sediment in a depositional area near the down gradient edge of AOC-2.

Based on the location and relatively high concentration of arsenic (4,700 mg/kg) for sample AOC4-SD-01-00, it seems possible for contaminants to migrate off site at potentially hazardous concentrations. The lateral and vertical extent of arsenic contamination is not defined in this area and additional characterization is recommended.

5.2.3.1 Surface Water Sampling in AOC-4

Cyanides and PAHs were not detected in either water sample collected from AOC-4. These constituents do not appear to be COCs for surface waters potentially discharging from the site. Arsenic was detected at 59 µg/l in sample AOC4-W-01, and at 61 µg/l in the associated field duplicate. Arsenic was detected at 50 µg/l in AOC4-W-02. These concentrations were below the project-specific screening level of 150 µg/l, but are above the California MCL for drinking water of 10 µg/l. These results, especially when considered with the results of sample AOC4-SD-01-00, suggest that impacts to groundwater or downstream surface waters are possible. It is unclear whether these contaminants have already migrated downstream to Jackson Creek. Additional assessment is recommended.

5.3 Soluble Metals

Two samples from AOC-1 and two samples from AOC-2 were analyzed for soluble metals using the WET. Detected concentrations of soluble arsenic varied greatly in relation to total arsenic. No clear relationship between the two was observed. Arsenic was detected at 8.9 µg/l in sample AOC1-D-34-12, above the California State STLC hazardous waste criteria limit of 5.0 µg/l. The total arsenic concentration in this same sample was 290 mg/kg. Other samples with similar total arsenic concentrations did not yield soluble arsenic at concentrations above the hazardous waste limit. If the thresholds for soluble hazardous waste are exceeded and they are hauled to a disposal facility, these wastes may be subject to land disposal restrictions per Title 40 of the Code of Federal Regulations, Part 268. These restrictions typically require stabilization, encapsulation, or some other appropriate type of treatment prior to disposal.

6 References

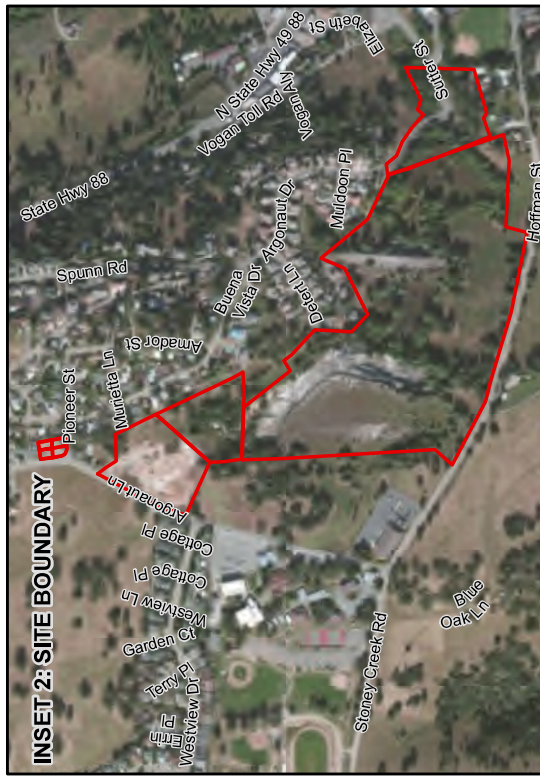
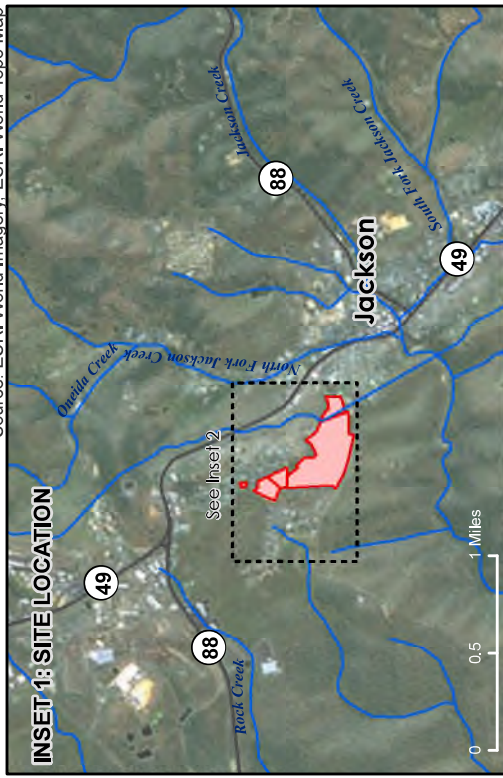
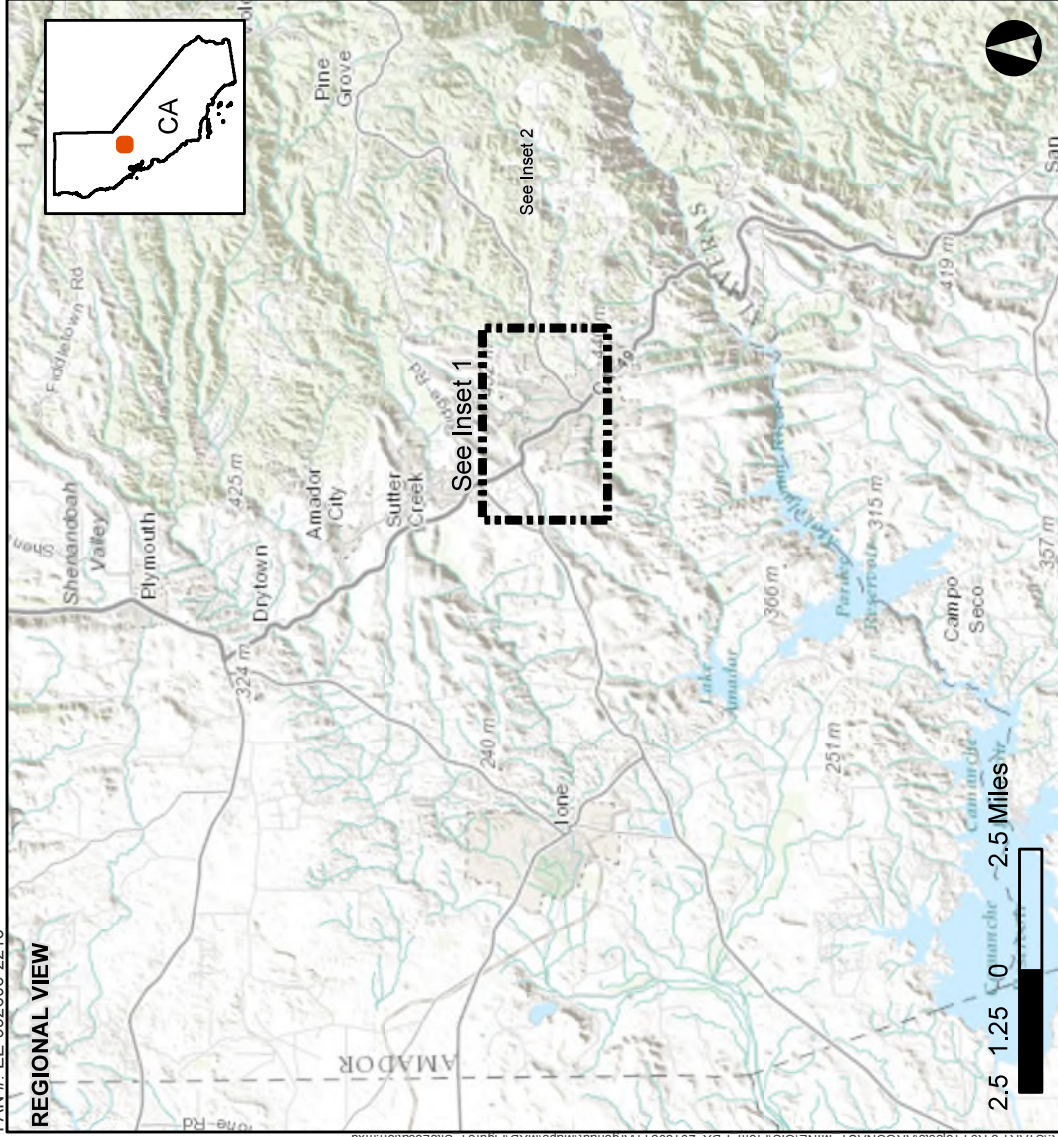
- ACEHD 2003. *Letter from R. Fourt, Registered Environmental Health Specialist with ACEHD to L. White, Chief Building Official, City of Jackson, RE: Proposed Grading and Development at Lots 30 and 31, Argonaut Heights, Jackson (APN 044-071-002 and 044-071-003)*. March 4, 2003.
- California EPA 2005. *Use of California Human Health Screening Levels (CHHSLs) in Evaluation of Contaminated Properties*. January.
- California EPA 2009. *Revised California Human Health Screening Levels (CHHSLs) for Lead*. September.
- E&E 2013. *Sampling and Analysis Plan, Argonaut Mine Tailings Pile Assessment, Jackson California (SAP)*, July 2013.
- URS 2009. *Argonaut Mine Tailings Site, Site Investigation Report, Draft*. URS Corporation, March 2009.
- URS 2011. *Interim Soil Removal Action Work Plan, Argonaut Mine Tailings Site, Jackson, California, Draft Final*. URS Corporation, June 2011.
- U.S. EPA. 1998a *Remedial Site Assessment Decision, Argonaut Mine Tailings, Pioneer Mine*, EPA ID# CAD983650011, June 1998.
- U.S. EPA, 1998b, *Preliminary Assessment, Argonaut Mine Tailings (Pioneer Mine), Argonaut Lane, Hoffman Street, Jackson, Amador County, California*, October 1998.
- U.S. EPA, 1991. *Management of Investigation-Derived Wastes During Site Inspections*, Office of Emergency and Remedial Response, OERR Directive 9345.3-02, May.
- U.S. EPA, 2001a. *Requirements for Quality Assurance Project Plans* (EPA QA/R 5, EPA/240/B 01/003), March.
- U.S. EPA, 2001b. *Region 9 Draft Superfund Data Evaluation/Validation Guidance* (EPA Region 9 R9/QA/00.4.1), March.
- U.S. EPA, 2002. *Guidance on Choosing a Sampling Design for Environmental Data Collection*, (U.S. EPA QA/G5S, EPA/240/R 02/005) December.
- U.S. EPA, 2003. *Superfund Lead-Contaminated Residential Sites Handbook* (OSWER Directive 9285.7-90), August.
- U.S. EPA, 2005. *Uniform Federal Policy for Implementing Environmental Quality System*, (EPA/505/F-03/001), March.
- U.S. EPA, 2006. *Guidance on Systematic Planning Using the Data Quality Objectives Process* (EPA/240/B-06/001), February.
- U.S. EPA, 2007. *Method 6200 Field Portable X-Ray Fluorescence Spectrometry for the Determination of Elemental Concentrations in Soil and Sediment, Revision O*, February.



6. References

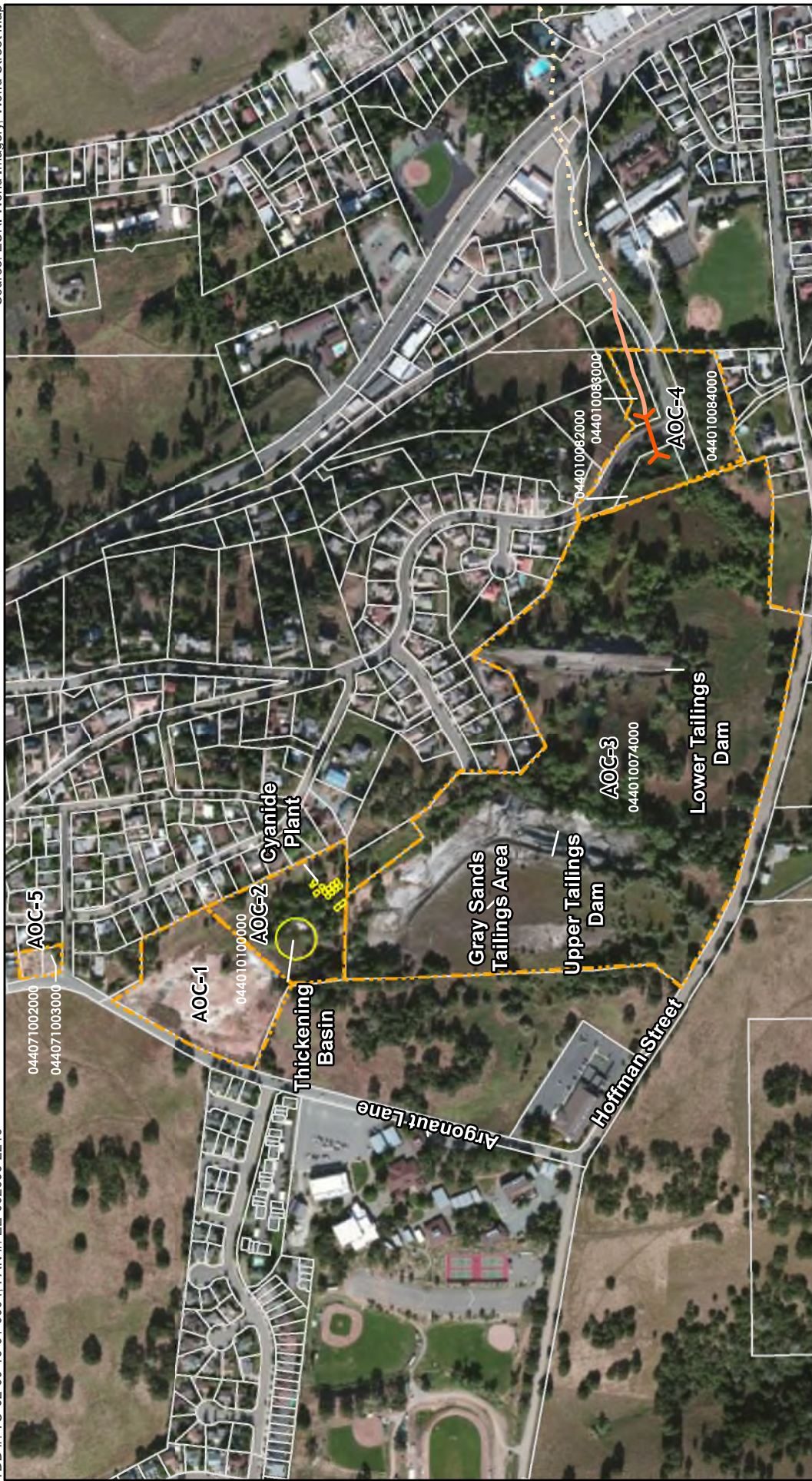
U.S. EPA, 2013. *Regional Screening Levels for Chemical Contaminants at Superfund Sites*, May, 2013.

Appendix A Figures



- LEGEND**
- Sample Locations Boundary
 - Rivers
 - Major Roads

Figure 1
Site Location Map
Argonaut Mine Tailings Pile
Jackson, California



LEGEND

- Vats and Tanks Associated with the Cyanide Plant in AOC2
- Approximate AOC Boundary
- Taxlots (Labeled with 12 digit ID if within the site boundary)
- Culvert
- Surface Drainage (Approximate)
- Underground Drainage (Approximate)
- AOC: Area of Concern

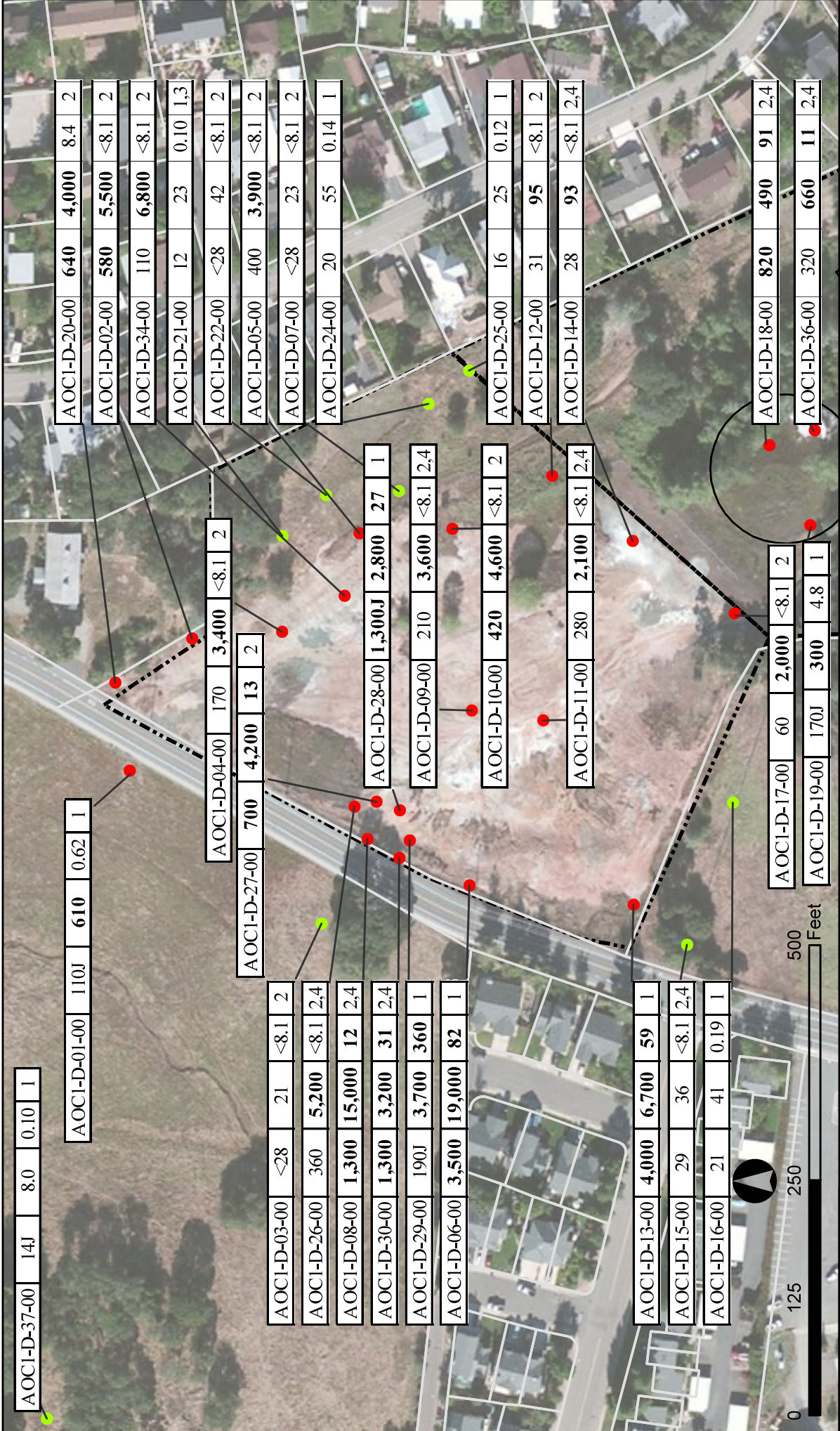


Figure 2

Site Features Map Argonaut Mine Tailings Pile

Jackson, California





LEGEND

ESLs: Lead: 400 Arsenic: 61 Mercury: 10

Below ESL Above ESL

Approximate AOC Boundary

Notes: Lab Analysis shown when possible. All concentrations in milligrams per kilogram (mg/kg) < - below the practical quantifiable detection limit US EPA - United States Environmental Protection Agency Location AOC1-D-23 not shown. No sample was analyzed from this interval. XRF - X-Ray Fluorescence

Figure 3

AOC-1: Lead, Arsenic, and Mercury Concentrations in Surface Soil Samples

Argonaut Mine Tailings Pile

Jackson, California

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Sample ID **Lead Concentration** **Arsenic Concentration** **Mercury Concentration** **Analytical Method Code**

1. US EPA Method 6010B

2. Analysis using XRF Technology US EPA Method 6200

3. Lab Analysis on unprocessed sample (not sieved)

4. XRF Analysis on unprocessed sample (analyzed directly through plastic bag)

Bold - Above Environmental Screening Level (ESL)

SD - Sediment sample

J - Value is estimated

AOC - Area of Concern

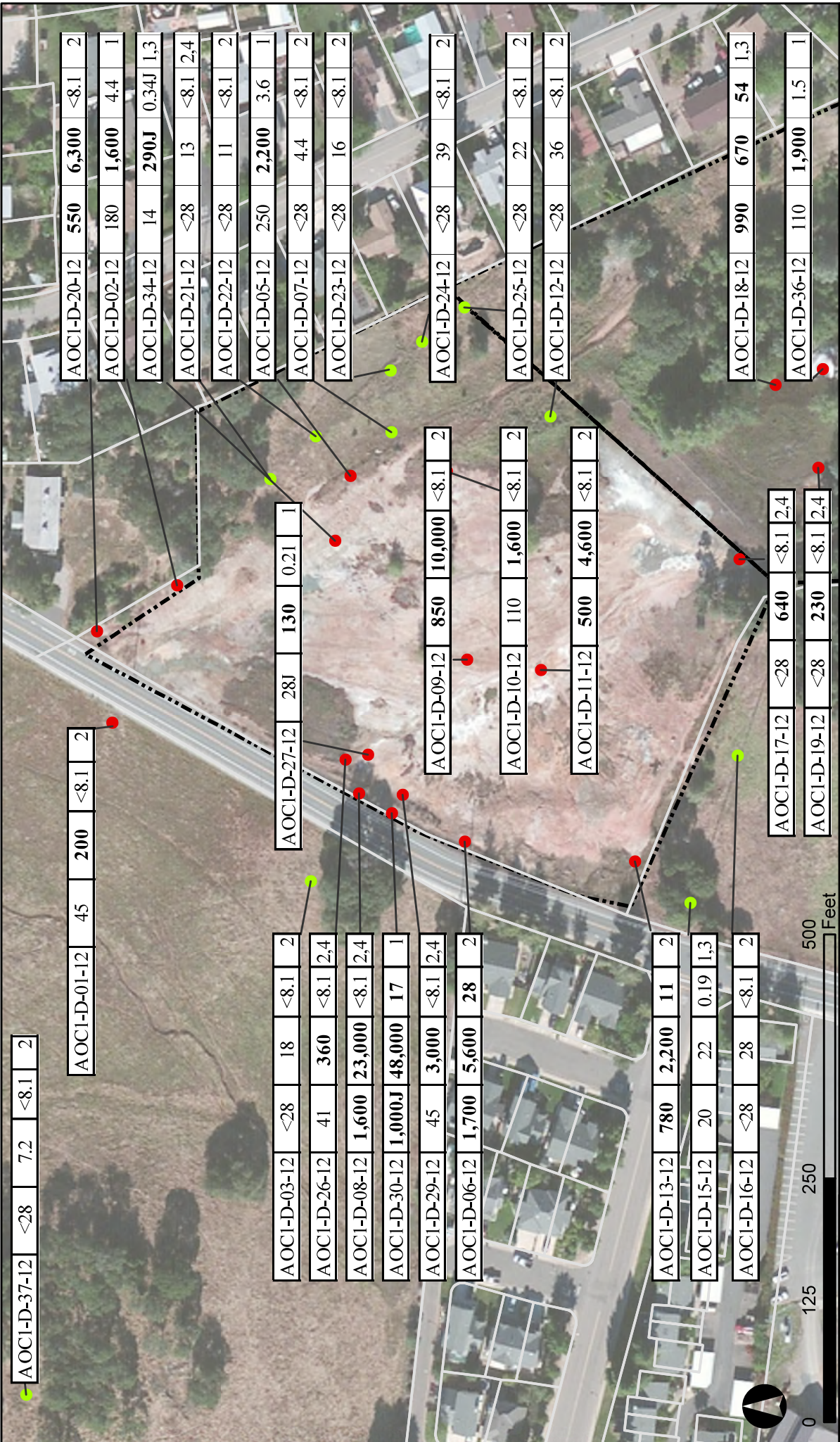
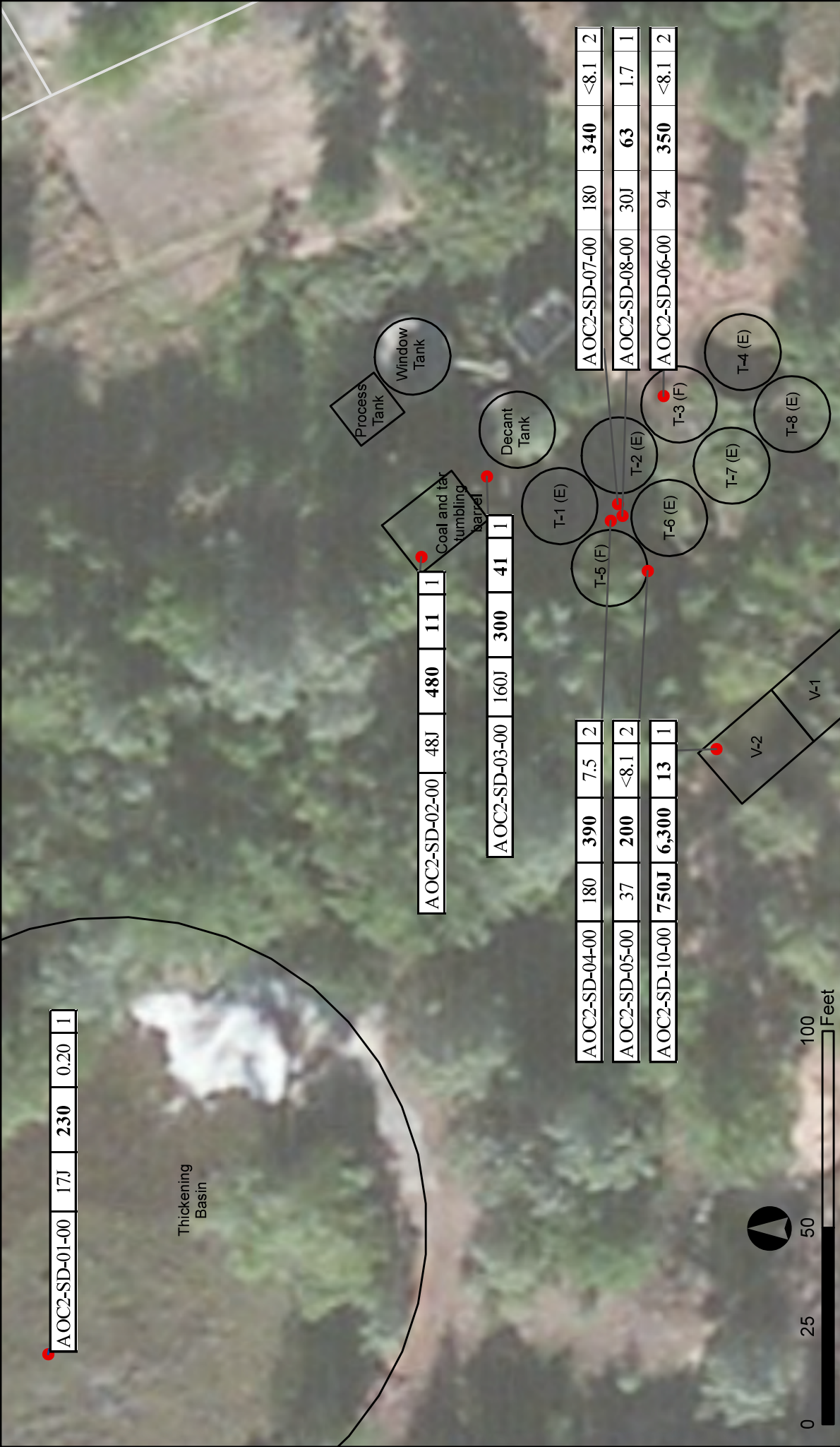


Figure 4

AOC-1: Lead, Arsenic, and Mercury Concentrations in Subsurface Soil Samples Argonaut Mine Tailings Pile

Jackson, California





LEGEND

● Above ESL

ESLs:
Lead: 400
Arsenic: 61
Mercury: 10

Notes:
Lab Analysis shown when possible.
All concentrations in milligrams per kilogram (mg/kg)
< - below the practical quantifiable detection limit
US EPA - United States Environmental Protection Agency
T - Tank
V - Vat

Figure 5

AOC-2: Lead, Arsenic, and Mercury Concentrations in Surface Soil Samples

Argonaut Mine Tailings Pile

Jackson, California

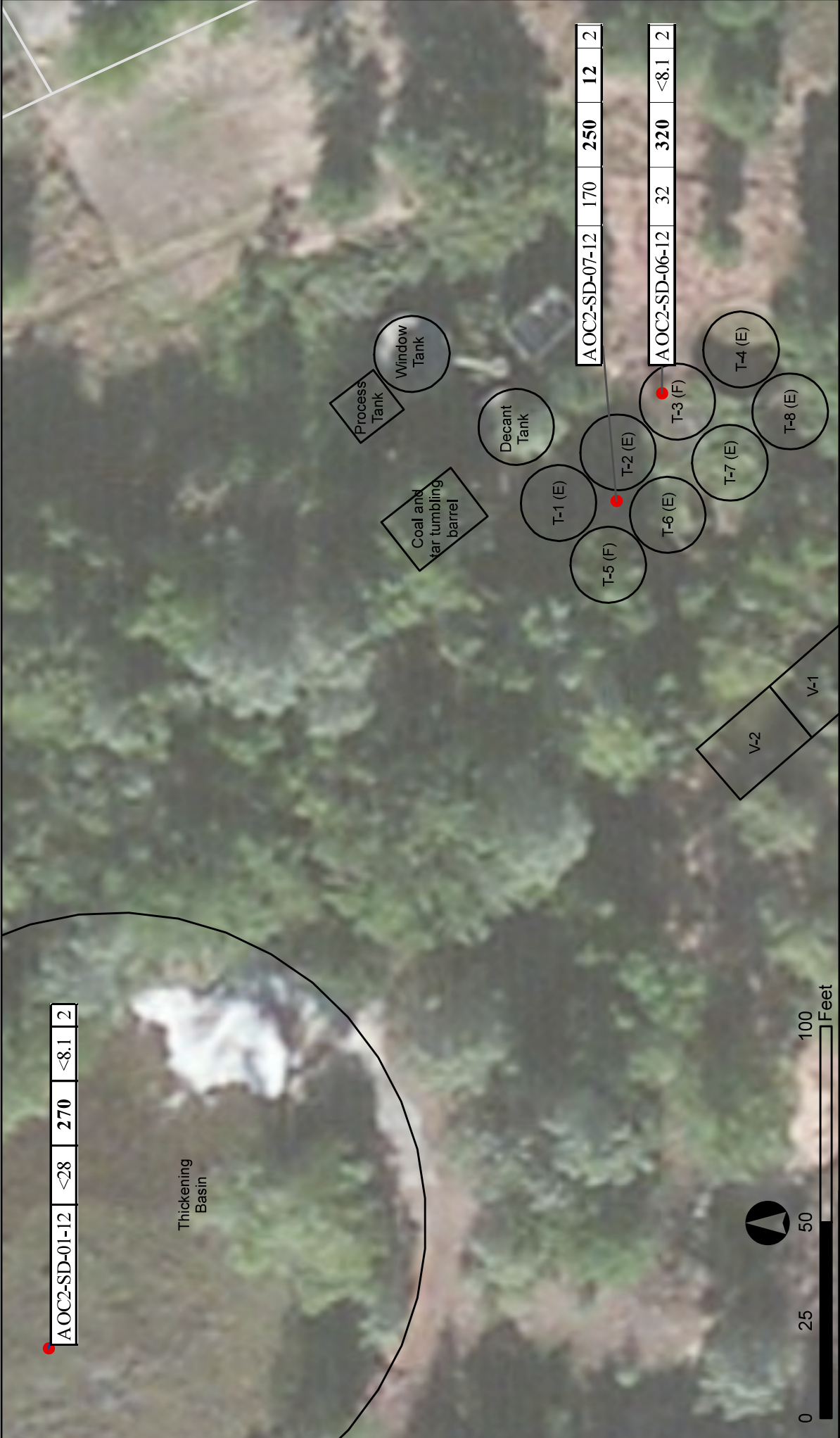
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Analytical Method Codes:

1. US EPA Method 6010B
2. Analysis using XRF Technology US EPA Method 6200
3. Lab Analysis on unprocessed sample (not sieved)
4. XRF Analysis on unprocessed sample (analyzed directly through plastic bag)

Sample ID | **Lead Concentration** | **Arsenic Concentration** | **Mercury Concentration** | **Analytical Method Code**

Bold - Above Environmental Screening Level (ESL)
SD - Sediment sample
J - Value is estimated
AOC - Area of Concern
XRF - X-Ray Fluorescence



LEGEND

● Above ESL

ESLs:
Lead: 400
Arsenic: 61
Mercury: 10

Notes:
Lab Analysis shown when possible.
All concentrations in milligrams per kilogram (mg/kg)
< - below the practical quantifiable detection limit
US EPA - United States Environmental Protection Agency
T - Tank
V - Vat

Sample ID	Lead Concentration	Arsenic Concentration	Mercury Concentration	Analytical Method Code
AOC2-SD-01-12	<28	270	<8.1	2
AOC2-SD-07-12	170	250	12	2
AOC2-SD-06-12	32	320	<8.1	2

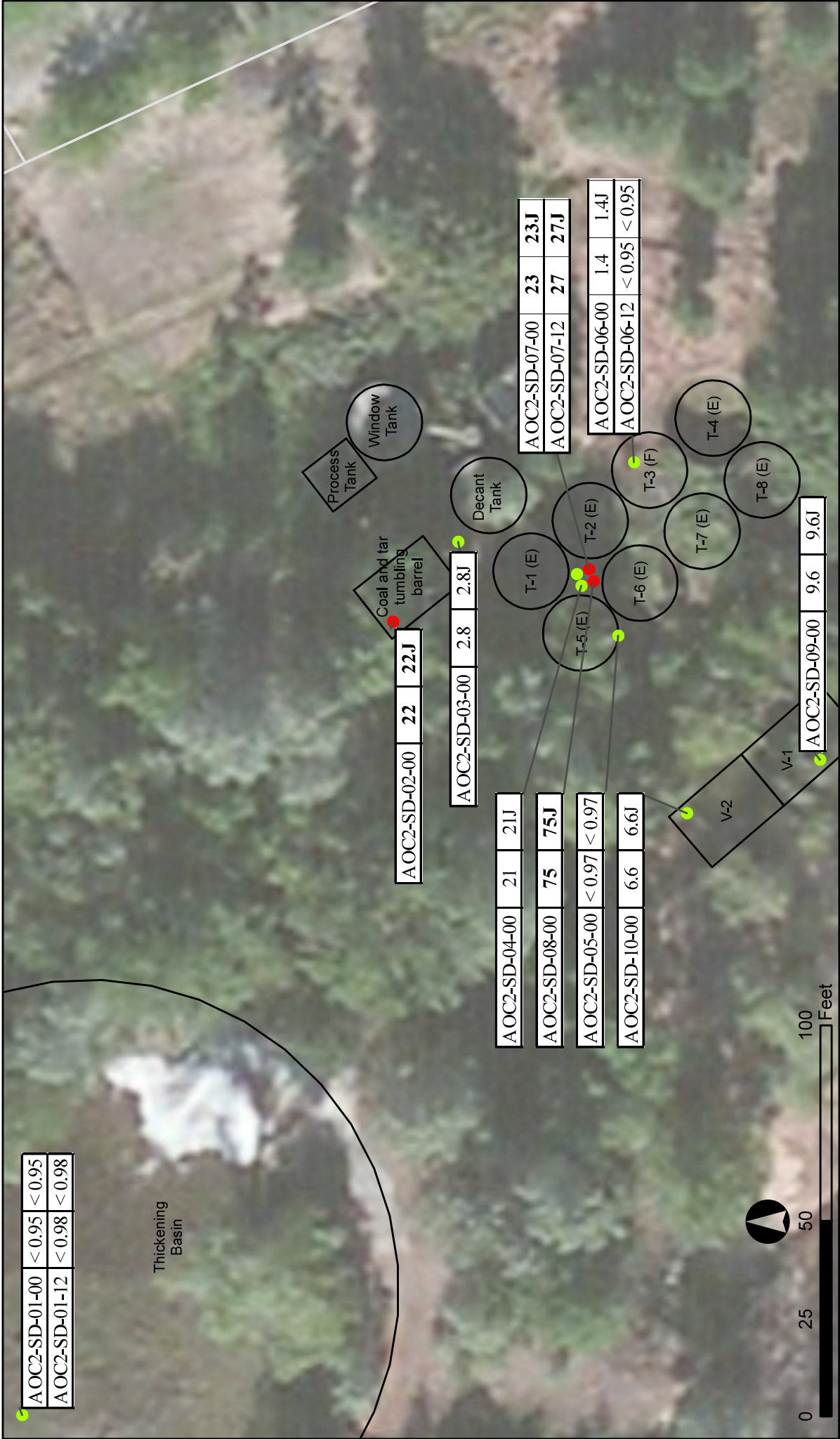
Analytical Method Codes:
1. US EPA Method 6010B
2. Analysis using XRF Technology US EPA Method 6200
3. Lab Analysis on unprocessed sample (not sieved)
4. XRF Analysis on unprocessed sample (analyzed directly through plastic bag)

Bold - Above Environmental Screening Level (ESL)
SD - Sediment sample
J - Value is estimated
AOC - Area of Concern
XRF - X-Ray Fluorescence

Figure 6

AOC-2: Lead, Arsenic, and Mercury Concentrations in Subsurface Soil Samples Argonaut Mine Tailings Pile

Jackson, California



LEGEND

Below ESL

Above ESL

Sample ID	Cyanide, Amenable	Cyanide, Total
-----------	-------------------	----------------

Notes:

Lab Analysis by U.S. EPA method 9012A

All concentrations in milligrams per kilogram (mg/kg)

-00 Surface soil sample

-12 Subsurface soil sample

< - below the practical quantifiable detection limit

Bold - Above Environmental Screening Level (ESL)

SD - Sediment sample

J - Value is estimated

AOC - Area of Concern

US EPA - United States Environmental Protection Agency

XRF - X-Ray Fluorescence

T - Tank

V - Vat

Figure 7

AOC-2: Cyanide Concentrations in Soil Samples

Argonaut Mine Tailings Pile

Jackson, California

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Figure 8

AOC-2: PAH Concentrations in Soil Samples

Argonaut Mine Tailings Pile

Jackson, California

Notes:

Lab Analysis by U.S. EPA Method 8270C

All concentrations in milligrams per kilogram (mg/kg)

P: Product (Coal Tar)

-00: Surface soil sample

-12: Subsurface soil sample

SD: Sediment sample

J - Value is estimated

Analyses that were not detected are not shown

AOC - Area of Concern

US EPA - United States Environmental Protection Agency

XRF - X-Ray Fluorescence

T - Tank

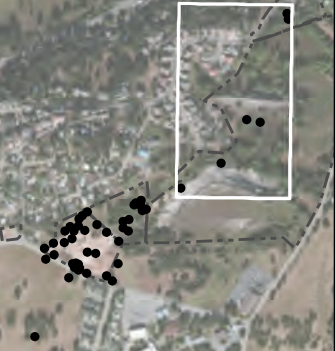
V - Vat

PAH - Polycyclic aromatic hydrocarbon

LEGEND

PAH Concentration

- All below the practical quantifiable detection limit
- Below ESL
- Above ESL



LEGEND

- Below ESL (Green dot)
- Above ESL (Red dot)

Soil ESLs:

- Lead: 400
- Arsenic: 61
- Mercury: 10

Water ESLs:

- Lead: 2.4
- Arsenic: 150
- Mercury: 0.050

Notes:

Lab Analysis shown when possible.
All concentrations in milligrams per kilogram (mg/kg)
< - below the practical quantifiable detection limit

US EPA - United States Environmental Protection Agency

Analytical Method Codes:

- 1. US EPA Method 6010B
- 2. Analysis using XRF Technology US EPA Method 6200
- 3. Lab Analysis on unprocessed sample (not sieved)
- 4. XRF Analysis on unprocessed sample (analyzed directly through plastic bag)

Sample ID | **Lead Concentration** | **Arsenic Concentration** | **Mercury Concentration** | **Analytical Method Code**

Notes:

- Bold** - Above Environmental Screening Level (ESL)
- SD** - Sediment sample
- J** - Value is estimated
- AOC** - Area of Concern
- XRF** - X-Ray Fluorescence

Figure 9

AOC-4: Lead, Arsenic, and Mercury Concentrations in Surface Soil and Water Samples Argonaut Mine Tailings Pile

Jackson, California

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LEGEND

- All below the practical quantifiable detection limit
- Below ESL
- Above ESL

Sample ID	Cyanide, Amenable	Cyanide, Total
AOC4-SD-02-00	23	23J
AOC4-SD-03-00	< 0.98	< 0.98
AOC4-SD-04-00	1.0	1.0J
AOC4-W-02	< 0.06	< 0.06
AOC4-SD-01-00	1.4	1.4J
AOC4-W-01	< 0.06	< 0.06

Notes:

Lab Analysis by U.S. EPA method 9012A

Sediment concentrations in milligrams per kilogram (mg/kg)

Water concentrations in milligrams per liter (mg/L)

-00 Surface soil sample

-12 Subsurface soil sample

< - below the practical quantifiable detection limit

Bold - Above environmental screening level (ESL)

SD - Sediment sample

W - Water sample

J - Value is estimated

AOC - Area of Concern

US EPA - United States Environmental Protection Agency

XRF - X-Ray Fluorescence

Figure 10

AOC-4: Cyanide Concentrations in Soil and Water Samples

Argonaut Mine Tailings Pile

Jackson, California

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LEGEND

- Below the practical quantifiable detection limit
- Below ESL
- Approximate AOC Boundary
- Taxlots

Notes:

Lab Analysis by U.S. EPA Method 8270C
All concentrations in milligrams per kilogram (mg/kg)
P: Product (Coal Tar)
-00: Surface soil sample
-12: Subsurface soil sample
SD: Above Environmental Screening Level (ESL)
J - Value is estimated
Analytes that were not detected are not shown
AOC - Area of Concern
US EPA - United States Environmental Protection Agency
XRF - X-Ray Fluorescence
PAH - Polycyclic aromatic hydrocarbon

Figure 11

AOC-4: PAH Concentrations in Soil and Water Samples
Argonaut Mine Tailings Pile
Jackson, California



Figure 12

AOC-1: Proposed Decision Units Argonaut Mine Tailings Pile

Jackson, California

LEGEND

Arsenic Soil Concentration

< ESL (61 mg/kg)

> ESL

Decision Unit Areas

Step-out Sampling Proposed (Boundary Unknown)

Site Features

Approximate AOC Boundary

Taxlots

Approximate location of URS Soil Boring SB-2 (Source: DTSC based on the URS RI report (URS 2008))

Analytical Method Codes:

1. US EPA Method 6010B

2. Analysis using XRF Technology US EPA Method 6200

3. Lab Analysis on unprocessed sample (not sieved)

4. XRF Analysis on unprocessed sample (analyzed directly through plastic bag)

Lab analysis shown when possible. All concentrations in milligrams per kilogram (mg/kg)

Bold - Above Environmental Screening Level (ESL)

D - Discrete soil sample

J - Value is estimated

AOC - Area of Concern

US EPA - United States Environmental Protection Agency

XRF - X-Ray Fluorescence

in - Inches

ft - Feet

yd - Yard

ex - Excavation

bgs - Below Ground Surface

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Average Arsenic Concentrations (mg/kg) in AOC-1

Decision Unit Area	0-2 in bgs	12-18 in bgs	Area (ft ²)	Area (Acres)	Volume @ 1 ft ex (y d ³) ^B	Volume @ 2 ft ex (y d ³) ^B
1 ^A	34	18	46,000	1.06	1,700	3,410
2	3,700	1,900	152,000	3.49	5,630	11,300
3	6,500	12,000	20,900	0.479	774	1,550
4 ^A	39	25	56,500	1.30	2,090	4,190
5 ^A	15	13	325,000	7.47	12,000	24,100
6	?	?	41,900	0.96	1,550	3,100
Total Proposed for Excavation	-	-	215,000	4.94	7,950	16,000

Notes: A = Area not proposed for excavation, quantities excluded from total, B = Estimates based on area shown and are in-place quantities

